Selective Anatomy

Prep Manual for Undergraduates

Volume II

Thorax | Abdomen | Lower Limb | General Embryology | Genetics





Vishram Singh

ELSEVIER

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VOLUME II

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Write a short note on the azygos vein.

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2. Abdomen

7. Anterior abdominal wall

Write a short note on the caput medusae.

Describe the umbilicus in brief and discuss its anatomical, embryological, and clinical importance.

Enumerate the muscles of the anterior abdominal wall.

Give the origin, insertion, and nerve supply of the external oblique muscle.

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Enumerate the coverings of the direct inguinal hernia.

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Write a short note on spermatic cord.

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Give the histological features of the vas deferens.

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What are male external genital organs?

Describe penis in brief under the following headings: (a) definition, (b) parts, (c) structure of body, (d) arterial supply, (e) venous drainage, (f) lymphatic drainage, (g) innervation, (h) mechanism of erection, and (I) applied anatomy.

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Give a brief account of 4 quadrants of the abdomen.

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Write a short note on greater omentum.

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Enumerate the contents of lesser omentum.

Write a short note on Morison's pouch (hepatorenal pouch).

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10. Stomach and spleen

Stomach

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Enumerate the histological features of stomach.

Give the differences in histological features of cardiac, body/fundus, and pyloric parts of the stomach in a tabular form.

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Describe spleen under the following headings: (a) introduction, (b) external features, (c) relations, (d) blood supply, (e) histology, and (f) applied anatomy.

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Enumerate the factors responsible for fixation of the liver.

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12. Duodenum, pancreas, and portal vein

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Write a short note on the ligament of treitz.

Describe the histological features of the duodenum.

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Describe the pancreas under following headings: (a) introduction, (b) location, (c) parts, (f) ducts, (g) blood supply, and (h) applied anatomy.

Describe the histological features of the pancreas.

Describe development of the pancreas and associated congenital anomalies in brief.

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Define portocaval anastomoses with their sites and related clinical significance.

Give a brief account of the development of the portal vein.

13. Small and large intestines

Small intestine

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Give the differences between jejunum and ileum in the tabular form.

Write a short note on mesentery.

Give the histological differences between the jejunum and ileum in a tabular form.

Write a short note on Meckel’s diverticulum (diverticulum ilei).

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Describe parts and functions of the large intestine. Give its cardinal features.

What are differences between the small and large intestines?

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Give a brief account of the inferior mesentery artery.

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Discuss histological features of the kidney.

Describe development of the kidney and associated common congenital anomalies in brief.

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Give histological features of the ureter (fig. 14.8).

Describe the suprarenal gland in brief: (a) external features, (b) arterial supply, and (c) venous drainage.

Give differences between the right and left suprarenal glands.

Give histological features of the suprarenal/adrenal gland.

15. Diaphragm, muscles of posterior abdominal wall, and great vessels of abdomen

Diaphragm

Describe diaphragm under the following headings: (a) introduction, (b) origin and insertion, (c) openings of diaphragm and structure passing through them, (d) nerve supply, (e) actions, and (d) development.

Muscles of posterior abdominal wall

What are muscles of the posterior abdominal wall?

Give the origin, insertion, nerve supply, and actions of the psoas major muscle.

Write a short note on psoas sheath and discuss its clinical significance.

Enumerate the nerves that appear in relation to the psoas major muscle.

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Describe inferior vena cava under the following headings: (a) introduction, (b) tributaries, and (c) development.

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Enumerate the histological features of the urinary bladder.

Write a brief note on the development of the urinary bladder and enumerate common congenital anomalies associated with it.

Describe male urethra under the following headings: (a) introduction, (b) parts, and (c) applied anatomy.

Give a brief account of development of the male urethra.

Write a short note on the female urethra.

Give differences between the male and female urethra.

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Describe histological features of the fallopian tube.

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Give the histological features of the vagina.

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Write a short note on the superficial perineal pouch.

Write a short note on the deep perineal pouch.

Describe the ischiorectal/ischioanal fossa in brief.

Describe the pudendal canal (Alcock's canal) in brief.

Describe the pudendal nerve in brief.

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Write a short note on the femoral canal.

Write a short note on the femoral artery.

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Describe the obturator nerve in brief.

Write a short note on the lumbar plexus (fig. 20.14).

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Describe the superficial peroneal nerve in brief.

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4. General embryology

24. General embryology

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Write a short note on yolk sac.

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Write a short note on amnion and discuss its applied anatomy.

Describe in brief the amniotic fluid and its applied importance.

Write a short note on chorion.

Write a short note on the umbilical cord.

Describe placenta in brief and discuss its applied anatomy.

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Dedication

Dedicated to
 My Students: Past, and Present

Foreword

It gives me a great pleasure to write the Foreword for Professor Vishram Singh's book *Selective Anatomy Prep Manual for Undergraduates*. There was a long-felt need for a suitable book on anatomy in question-answer format to help students not only to revise vast course of anatomy before examination in limited time but also present their knowledge in an easy format.

It is a herculean task to select the frequently asked questions in examinations of various universities and answer them in a manner as expected by an examiner.

Professor Vishram Singh is an eminent and highly regarded Anatomist. He has authored more than dozen books and published a number of research papers in national and international journals.

This book is in two volumes in question-answer format. Volume I covers the complete syllabus of Paper I and Volume II, the syllabus of Paper II. The book is profusely illustrated with four-color line diagrams which can be easily reproduced by the students during examination.

This book is an appropriate comprehensive manual for university examination, thus I strongly recommend it to the undergraduate medical students.

Wishing Professor Vishram Singh for his future endeavor.

Vijay Kumar Arora

Professor (Dr) VK Arora
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Preface

Vishram Singh

The Medical Council of India has reduced the duration of teaching of 1st year MBBS course from 1½ years to 1 year. It has also introduced the specific pattern of questions such as long and short answer questions, short notes, drawing and labeling of diagrams, providing anatomical, embryological, and genetic basis of clinical problems and MCQs.

Each student tries his/her best to clear the examination. However, many students do not know how to present the answers considering the marks allotted.

This book is in question-answer format in 2 volumes. Volume I covers the syllabus of Paper I, while Volume II deals with the syllabus of Paper II.

Having 40 years of teaching experience and being an examiner in various medical colleges and institutions, I have put my best effort in selecting frequently asked questions (FAQs) and tried to answer them in a concise manner acceptable to most of the examiners. Most of the diagrams are drawn by myself to ensure the accuracy and to see that they are easily reproduced by the students in examination.

Although, initially I was a bit hesitant to write a book in question and answer format but later my conscience allowed me to do so because the sole aim of a teacher is to solve the problems faced by the students and inspire them to become good doctors.

I hope that this book will definitely solve the problems of students and relieve them from pre-examination stress. However, the student should be aware that this book is meant only for revision purpose and not to replace the standard textbooks.

I am confident this book will serve the purpose for which it meant.

Lastly I will highly appreciate comments both good and bad about the book from both students and faculty because that will help me to improve the book in future.

"Necessity is the mother of invention."

Acknowledgments

Vishram Singh

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SECTION I
Thorax

OUTLINE

CHAPTER 1

Thoracic cavity

❖ Define thoracic cavity and give its boundaries and contents.

It is a cavity of thorax. It is enclosed in an elastic osseocartilaginous framework which helps in both increasing and decreasing the volume of thoracic cavity.

Boundaries

Anterior

Sternum.

Lateral

12 ribs with their costal cartilages and intercostals spaces containing intercostal muscles, membranes, nerve and vessels.

Posterior

Bodies of 12 thoracic vertebrae and the intervening international discs.

Contents

The major contents are:

- Lungs
- Heart

❖ Write a short note on the thoracic inlet.

It is a superior aperture of the thoracic cavity. It is reniform in shape and measuring 10 cm in transverse plane and 5 cm in anteroposterior plane. The inlet slopes downwards and anteriorly at an angle of 45°. It is partially closed on each side by a suprapleural membrane (also called **Sibson's fascia**).

Boundaries

Posterior

Body of first thoracic vertebra.

On each side

First rib and its costal cartilage.

Anterior

Upper border of manubrium sterni.

❖ Enumerate the structures passing through the thoracic inlet.

The major structures are:

Two tubes

Trachea and esophagus

Two sets of arteries

- Branches of arch of aorta viz. brachiocephalic trunk, left common carotid, and left subclavian
- Right and left internal thoracic arteries

Four sets of neural structures:

- Right and left vagus nerves
- Right and left phrenic nerves
- Right and left sympathetic trunks
- Right and left first thoracic nerves (ventral rami)

N.B.

Apices of the lungs covered by cervical pleura also project upward through inlet into the root of the neck.

❖ Write a short note on the suprapleural membrane (Sibson's fascia).

It is a tough triangular membrane, which on either side partly separates the thoracic cavity from the neck.

Features (fig. 1.1)

• Its apex is attached to the tip of the transverse process of the seventh cervical (C7) vertebra.

• Its base is attached to the inner border of the first rib and its cartilage.

• Its inferior surface is fused with cervical pleura.

• Its superior surface is related to subclavian vessels.

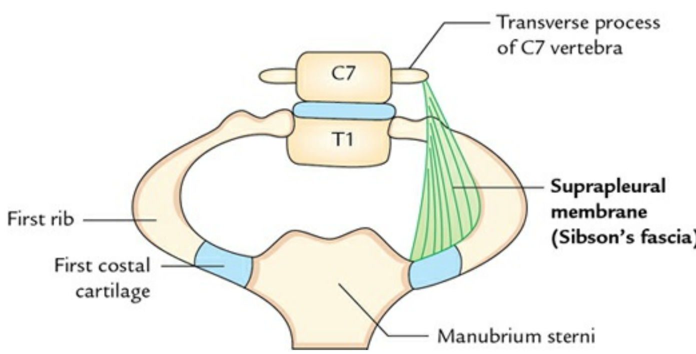


FIG. 1.1 Suprapleural membrane.

N.B.

Morphologically, Sibson's fascia represents the degenerated tendon of the scalenus minimus (pleuralis) muscle.

Applied anatomy

• It protects the apex of lung from injury.

• It prevents the puffing of root of neck during respiration.

❖ Describe the thoracic outlet in brief.

It is the inferior aperture of the thoracic cavity and closed completely by thoracoabdominal diaphragm (or diaphragm).

Boundaries

Anterior

Xiphoid process.

Lateral

Costal margin formed by 7th to 9th costal cartilages and 11th and 12th ribs.

Posterior

Body of T12 vertebra.

N.B.

The structures freely pass to and from between thoracic and abdominal cavities through openings in the thoracoabdominal diaphragm.

❖ Enumerate the major (large) openings in the diaphragm and structures passing through them.

There are 3 major (large) openings in the diaphragm. The details of these openings and structures passing through them are given in Table 1.1.

Table 1.1

Major openings of the diaphragm and structures passing through them

Opening	Vertebral level	Shape	Structures passing through
Vena caval opening	T8	Quadrangular	Inferior vena cava Right phrenic nerve
Esophageal opening	T10	Elliptical	Esophagus Right and left vagal trunks Esophageal branch of left gastric artery
Aortic opening	T12	Circular	*From left to right:* Aorta Thoracic duct Azygos vein

❖ Write a short note on the cervical rib.

It develops from costal element of the transverse process of the C7 vertebra. It is present in about 0.5% of the cases. Its posterior end is attached to transverse process of the C7 vertebra, and its distal extremity is free or attached to the first rib.

Applied anatomy

The cervical rib reduces the size of scalene triangle and may cause:

- Tingling, pain, and numbness along the medial side of the hand and little finger, due to compression of the lower trunk of the brachial plexus
- Pallor and coldness of the upper limb due to compression of subclavian artery
- Reduction in radial pulse pressure

❖ Enumerate the structures passing in front of the neck of the first rib.

From medical to lateral side, these are (Fig. 1.2):

- Sympathetic chain
- First posterior intercostal vein
- Superior intercostal artery
- First thoracic nerve (ventral ramus)

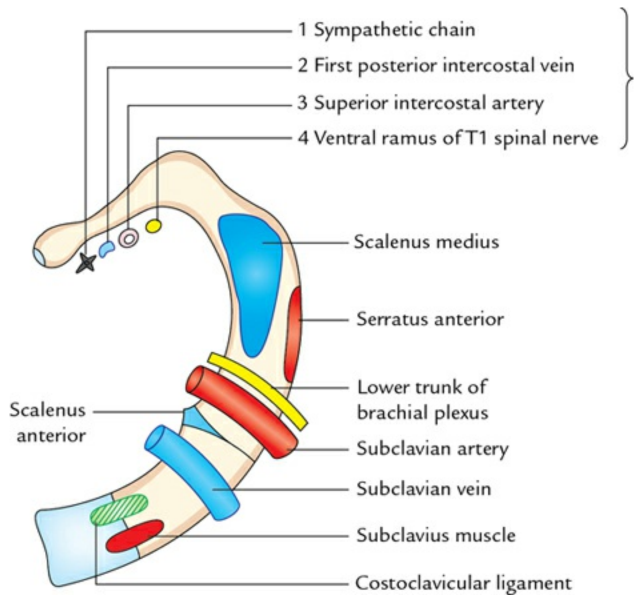


FIG. 1.2 Structures passing in front of the neck of the first rib.

❖ Write a short note on the sternal angle (angle of louis).

It is a horizontal bony angulation formed at the junction of manubrium and body of sternum. It can be palpated in a living person as a bony transverse ridge about 5 cm below the suprasternal notch.

Anatomical events taking place at sternal angle are:

- Articulates on either side with the costal cartilage of the 2nd rib which helps in counting the ribs in clinical practice
- Ascending aorta ends at this level
- Arch of aorta begins and ends at this level
- Descending aorta begins at this level
- Pulmonary trunk divides into two pulmonary arteries at this level
- Azygos vein enters the superior vena cava at this level
- Trachea divides into two principal bronchi at this level
- Marks the junction between superior and inferior mediastinum
- Marks the junction between two discontinuous dermatomes C4 (above) and T2 (below)
- Superior vena cava pierces the fibrous pericardium at this level

❖ Define intercostal space and enumerate its contents.

It is a space between two consecutive ribs and their costal cartilages.

Contents

A typical intercostal space contains (Fig. 1.3):

- 3 intercostal muscles.
- A neurovascular bundle.

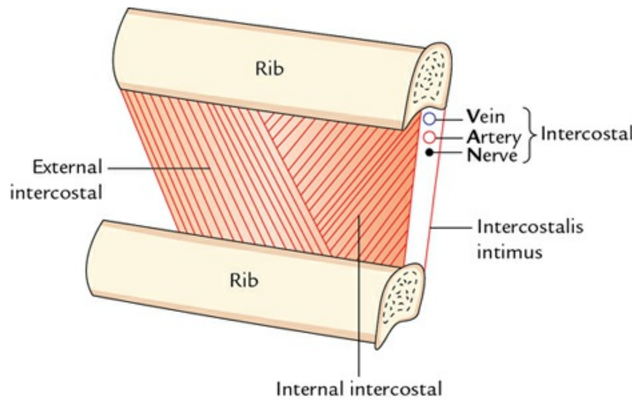


FIG. 1.3 Contents of the intercostal space.

The *intercostal muscles* are arranged in 3 layers. From superficial to deep, these are:

- External intercostal
- Internal intercostal
- Transversus thoracis

N.B.

The transversus thoracis is divided into 3 parts: sternocostalis, intercostalis intimi, and subcostalis.

The *neurovascular bundle* consists of intercostal nerve, intercostal vein, and intercostal artery. The neurovascular bundle runs between the middle and inner layers of intercostal muscles and lies in the subcostal groove on the inner surfaces of the rib near its lower border.

❖ Give the origin, insertion, and actions of intercostal muscles in tabular form.

These are given in Table 1.2.

Table 1.2

Origin, insertion, and actions of intercostal muscles

Muscle	Origin	Insertion	Actions
External intercostals	Lower border of the rib above the space	Outer lip of the upper border of the rib below the space	Elevates 2nd to 12th ribs during inspiration
Internal intercostals	Floor of the costal groove of the rib above the space	Inner lip of the upper border of the rib below the space	Elevates 2nd to 12th ribs during inspiration
Transverse thoracis (a) Subcostalis (confined to posterior part)	Inner surface of the rib near the angle	Inner surface of the 2nd or 3rd rib below	
(b) Intercostalis intimus (confined to middle 2/4th)	Inner surface middle 2/4th of the upper rib	Inner surface of the rib below	Elevates the ribs during expiration
(c) Sternocostalis (confined to anterior part)	• Lower 1/3rd of the posterior surface of the body of the sternum • Posterior surface of the xiphoid process • Posterior surface of the costal cartilages of the lower 3rd or 4th true ribs near the sternum	Costal cartilages of the 2nd to 6th ribs.	Depresses 2nd to 6th rib

N.B.

The intercostal muscles are supplied by the intercostal nerves.

❖ Give the direction of fibres of intercostal muscles.

Muscle	Direction of fibres
External intercostal	Downward, forward, and medially
Internal intercostal	Downward, backward, and laterally
Transversus thoracis	Downward, backward, and laterally

❖ Write a short note on the intercostal nerves.

The intercostal nerves are anterior primary rami of thoracic spinal nerves and are located in the intercostal spaces. Thus, there are 11 intercostal nerves in the thoracic wall.

Unique feature

The intercostal nerves retain their segmental character unlike the anterior primary rami of other regions where they form nerve plexuses, viz. cervical, brachial, lumbar, and sacral.

Classification of intercostal nerves

Typical intercostal nerves

They remain confined within the respective intercostal spaces of thoracic wall, viz. 3rd, 4th, 5th, and 6th intercostal nerves.

Atypical intercostal nerves

They extend beyond the thoracic wall, e.g., 1st, 2nd, 7th, 8th, 9th, 10th, and 11th intercostal nerves.

N.B.

The 7th to 11th intercostal nerves are called **thoracoabdominal nerves** as they leave the thoracic wall to supply the anterior abdominal wall.

❖ Write a short note on a typical intercostal nerve.

The anterior primary rami of the 3rd to 6th thoracic spinal nerves are termed atypical spinal nerves and supply the thoracic wall.

Course (fig. 1.4)

Each intercostal nerve emerges through the respective intervertebral foramen and enters into respective intercostal space. The courses in the intercostal space are as follows:

- In the posterior part of intercostal space, it runs between the pleura and posterior intercostal membrane as far as the angle of the rib.
- Thereafter, it continues its course in the costal groove between internal intercostal and intercostalis intimi muscles.
- Finally, it runs between the internal intercostal and sternocostalis muscles.
- At the anterior end of intercostal space, the nerve passes in front of internal mammary artery and runs forward, piercing the internal intercostal muscle, anterior intercostal membrane to become the *anterior cutaneous nerve.*

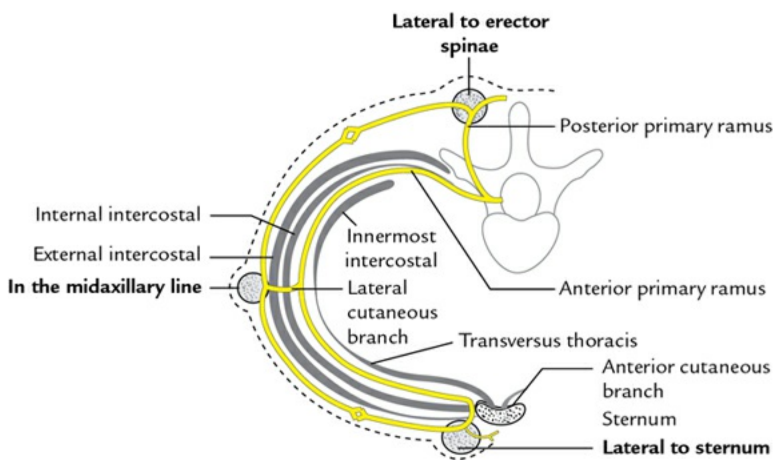


FIG. 1.4 Typical intercostal nerve.

Branches

- *White ramus communicans* to the sympathetic trunk.
- *Collateral branch*: It arises in the posterior part of the intercostal space and runs along the inferior margin of the space.
- *Lateral cutaneous branch*: It appears in midaxillary line and divides into anterior and posterior branches.
- *Anterior cutaneous nerve* (terminal branch) appears on the side of sternum and divides into medial and lateral branches.
- *Muscular branches.*

Applied anatomy

- Irritation of intercostal nerves causes severe pain, which is referred to the front and side of the chest.

- Pus from tubercular abscess of the vertebral column tracks around the thoracic wall along the intercostal neurovascular bundle and points on the surface of the thoracic wall at 3 sites of exit of posterior, lateral, and anterior cutaneous branches of the spinal nerves (Fig. 1.4).

❖ Describe in brief the arterial supply of the thoracic wall.

The thoracic wall is richly supplied by blood by the intercostal arteries. The intercostal arteries are divided into two groups: (a) anterior intercostal arteries and (b) posterior intercostal arteries.

Anterior intercostal arteries

- There are two anterior intercostal arteries in each intercostal space (except in last 2 intercostal spaces).
- In the upper six intercostal spaces, they arise from *internal mammary artery*.
- In the 7th, 8th, and 9th intercostal spaces, they arise from *musculophrenic artery*.
- In the 11th and 12th intercostal spaces, there are no anterior intercostal arteries.

Posterior intercostal arteries

- There is only one intercostal artery in each space, giving a collateral branch that runs parallel to it. The two anastomose with the corresponding anterior intercostal arteries.
- In the upper two spaces, they arise from the *superior intercostal artery*.
- In the 3rd to 11th intercostal spaces, they arise from the *descending thoracic aorta*.

N.B.

Each intercostal space contains three intercostal arteries: one posterior and two anterior.

❖ Write a short note on the internal thoracic (mammary) artery.

There are two internal thoracic arteries, deep to the anterior chest wall, one on either side of the sternum. The details are as follows (Fig. 1.5):

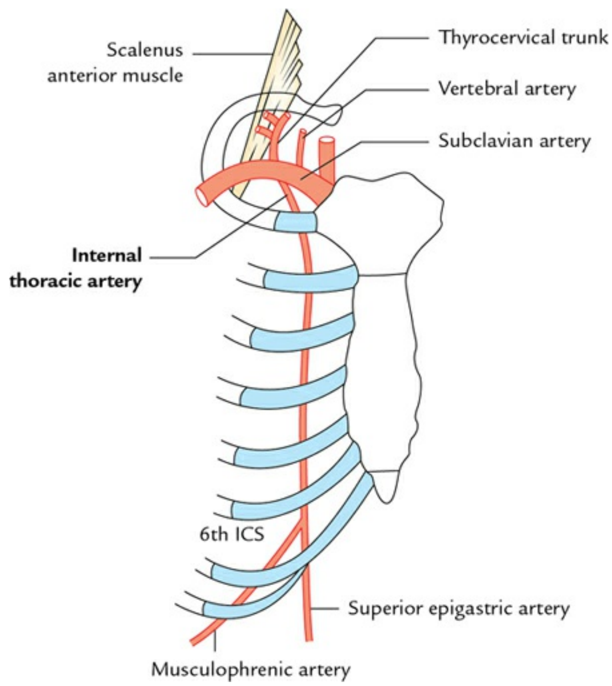


FIG. 1.5 Origin, course, and termination of right internal thoracic artery.

Origin

From the first part of subclavian artery, opposite to thyrocervical trunk, about 2.5 cm above the medial end of the clavicle.

Course

First it runs downward, forward and medially behind the medial end of the clavicle and first costal cartilage, in front of pleura. Subsequently, it runs vertically downward behind the upper six costal cartilages, 1.25 cm away from the margin of the sternum.

Termination

It terminates in the 6th intercostal space, by dividing into *superior epigastric* and *musculophrenic arteries*.

Branches

These are:

Pericardiophrenic artery

- A long slender branch that runs along the phrenic nerve to supply pleura and pericardium.

Anterior intercostal arteries

- The two anterior intercostal arteries are given to each of the upper six spaces.

Perforating arteries

- These accompany the anterior cutaneous nerves. *The perforating branches of the 2nd, 3rd, and 4th spaces are quite large and supply the mammary gland in female.*

Superior epigastric artery

- It runs downward to enter the rectus sheath behind the rectus abdominis muscle.

Musculophrenic artery

- It runs downward and laterally behind the 7th, 8th, and 9th costal cartilages. It gives rise to anterior intercostal arteries to the 7th, 8th, and 9th spaces.

Mediastinal arteries

- They are small inconstant branches that supply thymus, front of pericardium and anterior mediastinal fat.

Applied anatomy

- The internal thoracic artery is sometimes ligated in the 3rd intercostal space to enhance/increase the blood supply to the heart.

- The internal mammary artery may be used for coronary graft (**IMA Graft**), since it is less prone to develop atherosclerosis because of its histological peculiarity.

❖ Give a brief account of the intercostal veins.

Each intercostal space contains 3 intercostal veins (ICVs): two anterior and one posterior.

Anterior intercostal veins

They are two in each upper 9 intercostal spaces. The veins of upper 6 spaces drain into the *internal thoracic vein* while those in lower 3 spaces drain into the *musculophrenic vein*.

Posterior intercostal veins

There is only one posterior intercostal vein in each space. They drain as follows:

- On the right side:

❒ 1st drains into brachiocephalic vein.

❒ 2nd, 3rd, and 4th unite to form the *right superior intercostal vein*, which drain into the arch of the azygos vein.

❒ 5th to 11th drain into the azygos vein.

- On the left side:

❒ 1st drains into the left brachiocephalic vein.

❒ 2nd, 3rd, and 4th unite to form the *left superior intercostal vein*, which drain into the left brachiocephalic vein.

❒ 5th to 8th drain into the accessory hemiazygos vein.

❒ 9th to 11th drain into the hemiazygos vein.

❖ Give a brief description of mechanism of external respiration.

The external respiration consists of two components: (a) inspiration and (b) expiration.

Inspiration

During inspiration, the volume of thoracic cavity increases to create a negative intrathoracic pressure. As a result, the air is sucked into the lungs. The increase in volume of thoracic cavity occurs due to an increase in transverse, anteroposterior, and vertical diameters of the thoracic cavity.

- *Increase in transverse diameter of the thoracic cavity* occurs due to *bucket handle movements* of the 7th–10th ribs (vertebrochondral ribs) mainly. The ribs articulate in front with the sternum and behind with the vertebral column. Because the ribs curve downward as well as forward around the chest wall, they resemble bucket handle. Therefore, when the ribs are raised like *bucket handle,* the transverse diameter of thoracic cavity is increased (Fig. 1.6).
- *Increase in anteroposterior diameter of the thoracic cavity*: The anterior ends of the ribs lie at the lower level than the posterior ends; therefore, during elevation of ribs, the anterior ends move forward, leading to an increase in the anteroposterior diameter of the thoracic cavity. Since the anterior ends of vertebrosternal (the 2nd to 6th) ribs are fixed with sternum, the sternum also moves up and down along with up and down movements of ribs like *pump-handle movements* (Fig. 1.7). This leads to increase in anteroposterior diameter of the thoracic cavity.
- *Increase in vertical diameter* occurs due to descent of the diaphragm as a result of its contraction.

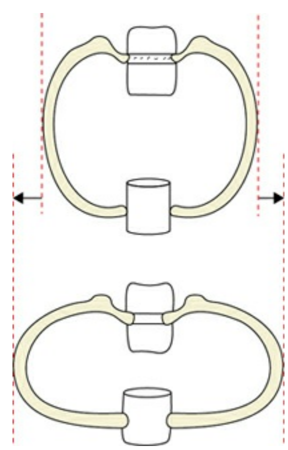


FIG. 1.6 Bucket-handle movements of the vertebrochondral ribs.

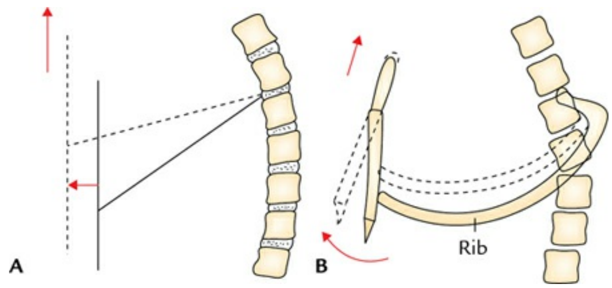


FIG. 1.7 Pump-handle movements of the vertebrosternal ribs.

CHAPTER 2

Mediastinum and pleura

Mediastinum

❖ Define mediastinum and give its boundaries and major contents.

It is a median region of thoracic cavity, sandwiched between two lungs enclosed in the pleural sacs. It contains all the thoracic viscera and great vessels except lungs. The contents of mediastinum are packed in the loose areolar tissue and limited on each side by mediastinal pleura. Hence, they form a kind of bulky mobile septum between the two pleural sacs. Mediastinum is elongated during inspiration and displaced to one or the other side if the pressure in the two pleural cavities is not the same.

Boundaries (fig. 2.1)

Anterior

Sternum

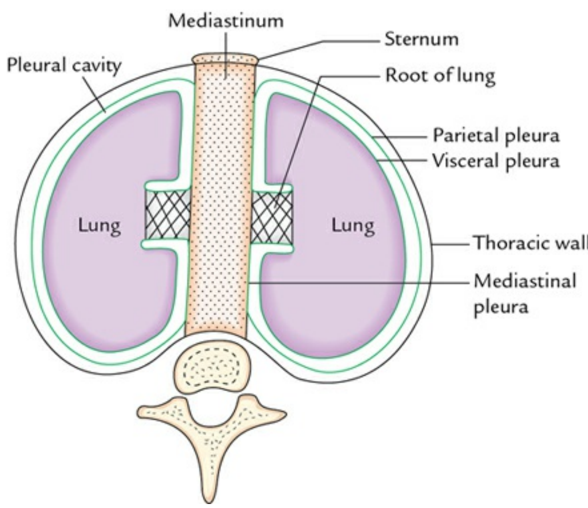


FIG. 2.1 Boundaries of mediastinum.

Posterior

Thoracic vertebral column.

Superior

Thoracic inlet.

Inferior

Diaphragm.

On each side

Mediastinal pleura.

Contents

The major contents of mediastinum are:

- Heart (enclosed in the pericardium)
- Thoracic aorta
- Pulmonary trunk
- Trachea
- Esophagus
- Thoracic duct
- Lymph nodes
- Thymus
- Three pairs of the neural structures (i.e., sympathetic trunks, vagus nerves, and phrenic nerves)

❖ What are subdivisions of the mediastinum?

The mediastinum is broadly divided into *superior mediastinum* and *inferior mediastinum* by an imaginary horizontal plane (sternal plane) passing from sternal angle to the lower border of the 4th thoracic vertebra (Fig. 2.2). The inferior mediastinum is further subdivided into the middle part (*middle mediastinum*) containing heart enclosed in pericardial sac, anterior part (*anterior mediastinum*) between the pericardium, and sternum and posterior part (*posterior mediastinum*) between the pericardium and the vertebral column.

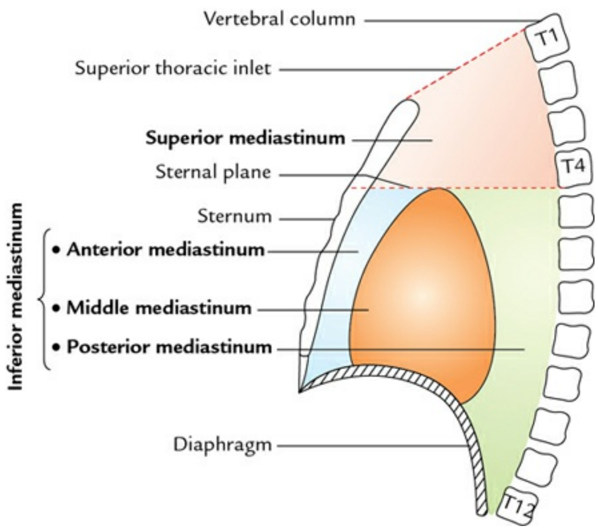
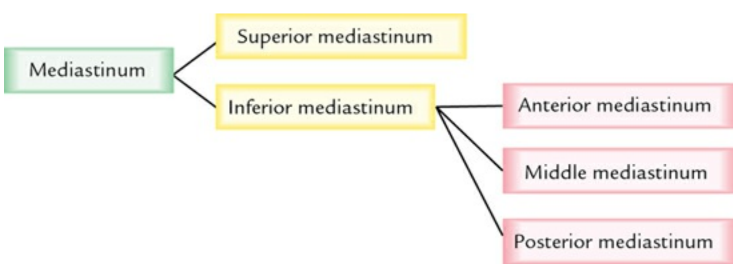


FIG. 2.2 Subdivisions of the mediastinum.

This is depicted in Flowchart 2.1.



FLOWCHART 2.1 Subdivision of the mediastinum.

N.B.

The anterior mediastinum is narrowest, middle mediastinum is widest, and posterior mediastinum is longest.

❖ Write a short note on the superior mediastinum.

It is an area of median region of thoracic cavity above the sternal plane.

Boundaries

Anterior

Manubrium sterni.

Posterior

Upper four thoracic vertebrae.

Superior

Thoracic inlet.

Inferior

Sternal plane.

Lateral (on each side)

Mediastinal pleura.

Contents (fig. 2.3)

Retrosternal structures

- Sternohyoid and sternothyroid muscles.
- Superior vena cava and its tributaries, viz. right and left brachiocephalic veins, azygos vein (terminal part).
- Thymus (remnant).

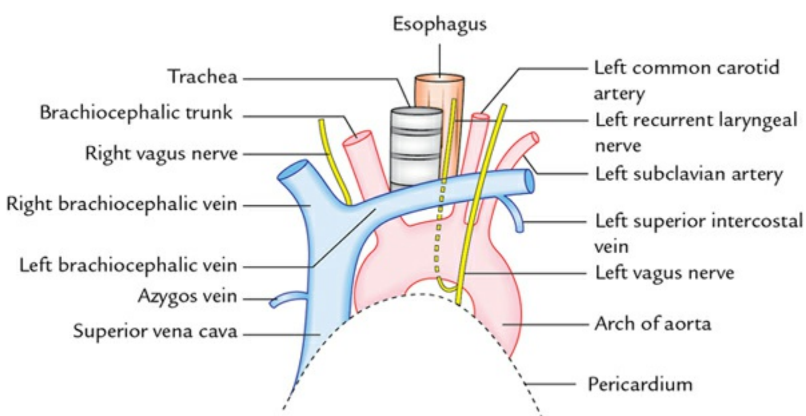


FIG. 2.3 Contents of the superior mediastinum.

Intermediate structures

- Aorta and its branches (i.e., brachiocephalic trunk, left common carotid artery, and left subclavian artery).
- Two sets of nerves, viz. right and left vagus, and right and left phrenic.

Prevertebral structures

- Trachea
- Esophagus
- Thoracic duct
- Left recurrent laryngeal nerve
- Lymph nodes (tracheal and tracheobronchial)
- Longus colli muscles
- Sympathetic chains

Applied anatomy

Mediastinal syndrome

The compression of structures in superior mediastinum by space occupying lesion, viz. enlarged lymph nodes, produces diverse signs and symptoms called mediastinal syndrome. Clinically, it presents as:

- *Dysphonea*: (difficulty in breathing), due to compression of trachea.
- *Dysphagia*: (difficulty in swallowing), due to compression of esophagus.
- *Dyspnea*: (hoarseness of voice), due to compression of left recurrent laryngeal nerve.
- *Horner's syndrome*, due to compression of sympathetic chain.
- *Engorgement of veins* in the upper half of the body, due to obstruction of superior vena cava.

Mediastinitis

It is inflammation of loose connective tissue of mediastinum. Generally it occurs when deep infections of the neck track downward along the fascial continuity between the neck and superior mediastinum.

❖ Write a short note on the anterior mediastinum.

It is a narrow part of the inferior mediastinum in front of pericardium. It is continuous above with pretracheal space, through superior mediastinum.

Boundaries

Superior

Sternal plane

Inferior

Diaphragm

Anterior

Sternum

Posterior

Pericardium

Contents

- Thymus
- Superior and inferior sternopericardial ligaments
- Retrosternal lymph nodes
- Mediastinal branches of internal mammary arteries
- Loose areolar tissue

❖ Write a short note on the middle mediastinum.

It is the widest middle part of the mediastinum occupied by pericardium enclosing heart and great blood vessels.

Boundaries

Superior

Sternal plane

Inferior

Diaphragm

Anterior

Anterior mediastinum

Posterior

Posterior mediastinum

Contents

- Heart enclosed in the pericardium
- Ascending aorta, pulmonary trunk, and pulmonary arteries
- Superior vena cava (lower part), inferior vena cava (upper part), pulmonary veins, and azygos vein (terminal part)
- Bifurcation of trachea and right and left principal bronchi
- Inferior tracheobronchial lymph nodes
- Pericardiophrenic vessels
- Phrenic nerve and deep cardiac plexus

❖ Write a short note on the posterior mediastinum.

It is the longest posterior part of the inferior mediastinum.

Boundaries

Superior

Sternal plane

Inferior

Diaphragm

Anterior

From above downward:

- Bifurcation of trachea
- Pulmonary vessels
- Pericardium
- Posterior surface of diaphragm

Posterior

Lower 8 thoracic vertebrae and intervening intervertebral discs.

Lateral (on each side)

Mediastinal pleura.

Contents

Longitudinal structures

- Esophagus
- Descending thoracic aorta
- Thoracic duct
- Azygos vein
- Vagus nerves
- Splanchnic nerves

Horizontal structures

- Hemiazygos and accessory hemiazygos veins
- Posterior intercostal arteries and veins

Others

Posterior mediastinal lymph nodes.

Applied anatomy

Extension of pus/fluid from neck into posterior mediastinum

The posterior mediastinum through the superior mediastinum is continuous with the spaces in the neck between pretracheal and prevertebral fascia (i.e., retropharyngeal space, space on either side of esophagus and trachea) through superior mediastinum. Therefore fluid/pus from these spaces may spread into the posterior mediastinum.

Pleura

❖ Write a short note on the pleura.

It is a serous membrane lined by mesothelium (flattened epithelium) which encloses the lung on each side of mediastinum.

Layers of pleura

This membrane is in the form of a closed sac, which is invaginated by lungs from its medial side. As a result, it becomes a double-layered sac, forming an outer *parietal layer* and an inner *visceral layer*.

Visceral layer (pulmonary pleura)

It invests the lung and adheres to it. At the hilum of lung, it may be traced as a tubular extension toward the mediastinum, where it is continuous with the parietal pleura.

Parietal layer (parietal pleura)

It lines the parieties, i.e., thoracic wall, diaphragm, and mediastinum, and bounds to these structures by loose areolar tissue – *endothoracic fascia*.

❖ What are the subdivisions of the parietal pleura?

According to the region where it lies or the surface which it covers, it is divided into 4 parts as follows:

Cervical pleura

It extends into the root of the neck [1 to 1.5 inches (2.5 to 5 cm) above the middle third of the clavicle] and covers the apex of the lung. This part lines the inner surface of the *suprapleural membrane* or *Sibson's fascia*.

Costal pleura

Lines the inner surface of thoracic wall (i.e., lining the ribs, costal cartilages, intercostal spaces, and back of sternum).

Diaphragmatic pleura

Lines the upper thoracic surface of the diaphragm.

Mediastinal pleura

Lines the side of the mediastinum and thus forms the lateral boundary of the mediastinum.

❖ Enumerate the sites where pleura extends beyond the thoracic cage.

The pleura extends beyond the thoracic cage at the following 5 sites:

- On either side in the root of the neck
- In the right xiphocostal angle
- On either side in the costovertebral angle

❖ What are the differences between visceral and parietal pleurae?

The differences between parietal and visceral pleurae are given in the box below:

Parietal pleura	Visceral pleura
Simple arrangement	Complex arrangement
Lines parieties	Lines lungs
Develops from somatopleuric mesoderm	Develops from splanchnopleuric mesoderm
Innervated by somatic nerves	Innervated by autonomic nerves
Sensitive to pain due to prick and cut	Insensitive to pain due to prick and cut

❖ Write a short note on the pulmonary ligament and give its functional significance.

It is a double-layered triangular fold of *cuff of pleura*, which hangs downward below the root of lung as far as the diaphragm (Fig. 2.4).

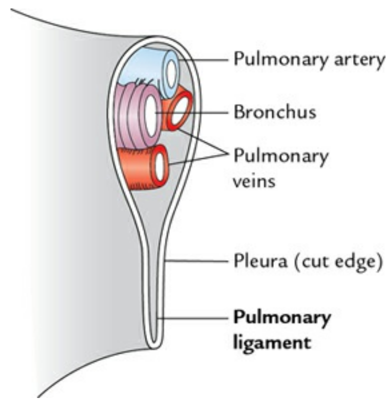


FIG. 2.4 Pulmonary ligament.

N.B.

The parietal and visceral layers of pleura become continuous with one another by means of a *cuff of pleura* that surrounds the root of the lung.

Functions

- Provides the dead space for the expansion of pulmonary veins during the increased venous return.
- Allows the descent of root of lung (along with the descent of diaphragm) during inspiration to create a dead space between the apex of lung and suprapleural membrane, which helps in the expansion of the apex of lung.

❖ Define pleural cavity and pleural recesses and discuss their applied anatomy.

Pleural cavity

It is a potential space between the parietal and visceral layers of the pleura. Normally, it contains 5 to 10 ml of clear fluid, which lubricates the opposing surfaces of parietal and visceral pleurae during respiratory movements.

Pleural recesses

These are parts of pleural cavities, which are not occupied by lungs during *quiet respiration*. They provide reserve spaces to be occupied by the lungs during *deep inspiration*. The various pleural recesses are (Fig. 2.5):

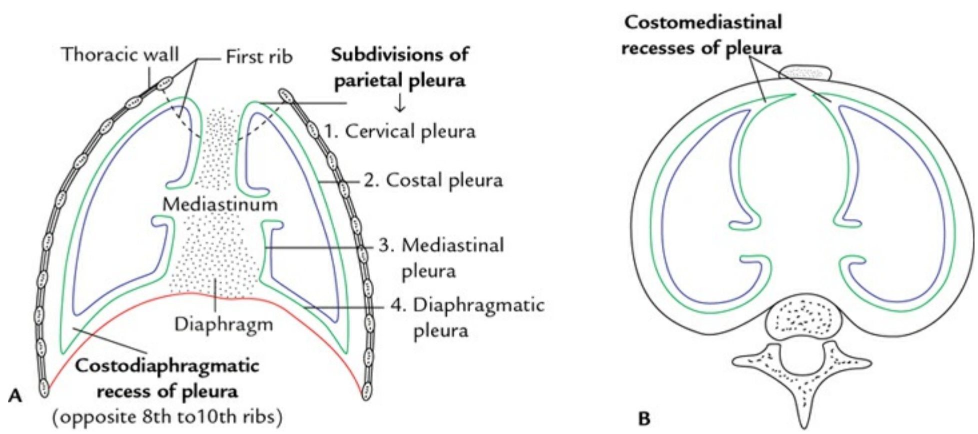


FIG. 2.5 Pleural recesses. A. As seen in vertical section. B. As seen in transverse section.

Costodiaphragmatic recesses

These are two slit-like spaces one on each side between the costal and diaphragmatic pleurae. They are the most dependent parts of pleural cavities and are situated in the costophrenic angles.

Costomediastinal recesses

These are slit-like spaces one on each side between the costal and mediastinal pleurae. They are situated along the anterior margins of the lungs.

Applied anatomy

Pleurisy/pleuritis

It is the inflammation of the pleura. Due to inflammation, the pleural surfaces become coated with inflammatory exudates, causing their roughening. This roughening produces *friction*, and the *pleural rub* can be heard with the stethoscope during inspiration and expiration. Often, the exudates become invaded by fibroblasts, which lay down collagen fibers, leading to formation of fibrous bands.

Pleural effusion (fig. 2.6)

It is the abnormal accumulation of fluid in pleural cavity. Being the most dependent parts, the fluid first collects in the costodiaphragmatic recess. Clinically, it presents as:

- Decreased lung expansion on the side of effusion.
- Decreased breath sounds
- Dullness on percussion over the area of effusion

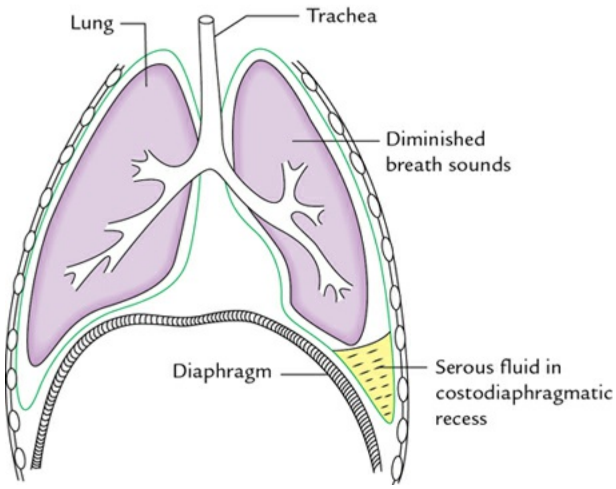


FIG. 2.6 Pleural effusion.

CHAPTER 3

Lungs

❖ What are lungs? Discuss their general features.

Introduction

- Lungs (right and left) are organs of respiration. They are located in the thoracic cavity one on either side of the mediastinum, enclosed in the pleural sacs.
- Lungs of children are pink in color and those of young adults brown or grey in color. Gradually, they become mottled black due the deposition of carbon particles inhaled from the atmosphere.
- Lungs are made up of soft, elastic spongy tissue filled with air.

General features

Each lung is conical in shape and presents:

- An apex
- A base
- Two surfaces: Costal and medial
- Three borders: Anterior, posterior, and inferior.

Apex

It is blunt and projects into the root of the neck about 2.5 cm above the medial 1/3rd of the clavicle. It is covered by the cervical pleura and grooved anteriorly by the subclavian artery.

Base (diaphragmatic surface)

It is related to the diaphragm. It is semilunar and concave due to the upward convexity of the diaphragm.

Costal surface

It is large and convex. It is related to the ribs and intercostals spaces and bears impressions of ribs and costal cartilages.

Medical surface

It contains the hilum of the lung. It is divided into two parts: anterior and posterior. Its anterior part is called *mediastinal surface* because it is related to the mediastinum. Its posterior part is called *vertebral surface* because it is related to the vertebral column.

Anterior border

It is thin and shorter than posterior border. It separates the mediastinal and costal surfaces. The anterior border of the right lung is straight, while that of left lung presents a wide cardiac notch, which is occupied by heart and pericardium.

Posterior border

It is thick and ill-defined. It separates vertebral and costal surfaces.

Inferior border

It is semilunar. It separates the base from the costal and medial surfaces.

❖ Give the brief account of fissures and lobes of the lungs.

- **Right lung** has two fissures – oblique and horizontal, which divide it into 3 lobes: upper, middle, and lower.

- **Left lung** has only one fissure – an oblique tissue, which divides it into two lobes: upper and lower.

❖ Enumerate the difference between the right and left lungs.

These are given in the box below:

Right lung	Left lung
Larger, wider, shorter, and heavier (weight about 700 g)	Smaller, narrower, longer and lighter (weight about 600 g)
Anterior border straight and does not present cardiac notch and lingua	Anterior border not straight and presents cardiac notch and lingua
Consists of 3 lobes (upper, middle, and lower)	Consists of 2 lobes (upper and lower)
Presents two bronchi (eparterial and hyparterial) in its hilum	Presents only one bronchus in its hilum

❖ Enumerate the main structures related to the mediastinal surfaces of the right and left lungs.

These are given in Table 3.1 and impressions caused by them are shown in Figure 3.1.

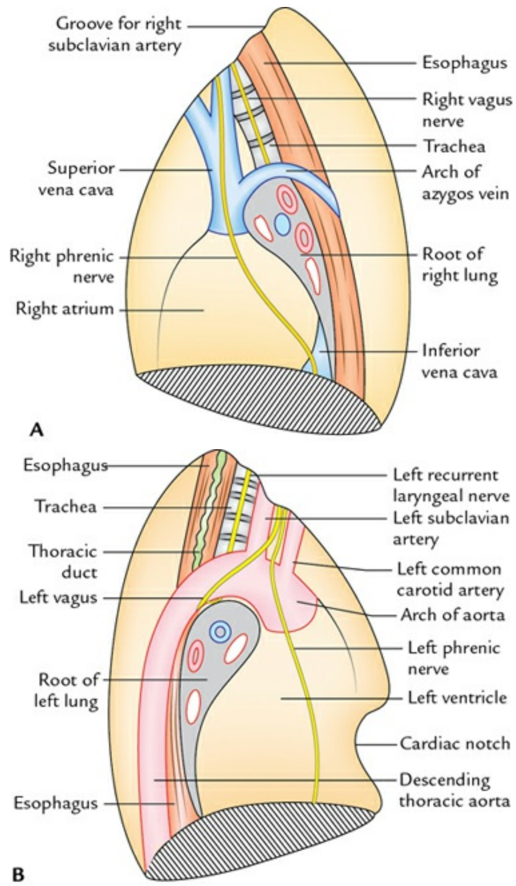


FIG. 3.1 Impressions on the mediastinal surfaces of the lungs: A, impressions on the mediastinal surface of the right lung; B, impressions on the mediastinal surface of the left lung.

Table 3.1

Structures related to the mediastinal surfaces of the right and left lungs

Right lung	Left lung
Right atrium	Left ventricle
Superior vena cava	Left common carotid and left subclavian arteries
Arch of azygos vein	Arch of aorta
Esophagus	Esophagus, thoracic duct, and descending thoracic aorta
Right vagus nerve	Left vagus nerve and left recurrent laryngeal nerve
Trachea	—
Inferior vena cava	Pulmonary trunk

❖ What is arterial supply of the lungs?

- **Oxygenated blood** to the lungs is supplied by the bronchial arteries:

❒ On *the right side*, there is only *one bronchial artery*, which arises from right third **posterior** intercostal artery or left upper bronchial artery

❒ On *the left side*, there are *two bronchial arteries:* upper and lower, which arise from the descending thoracic aorta

- **Deoxygenated blood** to the lungs is supplied by the pulmonary arteries.

❖ Define hilum and root of a lung.

The **hilum** of lung is a depressed bare area on its mediastinal surface, through which structures enter and leave the lung. The structures entering and leaving the hilum together form the *root of the lung*.

❖ Write a short note on root of the lung.

- It is a short broad pedicle, which connects the lung to the mediastinum. It consists of all structures that enter or leave the lung through its hilum.
- It is enclosed in tubular sheath pleura – the *cuff of pleura*.
- It lies opposite to the bodies of T5, T6, and T7 vertebrae.

Contents (fig. 3.2)

- Single bronchus (left principal bronchus) in the left lung root and two bronchi, i.e., two branches of right principal bronchus (eparterial and hyparterial) in the right lung root
- Pulmonary artery
- Pulmonary veins (superior and inferior)
- Single bronchial artery on the right side and two (upper and lower) bronchial arteries on the left side
- Lymph vessels
- Bronchopulmonary lymph nodes
- Bronchial veins
- Pulmonary nerve plexuses
- Loose areolar tissue

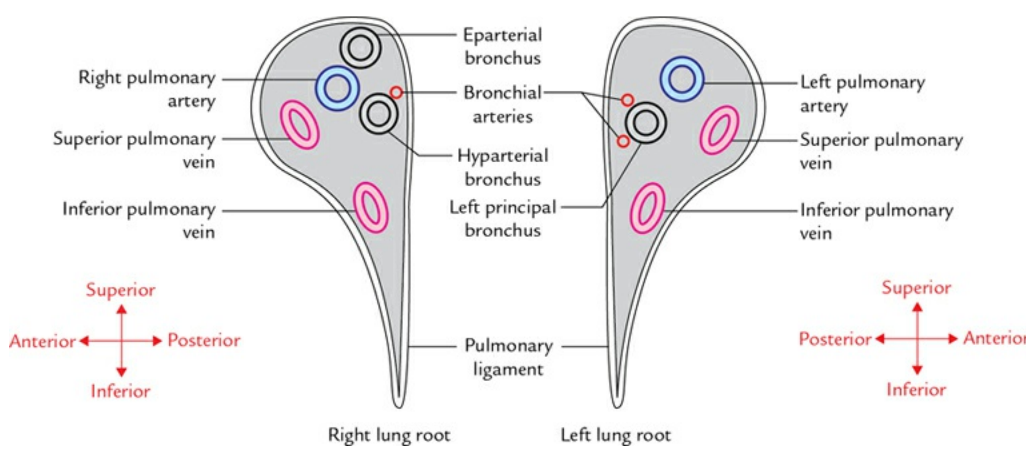


FIG. 3.2 Arrangement of structures present in the roots of lungs.

Arrangement structures in the root of the lung (fig. 3.2)

From before backward (same on two sides):

- Superior pulmonary vein

- Pulmonary artery
- Bronchus

From above downward (different on two sides) as given in the box below:

Right side	**Left side**
Eparterial bronchus	Pulmonary artery
Pulmonary artery	Bronchus
Hyparterial bronchus	Inferior pulmonary vein
Inferior pulmonary vein	

❖ Enumerate the relations of the root of the lung.

Anterior (common on two sides)

• Phrenic nerve

• Pericardiophrenic vessels

• Anterior pulmonary plexus

Posterior (common on two sides)

• Vagus nerve

• Posterior pulmonary plexus

Inferior (common on two sides)

Pulmonary ligament

Superior

• Arch of azygos vein on right side.

• Arch of aorta on left side.

❖ Describe the bronchopulmonary segments in brief under the following headings: (a) definition, (b) characteristic features, (c) number of segments in the right and left lungs, and (d) applied anatomy.

Definition

It is a structural and functional unit of the lung parenchyma aerated by a segmental (tertiary) bronchus.

Characteristic features (fig. 3.3)

- It is pyramidal in shape with apex pointing towards the hilum and base towards the surface of the lung.
- It is surrounded by a loose connective tissue.
- It is supplied by tertiary (segmental) bronchus, segmental branch of pulmonary artery, and segmental branch of bronchial artery.
- It is drained by intersegmental veins, present in the loose connective tissue of intersegmental planes.

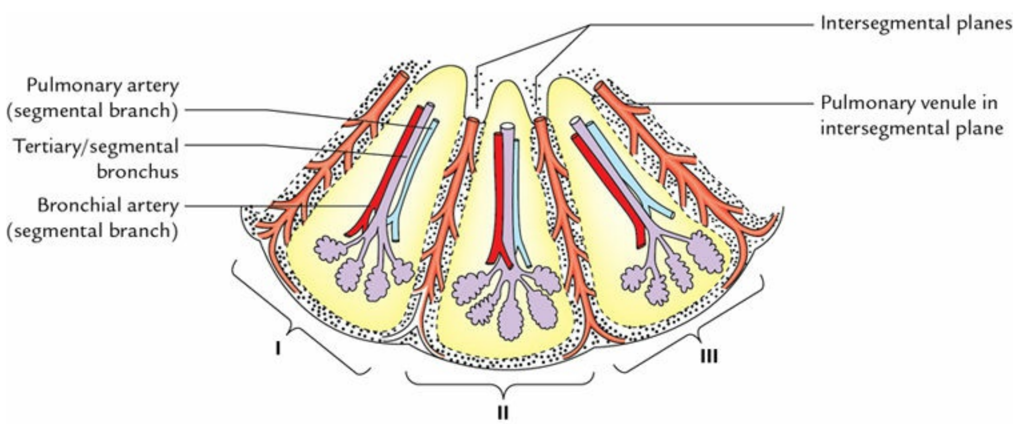


FIG. 3.3 Bronchopulmonary segments.

Number of segments in the right and left lungs (fig. 3.4)

The right lung consists of 10 segments, whereas left lung consists of 9 segments as given in the box below:

Right Lung

- *Superior lobe*: I, apical; II, posterior; III, anterior.
- *Middle lobe*: IV, lateral; V, medial.
- *Inferior lobe*: VI, superior (apical); VII, medial basal; VIII, anterior basal; IX, lateral basal; X, posterior basal.

Left Lung

• *Superior lobe*: I, apical; II, posterior; III, anterior; IV, superior lingular; V, inferior lingular.

• *Inferior lobe*: VI, superior (apical); VII, anterior basal; VIII, lateral basal; IX, posterior basal.

Note: Medial basal segment is absent in left lung.

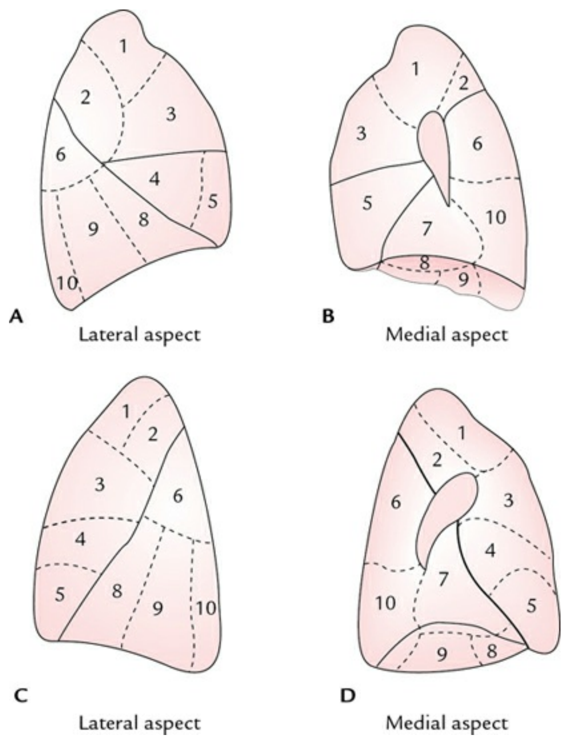


FIG. 3.4 A and B, Bronchopulmonary segments of the right lung; C and D, bronchopulmonary segments of the left lung. (*Note*: Medial basal segment is absent in the left lung.)

Applied anatomy

Segmental resection

Each segment can be delineated by bronchography. If the pathological lesion (such as bronchogenic carcinoma) is confined to one segment, that segment can be removed surgically (**segmental resection**). The localization of bronchopulmonary segment by the bronchoscopy also helps in postural drainage of lungs.

Lung abscess

It is more common in posterior segment of the upper lobe and apical segment of the lower lobe especially on the right side because **aspiration pneumonia** is common in these segments. This is because these segments are the most dependent in recumbent position.

CHAPTER 4

Pericardium and heart

Pericardium

❖ Write a short note on pericardium.

It is a fibroserous sac in the middle mediastinum. It encloses the heart and roots of the great vessels. It consists of two parts: *fibrous pericardium* and *serous pericardium* (Fig. 4.1).

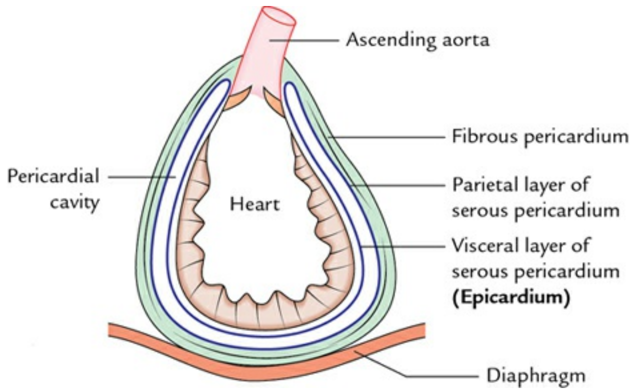


FIG. 4.1 Layers of the pericardium.

The ***fibrous pericardium*** is a cone-shaped outer fibrous sac around the heart and roots of great blood vessels. Its *apex* is narrow and blunt. It lies at the level of sternal angle where it fuses with the tunica adventitia of pulmonary trunk and ascending aorta.

Its *base* is broad. It blends with the central tendon of the diaphragm.

The ***serous pericardium*** is the inner double-layered sac of serous membrane. It consists of two layers: an outer parietal layer and an inner visceral layer.

- *Parietal layer* lining the inner surface of the fibrous pericardium is called *parietal pericardium*.
- *Visceral layer* covering the heart is called *epicardium* (Fig. 4.1).

N.B.

The two layers are continuous with each other at the roots of great blood vessels.

The potential space between the two layers is called *pericardial cavity*. It contains only thin film of serous fluid, which lubricates the opposed surfaces of parietal and visceral layers to allow the free movements of the heart.

❖ Write a short note on the transverse sinus of the serous pericardium.

- In *embryonic life*, it is a horizontal recess of serous pericardium between the arterial and venous ends of the heart tube. It develops due to degeneration of dorsal mesogastrium.
- In *adult life*, it lies behind the ascending aorta and pulmonary trunk (arterial end of the heart tube) and in front of the superior vena cava and superior pulmonary veins (venous end of the heart tube).

Boundaries (fig. 4.2)

Anterior

Ascending aorta and pulmonary trunk.

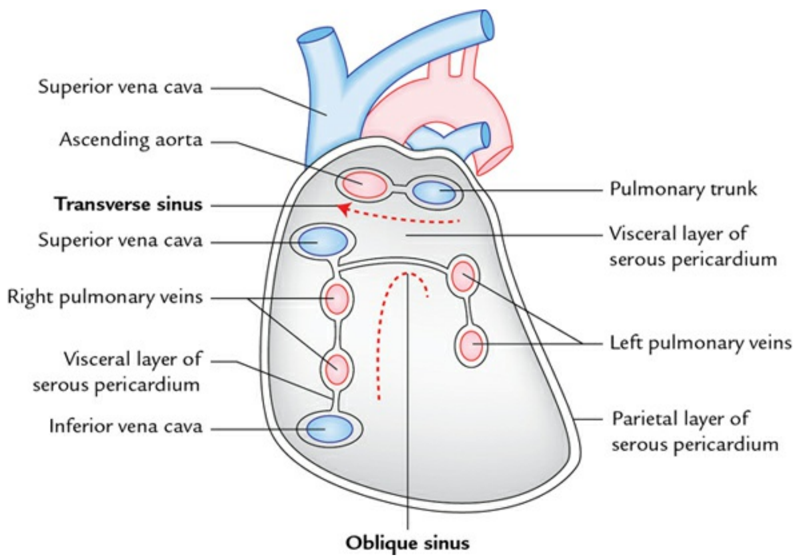


FIG. 4.2 Transverse and oblique sinuses of serous pericardium.

Posterior

Superior vena cava, upper margin of left atrium, and superior pulmonary veins.

On each side

Pericardial cavity.

Applied anatomy

During cardiac surgery, a temporary ligature is passed through the transverse sinus. The tubes of heart and lung machine are inserted into great vessels of heart, and then, the ligature is tightened.

❖ Write a short note on the oblique sinus of the pericardium.

It is a narrow cul-de-sac of serous membrane behind the left atrium of the heart. It is closed on all sides except inferiorly where it communicates with the rest of pericardial cavity. It develops due to absorption of pulmonary veins into the left atrium. It is formed by the reflected part of the parietal pericardium.

Boundaries

Anterior

Visceral pericardium covering the posterior surface of left atrium.

Posterior

Parietal pericardium lining the posterior surface of fibrous pericardium

Right side

Pericardial reflection along with the right pulmonary veins and inferior vena cava.

Left side

Reflection of pericardium along with the left pulmonary veins.

Above

Pericardial reflection along with the upper margin of left atrium.

Functions

- It permits the free pulsations of the left atrium.
- It suspends the heart in the pericardial cavity.

Applied anatomy

Pericarditis

It is the inflammation of serous pericardium. The pain of *pericarditis* is referred to the epigastrium.

Pericardial effusion

It is the collection of fluid in the pericardial cavity.

Cardiac tamponade

It is a condition, in which there is a rapid accumulation of large volume of fluid (serous fluid or blood) in the pericardial cavity. This leads to compression of heart from outside. The effects of cardiac tamponade are as follows:

- Interferes with the filling of atria during diastole
- Causes decrease in the cardiac output
- Causes increase in the heart rate and venous pressure

N.B.

Cardiac tamponade can cause death within a short time; hence immediate aspiration of fluid is necessary to restore the normal cardiac output.

❖ Enumerate the contents of the pericardium.

These are:

• Heart

• Coronary vessels

• Ascending aorta

• Pulmonary trunk

• Lower half of the superior vena cava

• Terminal part of the inferior vena cava

• Terminal parts of the pulmonary veins

Heart

❖ Define the apex of the heart and the apex beat. Discuss the clinical significance of apex beat.

Apex of the heart

It is the outermost and lowermost conical part of the heart formed by the left ventricle. It is situated in the left 5th intercostal space, 9 cm (3½ ") lateral to the midsternal line/just medial to the midclavicular line.

Apex beat (also called cardiac pulse)

- It is the lowermost and outermost thrust of the heart against the chest wall in the region of left precordium during systole.
- In *the adults*, it is felt in the left 5th intercostal space, 9 cm (3½ ") lateral to the midsternal line, just medial to the midclavicular line.
- In *the children*, it is felt in the left 2nd or 3rd intercostal space, just lateral to the midclavicular line.

❖ Describe the right atrium of the heart in brief under the following headings: (a) general features, (b) development, and (c) internal features.

General features

- It is the right upper chamber of the heart, which receives venous blood from all parts of the body through:

❒ Superior vena cava (SVC)

❒ Inferior vena cava (IVC)

❒ Coronary sinus.

- It pumps blood into the right ventricle.
- Its right border presents a shallow vertical groove, which extends from an angle made between SVC and right margin of right auricle to the right border of the inferior IVC. It is produced by a muscular ridge inside called *crista terminalis*.

Development

- *Smooth posterior part* (or *sinus venarum*) develops from right horn of sinus venosus.
- *Rough anterior part* (or *pectinate part*) develops from primitive atrial chamber.

Internal features (interior of the right atrium)

The interior of right atrium is divided into smooth posterior part and rough anterior part

- *Smooth posterior part* presents the following features (Fig. 4.3):

❒ Opening of superior vena cava at its upper end.

❒ Opening of inferior vena cava at its lower end. It is guarded by a rudimentary valve called *valve of inferior vena cava/Eustachian valve.*

❒ Opening of coronary sinus between the opening of IVC and right atrioventricular (AV) orifice. It is guarded by a *valve of the coronary sinus*.

❒ Foramina venarum miniarum (minute openings of venae cordis minimae, the numerous small veins present in the walls of all the chambers of the heart.

❒ Intervenous tubercle (of Lower): a small projection on the posterior wall of atrium just below the opening of SVC. Fossa ovalis and annulus ovalis.

- *Rough anterior part* presents the following features (Fig. 4.3):

❒ *Crista terminalis:* It is an internal muscular ridge extending vertically from right side of SVC to the right side of the IVC.

❒ *Musculi pectinati*: These are transverse ridges, which arise from crista terminalis and run forward and downward toward the atrioventricular orifice for insertion. The musculi pectinati resembles with the teeth of a comb.

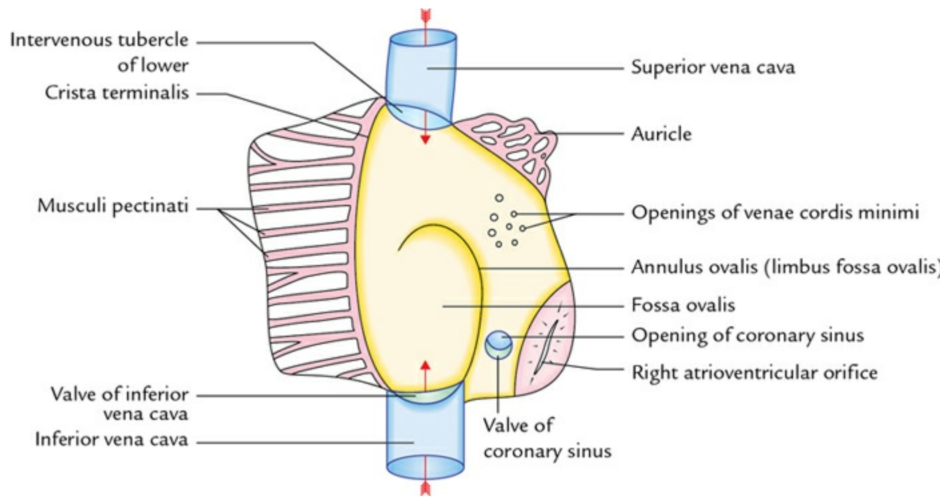


FIG. 4.3 Interior of the right atrium.

❖ Describe the sternocostal surface of the heart in brief and discuss its applied anatomy.

The *sternocostal surface of the heart* faces forward, upward, and to the left. It has 3 borders, i.e., right, inferior, and left, which separates it from base, diaphragmatic surface, and left surface, respectively.

It is formed by:

- Anterior surface of the right atrium and right auricle
- Anterior surface of the right ventricle (⅔rd)
- A small strip of the anterior surface of left ventricle and left auricle

Features

- *Anterior part of the artrioventricular (coronary) sulcus* passes downward and to the right from right of the roots of great vessels to the junction of right and inferior borders. It contains trunk of right coronary artery.
- *Anterior interventricular groove* passes downward parallel to the left border of the heart and contains anterior interventricular (left anterior descending) branch of the left coronary artery and great cardiac vein.

Relations

- Covered by pericardium
- Anterior margins of both lungs and pleurae
- Posterior surface of body of the sternum and the 3rd to 6th costal cartilages of both sides

Applied anatomy

- *Area of superficial cardiac dullness*: Most of sternocostal surface is covered by lungs except the part which lies behind the cardiac notch of the left lung. It is dull on percussion as it is not covered by the lungs.
- During open-heart surgery, the sternocostal surface is exposed by incising the pericardium.

❖ Give a brief account of conducting system of the heart.

It is made up of modified cardiomyocytes specialized for initiation and conduction of cardiac impulse.

Parts

It consists of following parts:

Sinoatrial node (SA node)

It is situated in the right atrium below the opening of SVC in the upper part of sulcus terminalis. It is also known as the *'pacemaker' of the heart*.

Atrioventricular node (AV node)

It is situated in the lower and dorsal part of interatrial septum near the opening of coronary sinus.

Atrioventricular bundle (AV bundle)

It connects the atrial and ventricular musculature.

Right and left bundle branches

They pass on respective sides in the interventricular septum.

Purkinje fibers

They arise from right and left bundle branches and form the subendocardial plexus.

Applied anatomy

Defects of conducting system lead to *cardiac arrhythmias*.

❖ Describe the arterial supply of the heart in brief.

The heart is supplied by two coronary arteries, right and left, which arise from the ascending aorta (Fig. 4.4).

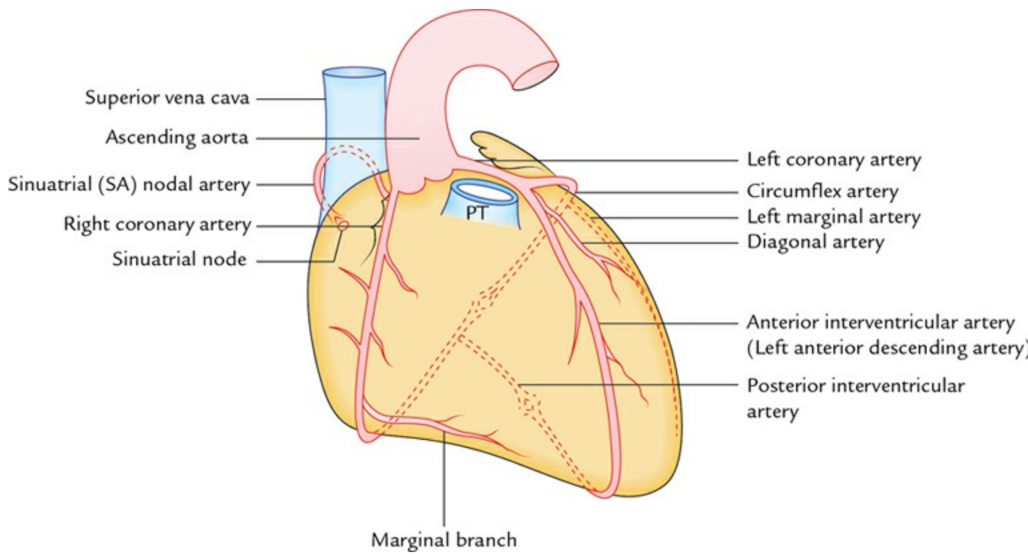


FIG. 4.4 Arterial supply of the heart (PT = pulmonary trunk).

Right coronary artery (fig. 4.4)

It is smaller than the left coronary artery. It arises from the anterior aortic sinus of ascending aorta and descends in the right anterior part of the coronary sulcus up to the junction of right and inferior margins of the heart. Here, it gives a *marginal branch* to the lower margin of the sternocostal surface. Then it curves around the lower margin of the heart to reach the diaphragmatic surface where it continues in the right posterior part of the coronary sulcus. After crossing the crux of the heart, it terminates by anastomosing with the circumflex branch of the left coronary artery.

Branches

These are:

- *Larger branches*

❒ Marginal artery

❒ Posterior interventricular artery

- *Smaller branches*

❒ SA nodal artery in 60% cases

❒ Right conus artery

❐ Unnamed branches to the right atrium and left ventricle

Left coronary artery

It is larger than the right coronary artery. It arises from the **left posterior aortic sinus**. It passes to the left between the pulmonary trunk and left auricle. Here, it gives the anterior interventricular artery, and then, it curves around the left border of the heart to continue as the circumflex artery in the left posterior coronary sulcus (Fig. 4.4). Near the posterior interventricular sulcus, it terminates by anastomosing with the right coronary artery.

Branches

These are:

• *Larger branches*

❐ Anterior interventricular/left anterior descending artery (LAD)

❐ Diagonal artery

❐ Circumflex artery

• *Smaller branches*

❐ Left conus artery

❐ Unnamed branches to the left atrium and left ventricle

Applied anatomy

Angina pectoris

It is pain (moderately severe) felt in the left precordium, which often radiates to the left shoulder, medial side of left arm and forearm. It usually occurs on exertion which remains for about 20 min and relieved on taking rest. The angina pectoris occurs due to narrowing of coronary arteries, leading to ischemia of cardiac muscle.

Myocardial infarction (MI)

A sudden blockage of one of the major branches of coronary arteries leads to myocardial ischemia and myocardial necrosis. It often leads to death. Clinically, it presents as:

• Sinking pain in the chest for more than 30 min

• Nausea, vomiting, sweating, shortness of breath, and tachycardia

• Pain radiates to the left shoulder, left side of arm, and forearm

N.B.

The arteries commonly blocked in order of frequency are:

• Anterior interventricular artery/left anterior descending artery (LAD) = 40–50%

- Right coronary artery = 30–40%
- Circumflex branch of left coronary artery = 15–20%

❖ Give a brief account of the coronary dominance.

If the posterior interventricular artery arises from right coronary artery, it is called *right coronary dominance* (80%) cases. On the other hand, if the posterior interventricular artery arises from left coronary artery, it is called *left coronary dominance* (20% cases).

N.B.

Mostly, there is a right coronary dominance.

In *balanced coronary dominance*, both coronary arteries give rise to the posterior interventricular artery. Both the posterior interventricular arteries run parallel to each other in posterior interventricular sulcus.

❖ What is the third coronary artery?

In 36% cases, the *right conus artery* arises separately from the anterior aortic sinus and termed *third coronary artery*.

Note in 64% cases, it is the first branch of right coronary artery.

❖ Describe in brief the venous drainage of the heart.

The venous blood from the heart is drained by the following veins (Fig. 4.5):

- Great cardiac vein
- Small cardiac vein
- Posterior vein of left ventricle
- Oblique vein of left atrium (vein of Marshal)
- Right marginal vein
- Anterior cardiac veins
- Venae cordis minimae (Thebesian veins/smallest cardiac veins)

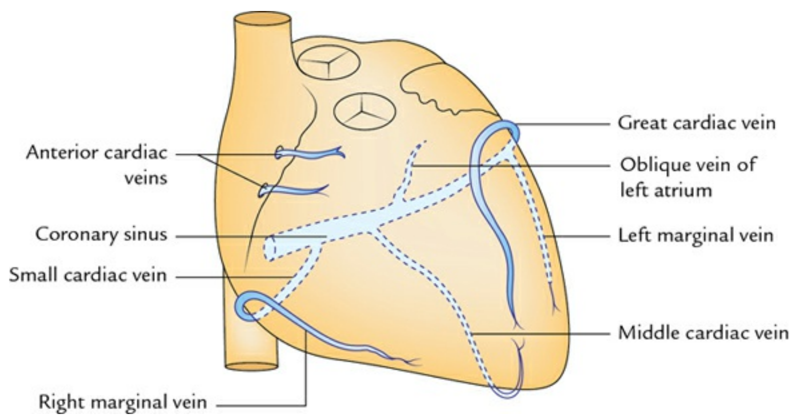


FIG. 4.5 Venous drainage of the heart.

The first 6 veins drain into the right atrium through the coronary sinus.

- The *Anterior cardiac veins* drain directly into the right atrium.
- The *Venae cordis minimae* (Thebesian veins) drain venous blood from endocardium of all chambers of the heart and open directly into cavity of the respective chambers.

❖ Write a short note on the coronary sinus.

It is a wide venous channel lying in the posterior part of the coronary sulcus between the base and the diaphragmatic surface of the heart. It opens into the posterior wall of right atrium, left to the opening of inferior vena cava.

Tributaries (fig. 4.6)

These are:

- Great cardiac vein
- Small cardiac vein
- Posterior vein of left ventricle
- Oblique vein of left atrium (vein of Marshall)
- Right marginal vein

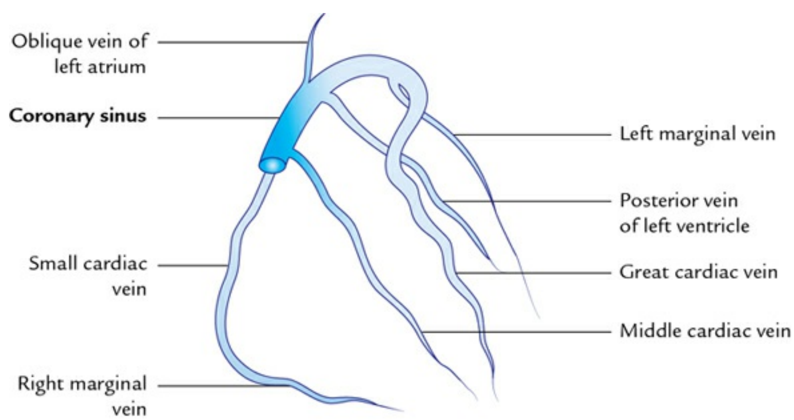


FIG. 4.6 Tributaries of the coronary sinus.

❖ Enumerate the embryonic dilatations of the primitive heart tube and name the structures derived from them in a tabular form.

The primitive heart tube presents 5 dilatations. From cranial to caudal, these are (Fig. 4.7):

- Truncus arteriosus
- Bulbus cordis
- Primitive ventricle
- Primitive atrium
- Sinus venosus

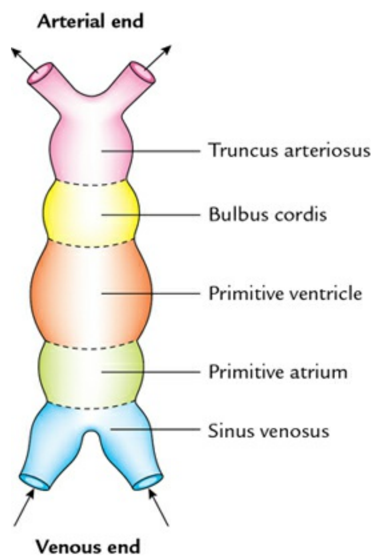


FIG. 4.7 Dilatations of the primitive heart tube.

The derivatives from these dilatations are given in the box below:

Embryonic dilatation of the primitive heart tube	Derivatives
Truncus arteriosus	Ascending aorta Pulmonary trunk
Bulbus cordis	Smooth upper parts of the right and left ventricles
Primitive ventricle	Trabeculated parts of the right and left ventricles
Primitive atrium	Trabeculated parts of the right and left atrium
Sinus venosus	Smooth part of the right atrium Coronary sinus Oblique vein of the left atrium

❖ Write a short note on the dextrocardia.

In this condition, there is transposition of heart chambers and associated blood vessels like a mirror image. As a result, heart beat is felt in the right 5th intercostal space instead in the left 5th intercostal space. *The dextrocardia is the most common positional anomaly of the heart.*

❖ Describe the development of interatrial septum in brief and discuss the congenital anomalies associated with it.

Development of interatrial septum (fig. 4.8)

- It develops in the 4th week of intrauterine life from the roof of the primitive atrial chamber.
- It develops from two sources: *septum primum* and *septum secundum*.
- Upper part of the interatrial septum is formed by the septum secundum and the lower part by the septum primum.

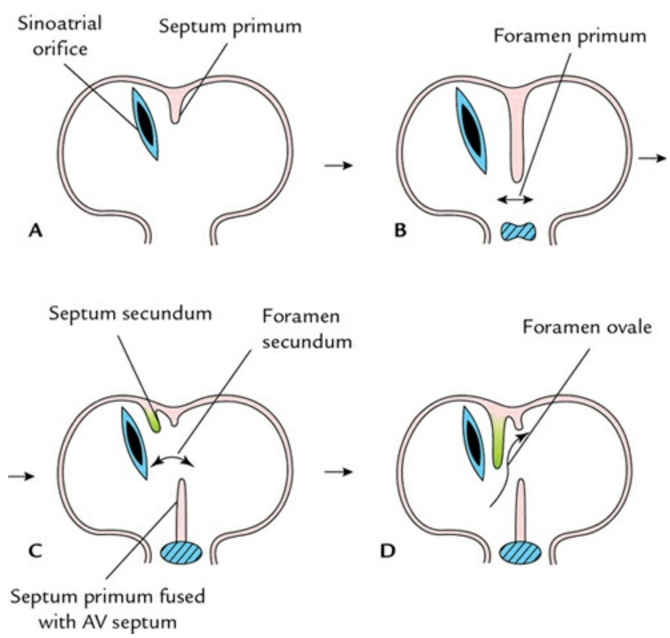


FIG. 4.8 Development of interatrial septum.

The details are as follows:

- The ***septum primum*** is sickle-shaped/crescent-shaped membrane that grows from the roof of the primitive atrium. It runs downward to reach the *atrioventricular cushion* (septum intermedium) but falls short of it. The gap between the septum primum and septum intermedium is called foramen (***ostium primum***). Soon, it grows further and before it fuses with septum intermedium; its upper part breaks open to form ***foramen secundum.***
- The **septum secundum** is also a crescentic membrane that arises from the roof of primitive atrium, a little to the right of the origin of the septum primum. It extends downward and overlaps the foramen secundum, but there remains a gap between the septum primum and septum secundum, which is oval in shape; it is called ***foramen ovale.*** This foramen appears as an oblique cleft in profile view and allows the blood to pass from right atrium to the left atrium.

Congenital anomalies

Atrial septal defect (ASD)

It is a common congenital anomaly that occurs in 0.07% cases and is 2 times more common in female infants.

Types They are of 4 types:

- *Ostium primum defect*: In this, the septum primum fails to reach the atrioventricular cushion, or there is defective formation of the atrioventricular cushion. As a result, foramen primum persists.
- *Ostium secundum defect*: In this, the septum secundum fails to develop, or there is excessive resorption of septum primum. As a result, a large opening exists between the two atria.
- *Cor triloculare biventriculare*: In this, there is a complete absence of interatrial septum. It is the most severe abnormality of atrial septal defect and is always associated with the other congenital defects of the heart.
- *Patent foramen ovale*: In this, there is failure of proper approximation of septum primum and septum secundum. It is clinically not significant because it does not allow shunting of the blood from right atrium to left atrium. This defect is also sometimes called *probe patency of foramen ovale*.

❖ Write a short note on the development of interventricular septum and discuss the congenital anomalies associated with it.

Development (fig. 4.9)

The interventricular septum develops in the 7th week of IUL. The interventricular septum consists of 3 parts. From below upward, these are: muscular part, membranous part, and bulbar part. The three parts develop from 3 different sources:

- *Muscular part (major part)* develops from muscular ridge which grows upwards from the floor of primitive ventricle.
- *Membranous part* develops from fused atrioventricular cushions.
- *Bulbar part* develops from right and *left bulbar septa, which is derived* from right and left bulbar ridges.

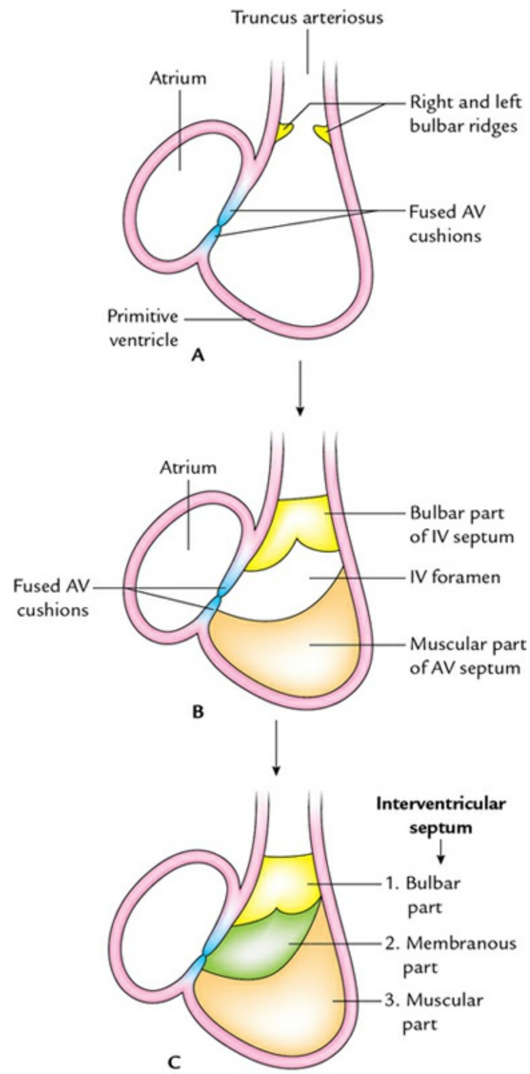


FIG. 4.9 Development of the interventricular septum.

N.B.

Clinically, both membranous and bulbar parts together are called the membranous part of the interventricular septum.

Congenital anomalies

Ventricular septal defect (VSD) (fig. 4.10)

It is the most common congenital anomaly of the heart. This defect commonly occurs in the membranous part, due to failure of fusion of the right and bulbar ridges with the atrioventricular cushions. This leads to flow of blood from left to right ventricle. As a result, the output from left ventricle is reduced. Clinically, it presents as excessive fatigue on exertion.

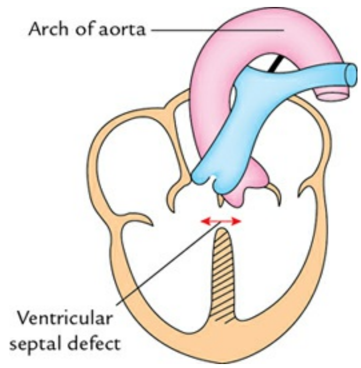


FIG. 4.10 Ventricular septal defect.

Tetralogy of fallot

This common congenital anomaly occurs due to unequal division of the conus, leading to formation of narrow pulmonary trunk and wide ascending aorta.

As the name implies, this anomaly includes four cardiac anomalies as follows (Fig. 4.11):

- Pulmonary stenosis
- Overriding of aorta
- Ventricular septal defect
- Right ventricular hypertrophy

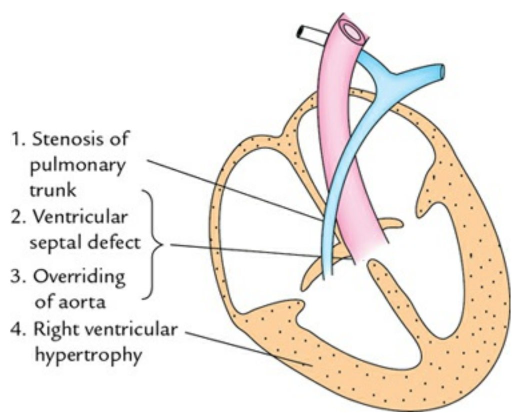


FIG. 4.11 Fallot's tetralogy.

Clinical presentation

- Breathlessness on exertion
- Cyanosis

N.B.

The Fallot's tetralogy is the *commonest congenital cyanotic heart disease*. The child with this anomaly suddenly ceases his activity and assumes knee-chest position and *squatting posture*. This is because by doing so he gets relief as squatting reduces the venous return by compressing the abdominal veins and increases the systemic vascular resistance by kinking the femoral and popliteal arteries. Both these mechanisms reduce the right to left shunting of blood through the ventricular septal defect and improve the pulmonary circulation.

❖ Discuss the histological features of the cardiac muscle.

The cardiac muscle is the muscle of the heart. It presents the following histological features (Fig. 4.12). It consists of short cylindrical fibers, which branch and anastomose with each other. Each fiber contains a single centrally placed large nucleus. These fibers show faint transverse striations and are joined together by the surface specializations called *intercalated discs*, which appear as zigzag transverse lines. In some cells, a perinuclear space is seen.

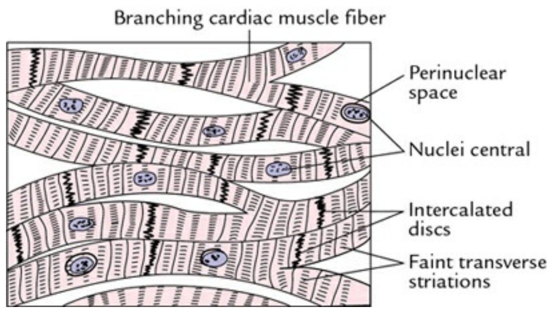


FIG. 4.12 Cardiac muscles.

N.B.

The conducting system of the heart is made up of modified cardiac muscle fibers, which are thicker, larger, and contain few myofilaments. These fibers are present just deep to the endocardium.

CHAPTER 5

Superior vena cava, aorta, pulmonary trunk, and thymus

❖ Describe the superior vena cava in brief under the following headings: (a) introduction (b) relations, (c) tributaries, and (d) applied anatomy.

Introduction

- It is the large venous channel, which collects blood from the upper half of the body and drains it into the right atrium.
- It is formed by the union of right and left brachiocephalic veins behind the right first costal cartilage.
- It terminates by opening into the upper part of right atrium behind the right third costal cartilage.

Relations

Anterior

- Chest wall
- Right margin of the right lung and pleura
- Right internal thoracic vessels

Posterior

- Trachea and right vagus
- Root of right lung

Medial

- Ascending aorta
- Brachiocephalic artery

Lateral

- Right phrenic nerve and pericardiacophrenic vessels
- Right lung and pleura

Tributaries

- Azygos vein
- Several small mediastinal and pericardial veins

Applied anatomy

Obstruction of superior vena cava (SVC)

It may occur either above or below the opening of azygos vein.

- *In the obstruction of SVC above the opening of azygos vein*, the venous blood from upper half of the body is returned through the azygos vein.

  Clinical presentation: Superficial veins on the chest wall are dilated up to the costal margin.

- *In the obstruction of SVC below the opening of azygos vein*, the venous blood from lower half of the body is returned through inferior vena cava via femoral vein.

  Clinical presentation

- Superficial veins are dilated on both chest and abdomen.

- Superficial vein connecting lateral thoracic vein and superficial epigastric vein is termed *thoracoepigastric vein*.

❖ Describe the arch of aorta under the following headings: (a) origin and course, (b) relations, (c) branches, (d) development, and (e) applied anatomy.

Origin and course (fig. 5.1)

- It is the continuation of the ascending aorta behind the sternal angle.
- It runs upward, backward, and to the left across the left side of the bifurcation of the trachea. Then passes downward behind the left bronchus, arching over the root of left lung to end at the sternal angle (lower border of the 4th thoracic vertebra) by becoming continuous with the descending aorta.

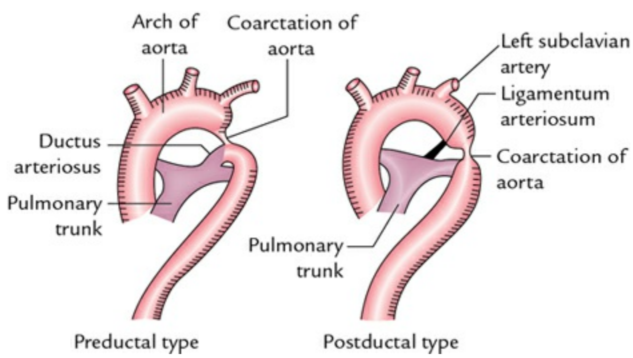


FIG. 5.3 Coarctation of aorta.

N.B.

The arch of aorta lies in the superior mediastinum. It begins and terminates at the same level, although it begins anteriorly and terminates posteriorly.

Relations (fig. 5.2)

Posterior and to the right

- Trachea
- Esophagus
- Left recurrent laryngeal nerve
- Thoracic duct
- Vertebral column

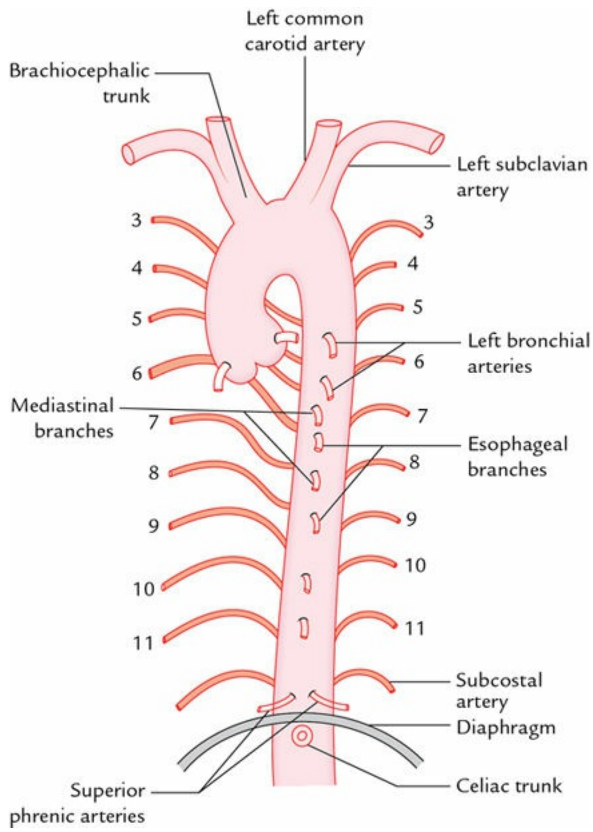


FIG. 5.4 Branches of thoracic aorta.

Anterior and to the left

- Left lung and pleura
- Left phrenic nerve
- Left vagus nerve
- Left cardiac nerves (superior cervical cardiac branch of left sympathetic chain and inferior cardiac branch of left vagus nerve)
- Left superior intercostal vein

Inferior

- Left bronchus
- Bifurcation of pulmonary trunk
- Ligamentum arteriosum
- Left recurrent laryngeal nerve
- Superficial cardiac plexus

Superior

- Brachiocephalic trunk
- Left common carotid artery
- Left subclavian artery
- Left brachiocephalic vein.
- Thymus

Branches

- Brachiocephalic trunk
- Left common carotid artery
- Left subclavian artery

Applied anatomy

Aortic knuckle

In X-ray chest PA view, a bulblike projection is seen at the left margin of the upper end of the cardiac shadow. It is formed by the distal part of the arch of aorta and termed *aortic knuckle.*

Aneurysm of arch of aorta

It is localized dilatation of the arch of aorta. Clinically, it presents as *tracheal tug*, a feeling of tugging sensation in the region of suprasternal notch.

❖ Describe the development of arch of aorta in brief and associated congenital anomalies.

Development

The arch of aorta develops at the end of 4th week of IUL from the following three sources:

- *Left horn of aortic sinus*, which forms the part of arch of aorta between brachiocephalic trunk and left common carotid artery.
- *Left 4th aortic arch*, which forms the part of arch of aorta between left common carotid artery and ductus arteriosus.
- *Left dorsal aorta*, which forms the rest of arch up to the descending aorta.

Congenital anomalies

Coarctation of aorta (fig. 5.3)

It is congenital stenosis of the arch of aorta distal to the origin of left subclavian artery. It occurs due to defect in the tunica media followed by intima proliferation. The coarctation of aorta may be preductal or postductal.

- *Preductal type*: In this, narrowing/stenosis is just proximal to the opening of ducts arteriosus.
- *Postductal type*: In this, the narrowing/stenosis is just distal to the entrance of ducts arteriosus. The ducts arteriosus is commonly obliterated in this type.

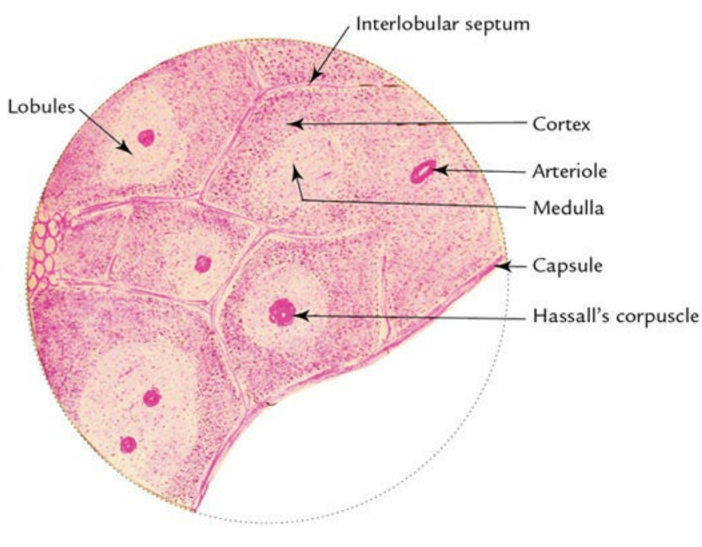


FIG. 5.5 Histological features of the thymus.*(Source:* Box. 7.1, Page 107, *Textbook of Histology and a Practical Guide,* 2e, JP Gunasegaran. Copyright Elsevier 2010, All rights reserved.)

In the *postductal type of coarctation of aorta,* an extensive collateral circulation develops between the branches of subclavian arteries and those of descending aorta. This includes the anastomoses between the anterior and posterior intercostal arteries.

Clinical presentation: The anterior and posterior intercostal arteries are enlarged greatly and produce a characteristic **notching of the lower borders of the ribs.**

Patent ductus arteriosus (PDA)

During fetal life, the ductus arteriosus (DA) is short wide channel, which connects the beginning of the left pulmonary artery with the arch of the aorta just distal to the origin of left subclavian artery. It shunts most of the blood from right ventricle into the aorta, thus short-circuiting the lungs. Functionally, it is closed shortly (within about a week) after birth by the contraction of smooth muscle of the DA. However, anatomically, it is closed within about 2 months (8 weeks) by means of intima proliferation mediated by *bradykinin*. The remnants of the ductus form a fibrous band called *ligamentum arteriosum.*

The *patent ducts arteriosus* occurs if it fails to close. This leads to shunting of blood from aorta into the pulmonary circulation causing serious circulatory problems.

N.B.

Patent ductus arteriosus is the *most common congenital anomaly of the great blood vessels* occurring in about 8/10,000 births.

Clinically, it presents as progressive enlargement of left ventricle and pulmonary hypertension.

❖ Give a brief account of descending thoracic aorta.

Introduction

It is a continuation of the arch of aorta. It begins on the front of the left side of the lower border of T4 vertebra. It descends downward with a slight inclination to the right and terminates in front of the lower border of the T12 vertebra where it continues as *abdominal aorta.*

Branches (fig. 5.4)

- Posterior intercostal arteries on each side from the 3rd to 11th (9 pairs)
- Subcostal artery on each side
- Two left bronchial arteries
- Esophageal branches
- Pericardial branches
- Mediastinal branches
- Superior phrenic arteries

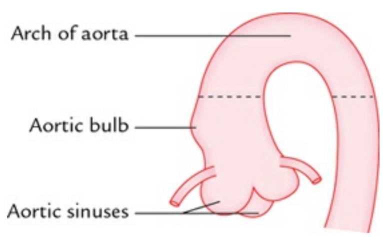


FIG. 5.1 Arch of aorta.

❖ Write a short note on the thymus.

The thymus is a *central lymphoid organ* present in the superior and anterior mediastinum. It is an unequal bilobed gland.

It is well developed in fetus and early childhood. It attains peak development at puberty, and thereafter, it starts involuting. Finally, it is replaced by a fibrofatty tissue in old age. The following figures giving weight of thymus in different age groups rightly justify this fact.

- At birth = 12–15 g.
- At puberty = 30–40 g.
- In old age (viz. 60 years and above) = 10–15 g.

Development

It is an epitheliolymphoid organ that develops from two sources:

- Epithelial reticular cells from endodermal lining of the 3rd pharyngeal pouch
- Lymphocytes from mesoderm

❖ Give the histological features of the thymus gland.

These are as follows (Fig. 5.5):

- Septa arising from connective tissue capsule divides the lobe into incomplete lobules (Note: septa does not reach into medulla)
- Cortex is darkly-stained due to dense collection of lymphocytes as compared to medulla
- Medulla is lightly stained due to less densely packed lymphocytes
- Presence of *thymic* or *Hassall's corpuscles* in medulla. They consist of central homogeneous hyaline material surrounded by concentric layers of flattened epithelioreticular cells
- Presence of the *cellular reticulum* formed by the epithelial reticular cells

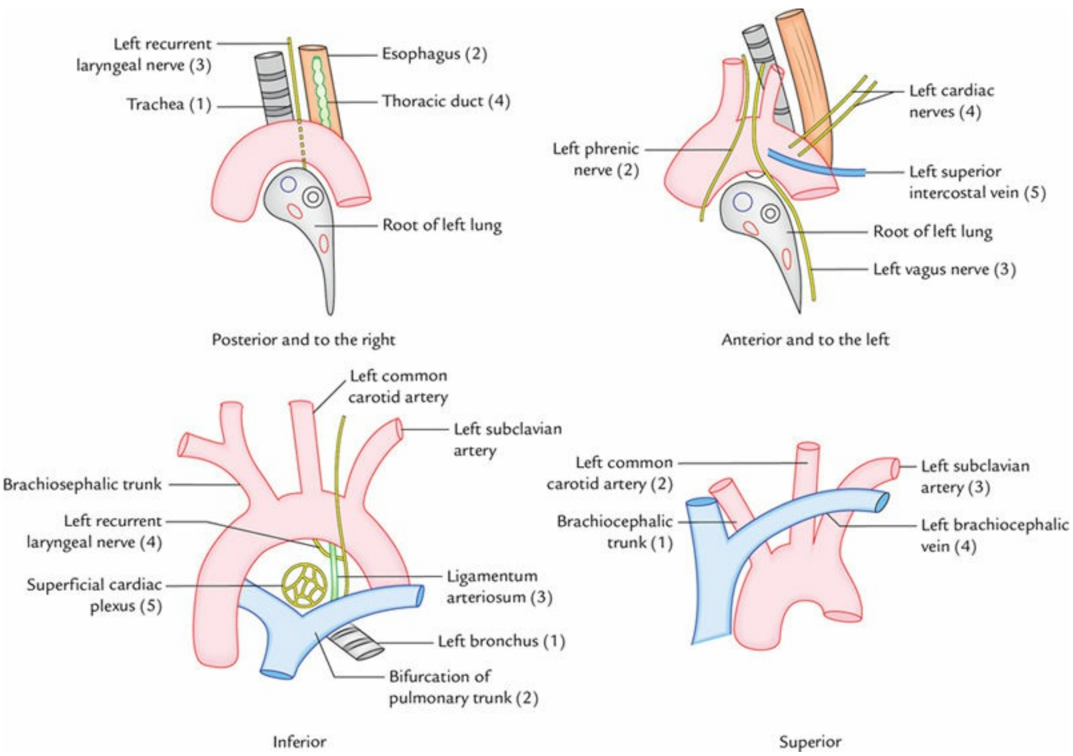


FIG. 5.2 Relations of the arch of aorta.

CHAPTER 6

Trachea, esophagus, thoracic duct, and azygos vein

❖ Describe trachea under the following headings: (a) extent, (b) relations, (c) development, (d) histology, and (e) applied anatomy.

Trachea (syn. windpipe) is 12 cm long, flexible, fibrocartilaginous tube, lying more or less in the midline in the lower part of the neck and superior mediastinum.

Extent

It extends from lower border of the cricoid cartilage (opposite to the lower border of C6 vertebra) as a continuation of larynx to the lower border of the T4 vertebra, where it bifurcates into two principal bronchi.

Relations

In the neck

Anterior

• Skin

• Superficial fascia with platysma and investing layer of deep fascia

• Sternothyroid and sternohyoid muscles

• Isthmus of thyroid gland (opposite 2nd, 3rd, and 4th tracheal rings)

• Anastomosis between superior thyroid arteries

• Pretracheal fascia

• Inferior thyroid veins

• Left brachiocephalic vein (in children only)

Posterior

• Esophagus

• Recurrent laryngeal nerves

• Lobes of thyroid gland (one on either side)

In the thorax

Anterior

• Manubrium sterni

• Sternothyroid muscles

• Pretracheal fascia

• Left brachiocephalic vein

• Arch of aorta

• Brachiocephalic trunk, left common carotid artery and Remains of thymus

Posterior

• Esophagus

• Left recurrent laryngeal nerve

• Vertebral column

Right side

• Right lung and pleura

• Azygos vein

• Right vagus nerve

Left side

• Left common carotid artery

• Left subclavian artery

• Left vagus nerve

Development

The trachea develops from *laryngotracheal diverticulum* (respiratory diverticulum) of primitive foregut. It gets separated from esophagus by the *tracheoesophageal septum*. The defective development of this septum gives rise to a common congenital anomaly called *tracheoesophageal fistula*.

Histology

Histologically, the wall of trachea from within outward consists of 4 layers (Fig. 6.1): (a) mucosa, (b) submucosa, (c) cartilage/smooth muscle layer, and (d) adventitia.

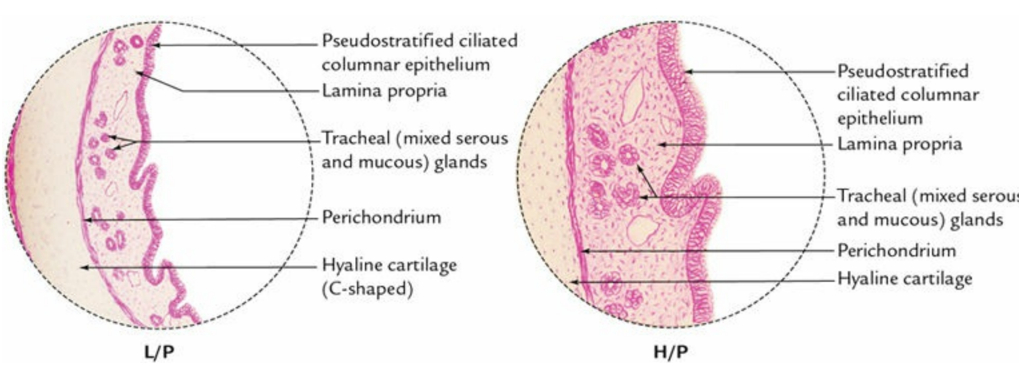


FIG. 6.1 Histological features of the trachea.(*Source:* Box 16.2, Page 349, *Textbook of Histology and a Practical Guide*, 2e, JP Gunasegaran. Copyright Elsevier 2010, All rights reserved.)

Mucosa

- Lining epithelium is pseudostratified ciliated columnar with few goblet cells
- Lamina propria is made up of loose connective tissue, rich in elastic fibers

Submucosa

- Consists of loose areolar tissue
- Contains large number of mixed seromucous glands

Cartilage and smooth muscle layer

Consists of C-shaped hyaline cartilages with their gaps facing posteriorly, which are filled by smooth muscle (*trachealis*) and fibroelastic ligament.

Adventitia

- Consists of dense connective tissue rich in elastic fibers
- Contains nerves and vessels

Applied anatomy

Carina

It is a sharp ridge-/keel-shaped process seen during bronchoscopy at the tracheal bifurcation. It is situated 25 cm below the incisor teeth. It is a useful clinical landmark. The mucous lining of carina is highly sensitive and *cough reflex* is usually initiated here.

Tracheostomy

It is a life-saving surgical procedure in which an opening is made in the trachea to insert tracheostomy tube in cases of respiratory obstruction.

Tracheoesophageal fistula (fig. 6.2)

It occurs due to failure of separation of trachea from esophagus following defective development of tracheoesophageal septum. In most of the cases (85%), lower segment of esophagus communicates with the trachea. :

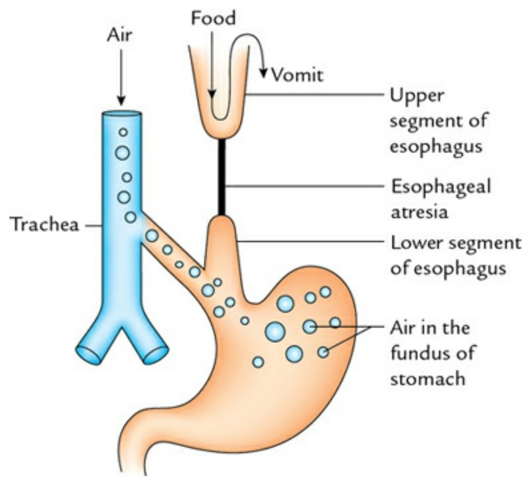


FIG. 6.2 Tracheoesophageal fistula.

Clinical presentation

- Infant vomits after every feed given to him/her.
- Presence of air in fundus of stomach (a diagnostic sign of tracheoesophageal fistula).

❖ Enumerate the differences between right and left principal bronchi. Discuss its applied anatomy.

The differences between right and left principal bronchi are given in Table 6.1 and shown in Figure 6.3.

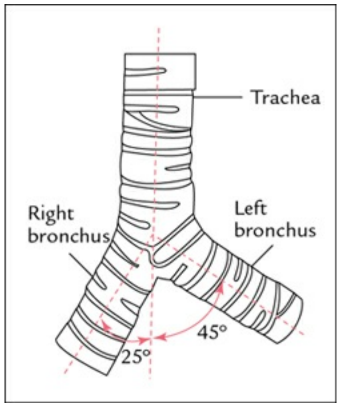


FIG. 6.3 Differences between the right and left principal bronchi.

Table 6.1

Differences between right and left principal bronchi

Right principal bronchus	Left principal bronchus
Short (2.5 cm long)	Long (5 cm long)
Wide	Narrow
Lies more or less in line with trachea	Does not lie in line with trachea (deflected to the left)
Angle of deviation from long axis of trachea, 25°	Angle of deviation from long axis of trachea, 45°
Usually divides before entering into the lung	Usually divides after entering into the lung

Applied anatomy

Inhaled foreign bodies usually enter into the right principal bronchus because it is shorter, wider, and lies more or less in line with trachea.

❖ Describe esophagus under the following headings: (a) introduction, (b) constrictions, (c) blood supply, (d) nerve supply, (e) histological features, and (f) applied anatomy.

Introduction

- It is a 10" (25 cm) long muscular tube that connects pharynx to the stomach and provides passage for bolus of food and liquids during the third stage of deglutition.

- It extends from lower border of the cricoid cartilage/body of C6 vertebra to the cardiac orifice of the stomach (at the level of lower border of T11 vertebra).

Constrictions (fig. 6.4)

Normally, the esophagus shows four sites of constrictions/narrowings. From above downward, these are:

- At its commencement (caused by cricopharyngeus muscle)

- Where it is crossed by aortic arch

- Where it is crossed by left bronchus

- Where it pierces the diaphragm

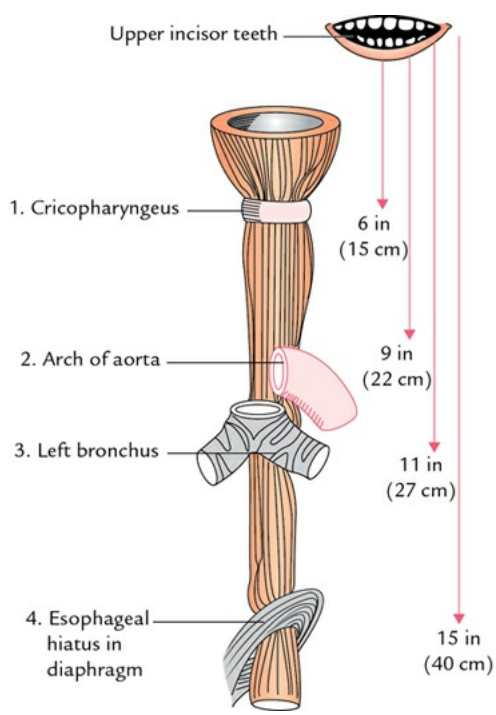


FIG. 6.4 Sites of anatomical constrictions of the esophagus.

These sites in order from above downward are 6"(15 cm), 9" (22 cm), 11" (27 cm), and 15" (40 cm) away from the upper incisor teeth.

N.B.

The narrowest part of esophagus is at its commencement.

Blood supply

Arterial supply

- *Cervical part of esophagus*, by branches of the inferior thyroid arteries
- *Thoracic part of esophagus*, by branches of the thoracic aorta
- *Abdominal part of esophagus*, by left gastric and left inferior phrenic arteries

Venous drainage

- From *cervical part*, by inferior thyroid veins into the superior vena cava
- From *thoracic part*, by azygos veins into the superior vena cava
- From *abdominal part*: (i) by left gastric veins into the portal vein and (ii) hemiazygos vein into the inferior vena cava

Nerve supply

- By *sympathetic fibers* derived from T5–T9 spinal segments, which are sensory and vasomotor
- By *parasympathetic fibers* derived from vagus and recurrent laryngeal nerves, which are sensory, motor, and secretomotor

Histological structure (fig. 6.5)

In transverse section, esophageal tube presents an irregular lumen. Its wall from inside out consists of 4 layers, viz. mucosa, submucosa, muscular layer, and adventitia.

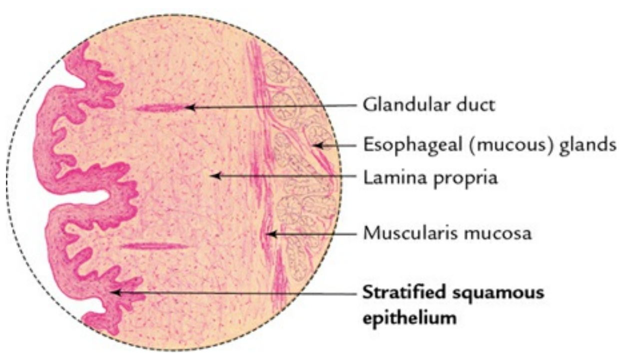


FIG. 6.5 Histological features of the esophagus.(*Source:* Box 12.6, Page 223, *Textbook of Histology and a Practical Guide, 2e,* JP Gunasegaran. Copyright Elsevier 2010, All rights reserved.)

Mucosa

It is thrown into folds.

- Epithelium – Stratified squamous of nonkeratinized variety.
- Lamina propria – Thick and contains lymphoid aggregations.
- Muscularis mucosae – Thick prominent and consists of longitudinal smooth muscle fibers.

Submucosa

It is wide and contains mucous secreting small esophageal glands.

Muscular layer

Its structure varies in upper middle and lower 1/3rd.

- In the upper 1/3rd, it is made up of skeletal muscle fibers.
- In the middle 1/3rd, it is made up of both skeletal and smooth muscle fibers.
- In the lower 1/3rd, it is made up of smooth muscle fibers.

Applied anatomy

Esophageal varices

It is a dilation and tortuosity of the anastomotic venous channels between the tributaries of left gastric vein and hemiazygos vein (portacaval anastomosis) at the lower end of esophagus, in portal hypertension. The rupture of these varices leads to *hematemesis* (vomiting of frank red color blood).

Achalasia cardia

It is a clinical condition in which there is a failure of relaxation of musculature at the lower end of the esophagus. As a result, food accumulates in the esophagus causing regurgitation. Note the regurgitation does not include gastric contents; hence, it is not sour tasting. It occurs due to neuromuscular incoordination of the muscles of the lower end of the esophagus causing loss of peristalsis.

N.B.

- *Achalasia cardia* is the most common esophageal motility disorder with the incidence of 1 in 1,00,000.
- *Esophageal carcinoma*: It is mostly adenocarcinoma and occurs in the lower 1/3rd of the esophagus.
- *Dysphagia*: It is a name given to painful/difficult swallowing. It occurs due to (a) compression of esophagus from outside by aortic arch aneurysm, etc. or (b) by narrowing of lumen due to stricture. It can be diagnosed by barium swallow.

❖ Describe the thoracic duct under the following headings: (a) introduction, (b) course and relations, (c) tributaries, (d) development, and (e) applied anatomy.

Introduction

- T*horacic duct* is the largest lymphatic channel of the body present in thoracic region. It drains lymph from whole of the body except right upper quadrant, which is drained by *right lymphatic duct* (Fig. 6.6).
- It extends from lower border of T12 to C7 vertebrae.
- It is 45 cm long and beaded in appearance.
- It commences from the cranial end of *cisterna chyli* and terminates at the root of neck by opening in the angle between left subclavian and left internal jugular veins.

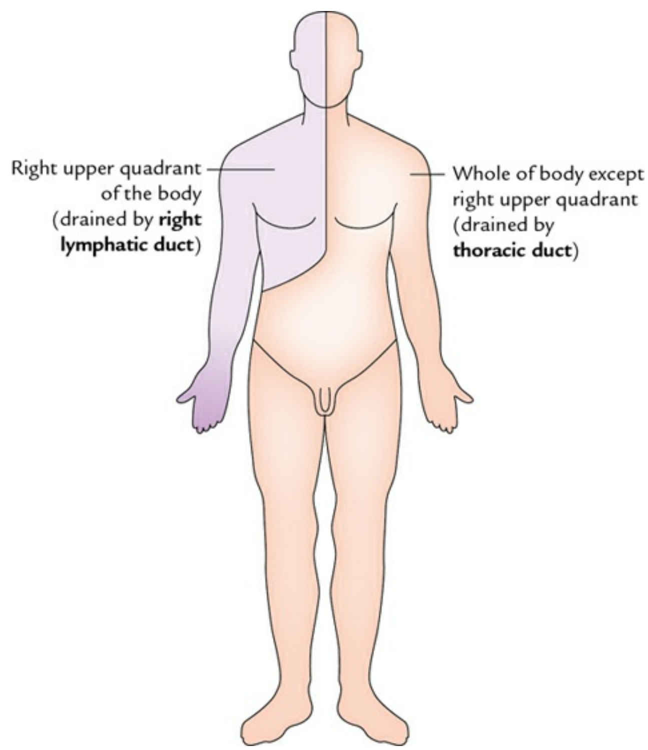


FIG. 6.6 Lymphatic territory of the thoracic duct.

Course and relations (fig. 6.7)

- After arising from the cranial end of cisterna chyli, it enters the thoracic cavity through aortic orifice of diaphragm on the right side of descending thoracic aorta and on the left side of azygos vein.
- At first, it ascends in the posterior mediastinum behind the esophagus. Then, it crosses behind the esophagus from the right to the left at the level of the T5 vertebra. Then, it ascends along the left border

of the esophagus in the superior mediastinum and neck until it reaches the level of the transverse process of C7 vertebra.

- In the neck at the level of C7 vertebra, it arches laterally on the left side behind the carotid sheath and in front of vertebral system to terminate by entering into the junction of the internal jugular and subclavian veins.

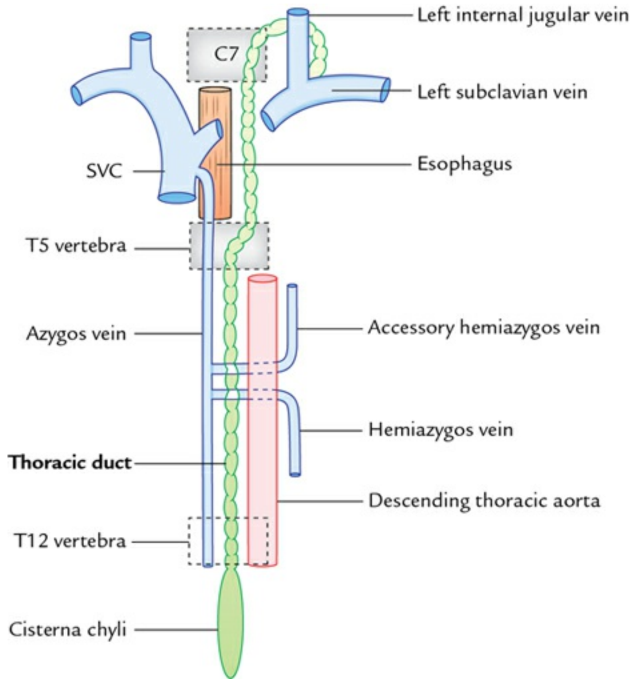


FIG. 6.7 Origin, course, and termination of the thoracic duct.

Tributaries

In the abdomen

Descending thoracic lymph trunks from lower six intercostal spaces.

In the thorax

Lymph trunks from:

- Upper six intercostal spaces
- Posterior mediastinum
- Upper lumbar region

In the neck

- Left jugular lymph trunk
- Left subclavian lymph trunk
- Left bronchomediastinal lymph trunk

Development

- It develops from two longitudinal lymph channels present by the side of primitive vertebral column.
- They get connected by transverse channel at the level of T5 vertebra.
- Right longitudinal channel above the communicating transverse channel and left longitudinal channel below the transverse channel disappear and give rise to thoracic duct.

Applied anatomy

- *Obstruction of thoracic duct* may be caused by microfilarial parasites *(Wuchereria bancrofti)* or surrounding tumors. This may lead to the accumulation of chyle in thorax, peritoneal cavity, and tunical vaginalis, leading to *chylothorax*, *chyloperitoneum*, and *chylocele*, respectively.
- Inadvertent damage of thoracic duct in block dissection of neck causes leakage of chyle, which may lead to chylothorax.

❖ Write a short note on the azygos vein.

The azygos vein is an unpaired ('azygos' = single/without companion) vein, situated on the posterior thoracic wall in upper lumbar region. It connects the superior and inferior vena cava and drains the venous blood from the thoracic wall and upper lumbar region.

Formation

It is formed by the union of (a) right subcostal vein, and (b) right ascending lumbar vein at the level of T12 vertebra.

Course

After formation, it ascends to enter the thoracic cavity through aortic orifice of the diaphragm (in aortic opening, the abdominal aorta is on the left side, thoracic duct in the middle, and azygos vein on the right side). In the thorax, it ascends up to the T4 vertebra where it arches forward over the root of the right lung to terminate in the superior vena cava at the level of the right second costal cartilage.

Tributaries (fig. 6.8)

- Right superior intercostal vein (formed by union of the 2nd, 3rd, and 4th posterior intercostal veins)
- The 5th to 11th right posterior intercostal veins
- Accessory hemiazygos vein (at the level of upper part of T8 vertebra)
- Hemiazygos vein (at the level of lower part of T8 vertebra)
- Right bronchial vein (near the termination of azygos vein)
- Esophageal veins
- Mediastinal veins
- Pericardial veins

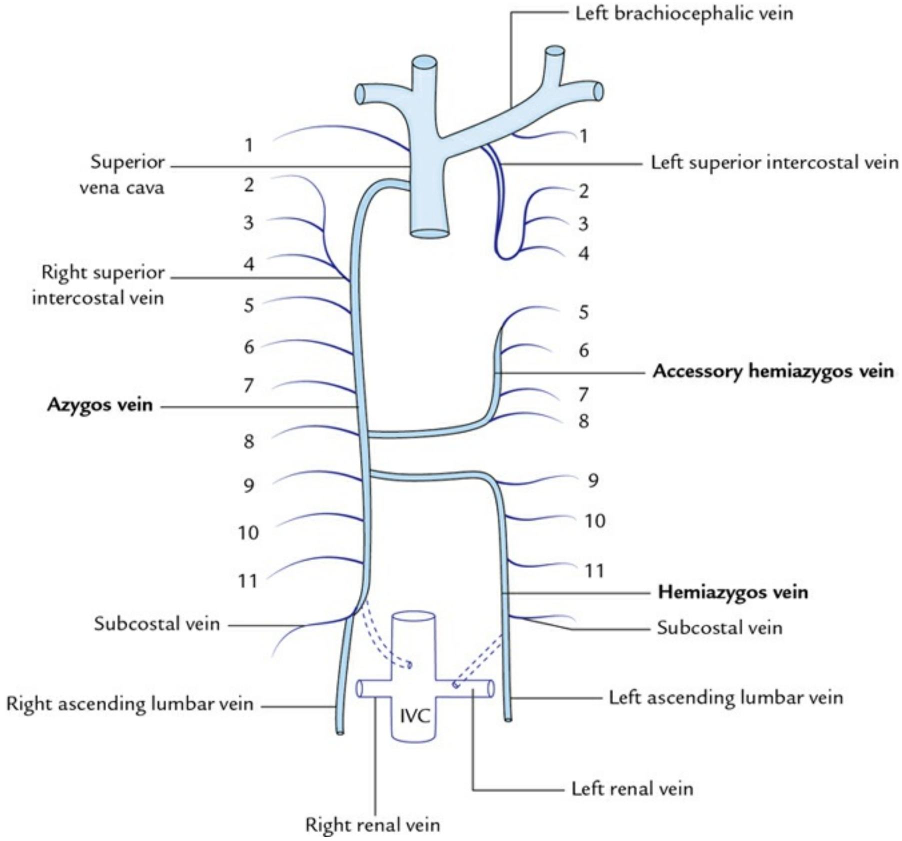


FIG. 6.8 Azygos vein.

Applied anatomy

In the case of superior or inferior vena cava obstructions, the azygos vein serves as an important channel to establish collateral circulation.

❖ Write a short note on lobe of the azygos vein.

In 1% of population, the apex of right lung splits into medial and lateral parts by a fissure. The bottom of fissure contains the arch of the azygos vein suspended by a fold of pleura called pleural septum/mesoazygos. The medial part of the split apex of right lung is called lobe of azygos vein. It is caused by upward development of apical bronchus, medial to the azygos vein (note normally it develops lateral to the arch of azygos vein).

Applied anatomy

The lobe of azygos vein presents as a small dense shadow close to the right sternal angle in plane X-ray chest PA view. It may be confused to enlarged mediastinal lymph node.

SECTION II
Abdomen

OUTLINE

CHAPTER 7

Anterior abdominal wall

❖ Write a short note on the caput medusae.

Definition

The *caput medusae* is a clinical sign characterized by the radiation of dilated and tortuous veins from umbilicus like the spokes of a wheel (Fig. 7.1).

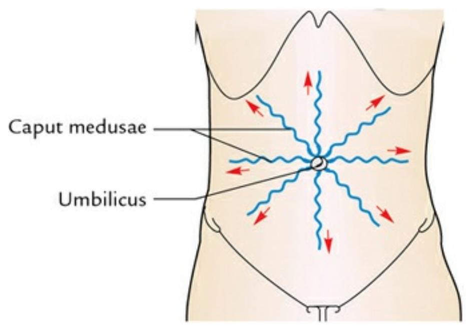


FIG. 7.1 Caput medusae.

Anatomical basis

The umbilicus is one of the important sites of portacaval anastomosis. This anastomosis takes place between the paraumbilical veins in the falciform ligament (tributaries of portal vein) and subcutaneous veins of anterior abdominal wall (tributaries of superior and inferior epigastric veins, which in turn are tributaries of inferior vena cava).

In *portal hypertension*, the blood from portal tributaries is shunted into the cava tributaries, leading to their dilatation and tortuosity. Such veins radiate from umbilicus like spokes of a wheel. This condition is termed *caput medusae* because of its resemblance to the head of Medusa, a mythical lady in Greek mythology who had serpents on her head instead of hair.

❖ Describe the umbilicus in brief and discuss its anatomical, embryological, and clinical importance.

The umbilicus is a puckered scar on the anterior abdominal in the midline and represents the site of attachment of umbilical cord in the fetal life. It lies at the level of intervertebral disc between L3 and L4 vertebrae. It is the most important soft tissue landmark on the anterior abdominal wall.

Anatomical importance

- Skin around umbilicus is supplied by T10 spinal segment, hence pain from viscera supplied by T10 segment such as appendix is referred to the skin around umbilicus.
- It is one of the *important sites of portacaval anastomosis*; in portal hypertension, the dilated and tortuous superficial veins radiate from umbilicus like spokes of a wheel, which is called **caput medusae**.
- It is one of the common sites of abdominal hernias.
- With reference to the lymphatic and venous drainage of anterior abdominal wall, the horizontal plane at the level of umbilicus acts a *watershed line*.

❒ Lymph from skin above umbilicus is drained into pectoral group of axillary lymph nodes, and from skin below the umbilicus into superficial inguinal lymph nodes. Therefore, both axillary and superficial inguinal lymph nodes are involved in carcinoma of umbilicus.

❒ Venous blood from skin above the plane of umbilicus flows upward to drain into axillary veins and from skin below the plane of umbilicus flows downward to drain into great saphenous veins.

Embryological importance

The umbilicus is a meeting point of four folds of embryonic plate and 3 systems (i.e., digestive, excretory, and vascular) during fetal life. Therefore, it is the site of attachment of 4 embryological remnants (Fig. 7.2). These are:

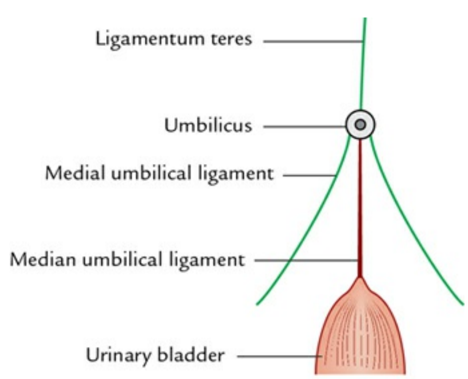


FIG. 7.2 Embryological remnants at umbilicus.

Ligamentum teres

It represents the obliterated left umbilical vein and extends from umbilicus to the liver.

Median umbilical ligament

It represents the obliterated urachus and extends from umbilicus to the apex of urinary bladder.

Right and left medial umbilical ligaments

They represent the remnants of two umbilical arteries and extend from the umbilicus to the superior vesicle arteries.

Clinical importance

- It is of great cosmetic value; hence, surgical incision should not be given across the umbilicus.
- It is the site of referred pain of viscera supplied by T10 spinal segment.
- It may be the site of *urinary fistula* due to nonobliteration of urachus.
- It is the site of *exomphalos* and *congenital umbilical hernias*.
- It may be the site of *fecal fistula*.

The umbilicus is therefore considered as the **hot-bed of embryology** by the clinicians.

❖ Enumerate the muscles of the anterior abdominal wall.

The anterior abdominal consists of 5 pairs of muscles: 3 pairs of flat muscles placed anterolaterally and 2 pairs of vertical muscles placed anteriorly on either side of median plane.

Flat muscles

- External oblique
- Internal oblique
- Transversus abdominis

Vertical muscles

- Rectus abdominis
- Pyramidalis

❖ Give the origin, insertion, and nerve supply of the external oblique muscle.

Origin

By 8 fleshy slips from the middle of lower 8 ribs, interdigitating with serratus anterior and latissimus dorsi. The fibers run downward, forward, and medially.

Insertion

- By aponeurosis into xiphoid process, linea alba, symphysis pubis, and pubic crest.
- By inguinal ligament into the anterior superior iliac spine and the pubic tubercle.
- By fleshy fibers into the anterior 2/3rds of the outer lip of the iliac crest.

Nerve supply

By ventral rami of low 6 thoracic spinal nerves (T7–T12).

❖ Give the origin, insertion, and nerve supply of the internal oblique muscle.

Origin

From before backwards:

- Lateral 2/3rd of the inguinal ligament.
- Anterior 2/3rd of the intermediate area of the iliac crest.
- Thoracolumbar fascia.

The fibers run upward, forward, and medially, crossing the fibers of external oblique at the right angle.

Insertion

- Posterior part by fleshy fibers into the lower three or four ribs and their cartilages.
- Remaining muscle is inserted by aponeurosis into the 9th, 8th, and 7th costal cartilages, xiphoid process, linea alba, pubic crest, and pectineal line of the pubis.

Nerve supply

By ventral rami of lower 6 thoracic spinal nerves and first lumbar nerve (T7–L1).

❖ Give the origin, insertion, and nerve supply of the transversus abdominis muscle.

Origin

From before backwards:

- Lateral 1/3rd of inguinal ligament.
- Anterior 2/3rd of the inner lip of iliac crest.
- Thoracolumbar fascia.
- Inner surfaces of lower 6 costal cartilages interdigitating with diaphragm.

Insertion

- By broad aponeurosis into the xiphoid process and linea alba.
- By the conjoint tendon into the pubic crest and pectineal line of pubis.

Nerve supply

By ventral rami of lower 6 thoracic spinal nerves and first lumbar nerve (T7–L1).

❖ Write a short note on the inguinal ligament.

The inguinal ligament is formed by the lower border of the aponeurosis of external oblique muscle that has folded backward upon itself. It extends from anterior superior iliac spine to the pubic tubercle in the inguinal region.

The inguinal ligament is convex downward (i.e. toward the thigh) where it gives attachment to fascia lata (the deep fascia of the thigh) and concave toward the abdomen where it gives attachment to internal oblique and transverses abdominis muscles.

N.B.

The inguinal ligament is convex downward due to the downward pull exerted by the fascia lata.

Extensions

The extensions of inguinal ligament are:

- Lacunar (Gimbernat) ligament
- Pectineal ligament (ligament of Cooper)
- Reflected part of inguinal ligament
- Ilioinguinal ligament

❖ Give a brief account of the cremasteric muscle and add a note on cremasteric reflex.

Cremasteric muscle

The cremasteric muscle consists of muscle fasciculi that spring from the middle of the inguinal ligament. They form loops around the spermatic cord and testis; and get attached to the pubic tubercle, pubic crest, and conjoint tendon. The gaps between the loops are filled by *cremasteric fascia*. The cremaster muscle and cremasteric fascia together form the *musculofascial sac* to suspend the testis.

Nerve supply

By the genital branch of genitofemoral nerve (L1).

Actions

- It suspends the testis that can be elevated by its contraction.
- It helps to close the superficial inguinal ring when intra-abdominal pressure is raised.

Cremasteric reflex

Upon stroking the skin of the upper part of the medial aspect of thigh, there is a reflex contraction of cremasteric muscle, leading to an elevation of the testis. The cremasteric reflex is brisk in children (Fig. 7.3).

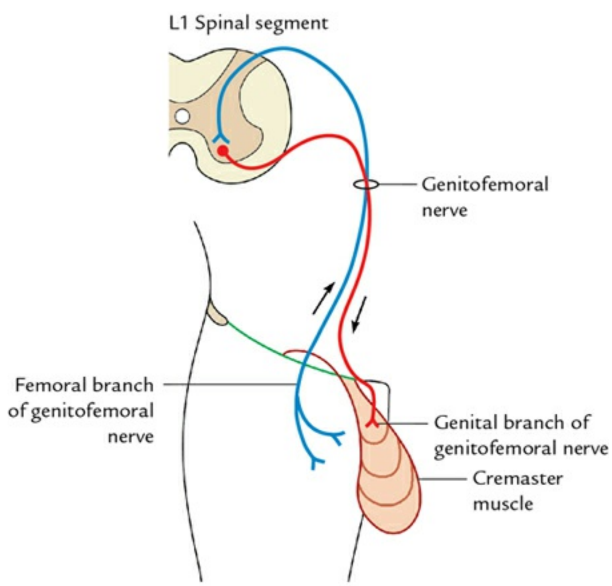


FIG. 7.3 Cremasteric reflex.

N.B.

This reflex is mediated by L1 **spinal segment**. The **afferent limb** is formed by femoral branch of genitofemoral nerve and **efferent limb** by the *genital branch of the genitofemoral nerve*. This reflex is lost in upper motor neuron lesions.

❖ Write a short note on conjoint tendon/falx inguinalis.

The conjoint tendon is formed by the fusion of the lower aponeurotic arching fibers of internal oblique and transverses abdominis muscles. It is attached to the public crest and pectineal line. It lies in front of the rectus muscle. It strengthens the posterior wall of the inguinal canal in its medial 1/3rd opposite the superficial inguinal ring.

❖ Give the origin, insertion, and nerve supply of the rectus abdominis muscle.

Origin

By two tendinous heads.

Lateral head

From the lateral part of the pubic crest.

Medial head

From the anterior pubic ligament.

Insertion

The fibers run vertically upward towards the costal margin and gets inserted on the thoracic cage, along a horizontal line extending laterally from xiphoid process and cutting in order the 7th, 6th, and 5th costal cartilages.

Nerve supply

By the lower 6 or 7 thoracic spinal nerves (T5–T12/T6–T12).

❖ Enumerate the main actions of the muscles of the anterior abdominal wall.

- Provide support and protection to abdominal viscera.
- Provide force for explosive acts, viz, defecation, micturition, and parturition.
- Play an important role in forceful expiatory acts such as coughing, sneezing, and nose blowing.
- Produce movements of the trunk, viz.

❒ *Flexion*, mainly by rectus abdominis muscles.

❒ *Lateral flexion*, by unilateral contraction of oblique muscles.

❒ *Rotation*, by a combined action of external oblique muscle of one side and internal oblique muscle of the opposite side.

❖ Describe rectus sheath under the following headings: (a) definition, (b) formation, (c) contents, and (d) applied anatomy

Definition

It is an aponeurotic sheath enclosing the rectus abdominis muscle and pyramidalis (if present). It has two walls: anterior and posterior.

Formation

The formation of rectus sheath differs in its upper, middle, and lower parts (Fig. 7.4).

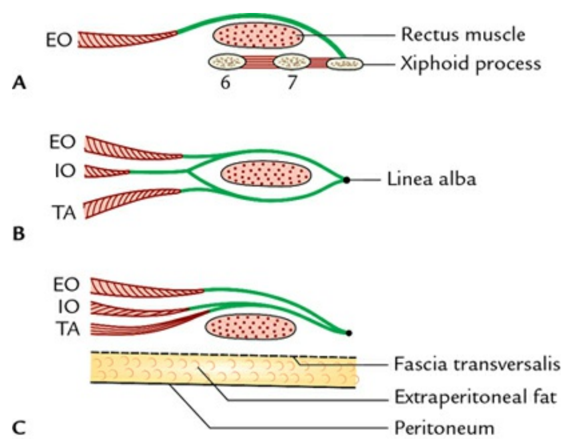


FIG. 7.4 Formation of the rectus sheath.

Above the costal margin

Anterior wall is formed by the external oblique (EO) aponeurosis alone. Posterior wall is absent. (Rectus muscle lies directly on the 5th, 6th, and 7th costal cartilages.)

From the costal margin down to arcuate line (a level midway between the umbilicus and symphysis pubis)

- Anterior wall is formed by the aponeurosis of external oblique and the anterior lamina of the aponeurosis of the internal oblique.
- Posterior wall is formed by the aponeuroses of the transversus abdominis, and internal oblique (posterior lamina) muscles.

From a level midway between the umbilicus, and the symphysis pubis down to the symphysis pubis

- Anterior wall is formed of the aponeuroses of external oblique, internal oblique, and the transverses abdominis muscles.
- Posterior wall is absent. (Rectus muscle lies directly on the fascia transversalis).

N.B.

The posterior wall of rectus sheath ends midway between umbilicus and pubic symphysis forming an arcuate line/linea semilunaris/fold of Douglas. This line is concave downward.

Contents (fig. 7.5)

• 2 muscles: Rectus abdominis and pyramidalis (if present).

• 2 vessels: Superior and inferior epigastric arteries.

• 2 veins: Superior and inferior epigastric veins.

• 6 nerves: Terminal parts of lower 5 intercostal nerves and a subcostal nerve.

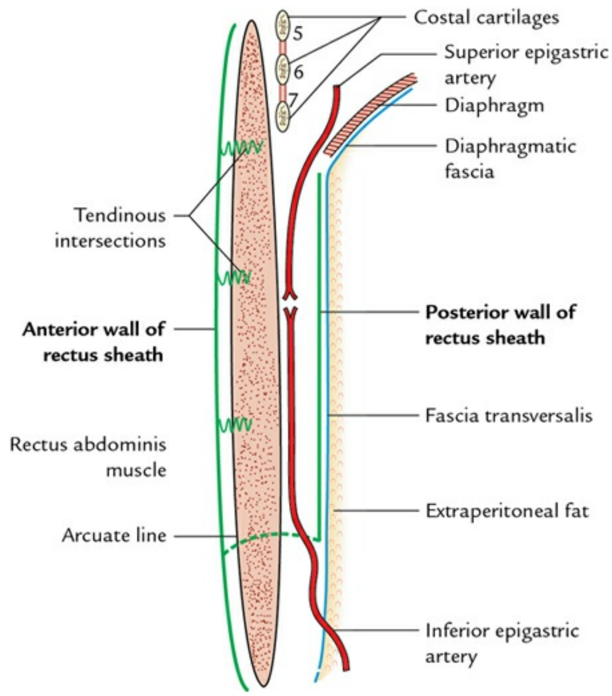


FIG. 7.5 Contents of the rectus sheath.

N.B.

The vessels and nerves lie posterior to the rectus abdominis muscle.

Functions

• It helps in maintaining the strength of the anterior abdominal wall.

• It prevents the bowing of recti abdominis during contraction of anterior abdominal wall.

Applied anatomy

• The aponeurotic sheaths of the right and left recti fuse in the midline to form **linea alba**. In multiparous women, the upper part of linea alba gets stretched and gap leading to the **divarication of recti**

abdominis.

- Knowledge of rectus sheath and its contents help the surgeon to do laparotomy by giving a paramedian incision, without cutting the rectus abdominis muscle.

❖ Describe the inguinal canal under the following headings: (a) introduction, (b) boundaries, (c) contents, (d) defense/protective mechanisms, (e) development, and (e) applied anatomy.

Introduction

- The inguinal canal is an oblique intermuscular slitlike passage in the lower part of the anterior abdominal wall for the transmission of spermatic cord in the male and the round ligament of the uterus in the female (Fig. 7.6).
- It is situated above the medial half of the inguinal ligament.
- It is about 4 cm in length.
- It begins at the deep inguinal ring and terminates at the superficial inguinal ring.
- It is directed downward, forward, and medially.
- It is larger in male than in female.

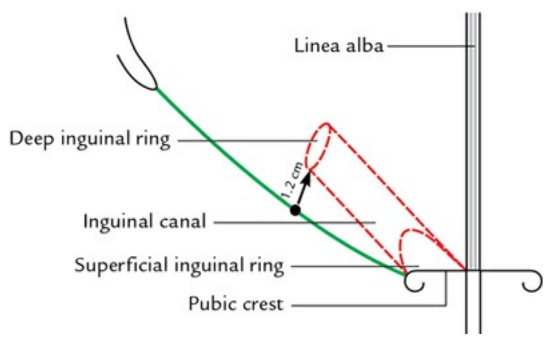


FIG. 7.6 Surface marking of the inguinal canal.

Boundaries (fig. 7.7)

Anterior wall

It is formed by the external oblique aponeurosis in the whole of its extent and by the lower fleshy fibers of the internal oblique in its lateral 1/3rd.

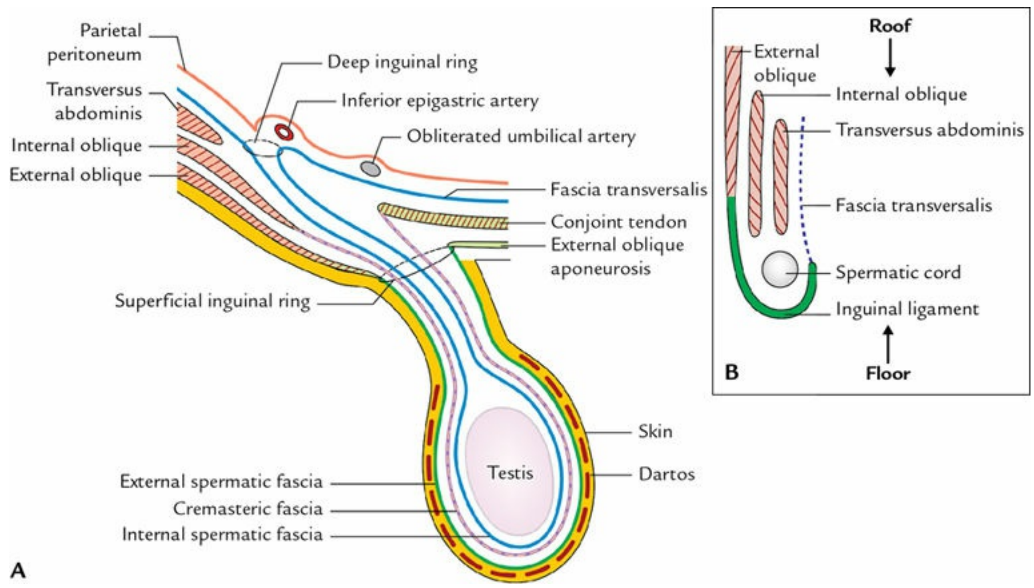


FIG. 7.7 Boundaries of the inguinal canal.

Posterior wall

It is formed by fascia transversalis in the whole of its extent, conjoint tendon in its medial half, reflected part of the inguinal ligament in its medial fourth, and interfeveolar ligament in its lateral 1/3rd.

Floor

It is formed by the upper grooved surface of the inguinal ligament and at the medial end by the lacunar ligament.

Roof

It is formed by the lower arched fibers of the internal oblique and transversus abdominis muscles.

Contents/structures passing through the inguinal canal

- Spermatic cord in males and round ligament of uterus in females
- Ilioinguinal nerve

Superficial inguinal ring

It is a small/oblique triangular aperture in the aponeurosis of the external oblique muscle, above and lateral to pubic tubercle. The medial and lateral margins of the superficial inguinal ring are called *crura*.

The *lateral crus* is attached to the pubic tubercle and *medial crus* to the front of pubic symphysis. The base of superficial inguinal ring is formed by the pubic crest.

Deep inguinal ring

It is an oval aperture in the fascia transversalis, half an inch (1.25 cm) above the mid-inguinal point and just lateral to the inferior epigastric artery.

Defense/protective mechanisms of the inguinal canal

These are the mechanisms that prevent the abdominal contents to enter the inguinal canal, thus preventing inguinal hernias to occur. These are as follows:

Flap-valve mechanism

The increased intra-abdominal pressure approximates the anterior and posterior walls and obliterates the inguinal canal.

Slit-valve mechanism

The contraction of external oblique approximates two crura of the superficial inguinal ring.

Shutter mechanism

The contraction of the arching fibers of the internal oblique approximates the roof with the floor of the inguinal canal like a shutter.

Ball-valve mechanism

When the cremaster muscle contracts, it draws upward the spermatic cord to plug the superficial inguinal ring.

- The ***Posterior guard*** superficial inguinal ring is guarded posteriorly by the conjoint tendon and reflected part inguinal ligament.

- The ***Anterior guard*** deep inguinal ring is guarded anteriorly by the fibers of internal oblique muscle.

N.B.

The hormones also play an important role in maintaining the tone of inguinal musculature.

Development

Developmentally, the inguinal canal is formed by the formation of **processus vaginalis** and descent of gubernaculum of testis or ovary through the anterior abdominal wall.

Applied anatomy

Inguinal hernias

The inguinal canal is the region of potential weakness in the lower part of the anterior abdominal wall. Therefore, when intra-abdominal pressure is increased, the abdominal contents especially intestinal loop are pushed into the inguinal canal, leading to a clinical condition called inguinal hernia.

If the abdominal content are pushed through deep inguinal ring, it is called *indirect inguinal hernia*. On the other hand, if abdominal contents are pushed directly through the posterior wall of the inguinal canal, it is termed *direct inguinal hernia*.

N.B.

Indirect inguinal hernias: These are subdivided into 3 types: (a) vaginal, (b) congenital, and (c) bubonocele.

Direct inguinal hernias: These are subclassified into two types: (a) **medial direct inguinal hernia** if abdominal viscus is pushed through the medial part of the Hesselbach's triangle, i.e. medial to obliterated umbilical artery; and (b) **lateral direct inguinal hernia** if the abdominal viscus is pushed through the lateral part of the Hesselbach's triangle, i.e. lateral to the obliterated umbilical artery.

❖ Give the differences between the indirect and direct inguinal hernias.

The differences between the direct and indirect inguinal hernias are given in Table 7.1.

Table 7.1

Differences between the indirect and direct inguinal hernias

Indirect inguinal hernia	Direct inguinal hernia
Abdominal viscus enters the inguinal canal through deep inguinal ring	Abdominal viscus enters the inguinal canal directly by pushing its posterior wall in the region of the Hesselbach's triangle
Occurs due to persistence of processus vaginalis, i.e. congenital weakness (performed sac)	Occurs due to loss of tone of muscles forming posterior wall of inguinal canal, i.e. acquired weakness
Occurs in young age	Occurs in old age
Directed downward, forward, and medially	Directed forward
Neck of hernial sac lies lateral to inferior epigastric artery	Neck of hernial sac lies medial to inferior epigastric artery
Obstruction is common as the neck of hernia is narrow	Obstruction is not common as neck of hernia is wide
Swelling does not appear on internal ring occlusion test	Swelling reappears on internal ring occlusion test

❖ Enumerate the coverings of indirect inguinal hernia.

From deep to superficial, these are:

• Extraperitoneal tissue

• Internal spermatic fascia

• Cremasteric fascia

• External spermatic fascia

• Dartos muscle

• Skin

❖ Enumerate the coverings of the direct inguinal hernia.

The coverings of the lateral and medial direct hernias from deep to superficial are given in Table 7.2.

Table 7.2

Coverings of the lateral and medial direct inguinal hernias

Lateral direct hernia	Medial direct hernia
Extraperitoneal tissue	Extraperitoneal tissue
Fascia transversalis	Fascia transversalis
Cremasteric muscle and fascia	Conjoint tendon
External spermatic fascia	External spermatic fascia
Dartos muscle	Dartos muscle
Skin	Skin

❖ Write a short note on the Hesselbach's triangle/inguinal triangle.

The **Hesselbach's triangle** is a triangular area on the posterior aspect of anteroinferior wall of the abdomen, above the medial half of the inguinal ligament.

Boundaries (fig. 7.8)

Lateral

Inferior epigastric artery.

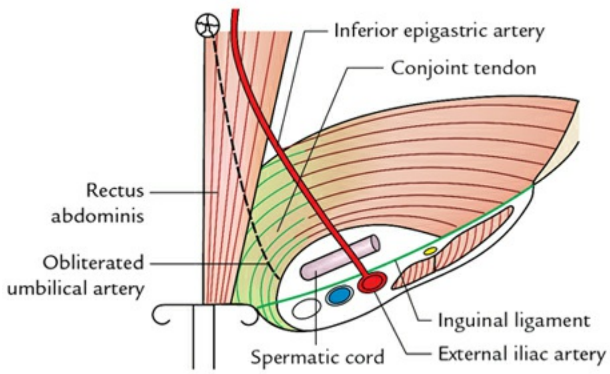


FIG. 7.8 Boundaries of Hesselbach's triangle.

Medial

Lateral border of rectus abdominis muscle.

Base

Medial half of the inguinal ligament.

Floor

Conjoint tendon and fascia transversalis (posterior wall of the inguinal canal).

Apex

Meeting point of the inferior epigastric artery and lateral border of the rectus abdominis muscle.

N.B.

The Hesselbach's triangle is divided into medial and lateral halves by the obliterated umbilical artery (lateral umbilical ligament).

Applied anatomy

The Hesselbach's triangle is the site of **direct inguinal hernia**.

❖ Write a short note on spermatic cord.

It is a cord like structure of soft tissues which extends from upper end of the posterior border of testis to the deep inguinal ring. It is about 3 inches (7.5 cm) long and contains the vas deferens and associated nerve and vessels (Fig. 7.9).

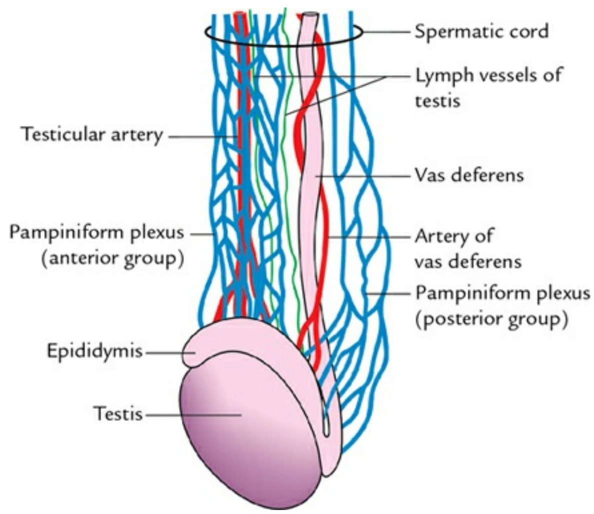


FIG. 7.9 Spermatic cord.

Coverings (fig. 7.10)

The coverings of spermatic cord (3 in number) are derived from muscles and fasciae of the anterior abdominal wall. From superficial to deep, these are:

- *External spermatic fascia,* derived from external oblique aponeurosis.
- *Cremasteric muscle and fascia,* derived from internal oblique aponeurosis.
- *Internal spermatic fascia,* derived from fascia transversalis.

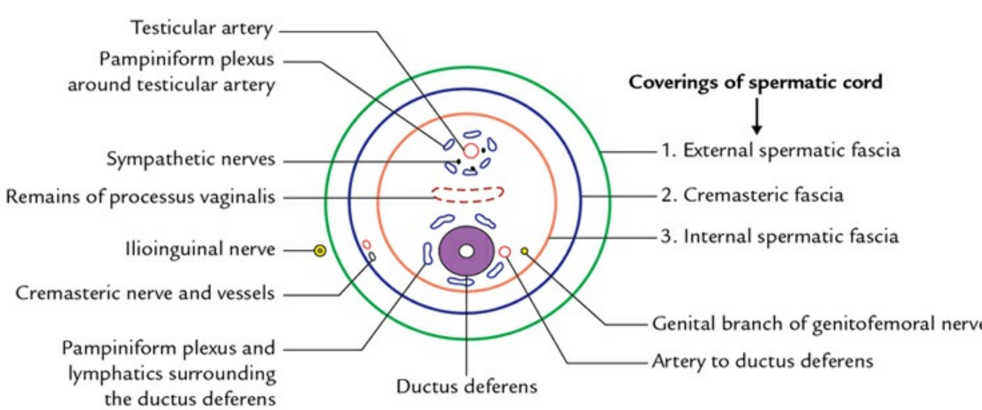


FIG. 7.10 Covering and contents of the spermatic cord.

Contents (fig. 7.10)

Three arteries:

- Testicular artery from abdominal aorta
- Cremasteric artery form inferior epigastric artery
- Artery of vas deferens from inferior vesicle artery

Three nerves:

- Ilioinguinal nerve from ventral ramus of L1 (strictly speaking, it lies on and not within the cord).
- Genital branch of genitofemoral nerve: It also gives rise to cremasteric nerve.
- Sympathetic fibers: they form plexus around the perivascular coat of testicular artery and convey the fibers from T10 and T12.

Three other structures:

- Vas deferens
- Pampiniform plexus of veins
- Lymphatics that drain the testis and epididymis into pre- and para-aortic lymph nodes

N.B.

The spermatic cord also contains fibrous remnants of **processus vaginalis**.

❖ Write a short note on vas deferens/ductus deferens.

The vas deferens is a thickwalled muscular tube measuring about 45 cm in length.
It is the continuation of the tail of epididymis. It transports the spermatozoa from testis to the urethra.

Course and relations (fig. 7.11)

During its course, it traverses through 3 regions:

- Scrotum
- Spermatic cord
- Lesser pelvis

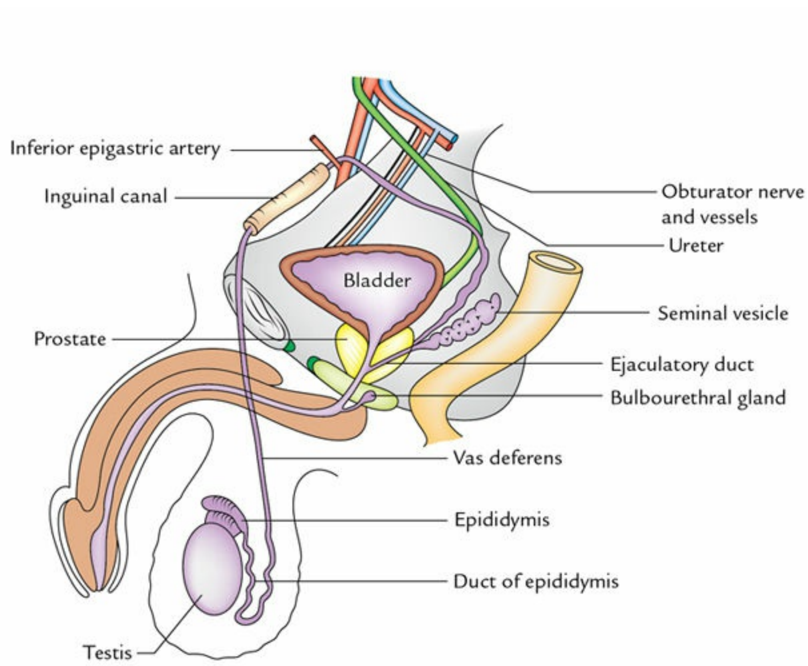


FIG. 7.11 Course and relations of vas deferens.

In the scrotum

The **1st part of vas deferens** is in the scrotum, where it begins at the tail of epididymis. First, it is tortuous, but gradually, it straightens up, as it ascends along the posterior border of testis, medial to the epididymis.

In the spermatic cord

The **2nd part of vas deferens** lies vertically in posterior part of spermatic cord. It runs upward to pass successively through the superficial inguinal ring, inguinal canal, and deep inguinal ring.

In the pelvis

The **third part of vas deferens** begins at the deep inguinal ring; it leaves the spermatic cord and hooks around the lateral side of the **inferior epigastric artery**. It then passes backward and medially, across the external iliac vessels, and enters the lesser pelvis.

In *the lesser pelvis:* It first lies along its lateral wall and then runs downward and backward deep to the peritoneum. Here, it crosses the obliterated umbilical artery, the obturator nerve and vessels, and the vesical vessels. It then crosses the ureter, to reach the base of the urinary bladder where it runs downward and forward medial to the seminal vesicle. Here, it approaches the opposite vas deferens and reaches the base of the prostate.

At the base of the prostate, the ductus deferens ends by joining the duct of the seminal vesicle at an acute angle to form the ejaculatory duct.

The terminal dilated end of vas deferens that lies behind the urinary bladder is called *ampulla*.

Applied anatomy

Vasectomy

For family planning, a small incision is placed in the upper part of scrotum on both sides. The position of vas deferens is identified by palpating the spermatic cord. (Note vas deferens can be easily identified within the spermatic cord because it has consistency of a plastic tube.) The spermatic cord is pulled out and its coverings are cut open. A small segment of each ductus deferens is cut and the cut ends are ligated on both sides.

❖ Give the histological features of the vas deferens.

A histological section of the ductus deferens (Fig. 7.12) presents a small lumen and a thick wall surrounding it.

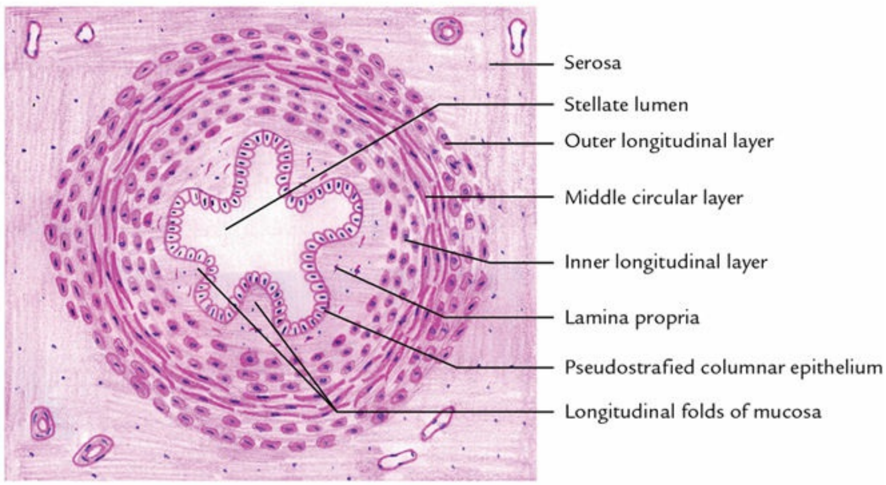


FIG. 7.12 Histological features of vas deferens.

Lumen

Narrow and stellate-shaped.

Wall

From within outward it consists of 3 layers: mucosa, muscular coat, and adventitia (fibrous coat).

- *Mucosa*

❒ *Epithelial lining* is pseudostratified columnar, with stereocilia.

❒ *Lamina propria* is the thin layer of connective tissue containing an extensive network of elastic fibers. It is thrown into 4–6 longitudinal folds.

- *Muscular coat*

Consists of 3 layers of smooth muscle fibers – inner and outer longitudinal layers and a thick powerful intermediate circular layer.

- *Adventitia*

Thin layer of connective tissues, containing blood vessels and nerves.

CHAPTER 8

Male external genital organs

❖ What are male external genital organs?

Anatomically, male external genital organs include penis, scrotum, spermatic cords, testis, and epididymis.

❖ Describe penis in brief under the following headings: (a) definition, (b) parts, (c) structure of body, (d) arterial supply, (e) venous drainage, (f) lymphatic drainage, (g) innervation, (h) mechanism of erection, and (I) applied anatomy.

Definition

Penis is a male organ of copulation and deposits semen into the vagina.

Parts (fig. 8.1)

Penis consists of two parts:

• *Root,* an attached portion.

• *Body,* a free pendulous portion.

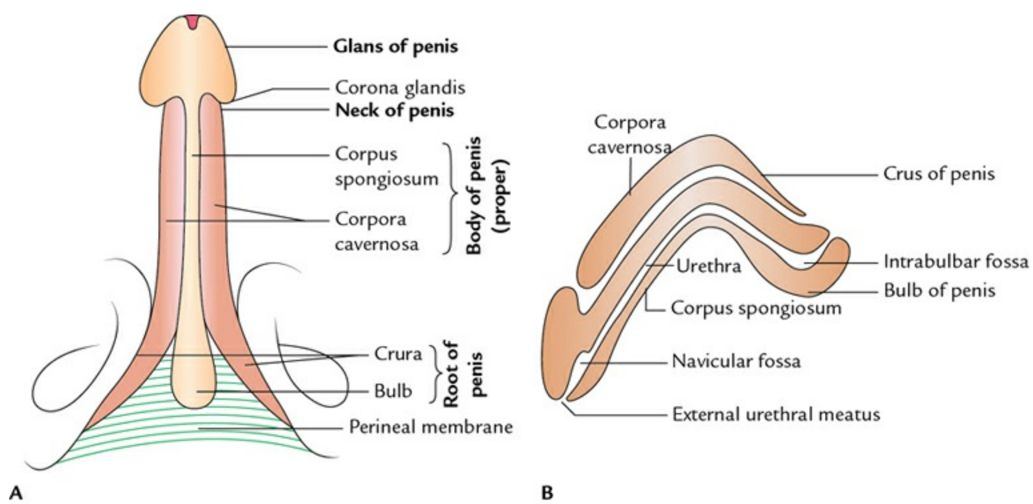


FIG. 8.1 Penis: A, parts (as seen from ventral aspect); B, transverse section through the body.

The **root** consists of two crura and a bulb. The *crura* are attached to the ischiopubic rami and covered by *ischiocavernosus muscles.* The *bulb* of penis is attached to the inferior aspect of the perineal membrane and covered by *bulbospongiosus muscle.*

The **body** is free pendulous part with an enlarged conical free end, the **glans of the penis.** It consists of two corpora cavernosa placed dorsally one on either side of midline and one corpus spongiosum placed ventrally between the two corpora cavernosa. The corpus spongiosum is traversed by the penile urethra. The body is covered by a membranous layer of superficial fascia of abdomen called *Buck's fascia/deep fascia* of penis.

Structure of body

The body consists of three elongated masses of erectile tissue: two corpora cavernosa and one corpus spongiosum. The corpora cavernosa are surrounded by a common fibrous sheath called *tunica albuginea.*

The corpus spongiosum is surrounded seperately by a thin layer of tunica albuginea.

Coverings

From superficial to deep penis is covered by skin, superficial fascia, and deep fascia (*Buck's fascia).* The skin of penis is thin, dark, and hairless. At the neck of penis, it is folded on itself to form *prepuce or foreskin*, which covers the glans penis to a variable extent.

Supports of penis

- *Fundiform ligament*, which extends downward from linea alba and splits to enclose the proximal part of the body.

- *Suspensory ligament*, which extends from pubic symphysis and blends with the fascia on either side of penis. It lies deep to fundiform ligament.

Arterial supply

The penis has rich blood supply by four pairs of arteries.

- *Deep arteries of penis*
- *Dorsal arteries of penis*
- *Arteries of bulb*

from internal pudendal arteries

- *Superficial dorsal arteries*, from superficial external pudendal arteries.

Venous drainage

By two veins: superficial and deep dorsal veins of the penis.

Lymphatic drainage

Lymph from glans penis is drained into deep inguinal lymph nodes particularly in **lymph node of Cloquet,** while lymph from rest of penis is drained into **medial group of deep inguinal lymph nodes.**

Innervation

- *Sensory innervation*, by dorsal nerve of penis and ilioinguinal nerve.

- *Motor (somatic) innervation*, by perineal branch of pudendal nerve.

- *Automatic innervation*, by inferior hypogastric plexus via prostatic plexus. The parasympathetic fibers (S2, S3, and S4) are vasoconstrictor, while sympathetic fibers are vasodilator.

Mechanism of erection

Following parasympathetic stimulation, the cavernous spaces of the penis get filled and dilated with blood from *helicine arteries.* This leads to compression of veins egressing from corpora cavernosa, impeding the return of venous blood. Consequently, the corpora cavernosa and corpus spongiosum become engorged with blood at venous pressure causing penis to become long, hard, and warm – the *erection of penis*.

Applied anatomy

- *Impotence*: Loss of erection of the penis.
- *Priapism*: Persistent erection of the penis.
- *Peyronie's disease/chordee*: Bending of penis during erection. It occurs due to the formation of localized fibrous plaque in corpora cavernosa. It is often associated with hypospadias.
- *Phimosis*: Narrowing of distal end of the prepuce.
- *Paraphimosis*: Tight prepuce stucking on glans posteriorly.
- *Circumcision*: Removal of prepuce/foreskin of the penis.

❖ What is scrotum? Enumerate the layers of the scrotal wall.

Scrotum is a large pendulous fibromuscular cutaneous bag lying below the pubic symphysis and posteroinferior to the penis.

Contents (fig. 8.2)

- Testes
- Epididymes
- Spermatic cords (lower part)

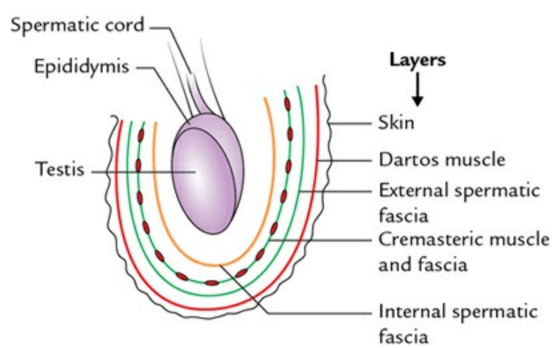


FIG. 8.2 Contents and layers of the scrotum.

Layers (fig. 8.2)

From without inward, these are:

- Skin
- Superficial fascia containing dartos muscle (smooth muscle)
- External spermatic fascia derived from external oblique
- Cremasteric fascia and muscle derived from internal oblique
- Internal spermatic fascia derived from fascia transversalis

N.B.

All the layers of anterior abdominal wall continue in the scrotal wall except transversus abdominis muscle, which does not continue into the scrotal wall.

Nerve supply

Anterior 1/3rd of scrotum by L1 spinal segment through:

- Ilioinguinal nerve

- Genital branch of genitofemoral nerve

Posterior 2/3rd of scrotum by S3 spinal segment through:

- Posterior scrotal nerve, a branch of the pudendal nerve
- Perineal branch of the posterior cutaneous nerve of the thigh

❖ Write a short note on pampiniform plexus of testis and discuss its applied anatomy.

The pampiniform plexus is a plexus of veins emerging from the testis. This plexus is arranged into two groups: *anterior group* around the testicular artery and *posterior group* around the vas deferens.

Fate of pampiniform plexus

At the superficial inguinal ring, it condenses to form 4 veins which join at the deep inguinal ring to form 2 veins. Beyond deep inguinal ring, these 2 veins unite to form a single testicular vein, which drains into inferior vena cava on the right side and left renal vein on the left side.

Applied anatomy

Varicocele

It is a clinical condition in which veins of the pampiniform plexus become dilated, tortuous, and elongated. It mostly occurs on the left side because: (a) left testicular vein drains at a right angle in the left renal vein; hence, venous pressure is high in the left testicular vein, (b) left testicular vein is compressed by loaded constipated sigmoid colon, and (c) blockage of the left renal vein due to invasion by a malignant tumor growing in the left kidney. The last two factors impede the return of venous blood by left testicular vein.

Clinically, varicocele presents:

- Vague, dragging sensations and aching pain in the scrotum
- On palpation, the veins of pampiniform plexus feel like '**bag of worms**'.

❖ Describe the testis under following headings: (a) introduction, (b) external features, (c) coverings, (d) structure, (e) arterial supply, (f) venous drainage, (g) nerve supply, (f) lymphatic drainage, and (g) applied anatomy.

Introduction

- The testis is an internal male reproductive organ present in the scrotum one on either side of median plane.
- It is suspended in the scrotum by the spermatic cord.
- It lies obliquely in the scrotum (tilted forward and laterally) as a result, its lower pole is directed backward and medially.
- The left testis lies at lower level than the right testis because left testis migrates early and has longer spermatic cord.

External features (fig. 8.3)

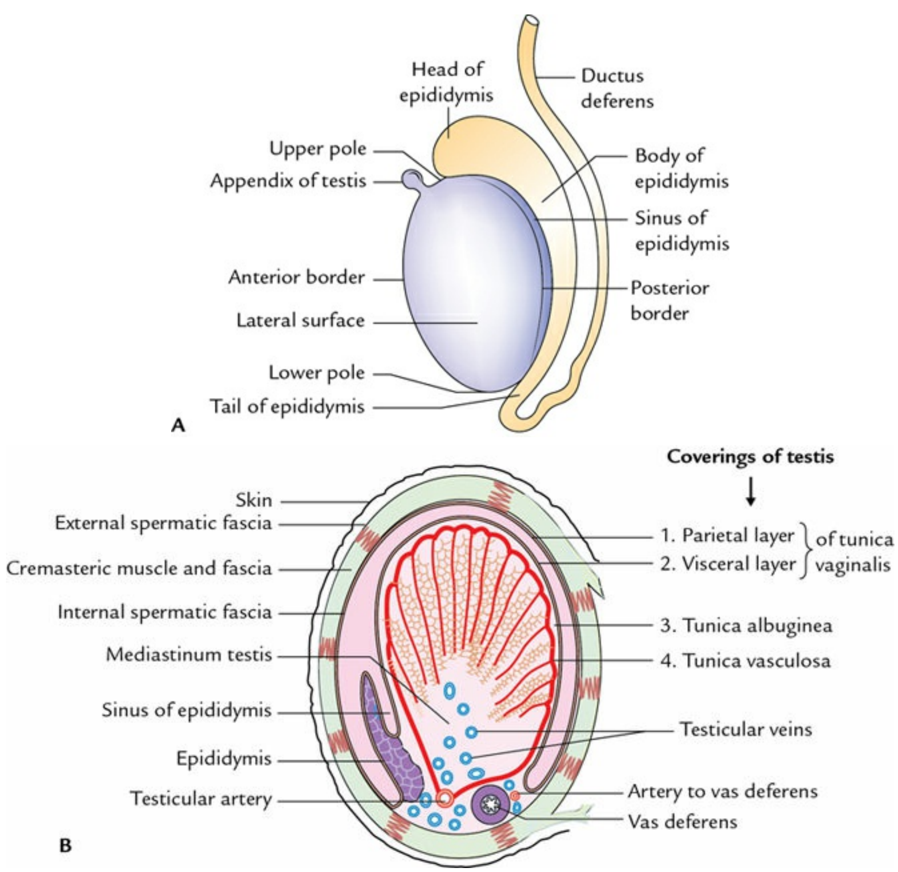


FIG. 8.3 Testis: A, external features (left testis lateral aspect); B, coverings.

Shape

Ellipsoid.

Dimension

Length 5 cm; breath 2.5 cm; anteroposterior dimension 3 cm.

Weight

10–15 gm.

2 poles

Upper and lower.

2 borders

Anterior and posterior.

2 surfaces

Medial and lateral.

N.B.

The appendix of testis (if present) is seen as a small pedunculated body attached to the upper end of the testis.

Coverings (fig. 8.3)

The testis is covered by 3 coats. From superficial to deep, these are:

- *Tunical vaginalis,* a serous coat consisting of visceral and parietal layers
- *Tunica albuginea,* a white dense fibrous coat
- *Tunica vasculosa,* a vascular coat. The surface of testis is covered by the visceral layer of **tunica vaginalis** (closed peritoneal sac) except where the testis attaches to the epididymis. A slit-like recess of tunica vaginalis between the body of epididymis and posterolateral surface of testis is called **sinus of epididymis**.

Structure

Macroscopic structure (fig. 8.4)

A section through the testis presents following macroscopic features:

- White dense fibrous coat (tunica albuginea) covering the testis all around, which is thickened posteriorly to form *mediastinum testis.*
- Fibrous septa extending from mediastinum testis to tunica albuginea divides the testis into 200 to 300 lobules. Each lobe contains 2–3 coiled *seminiferous tubules*.
- Seminiferous tubules open into the network of channels (**rete testis**) within mediastinum testis by *20 to 30 straight tubules* formed by the anastomoses of seminiferous tubules.
- *Efferent ductules* connect the rete testis to the upper end of the epididymis.

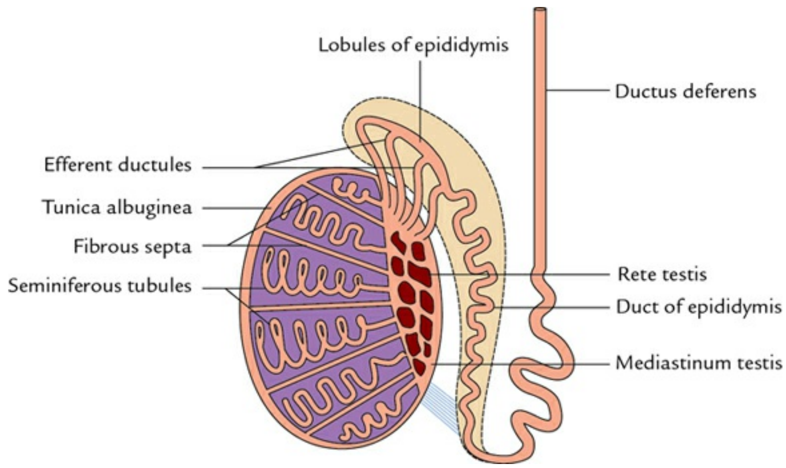


FIG. 8.4 Macroscopic structure of the testis.

Microscopic structure/histological structure

The histological section of the testis presents the following features (Fig. 8.5):

- Coiled seminiferous tubules sectioned in various planes.
- Columns of four to eight *layers of spermatogenic cells* lying between the basement membrane and the lumen of the tubule.
- Presence of *Leydig cells* between the seminiferous tubules.
- Presence of *spermatozoa* in the lumen of the tubule.
- Presence of *Sertoli/supporting cells* between the cells of spermatogenic lineage.

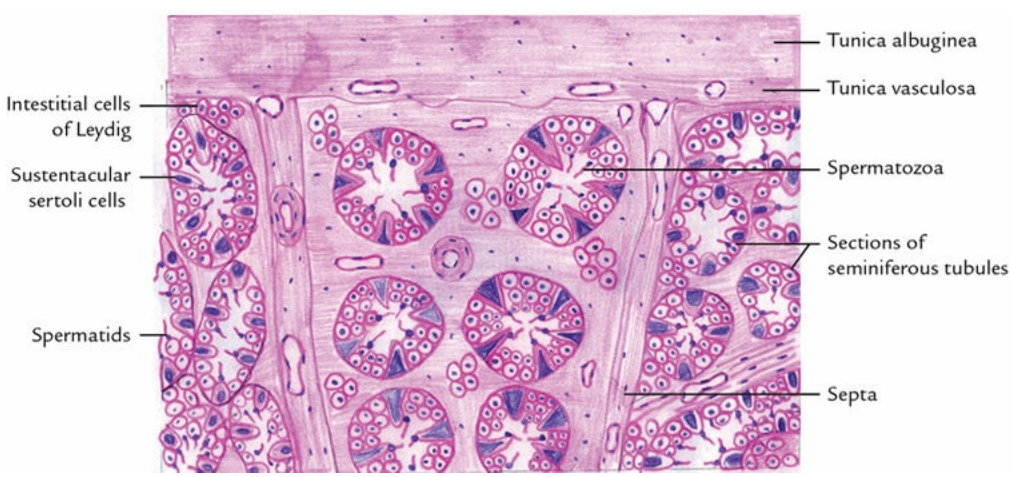


FIG. 8.5 Microscopic structure/histological structure of the testis.

N.B.

Spermatogenic cells are arranged in columns and from superficial to deep these are:

- *Spermatogonium:* lies near the basement membrane between Sertoli cells. They have clear cytoplasm, and their nuclei show chromatin network.

- *Primary spermatocyte:* Lies next to spermatogonium. They are large cells with spherical nuclei.
- *Secondary spermatocyte*: situated next to primary spermatocyte. They are small, and their nuclei show mitotic divisions.
- *Spermatid*: located near the lumen. They are small and have rounded nuclei.
- *Spermatozoa*: small cells with tail present in the lumen.
- *Sertoli cells:* large elongated pyramidal cells, wedged between the columns of spermatogenic cells.
- *Leydig cells:* lie in interstitial spaces between tubules either in single or in clumps.

Arterial supply

Testicular artery (main artery of testis)

It arises from abdominal aorta at the level of L2 vertebra. At the posterior border of testis, it divides into small and large branches.

- *Small branches* enter the posterior border.
- *Long branches* pierce the tunica albuginea and run on the surface of testis to ramify and form *tunica vasculosa.*

Artery to vas deferens, a branch of inferior vesical artery, also sometimes supplies the testis.

Venous drainage

By testicular vein into inferior vena cava on the right side and left renal vein on the left side.

N.B.

The temperature of blood in testis is maintained by *counter current heat exchange mechanism*. The temperature difference of blood flowing in the testis is 3° to 4°.

Nerve supply

By sympathetic fibers derived from T10 spinal segment and reach the testis through renal and aortic plexuses.

Lymphatic drainage

The lymph from testis is drained into **pre aortic** and **para aortic lymph nodes** at the level of L2 vertebra.

Applied anatomy

Varicocele

It is dilatation and tortuosity of veins of pampiniform plexus (for details see P. 76).

Hydrocele (fig. 8.6)

It is accumulation of fluid in the tunica vaginalis of testis

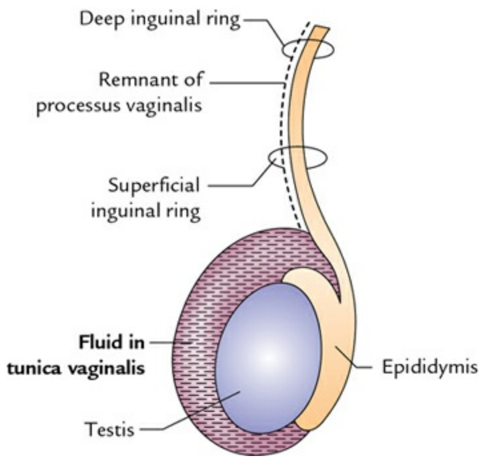


FIG. 8.6 Hydrocele.

Tumors of the testis

The two main varieties of testicular tumors are seminoma (*carcinoma of the seminiferous tubules*) and *teratoma* (malignant change in the totipotent cells). The cancer cells from testis spread upward via the lymph vessels to the lumbar (pre- and para-aortic) lymph nodes at the level of L1/L2 vertebra and produce secondary tumor in the abdomen.

Torsion of the testis

It is a clinical condition in which rotation of the scrotum occurs around the spermatic cord within the scrotum. It commonly affects the active young people and children and is accompanied by severe pain.

❖ Describe the development and descent of testis. Write a note on congenital anomalies associated with descent.

Development of the testis

The testis develops retroperitoneally on the posterior abdominal wall from a mesodermal **genital ridge** just medial to the developing kidney – the mesonephros at the levels of T10 to T12 segments.

The details are as follows:

Indifferent stage

- It begins in the 4th week of intrauterine life.
- The genital ridge is oval in shape and covered by coelomic epithelium.
- It differentiate into outer part called *cortex* and inner part called *medulla*.
- The surface epithelial cells proliferate to form finger-like cords, which penetrate the mesenchyme of the genital ridge. These cords are called *primitive sex cords*.
- The *primordial germ cells* from wall of yolk sac (derived from epiblast) migrate and get incorporated in the sex cords.

Definitive stage

- It begins in the 7th week of intrauterine life.
- The indifferent gonad begins to develop into testis under the influence of SRY gene of the Y chromosome.
- The primary sex cords increase in length and extend into the medulla. Towards the hilum these cords break up into tiny cell strands that anastomose with each other. They become canalized and form *rete testis*.
- The sex cords in cortex become horseshoe shaped and canalized to form *seminiferous tubules*.
- The dense fibrous layer (tunica albuginea) develops around the developing testis.
- The rete testis gets connected with the *mesonephric tubules* and *mesonephric duct*.
- The mesonephric tubules become *efferent ductules*, whereas mesonephric duct gives rise to *epididymis, vas deferens, seminal vesicle*, and *ejaculatory duct*.

N.B.

Sources of origin of various cell types of testis:

- *Primordial germ cells* are endodermal in origin and are derived from wall of yolk sac (recently, it is thought that they are derived from epiblast).
- *Sertoli cells* are derived from coelomic epithelium.
- *Leydig cells* are derived from the mesenchymal cells of the mesonephros.

Descent of testis (fig. 8.7)

The testis begins to descend in the 2nd month of intrauterine life to reach the scrotum.

- Reaches iliac fossa by 3rd month
- Reaches deep inguinal ring by 6th month
- Transverses inguinal canal during 7th month
- Reaches superficial inguinal ring by 8th month
- Reaches in the scrotum (near bottom) by 9th month

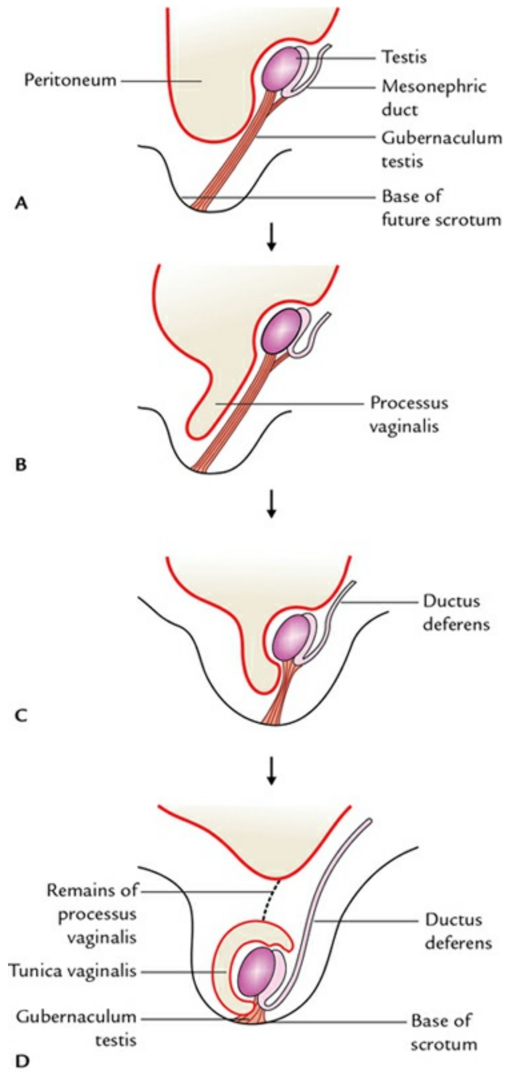


FIG. 8.7 Descent of the testis.

Factors responsible for the descent of testis are grouped as:

- Male sex hormones and maternal gonadotrophins (most important factor)

- Gubernaculum testis and differential growth of body wall
- High intra-abdominal temperature, not suitable for spermatogenesis
- Formation of inguinal bursa, an outpouching of the various layers of anterior abdominal wall to form scrotum
- Formation of processus vaginalis, a diverticulum of peritoneal cavity that guides the descent of testis
- Squeezing action of inguinal muscles as the testis enters into the inguinal canal
- Specific neurotransmitter called CGRP (calcitonin gene-related peptide) released by genitofemoral nerve fibers supplying muscular fibers of gubernaculum

Congenital anomalies of descent (fig. 8.8)

These anomalies of descent are of two types: **cryptorchidism** (undescended testis) and **ectopic testis** (abnormally placed testis).

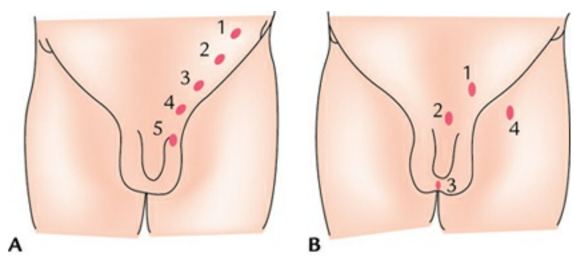


FIG. 8.8 Anomalous descent of the testis: A, cryptorchidism; B, ectopic testis.

Cryptorchidism (fig. 8.8a)

The descent of testis may be arrested at any point along its normal route of journey. Depending upon the location, it is classified into the following types:

- *Lumbar*, if located in abdomen (1).
- *Iliac fossa*, if located at the deep inguinal ring (2).
- *Inguinal*, if located within the inguinal canal (3).
- *Pubic*, if located at the superficial inguinal ring (4).
- *Scrotal*, if located high up in the scrotum (5).

N.B.

The complications of cryptorchidism are: (a) improper spermatogenesis and (b) development of malignancy. The unilateral absence of testis in scrotum is called *monarchism*, while bilateral absence of testis is called *anorchism*.

Ectopic testis (maldescent of testis) (fig. 8.8b)

In this condition, testis successfully descends along its normal path up to superficial inguinal ring, but thereafter, it deviates from normal path and reaches at sites other than the scrotum. The common sites of ectopic testis are:

- In superficial fascia of anterior abdominal wall above the superficial inguinal ring (1)
- At the root of penis/in front of pubis (2)
- In the perineum (3)
- In the femoral region of thigh (4)

❖ Write a short note on the epididymis.

The epididymis is an *elongated comma-shaped structure,* which lies on to the superior and posterolateral surface of the testis. It is made up of highly coiled tube.

Parts

From above downward the epididymis is divided into three parts: *head*, *body*, and *tail*.

The *head* (the upper expanded part) is connected to the upper pole of testis by *efferent ductules* and consists of highly coiled efferent ductules. The *body* (middle part) and *tail* (lower narrow part) are made up of a single highly coiled duct of epididymis, which emerges from the tail as the vas deferens.

Functions

- Storage and maturation of spermatozoa
- Absorption of the fluid
- Addition of substances to the seminal fluid to nourish the maturating spermatozoa

Arterial supply

By testicular artery.

❖ Give the histological features of epididymis.

Histological section of epididymis presents following features (Fig. 8.9):

- A number of tubules in varied sections.
- Lining epithelium is pseudostratified tall columnar with tall columnar cell possesses nonmotile stereo cilia.
- Presence of bunches of spermatozoa in lumen of tubules.
- Lamina propria is a thin fibrous layer surrounded by a thin muscle layer made up of circularly placed smooth muscle fibers.

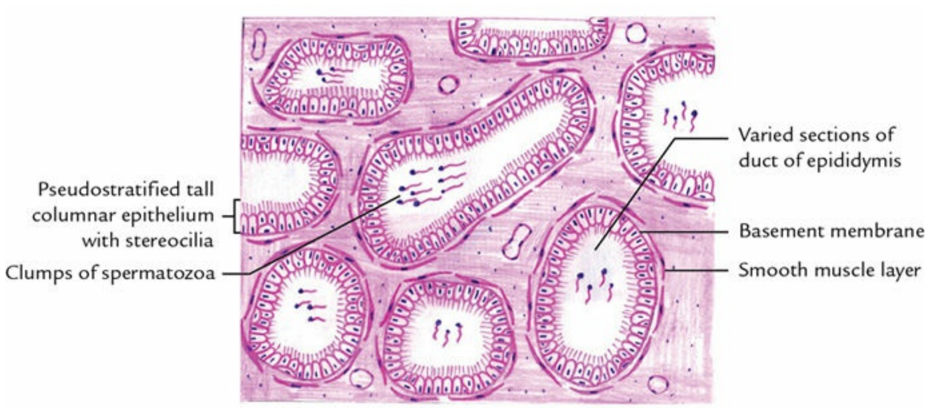


FIG. 8.9 Histological features of the epididymis.

CHAPTER 9

Abdominal cavity and peritoneum

❖ Give the boundaries of the abdominal cavity.

The abdominal cavity is the largest cavity of the body, located within the abdomen and pelvis.

Boundaries

Roof diaphragm

Inferior

Pelvic diaphragm

Posterior

Posterior abdominal wall

Anterior

Anterior abdominal wall

Lateral (on each side)

Flank (i.e., abdominal wall between rib cage and iliac crest).

❖ Give a brief account of 9 regions of the abdomen.

For descriptive purpose, the clinicians divide abdominal cavity into 9 regions by 2 vertical and 2 horizontal planes drawn on the anterior abdominal wall (Fig. 9.1).

- *The two vertical planes are:* **right and left midclavicular planes.**
- *The two horizontal planes are:* **transpyloric and transtubercular planes.**
- The 9 regions marked out in this way are arranged in 3 zones: upper, middle, and lower. These regions are given in the box below:

Zone	Abdominal regions from right to left
Upper	• Right hypochondrium • Epigastrium • Left hypochondrium
Middle	• Right lumbar region • Umbilical region • Left lumbar region
Lower	• Right iliac fossa • Hypogastrium • Left iliac fossa

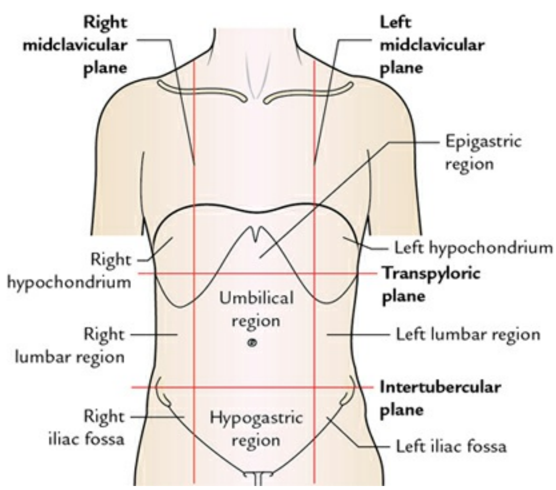


FIG. 9.1 Nine regions of the abdomen.

❖ Give a brief account of 4 quadrants of the abdomen.

Some clinicians divide abdominal cavity into 4 quadrants by two plans: (a) Transumbilical plane, passing horizontally through umbilicus, and (b) median vertical plane intersecting the transumbilical horizontal plane at umbilicus. The 4 quadrants marked in this way are (Fig. 9.2):

- Right upper quadrant
- Left upper quadrant
- Right lower quadrant
- Left upper quadrant

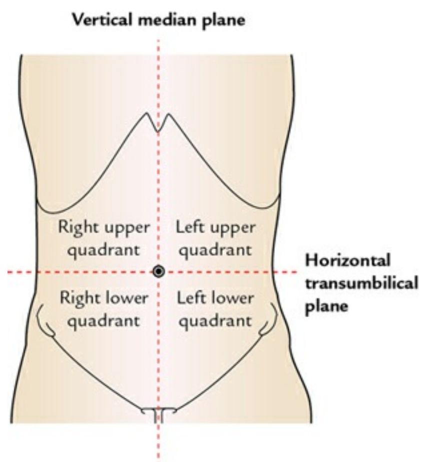


FIG. 9.2 Four quadrants of the abdomen.

❖ Describe peritoneum under the following headings: (a) definition, (b) layers, and (c) functions.

Definition

The peritoneum is a large sac of serous membrane lined with mesothelium within the abdomen. It is a closed sac in males, while in females it communicates to the exterior through vagina.

Layers

The serous sac of peritoneum is invaginated by the number of abdominal viscera. Consequently, peritoneum is divided into two layers:

- Outer parietal layer
- Inner visceral layer.

The *parietal peritoneum* is pain-sensitive to cut and temperature because it is innervated by the *somatic nerves*, whereas *visceral peritoneum* is pain-insensitive to cut and temperature because it is innervated by the *autonomic nerves*.

Functions

- Facilitation of movements of viscera
- Protection of viscera
- Absorption and dialysis of peritoneal fluid
- Facilitates healing and formation of adhesion
- Storage of fat

❖ Write a short note on greater omentum.

The greater omentum is a large fold of peritoneum studded with fat which hangs down from greater curvature of stomach like an apron (Fig. 9.3).

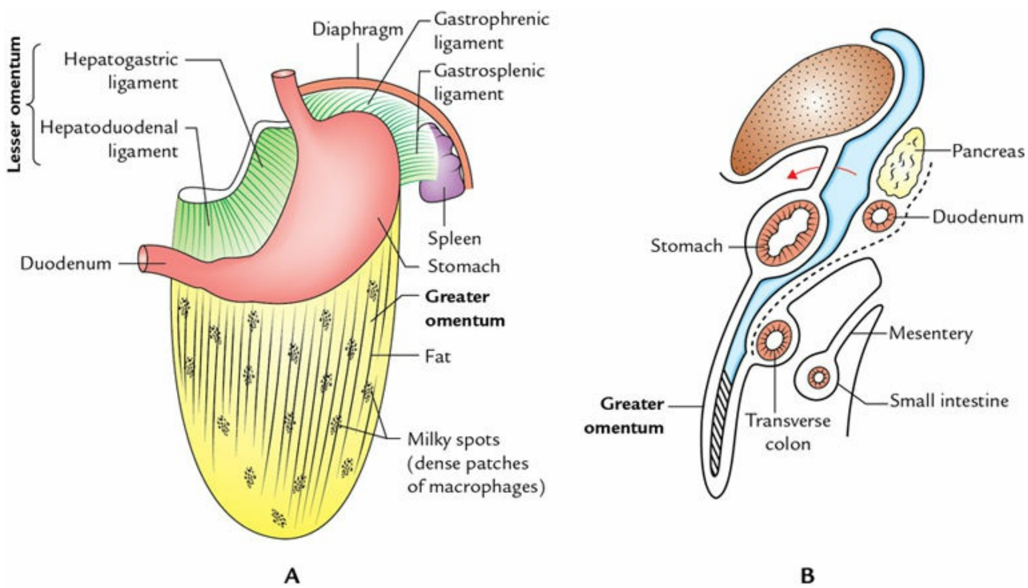


FIG. 9.3 Greater omentum: A, anterior view; B, sagittal section (left view).

Features

- It covers the loops of intestines to a variable extent:
- It is made up of 4 layers of peritoneum, which are fused together.
- It extends from greater curvature of stomach to the transverse colon.

Contents

The contents of greater omentum are:

- Adipose tissue
- Aggregation of macrophages, forming dense patches called *milky spots*
- Right and left gastroepiploic arteries and accompanying veins.

Functions

- Storehouse of fat.
- Limits the spread of infection by moving to the site of infection and sealing it off from the surrounding area; hence, it is also called *policeman of the abdomen*.

- Used as graft by surgeons.

❖ Draw a labeled diagram to show the vertical tracing of the peritoneum.

This is shown in Figure 9.4.

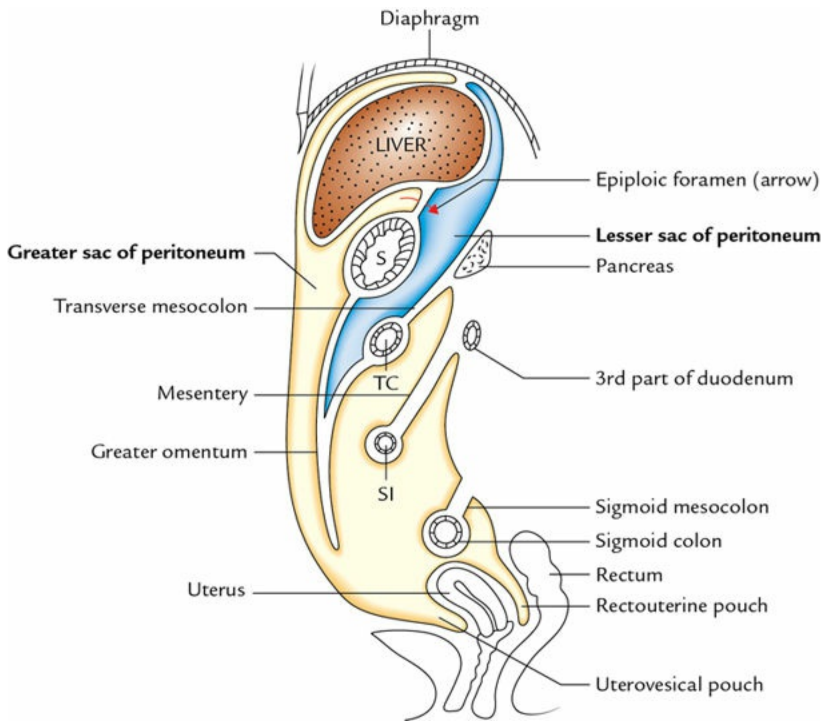


FIG. 9.4 Vertical tracing of peritoneum in female (sagittal section of abdomen). (S = stomach, TC = transverse colon, SI = small intestine).

❖ Draw a labeled diagram to show the horizontal tracing of the peritoneum above the transverse colon/supracolic compartment.

This is shown in Figure 9.5.

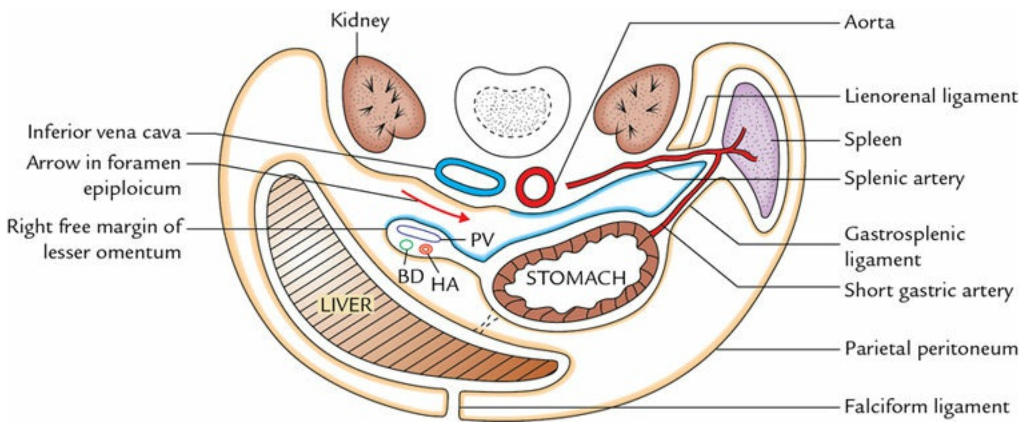


FIG. 9.5 Horizontal disposition of peritoneum (in supracolic compartment). (PV = portal vein, BD = bile duct, HA = hepatic artery).

❖ Write a short note on lesser sac/omental bursa.

The *lesser sac/omental bursa* is a large recess of peritoneal cavity situated behind the stomach, lesser omentum, and caudate lobe of the liver.

It communicates with the greater sac of peritoneal cavity through the *epiploic foramen of Winslow* (Fig. 9.6).

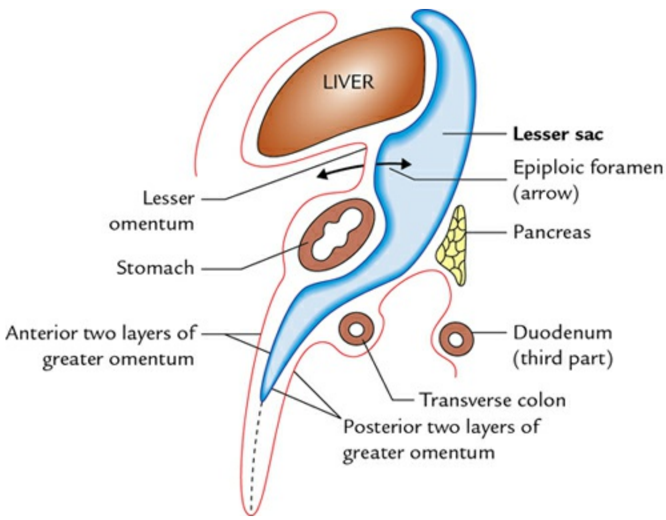


FIG. 9.6 Lesser sac (as seen in sagittal section).

Boundaries

Anterior wall

It is formed by:

- Caudate lobe of the liver
- Lesser omentum
- Anterior two layers of greater omentum

Posterior wall

It is formed by:

- Posterior two layers of greater omentum
- Structures forming the stomach bed, viz.

❒ Diaphragm

❒ Left kidney

❒ Left suprarenal gland

- ❐ Pancreas
- ❐ Transverse mesocolon
- ❐ Splenic artery
- ❐ Spleen

Recesses

The lesser sac presents 3 recesses:

Superior

Lies behind the lesser omentum and liver

Inferior

Lies within the greater omentum

Splenic

Lies between the gastrosplenic and lienorenal ligaments

Functions

- It facilitates the movements and dilatation of stomach.
- It acts as bursa.

Applied anatomy

- *Pseudocyst of pancreas:* The collection of fluid in the lesser sac following acute pancreatic is called *pseudocyst of pancreas*.
- The lesser sac is used by surgeons to reduce the strangulated internal hernia.

❖ Write a short note on epiploic foramen/foramen of winslow.

Epiploic foramen is an opening of about 3 cm size through which lesser sac communicates with the greater sac. It is vertically placed behind the lesser omentum.

Boundaries (fig. 9.7)

Anterior

Right free margin of lesser omentum containing portal vein posteriorly and hepatic artery and bile duct anteriorly with duct being to the right of artery. (***Mnemonic:*** The **D**uct is **D**exter, i.e., to the right.)

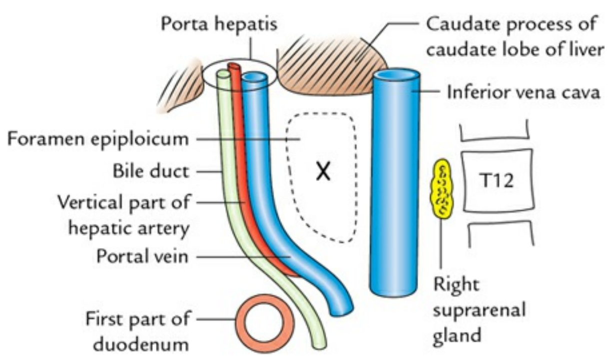


FIG. 9.7 Boundaries of the foramen epiploicum.

Posterior

Inferior vena cava, right suprarenal gland, and T12 vertebra.

Superior

Caudate process of the caudate lobe of the liver.

Inferior

First part of the duodenum and horizontal part of hepatic artery.

Applied anatomy

Internal hernia

Occasionally, a loop of small intestine may herniate through this foramen into the lesser sac. It often becomes strangulated by the edges of foramen. None of the boundaries of foramen can be incised/enlarged to release the strangulation; therefore, the bowel must be decompressed by a needle to allow its reduction.

Compression of hepatic pedicle

The hepatic pedicle is the right free margin of lesser omentum containing portal vein, hepatic artery, and bile duct. If the cystic artery is torn during *cholecystectomy*, hemorrhage can be controlled by compressing the hepatic artery (hepatic pedicle) between index finger within the epiploic foramen and thumb on its anterior wall. This enables the damaged vessel to be identified and secured.

Spread of infection

The epiploic foramen allows the spread of infection from greater sac to lesser sac and vice versa.

❖ Enumerate the contents of lesser omentum.

- Right and left gastric vessels near the lesser curvature of the stomach
- Portal vein, bile duct, and hepatic artery (in its right free border)
- Lymphatics and sympathetic fibers (running with the vessels)
- Extraperitoneal tissue

❖ Write a short note on Morison's pouch (hepatorenal pouch).

The right subhepatic space (i.e., right posterior intraperitoneal subphrenic space) is called hepatorenal pouch/Morison's pouch.

Boundaries (fig. 9.8)

Posterior

Peritoneum covering the diaphragm and upper pole of the right kidney.

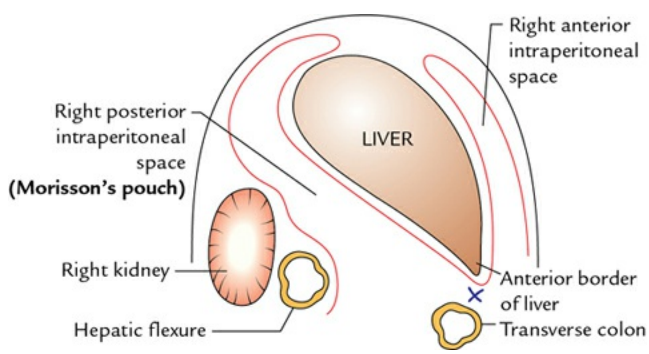


FIG. 9.8 Morison's pouch (hepatorenal pouch).

Anterior

Inferior surface of the right lobe of liver and gall bladder.

Above

Posterior/inferior layer of the coronary ligament.

Below

It opens into the general peritoneal cavity.

Applied anatomy

- Anteriorly, Morison's pouch communicates with right anterior intraperitoneal space around the sharp anterior margin of the right lobe of the liver. In case an abscess forms in this space, it is usually prevented from spreading around the sharp margin of liver into other subphrenic spaces by the formation of adhesion between the transverse colon and the anterior border of the liver.

- Since Morison's pouch is the most dependent part of the abdominal cavity proper in supine position, it is the most common site of the *subphrenic abscess*. The fluid may track in this pouch from a perforated peptic ulcer, appendix or gall bladder.

❖ Write a short note on rectouterine pouch (pouch of Douglas).

The rectouterine pouch or the pouch of Douglas is located between the rectum and uterus. It is the most dependent part of peritoneal cavity when the body is in upright position and the most dependent part of the pelvic cavity below the pelvic brim in supine position.

Boundaries (fig. 9.9)

Anterior

Uterus and the posterior fornix of the vagina.

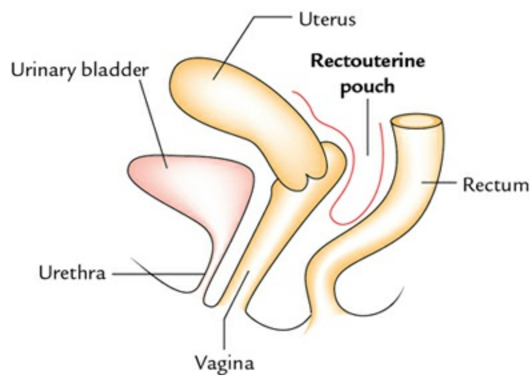


FIG. 9.9 Rectouterine pouch.

Posterior

Rectum

Inferior (floor)

Rectovaginal fold of the peritoneum

Applied anatomy

Pelvic abscess

During inflammation of the peritoneal cavity, the pus tends to collect here as it is the most dependent part of the peritoneal cavity.

Posterior colpotomy

The rectouterine pouch can be drained either through the rectum or through the posterior fornix of the vagina by inserting a needle (*posterior colpotomy*). The floor of the pouch is 5.5 cm from the anus and can be easily felt with finger passed through the rectum or the vagina.

CHAPTER 10

Stomach and spleen

Stomach

❖ Describe the stomach under following headings: (a) introduction, (b) external features, (c) relations, (d) arterial supply, (e) venous drainage, (f) lymphatic drainage, (g) nerve supply, and (h) applied anatomy.

Introduction

- The stomach is the widest and most distensible part of the gut.
- It lies obliquely in the upper, left part of the abdomen occupying epigastric, umbilical and left hypochondriac regions.
- Its *main functions* are:

❒ Storage of food (capacity 1000–1500 ml).

❒ Formation of chyme.

❒ Secretion of HCl and Castle's intrinsic factor.

External features (fig. 10.1)

Two orifices

Cardiac and pyloric

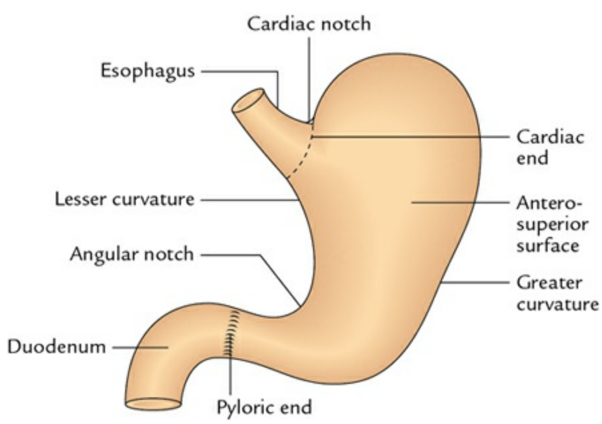


FIG. 10.1 External features of the stomach.

Two curvatures

Greater and lesser

Two surfaces

Anterior and posterior

Four parts

Cardiac, fundus, body, and pyloric.

Relations

Anterior

- Liver
- Diaphragm
- Anterior abdominal wall

Posterior (fig. 10.2)

- Diaphragm (left crus)
- Left kidney
- Left suprarenal gland
- Splenic artery
- Pancreas
- Transverse mesocolon
- Left colic flexure (splenic flexure of colon)
- Spleen

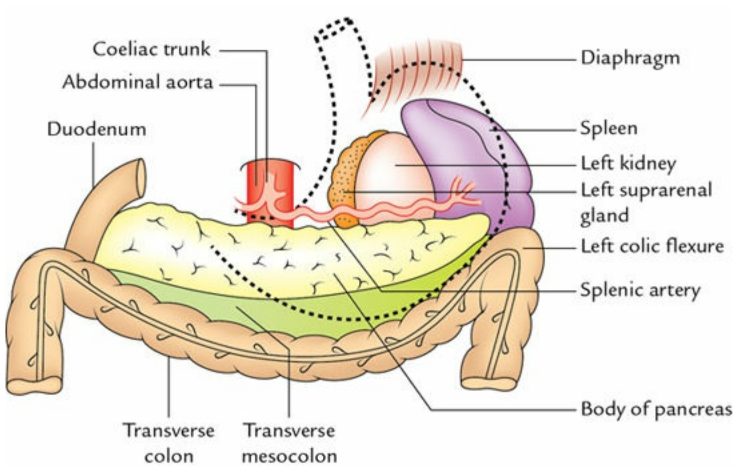


FIG. 10.2 Posterior relations of the stomach (stomach bed).

N.B.

All the structures forming *stomach bed*, are separated from stomach by lesser sac *except* spleen, which is separated from stomach by greater sac.

Arterial supply

It is provided by (Fig. 10.3):

- *Left gastric artery*, a branch of celiac trunk
- *Right gastric artery*, a branch of common hepatic artery
- *Left gastroepiploic artery*, a branch of splenic artery
- *Right gastroepiploic artery*, a branch of gastroduodenal artery.
- *Short gastric arteries*, branches of splenic artery

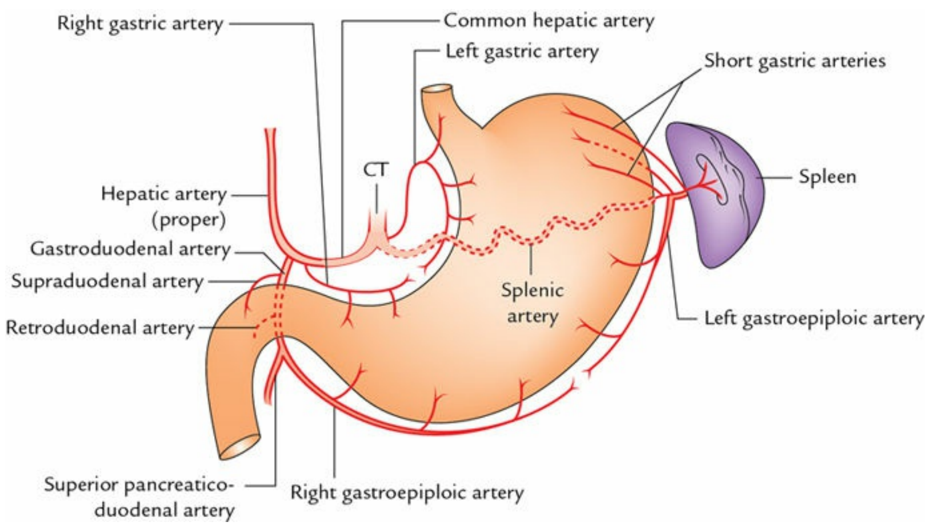


FIG. 10.3 Arterial supply of the stomach.

Venous drainage

It is done by:

- Left and right gastric veins into portal vein.
- Short gastric and left gastroepiploic vein into splenic vein.
- Right gastroepiploic vein into superior mesenteric vein.

Lymphatic drainage (fig. 10.4)

The lymph from stomach is drained as follows:

- *From upper 1/3rd of the area near the greater curvature (pancreaticolienal territory)*: into pancreaticolienal *(pancreaticosplenic)* lymph nodes.
- *From lower 2/3rd of the area near the greater curvature (inferior gastric territory)*: into right gastroepiploic lymph nodes.
- *From right 2/3rd of area near the lesser curvature (superior gastric territory)*: into left gastric lymph nodes.

• *From pyloric canal*: into pyloric right gastric and hepatic lymph nodes.

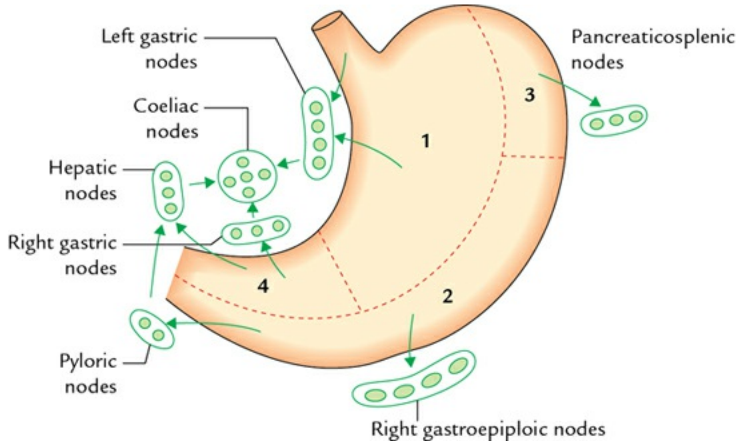


FIG. 10.4 Lymphatic drainage of the stomach.

N.B.

Ultimately, lymph from all these regional nodes drains into celiac group of lymph nodes.

Nerve supply

It is provided by:

• *Sympathetic nerve fibers*, derived from T6 to T9 spinal segments. They carry pain sensations and constrict pyloric sphincter.

• *Parasympathetic nerve fibers*, derived from vagus nerves. They increase gastric motility and relax pyloric sphincter.

Applied anatomy

Gastritis

It is the inflammation of the mucous membrane of stomach caused by HCl.

Gastric carcinoma

It commonly occurs in pyloric antrum along the greater curvature.

Gastric ulcers

They commonly occur along the lesser curvature because during swallowing, the liquids or bolus of food passes along this curvature in the *gastric canal (Magenstrasse)*.

Gastric pain

It is referred in the epigastrium because the stomach is supplied by T6 to T10 spinal segments.

❖ Enumerate the histological features of stomach.

Histologically, the stomach is divided into 3 parts: (a) cardiac, (b) body (includes fundic part), and (c) pyloric.

The key histological features of stomach in general are:

- Lumen is lined by *simple columnar epithelium*.
- Mucous membrane contains *gastric glands*, which open on the surface in *gastric pits*.

The three parts/regions (vide supra) present different histological structures.

Histological structure of cardiac part

A histological section through cardiac part often passes through cardioesophageal junction. Hence, present account presents the histological features of *cardioesophageal junction*.

Mucous membrane

- *Epithelium*

❒ Stratified squamous epithelium of esophagus abruptly changes into simple columnar epithelium of cardiac part of stomach.

❒ Cells of columnar epithelium look alike and have basal oval nuclei.

❒ Absence of goblet cells in the epithelium.

❒ Columnar epithelium, lining the surface dips from it to form *gastric pits*.

- *Lamina propria* contains gastric glands, which never extend through the muscularis mucosae. These gland dips up to ½ the thickness of mucosa.
- *Muscularis mucosae* is thin and consists of inner circular layer and outer longitudinal layer.

Submucosa may show some mucous secreting acini of esophagus.

Muscularis externa is the made up of inner circular and outer longitudinal layers.

Serosa is the outermost covering and is lined by squamous cells.

Histological section through body/fundus (fig. 10.5)

It presents the following features:

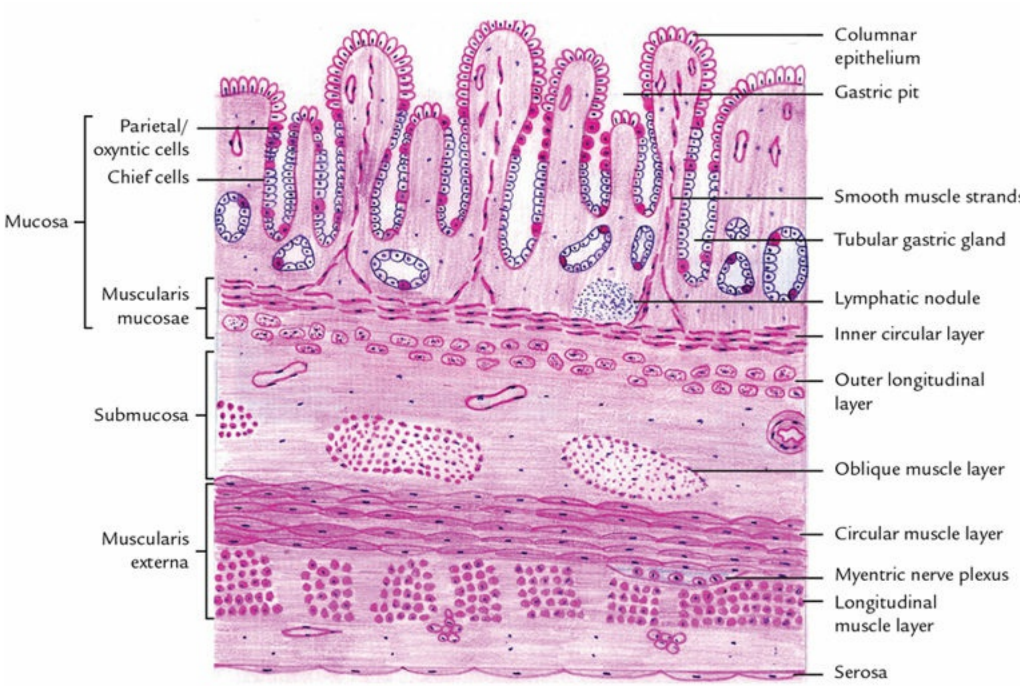


FIG. 10.5 Histological features of body/fundus of the stomach.

Mucosa

It is thick and thrown into prominent folds called *rugae*. It is lined by simple columnar epithelium, which invaginates into lamina propria to form *gastric pits*.

Laminae propria: It contains a large number of *straight tubular glands*, which open into gastric pits. These glands are oriented perpendicular to the surface.

❒ Deeper 2/3rd of each gland is secretory portion, while upper 1/3rd is conducting portion.

❒ Glands are lined by 3 main types of cells:

Chief/peptic/zymogenic cells: They are pyramidal in shape and occur in clusters in the basal third of the gland. They secrete *pepsin* and *lipase*.

Parietal/oxyntic cells: They are formed along the whole length of gland being more in the middle. They give characteristic *fried egg* appearance and secrete HCl and intrinsic factor.

Mucous cells: They line the proximal parts (necks) of the gland. They secrete mucous.

N.B.

Other cell types present in the gastric glands are: *argentaffin cells* that secrete *serotonin* and *undifferentiated stem cells*.

Muscularis mucosae: It is thin and made up of inner circular and outer longitudinal layers. Deep to it *submucosa* is made up of loose tissue and contains nerve and vessels.

Muscularis externa

It consists of inner oblique, middle circular, and outer longitudinal layers of smooth muscle fibres.

Serosa

It is thin outer coat lined by mesothelial squamous cells.

Histological features through pyloric part

It presents the following features:

Mucosa

It is lined up by tall columnar epithelium. Surface epithelium dips down to form deep pits, which extend up to ½ to ⅔rd of the thickness of mucous membrane.

Lamina propria

It contains *short and branched pyloric glands*, which open into gastric pits. Lymphatic follicles are seen between the glands especially in young age.

Muscularis mucosae

It is made up of inner circular and outer longitudinal layers.

Submucosa

It is made up of loose connective tissue and contains nerve and vessels.

Muscularis externa

It is made up of mainly thickened circular layer (which forms *pyloric sphincter*).

Serosa

It is made up of mesothelium lined by the squamous cells.

❖ Give the differences in histological features of cardiac, body/fundus, and pyloric parts of the stomach in a tabular form.

	Cardiac end	Body/fundus	Pyloric part
Gastric pits	Dips up to ½ thickness of the mucosa	Dips up to ⅓rd thickness of the mucosa	Dips up to ⅔rd thickness of the mucosa
Gland	Very short glands	Tubular J–shaped glands	Short and branched glands
Cells of the glands	Mucous cells, few parietal cells	Chief or zymogenic, parietal or oxyntic, mucous neck cells and few argentaffin and stem cells	Mucous cells and few argentaffin cells

Spleen

❖ Describe spleen under the following headings: (a) introduction, (b) external features, (c) relations, (d) blood supply, (e) histology, and (f) applied anatomy.

Introduction

Spleen is the largest lymphoid organ/hemolymphoid organ in the body, located in the left hypochondrium. It lies obliquely along the long axis of 10th rib and directed downwards, forwards and laterally. It filters blood from antigens and microorganisms and removes old and abnormal RBCs.

Its shape, size, and weight are as follows:

Shape

Wedge–shaped.

Size

1 inch thick; 3 inches broad; 5 inches long.

Weight

7 ounces (1 ounce = 30 gm).

External features

Two ends

Anterior and posterior: the superficial anterior end is expanded and looks like a border. it reaches up to the midaxillary line but does not cross it. the posterior end is deep and extends into the epigastric region.

Two surfaces

• *Diaphragmatic surface* is convex and smooth.

• *Visceral surface* is concave and irregular. It presents gastric, renal, colic, and pancreatic impressions.

Three borders

• *Superior border* is characteristically notched near its anterior end.

• *Inferior border* is rounded.

• *Intermediate border* is also rounded.

Hilum

It is located on the inferomedial part of the gastric impression along the long axis of spleen, just above the intermedial border.

Relations

Visceral surface

It is related to:

• Stomach

• Left kidney

• Left colic flexure

• Tail of pancreas

These viscera produce impressions on this surface as follows (Fig. 10.6):

• *Gastric impression*: Between the superior and intermediate borders.

• *Renal impression*: Between the intermediate and inferior borders.

• *Colic impression*: Near the anterior end.

• *Pancreatic impression*: Between the hilum and the colic impression.

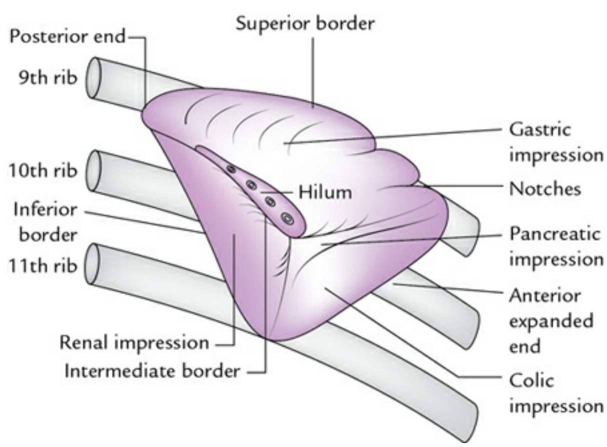


FIG. 10.6 Impressions on the visceral surface of the spleen.

Diaphragmatic surface

It is related to:

• Diaphragm.

• Costodiaphragmatic recess.

• Left lung.

• 9th, 10th, and 11th ribs (of the left side).

Peritoneal relations

The spleen is surrounded by peritoneum and reflected at the hilum to form *lienorenal* and *gastrosplenic ligaments*, which together constitute the ***splenic pedicle.***

• *Lienorenal ligament* contains tail of pancreas, splenic vessels, and pancreaticosplenic lymph nodes.

• *Gastrosplenic ligament* contains left gastroepiploic vessels and short gastric vessels.

Blood supply

Arterial supply

By the splenic artery, a branch of celiac trunk.

Venous drainage

By the splenic vein that joins superior mesenteric vein to form portal vein.

Histology

The histological section through spleen presents the following features (Fig. 10.7):

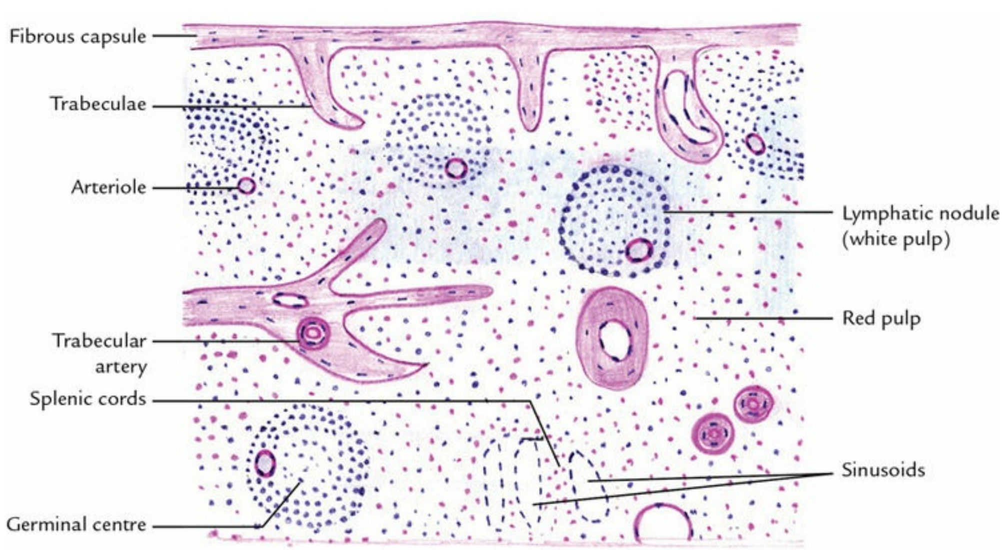


FIG. 10.7 Histological features of the spleen.

Fibrous capsule

It consists of collagen fibers, elastic fibers, and scattered muscle bundles. It sends trabeculae inside the splenic parenchyma.

Parenchyma

The parenchyma of the spleen is not differentiated into the cortex and medulla and presents uniform features. The splenic parenchyma (also called *splenic pulp*) is divided into two types depending upon the type of blood cells: (a) white pulp and (b) red pulp.

- ***White pulp***: It consists of discrete lymphoid nodules having eccentric arteriole – a striking/characteristic feature of parenchyma of spleen. The germinal center may be seen. It is surrounded by red pulp.

- ***Red pulp***: It consists of a diffuse delicate mesh work of reticular cells and reticular fibers. The spaces of the network are filled with: lymphocytes, macrophages, and RBCs. These cells are arranged in the form of anastomosing cords called *cords of Billroth*. The spaces between the Billroth's cords are occupied by sinusoids. The red pulp appears red because it contains numerous sinusoids filled with RBCs.

N.B.

Splenic nodules with eccentric arteriole are actually the periarterial aggregations of lymphatic tissue. The splenic nodules are also called ***Malpighian corpuscles.***

Applied anatomy

Palpation of spleen

- A normal spleen is not palpable. An enlarged spleen can be palpated underneath the left costal margin, during deep inspiration, in left lateral position. Note that the spleen becomes palpable only when it is enlarged twice of its normal size.

Splenomegaly (enlargement of spleen)

- The enlarged spleen (if massive) projects toward the right iliac fossa in the direction of the axis of 10th rib.

Laceration of spleen

- It is often caused by fractured rib. The blood collects underneath the left dome of diaphragm, leading to its irritation. As a result, the pain is referred to the tip of left shoulder (**Kehr's sign**).

CHAPTER 11

Liver and extrahepatic biliary apparatus

❖ Describe the liver under following headings: (a) introduction, (b) external features, (c) relations, (d) lobes, (e) hepatic segments, (f) blood supply, (g) venous drainage, (h) development, (i) histology, and (j) applied anatomy.

Introduction

Liver is a large wedge–shaped solid organ present in the right upper quadrant of the abdomen and occupies whole of right hypochondrium, greater part of epigastrium, and part of left hypochondrium.

- *Weight* = 1600 g in males and 1300 g in females.
- *Color* = Reddish brown.

External features

Two surfaces

- *Diaphragmatic surface:* It is convex and further divided into 4 surfaces:

❒ Superior

❒ Anterior

❒ Posterior

❒ Right lateral

- *Visceral surface:* It is slightly concave and presents:

❒ Fossa for gall bladder

❒ Fissure for ligamentum venosum

❒ Porta hepatis

One border

- **Inferior border:** It presents cystic notch and notch for ligamentum teres/interlobar notch.

Relations

- **Superior surface:** It is related to:

❒ Heart

❒ Domes of diaphragm

- **Anterior surface:** It is related to:

❒ Xiphoid process

❒ Anterior abdominal wall

❒ Diaphragm

- **Right lateral surface:** It extends from the 7th to 10th ribs. Its relations are as follows:

❒ Upper ⅓rd is related to diaphragm, pleura and lung.

❒ Middle ⅓rd is related to, diaphragm and costodiaphragmatic recess.

❒ Lower ⅓rd is related to diaphragm only.

- ***Posterior surface***: It is related to:

❒ Right suprarenal gland

❒ Inferior vena cava

❒ Esophagus

- *Inferior surface:*

❒ *Left lobe* is related to tube omentale and stomach.

❒ *Right lobe* is related to pylorus of stomach, gall bladder, 2nd part of duodenum and right kidney.

Lobes of the liver

They are described as anatomical lobes and physiological lobes.

Anatomical lobes (fig. 11.1)

The liver is divided into two anatomical lobes as under:

- On the anterosuperior surface, by the attachment of falciform ligament.
- On the visceral surface, by ligamentum teres (inferiorly) and fissure for ligamentum venosum (superiorly).

N.B.

Right lobe is larger and forms 5/6th of liver. It presents the caudate and quadrate lobes on its visceral surface.

- *Caudate lobe* between the groove for inferior vena cava and fissure for ligamentum venosum.
- *Quadrate lobe* below the porta hepatis between fossa for gall bladder and fissure for ligament teres.

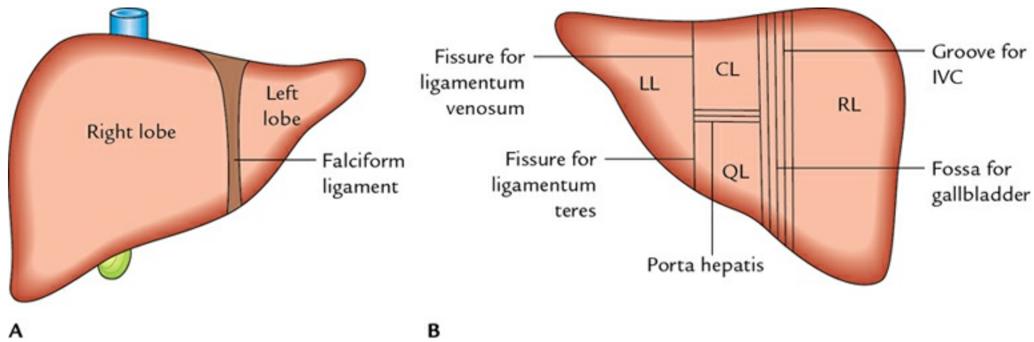


FIG. 11.1 Anatomical lobes of the liver.

Physiological lobes/true lobes (fig. 11.2)

The liver is divided into two physiological lobes by an imaginary sagittal plane called *Cantlie plane*.

- On the *anterosuperior surface*, it passes from *groove for inferior vena cava* to the *cystic notch*.
- On the *posteroinferior surface*, it passes from fossa for gall bladder to groove for the inferior vena cava and bisecting the caudate lobe into two halves.

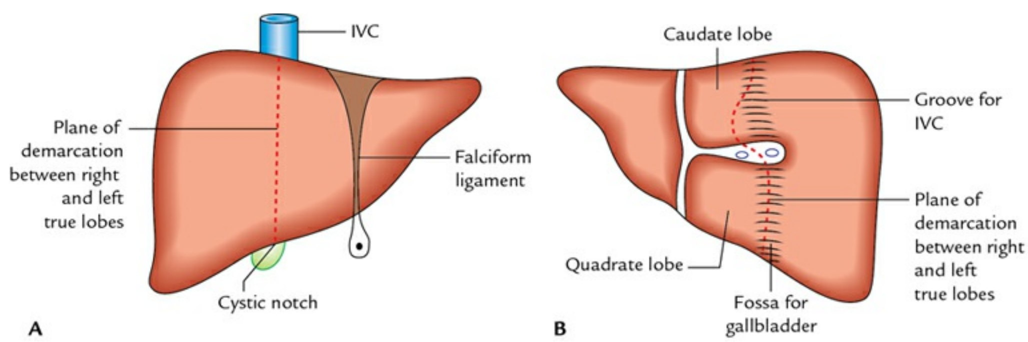


FIG. 11.2 Physiological/true lobes of the liver.

Hepatic segments

There are 8 hepatic segments:

- Right true lobe is subdivided into anterior and posterior parts.
- Left true lobe is subdivided into medial and lateral parts.

Each of the above four parts is further subdivided into upper and lower parts to form 8 hepatic segments. The hepatic segments thus formed are shown in the box given below:

Segments of right hemiliver	Segments of left hemiliver
Anterior superior	Medial superior
Anterior inferior	Medial inferior
Posterior superior	Lateral superior
Posterior inferior	Lateral inferior

Blood supply

The liver receives:

• 20% of its blood supply from *hepatic artery*.

• 80% of its blood supply from *portal vein*.

Venous drainage

Blood from hepatic sinusoid is drained into *interlobular veins*, which join to form *sublobular veins*. The *sublobular veins* join to form *hepatic veins*, which drain into inferior vena cava.

Development

Liver develops in the 4th week of intrauterine life from the following sources:

• Parenchyma of the liver develops from endodermal *hepatic bud*.

• Stroma and Kupffer cells of the liver develop from mesoderm of *septum transversum*.

• Sinusoids of liver develop from broken *vitelline* and *umbilical veins*.

N.B.

The hepatic bud arises from endodermal lining of the caudal end of the foregut. It grows cranially and gives rise to small bud on the right side called *pars cystica*. The main part of bud now called *pars hepatica.* Pars cystica gives rise to gall bladder and pars hepatica to parenchyma of the liver.

Histology

A section through liver presents the following histological features (Fig. 11.3A):

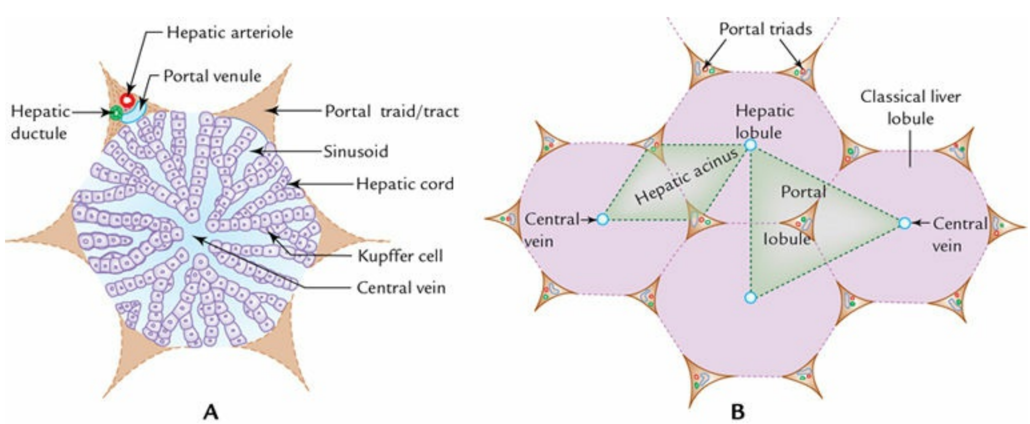


FIG. 11.3 Histological features of the liver: **A,** classical liver lobule; **B,** functional units of the liver.(*Source:* A. Fig. 12.14,

Classical hexagonal lobules

These are separated from each other by a connective tissue.

- Each lobule contains a central vein.
- Each lobule consists of anastomosing cords of hepatocytes radiating away from central vein.
- The spaces between the cords of hepatocytes are called sinusoids.

Portal triads/tracts

At each corner of lobule, a triangular area of connective tissue contains:

- A branch of portal vein (portal venule)
- A branch of hepatic artery (hepatic arteriole)
- Interlobular bile duct (hepatic ductule)

Kupffer cells

They are phagocytic cells found in the wall of sinusoids.

N.B.

Functional units of the liver (Fig. 11.3B)

- *Portal lobule*: A triangular area of the liver parenchyma enclosed by the lines connecting three adjacent central veins. It includes portions of 3 classical lobules with portal triad in the center.
- *Hepatic acinus*: A diamond–shaped area of the liver parenchyma enclosed by the lines joining two adjacent central veins and two portal triads.

Applied anatomy

Hepatitis

It is the inflammation of the liver, which is usually of viral origin. It manifests as jaundice and loss of appetite.

Cirrhosis of the liver

It is the fibrosis of liver parenchyma by proliferation of perilobular connective tissue to replace necrosed hepatocytes. The necrosis of hepatocytes usually occurs due to high intake of alcohol. Clinically, it manifests as shrinkage of liver jaundice and portal hypertension. The later may be associated with *hematemesis* (vomiting of blood).

❖ Give the visceral realtions of the liver.

Visceral relations of the liver (fig. 11.4)

These are relations on the posteroinferior surface of the liver. This surface of the liver presents groove for IVC, fossa for gall bladder, porta hepatis, and groove for ligamentum venosum and ligamentum teres hepatis. It is demarcated by grooves for ligamentum venosum and ligamentum teres into the right and left lobes. The right lobe presents two more lobes on this surface, viz. caudate lobe and quadrate lobe.

- ***Posterior surface of the right lobe*** *presents*:

❒ Bare area of the liver, which is related to the right suprarenal gland in its inferomedial part and diaphragm.

❒ Groove for inferior vena cava, lodging this vein.

- ***Posterior surface of left lobe*** of the liver is related to abdominal part of esophagus – causing *esophageal impression.*

- ***Inferior surface of the left lobe*** is related to tuberomentale and presents a large concave gastric impression.

- ***Inferior surface of the right lobe*** *presents* fossa of gall bladde.

❒ Quadrate lobe is related to *pylorus and first part of duodenum.*

❒ Inferior surface of right lobe, right to the fossa for gall bladder, is related to:

- 2nd part of duodenum – causing *duodenal impression.*

- Right colic (hepatic) flexor of colon – causing *colic impression.*

- Right kidney – causing *renal impression.*

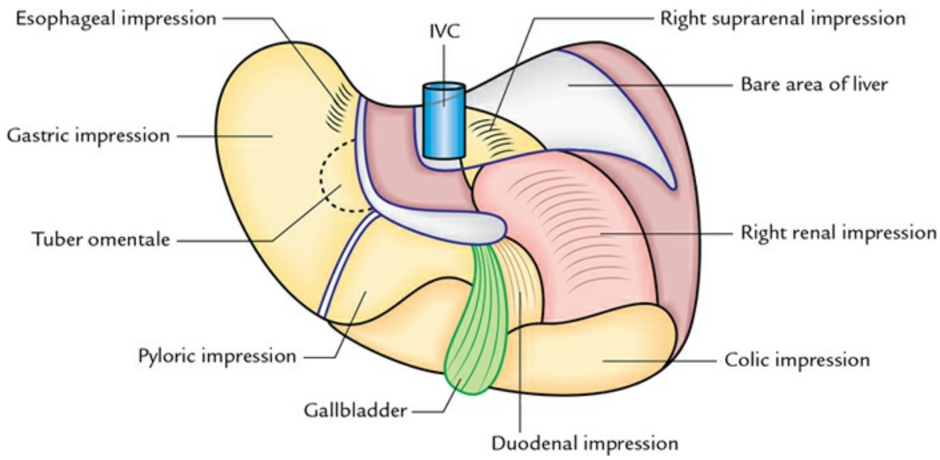


FIG. 11.4 Visceral relations of the liver.

❖ Enumerate the factors responsible for fixation of the liver.

- Hepatic veins that connect it to the IVC
- Lesser omentum that connects it to the stomach
- Falciform ligament that connects it to the diaphragm
- Coronary and the 2 triangular ligaments (right and left) which connect it to the diaphragm
- Ligamentum venosum that connects the left branch of portal vein to the IVC
- Ligamentum teres that connects the left branch of portal vein to the anterior abdominal wall at the umbilicus
- Pressure of the related organs

❖ Describe the extrahepatic biliary apparatus under the following headings: (a) components, (b) functions (c) gross anatomy of components, (d) blood supply, and (e) applied anatomy.

Components

The extrahepatic biliary apparatus consists of the following components (Fig. 11.5):

- Right and left hepatic ducts
- Common hepatic duct
- Gall bladder
- Cystic duct
- Bile duct

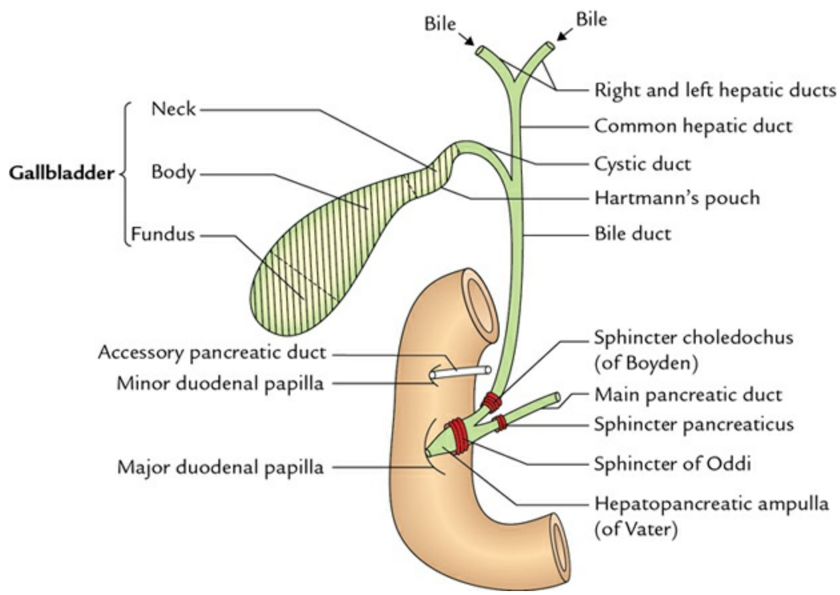


FIG. 11.5 Extrahepatic biliary apparatus.

Functions

The functions of extrahepatic biliary apparatus are:

- Collection of bile from the liver
- Storage of bile in the gall bladder
- Transmission of bile into the second part of duodenum

Gross anatomy of components

Hepatic ducts

The *right and left hepatic ducts* emerge from respective lobes of liver at porta hepatis. Near the right end of porta hepatis they join to form common *hepatic duct,* which is joined by cystic duct to form bile duct.

Gall bladder

It is a pear–shaped reservoir of bile situated in the fossa on the inferior surface of the right lobe of the liver.

Size:

Length 7.5–10 cm, width 3 cm, capacity 30–50 ml.

Parts

The gall bladder consists of 4 parts (Fig. 11.5):

❒ Fundus

❒ Body

❒ Infundibulum

❒ Neck

The dilatation in the posteromedial wall of the gall bladder is called **Hartmann's pouch.**

Relations

The relations of different parts of the gall bladder are given in the box below:

Part	Superior	Inferior
Fundus	Anterior abdominal wall	Transverse colon
Body	Inferior surface of liver	Transverse colon 2nd part of duodenum
Neck	Inferior surface liver near the right end of porta hepatis	1st part of duodenum

N.B.

The peritoneum surrounds fundus completely and body only on its inferior aspect.

Cystic duct

❒ It is about 3–4 cm long.

❒ Its mucous lining presents 5–12 crescentic folds arranged spirally to form the *spiral valve of Heister*.

❒ Its dilated posteromedial wall forms a pouch called *Hartmann's pouch.*

Bile duct:

It is formed by the union of common hepatic and cystic ducts.

❒ Length: 8 cm.

❒ Diameter: 6 mm.

Course

It runs downward and backward in the right free margin of the lesser omentum.

- Passes behind the 1st part of duodenum.
- Comes in contact with the pancreatic duct, near the middle of the 2nd part of duodenum.
- Two duct unites to form *hepatopancreatic duct* which courses obliquely through the wall of duodenum and opens on summit of major duodenal papilla.

Parts

It is divided into 4 parts:

- *Supraduodenal part*, 2.5 cm long and lies in right free margin of lesser omentum.
- *Retroduodenal part* lies in groove on the posterior aspect of the head of pancreas.
- *Infraduodenal part* lies in a groove on the posterior surface of the head of pancreas.
- *Intramural part* lies in the wall of duodenum and expands to form hepatopancreatic ampulla (*ampulla of Vater*).

Sphincters related to bile and pancreatic ducts

- Sphincter choledocus (of Boyden), around the bile duct.
- Sphincter pancreaticus, around pancreatic duct.
- Sphincter ampullae/sphincter of Oddi, around hepatopancreatic ampulla.

Blood supply

Arterial supply

It is provided by:

- *Cystic artery*, a branch of right branch of hepatic artery. It supplies all the parts of extrahepatic biliary apparatus except lower part of bile duct.
- *Accessory cystic artery*, a branch of common hepatic artery.
- *Superior pancreaticoduodenal artery*, supply lower part of bile duct.
- A small twig from hepatic artery proper, supply the middle part of the bile duct.
- Few arterial twigs from liver through fossa for gall bladder.

Venous drainage

It is done by:

Cystic vein drains into portal vein and numerous small veins from gall bladder, which enters through gall bladder fossa which drains into hepatic veins.

Applied anatomy

Cholecystitis

The inflammation of gall bladder is called *cholecystitis*. It manifests clinically as:

- Pain over right hypochondrium, radiating to the inferior angle of scapula or to the tip of right shoulder.

- Murphy’s sign positive.
- Enlarged cystic lymph node (of Lund).

Cholelithiasis

The formation of stones in the gall bladder is called cholelithiasis. Clinically, it presents as:

- Severe spasmodic pain (biliary colic).
- Murphy’s sign positive.
- Typically occurs in fat, fertile, flatus, female of 40 years of age.

Cholecystectomy

- Surgical removal of the gall bladder is called *cholecystectomy*.

❖ Write a short note on cystohepatic angle of calot.

Boundaries (fig. 11.6)

Above

Inferior surface of the liver.

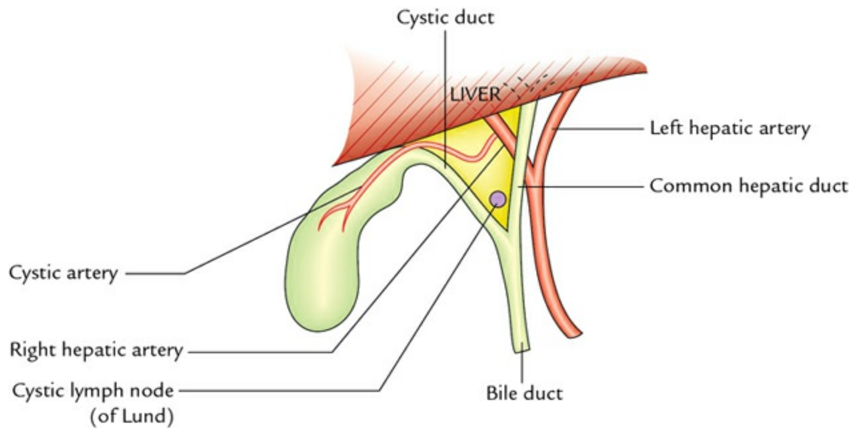


FIG. 11.6 Cystohepatic triangle (Calot's triangle).

Left side

Common hepatic duct.

Right side

Cystic duct.

Contents

- *Cystic lymph node* (of Lund) in the angle between cystic and common hepatic ducts.
- *Cystic artery*, a branch from right branch of hepatic artery.

Applied anatomy

Moynihan's hump

It is a dangerous anomaly in which the cystic artery is short and right hepatic artery takes a tortuous course/caterpillar like turn, which may be cut inadvertently during cholecystectomy and cause profuse bleeding.

❖ Give the anatomical basis of the referred pain of the gall bladder.

The gall bladder pain is referred to:

- Epigastrium
- Right shoulder and inferior angle of right scapula

Anatomical basis:

- Pain is referred to epigastrium through parasympathetic fibers (vagus nerve).
- Pain is referred to inferior angle of right scapula through sympathetic fibers derived from T7 spinal segment.
- Pain is referred to the right shoulder through phrenic nerve (C3, 4, 5) if there is irritation of diaphragm.

CHAPTER 12

Duodenum, pancreas, and portal vein

Duodenum

❖ Describe the duodenum under following headings: (a) introduction, (b) parts, (c) relations of 2nd part, (d) development of 2nd part, (e) arterial supply of 2nd part, (f) interior of 2nd part, and (f) applied anatomy.

Introduction

- Duodenum is the proximal, shortest, widest, and most fixed part of the small intestine.
- It extends from pylorus to the duodenojejunal flexure.
- It is 25 cm long and lies opposite to L1, L2, and L3 vertebrae.
- It is C-shaped and curved around the head of pancreas.
- It is devoid of mesentery.

N.B.

The term *duodenum* is the Latin corruption of Greek word *polydactyly*, meaning 12 fingers.

Parts of duodenum (fig. 12.1)

- *First part*, 5 cm long
- *Second part*, 7.5 cm long
- *Third part*, 10 cm long
- *Fourth part*, 2.5 cm long

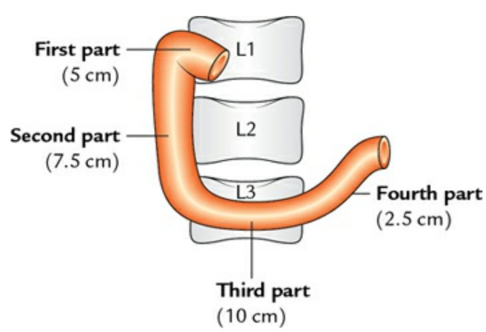


FIG. 12.1 Parts of the duodenum.

Relations of 2nd part of duodenum

Peritoneal relations

- It is retroperitoneal and fixed.

• Its anterior surface is covered with peritoneum except near the middle where it is related directly to the colon.

Visceral relations

• Anterior (Fig. 12.2A)

❒ Right lobe of liver

❒ Root of transverse mesocolon

❒ Small intestine

• *Posterior* (Fig. 12.2B)

❒ Right kidney

❒ Right renal vessels

❒ Inferior vena cava

❒ Right psoas major

• *Medial*

❒ Head of pancreas

❒ Bile duct

• *Lateral*

❒ Right colic flexure

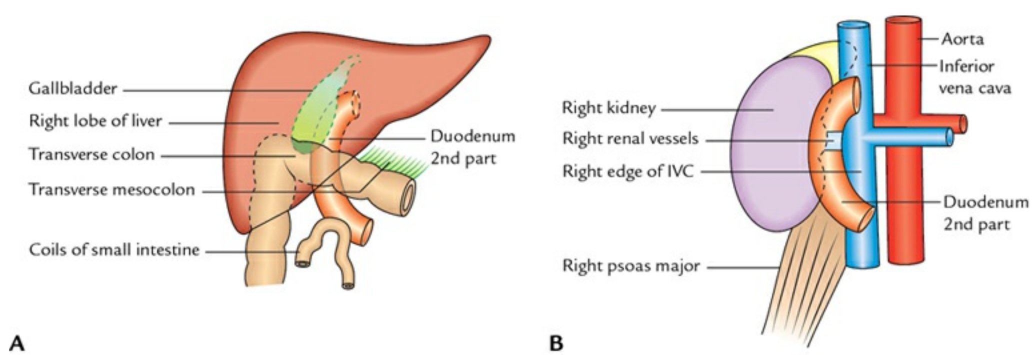


FIG. 12.2 Relations of the second part of duodenum: A, anterior relations; B, posterior relations.

Development of 2nd part

Upper half (i.e., up to the opening of bile duct) develops from foregut and lower half (i.e., distal to the opening of bile duct) develops from midgut.

N.B.

The mucous membrane is derived from endoderm of the gut, while musculature from the splanchnic layer of the lateral plate mesoderm.

Arterial supply of 2nd part (fig. 12.3)

- *Above the opening of bile duct*, by the *superior pancreaticoduodenal artery* (from artery of foregut).

- *Below the opening of bile duct*, by the *inferior pancreaticoduodenal artery* (from artery of midgut).

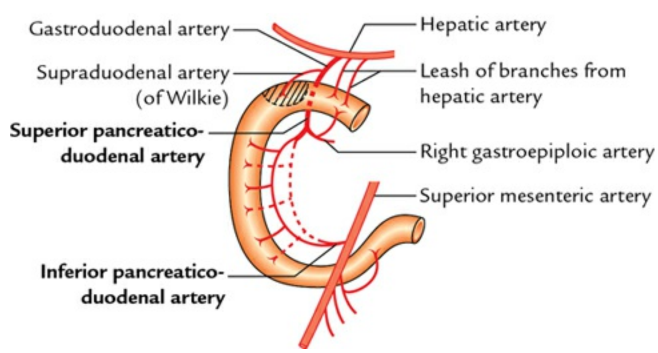


FIG. 12.3 Arterial supply of the duodenum.

Interior of 2nd part

It presents two important features:

- *Major duodenal papilla*, 8 to 10 cm distal to pylorus: The main pancreatic duct along with bile duct (also called hepatopancreatic duct) opens on its summit.

- *Minor duodenal papilla*, 6 to 8 cm distal to pylorus: An accessory pancreatic duct opens on its summit.

Applied anatomy

- First part of duodenum is vulnerable to *peptic ulceration* due to direct exposure to acidic chyme from stomach. It may erode gastroduodenal artery leading to severe hemorrhage.

- *Duodenal obstruction:* It may occur due to congenital stenosis, annular pancreas, compression by the superior mesenteric artery or contraction of the suspensory muscle of duodenum.

- *Duodenal diverticula* are fairly common along the concave border at the points of entry of arteries in the duodenal wall.

❖ Write a short note on the duodenal cap.

The *duodenal cap* is radiopaque triangular shadow of the 1st part of the duodenum seen in barium meal X-ray abdomen (Fig. 12.4). It is formed due to the following factors:

- First part of the duodenum runs upward, backward and to the right to continue as second part.
- Mucous membrane of the first part of the duodenum is smooth, i.e. devoid of circular folds.
- Knoblike pylorus invaginate into the first part of duodenum which keeps this part open so that it is filled with barium paste.
- Viscosity of the barium paste coming out of narrow pyloric canal into the 1st part of duodenum gives a conical appearance.
- Proximal half of the 1st part of duodenum is mobile because it has mesentery.

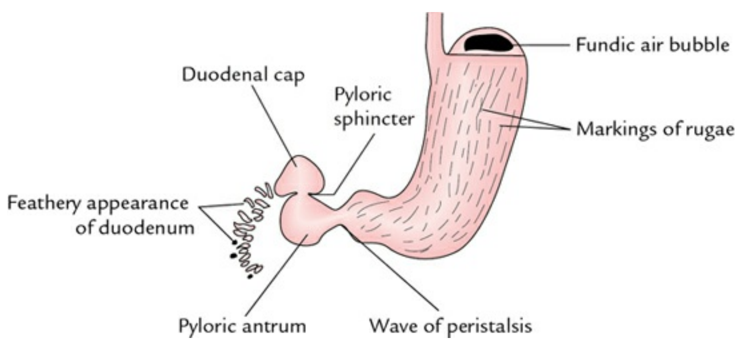


FIG. 12.4 Duodenal cap (tracing of barium meal X-ray abdomen).

❖ Write a short note on the ligament of treitz.

It is fibromuscular band that extends from the right crus of diaphragm to the duodenojejunal flexure. It is formed:

❒ In *the upper part* by skeletal muscle fibers.

❒ In *the middle part* by elastic fibers.

❒ In *the lower part* by smooth muscle fibers.

Its length determines the shape of duodenum, viz., C-shaped, J-shaped, or O-shaped.

Applied anatomy

- It helps the surgeons to identify duodenojejunal junction.
- Its contraction may cause the narrowing of angle of the duodenojejunal flexure leading to partial intestinal obstruction.

❖ Describe the histological features of the duodenum.

A histological section of duodenal wall presents 4 layers from within outward; these are (Fig. 12.5):

- *Mucosa* consists of lining epithelium, lamina propria, and muscularis mucosae.

❒ Lining epithelium is made up of columnar cells interspersed with goblet cells.

❒ Mucosa presents the numerous short leaf-like projections of varying heights called *villi*. Each villus has a core of lamina propria and stands of smooth muscle fibers from muscularis mucosae.

❒ Muscularis mucosae is thin and made up of two layers of smooth muscle fibers.

- *Submucosa* presents extensive aggregations of mucous secreting tubuloalveolar glands (**Brunner's glands**).
- *Muscularis externa* consists of two layers of smooth muscle fibers – an inner circular and an outer longitudinal.
- *Serous layer* is single layer of the squamous cells resting on basement membrane.

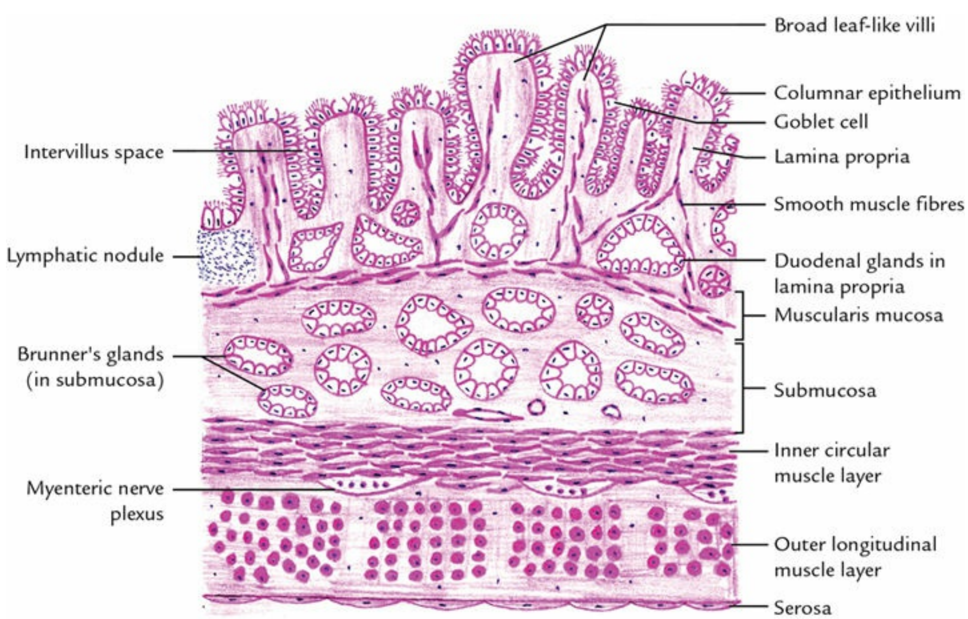


FIG. 12.5 Histological features of the duodenum.

Pancreas

❖ Describe the pancreas under following headings: (a) introduction, (b) location, (c) parts, (f) ducts, (g) blood supply, and (h) applied anatomy.

Introduction

- Pancreas is a soft lobulated, elongated (15–20 cm long) exoendocrine gland.
- Exocrine part secretes pancreatic juice, while endocrine part secretes insulin, glucagon, etc.
- It is J-shaped/retort-shaped and set obliquely.

Location (fig. 12.6)

It lies retroperitoneally more or less transversely on the posterior abdominal wall at the level of L1 and L2 vertebrae.

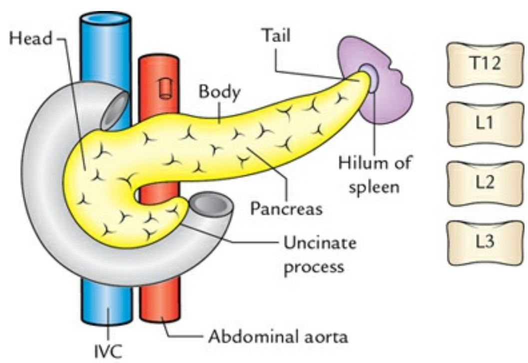


FIG. 12.6 Location and parts of the pancreas.

Parts (fig. 12.6)

From right to left, pancreas is divided into 4 parts:

- Head
- Neck
- Body
- Tail

Head of pancreas

External features

It is enlarged right end of the pancreas contained within the C-shaped curve of the duodenum. It is flattened from before backward and presents:

- *Two surfaces*: anterior and posterior.
- *Four borders*: superior, inferior, right, and left.
- *One process*: uncinate process.

Relations (fig. 12.7)

- *Posteriorly*, it is related to 3 structures. From right to left these are (Fig. 12.7B):

❒ Common bile duct (embedded in a pancreatic groove)

❒ Inferior vena cava and terminal parts of the renal veins

❒ Aorta

- *Anteriorly*, it is related to 3 structures (Fig. 12.7A):

❒ Transverse mesocolon

❒ Coils of jejunum

❒ Superior mesenteric vessels in front of the uncinate process of pancreas

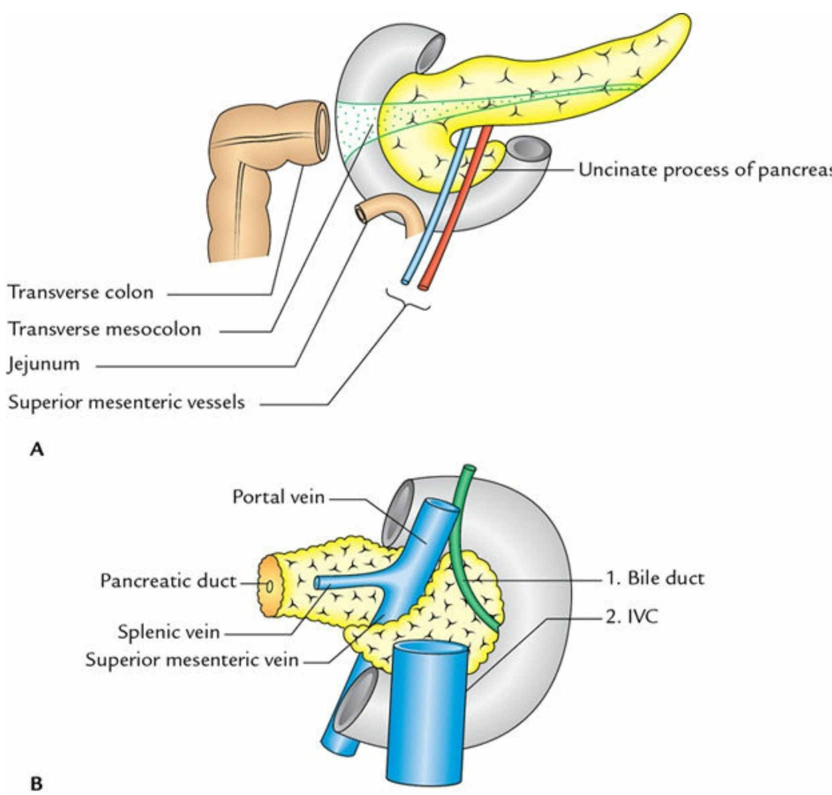


FIG. 12.7 Relations of the head of pancreas: **A,** anterior relations; **B,** posterior relations.

Neck of pancreas

External features

It is a slightly constricted part between the head and body. It presents:

- *Two surfaces*: anterior and posterior.
- *Two borders*: superior and inferior.

Relations

- *Posteriorly*, it is related to 3 veins: termination of the splenic and superior mesenteric veins, and beginning of the portal vein.
- *Anteriorly*, it is related to two structures: pylorus and peritoneum covering the posterior wall of the lesser sac.

Body of pancreas

External features

It is prismoid in appearance and appears triangular in cross section. It is directed slightly upward and backward. It presents:

- *Three borders*: anterior, superior, and inferior
- *Three surfaces*: anterior, inferior, and posterior

N.B.

A part of the body, a little to the left of neck projects upward, and called *tuber omentale.*

Relations

- *Anterior surface*: It is related to 3 structures:

❒ Lesser sac and stomach.

❒ Splenic artery along its upper border.

❒ Transverse mesocolon attached to its lower border.

- *Inferior surface:* It is related to 3 structures. From right to left, these are:

❒ Duodenojejunal flexure

❒ Loops of jejunum

❒ Transverse colon

• *Posterior surface*: It is related to 3 structures:

❒ Left crus of diaphragm

❒ Left psoas major (and the structures related to it)

❒ Left kidney

Tail of pancreas

External features

It is narrow left extremity of the pancreas which along with splenic vessels lies within the lienorenal ligament.

Relations

• *In front*: stomach (separated by the lesser sac)

• *Behind*: spleen and splenic vessels

• *Below*: left colic flexure

Ducts of pancreas

The exocrine part of pancreas is drained by two ducts:

Main pancreatic duct (duct of wirsung)

It lies near the posterior surface of the pancreas. It begins at the tail of pancreas and runs toward the right through the body. At the neck, it bends to run downward, backward, and to the right in the head. Its lumen is about 3 mm in diameter. It receives numerous small tributaries, at right angles to its long axis in a *herringbone pattern*. In the head of pancreas, it lies on to the left of the bile duct. The two ducts enter the wall of the 2nd part of duodenum. Here, they join to form the *hepatopancreatic ampulla of Vater*, which opens on the summit of the *major duodenal papilla* (8–10 cm distal to pylorus).

Accessory pancreatic duct (duct of santorini)

It begins in the lower part of the head, crosses in front of the main duct, and opens into the 2nd part of duodenum at the summit of minor duodenal papilla (6–8 cm distal to pylorus). Accessory pancreatic duct communicates with the main duct.

Blood supply (fig. 12.8)

Arterial supply

• *Upper half of the head* is supplied by the superior pancreaticoduodenal artery, a branch of the gastroduodenal artery (from coeliac trunk).

• *Lower half of the head* and its *uncinate process* is supplied by the inferior pancreaticoduodenal artery (from superior mesenteric artery).

• *Neck, body, and tail* are supplied by the pancreatic branches of the splenic artery (from coeliac trunk).

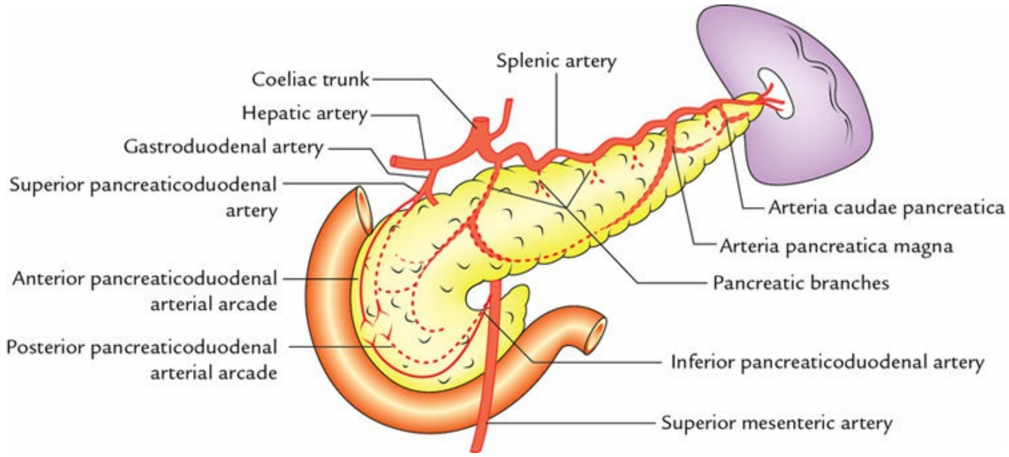


FIG. 12.8 Arterial supply of the pancreas.

Venous drainage

It is done by the superior and inferior pancreaticoduodenal veins.

• Superior pancreaticoduodenal vein drains into portal vein.

• Inferior pancreaticoduodenal vein drains into superior mesenteric vein.

Applied anatomy

Carcinoma head of pancreas

The carcinoma pancreas is common, and in 80% cases, it involves head. Clinically, it presents as:

• *Obstructive jaundice*, due to pressure on bile duct and hepatopancreatic ampulla.

• *Ascites*, due to pressure on portal vein.

• *Pyloric obstruction*, due to pressure on pylorus.

N.B.

The prognosis of carcinoma head of pancreas is very poor due to wide spread metastasis along the retroperitoneal channels.

Acute pancreatitis

It is a serious disease and occurs secondary to mumps. It may cause collection of fluid in the lesser sac called *pseudocyst of pancreas*.

Referred pain of pancreas

The pancreatic pain is referred to T6–T10 dermatomes on the front of abdomen. However, the involvement of local parietal peritoneum can cause severe pain in the middle of the back.

❖ Describe the histological features of the pancreas.

The pancreas is *exoendocrine gland*. The *exocrine part* secretes pancreatic juice, while *endocrine part* secretes hormones like insulin and glucagon.

A histological section through the pancreas presents following features (Fig. 12.9):

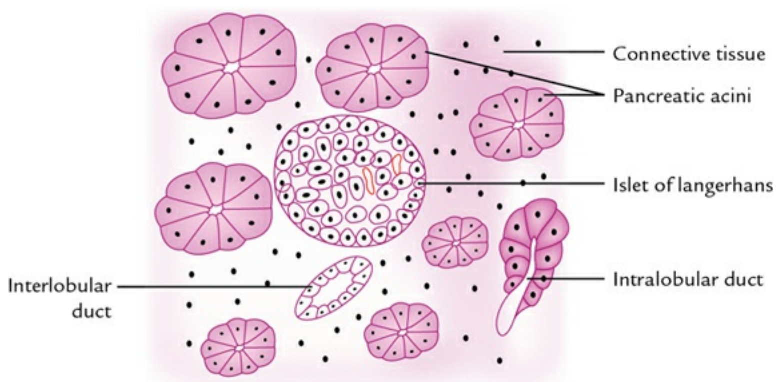


FIG. 12.9 Histological features of the pancreas.

Exocrine part consists of:

Masses of closely packed, darkly stained serous acini called *pancreatic lobules.*

- Cells lining the acini are truncated pyramidal shaped.
- Cells of acini possess round nucleus located near the base.
- Cells of acini have basal basophilia (dark stain) and apical eosinophilia (light stain).
- Lumen of acini is hardly visible.

Ducts of various sizes in connective tissue between the lobules. The ducts may be:

- Intercalated
- Intralobular, lined by cuboidal cells
- Interlobular, lined by columnar cells

N.B.

Cells of duct are better defined than the cells of acini.

Endocrine part

Consists of large lightly stained ellipsoidal areas called *islets of Langerhans* scattered throughout the acinar tissue.

- Islets of Langerhans are made up of clumps of small poorly stained cells.
- Cells of islets are arranged in regular cords.

- Presence of fenestrated capillaries in between the cells.
- Cells of islets are of two main types: α (alpha) and β (beta).
- Alpha cells (20%) are present at periphery, while beta cells (80%) are present in the central part.

❖ Describe development of the pancreas and associated congenital anomalies in brief.

Development of pancreas (fig. 12.10)

The pancreas develops from two buds called dorsal and ventral pancreatic buds, which arise at the junction of the foregut and midgut. These buds soon unite to form pancreas.

• Larger dorsal bud forms:

❒ Part of the head

❒ Whole of neck

❒ Whole of body and

❒ Whole of tail

• Smaller ventral bud forms:

❒ Lower part of the head and

❒ Uncinate process

• Main pancreatic duct is formed by:

❒ Duct of dorsal bud

• Accessory pancreatic bud is formed by:

❒ Duct of ventral bud

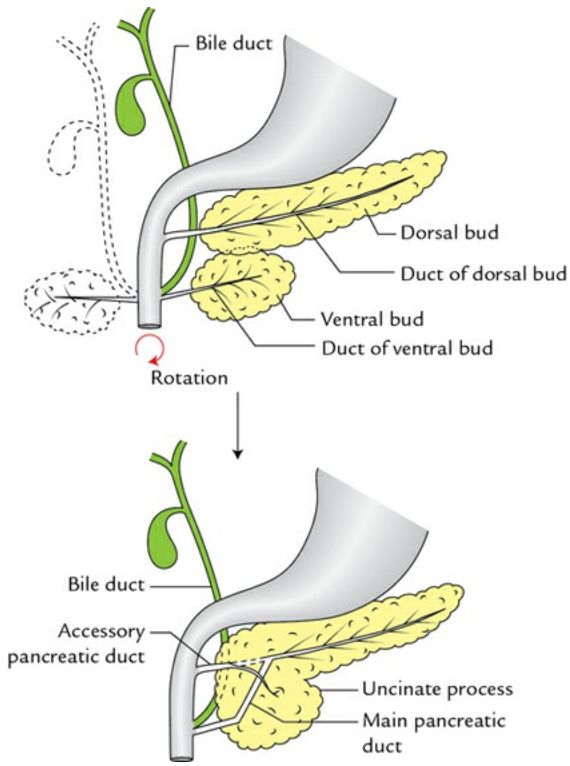


FIG. 12.10 Development of the pancreas.

Congenital anomalies

Annular pancreas

It is a condition in which pancreatic tissue encircles the 2nd part of the duodenum and leads to duodenal obstruction. It occurs when right and left parts of bifid ventral pancreatic bud fail to fuse and right bud migrate along the normal route, while left part migrates in opposite direction. As a result, the 2nd part of the duodenum becomes completely surrounded by the pancreatic tissue.

Accessory pancreatic tissue

The ectopic pancreatic tissue may be found in:

- Gall bladder
- Stomach
- Spleen
- Small intestine
- Meckel's diverticulum

Portal vein

❖ Describe the portal vein under the following headings: (a) introduction, (b) formation, (c) course, (d) termination, (e) parts, (f) relations, (g) tributaries, and (g) applied anatomy.

Introduction

- Portal vein is the large vein (about 8 cm long and 2 cm wide) of the abdomen. It collects the blood from gall bladder, pancreas, spleen, and abdominal part of gastrointestinal tract and conveys it to the liver from where it is drained into inferior vena cava through hepatic veins.
- It is called portal vein because it begins in one set of capillaries (gut capillaries) and ends in another set of capillaries (liver sinusoids).
- It conveys absorbed products of the digested food from intestine to the liver and provides 60–75% nutrition to the liver.

Formation (fig. 12.11)

It is formed by the union of the superior mesenteric and splenic veins behind the neck of pancreas at the level of L2 vertebra.

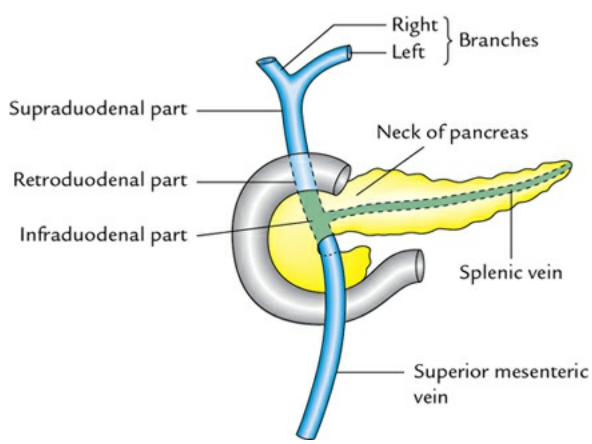


FIG. 12.11 Portal vein.

Course (fig. 12.11)

After formation, it runs upward and a little to the right, passing successively behind the neck of pancreas, first part of duodenum and right free margin of the lesser omentum.

Termination (fig. 12.11)

It terminates at the right end of the porta hepatis by dividing into right and left branches. The *right branch* is shorter and wider and enters the right lobe of the liver. The *left branch* is longer and narrower. It traverses porta hepatis to reach its left end and enters the left lobe of the liver.

Parts (fig. 12.11)

The portal vein is divided into 3 parts:

- Infraduodenal part
- Retroduodenal part
- Supraduodenal part

Relations

Infraduodenal part

- *Anterior*: Neck of pancreas
- *Posterior*: Inferior vena cava
- *Right side*: Bile duct

Retroduodenal part

- *Anterior*: First part of the duodenum
- *Posterior*: Inferior vena cava

Supraduodenal part

- *Anterior and to the right*: Bile duct
- *Anterior and to the left*: Hepatic artery
- *Posterior*: Inferior vena cava

Tributaries (fig. 12.11)

- *Superior mesenteric vein*
- *Splenic vein*

} Formative tributaries

- *Right gastric vein*
- *Left gastric vein*
- *Superior pancreaticoduodenal vein*

} Opens into trunk

- *Cystic vein*: Opens into right branch
- *Paraumbilical vein*: Opens into left branch

Applied anatomy

Portal hypertension

Normal portal pressure is 5–10 mgHg. The portal hypertension is usually caused by cirrhosis of the liver. It may lead to congestive splenomegaly, ascites, or complications of collateral circulation at portosystemic anastomoses.

❖ Define portocaval anastomoses with their sites and related clinical significance.

The portocaval anastomoses are sites of communication between the tributaries of portal vein and inferior vena cava. These communications form important routes of collateral circulation in portal obstruction.

Sites of portocaval anastomoses

The important sites of portocaval anastomosis are (Fig. 12.12):

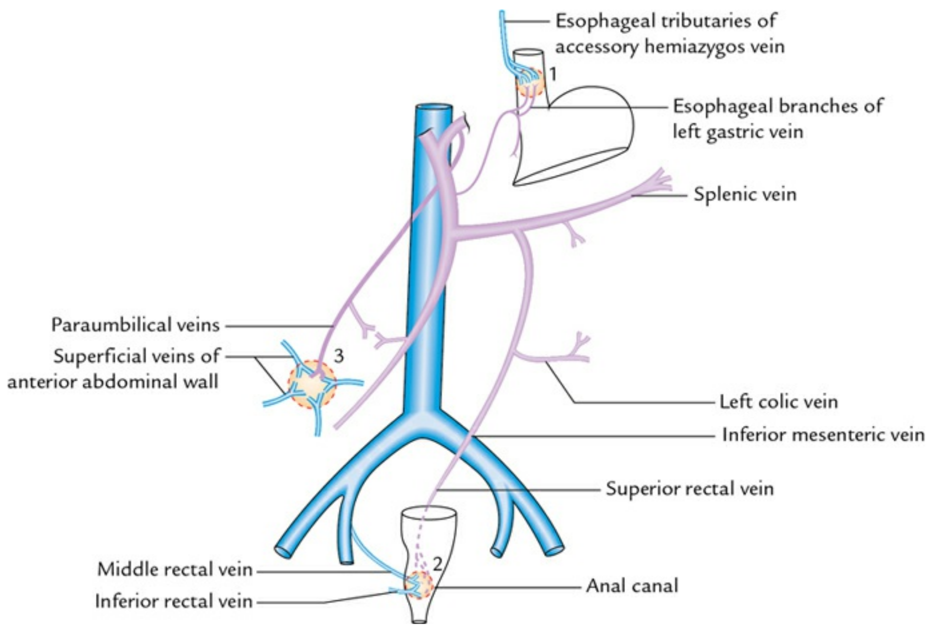


FIG. 12.12 Important sites of portocaval anastomoses.

Umbilicus

At umbilicus, the left branch of portal vein anastomoses with the following systemic veins through the *paraumbilical vein* in the falciform ligament:

- Superior epigastric and lateral thoracic veins, from above.
- Inferior epigastric and inferior thoracic veins, from below.
- Posterior intercostal and lumbar veins, from sides.

} Caval tributaries

Applied anatomy: In portal hypertension, the blood from portal vein is directed into systemic (caval) tributaries. This causes dilatation and tortuosity of caval tributaries, which radiates from umbilicus like the spokes of wheel. This clinical sign is called *caput medusae.*

Lower end of esophagus

At the lower end of esophagus, the esophageal tributaries of the left gastric vein (portal) anastomose with esophageal tributaries of the accessory hemiazygos vein (systemic).

Applied anatomy: In portal obstruction, these veins distend, dilate and become tortuous producing *esophageal varies*, which may bleed to cause hematemesis.

Anal canal

In the mid-anal canal close to pectinate line, the superior rectal vein (portal) anastomoses with middle and inferior rectal veins (systemic).

Applied anatomy: In portal obstruction, the radicals of superior rectal vein in the anal columns dilate to produce the *internal hemorrhoids/piles*.

Bare area of liver

At the bare area of liver, hepatic venules (portal) anastomose with the phrenic and intercostal veins (systemic).

Posterior abdominal wall

On the posterior abdominal wall, superior mesenteric and inferior mesenteric veins (portal) draining retroperitoneal organs, viz. duodenum ascending and descending colons anastomose with retroperitoneal veins of the abdominal wall and renal capsule (systemic).

❖ Give a brief account of the development of the portal vein.

The portal vein develops in the 2nd and 3rd month of intrauterine life, from two vitelline veins (right and left), which lie one on either side of developing duodenum. They soon get interconnected by three anastomotic channels; two ventral and one dorsal. The portal vein develops from these 3 channels.

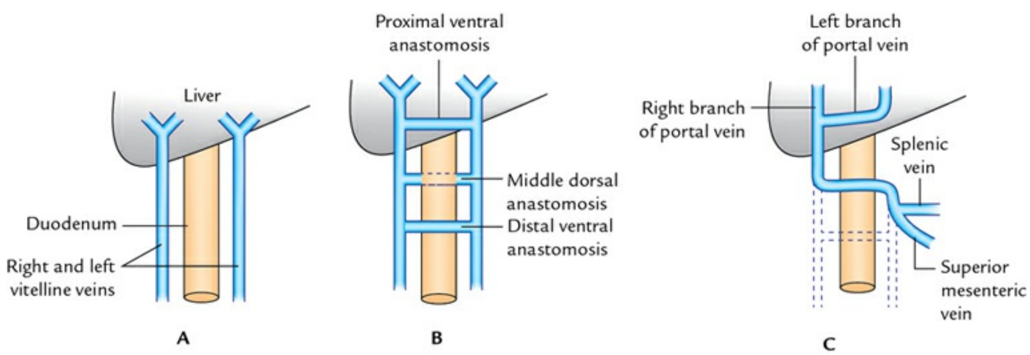


FIG. 12.13 Development of the portal vein.

The various parts of portal vein derived from these channels are as follows (Fig. 12.13):

- *Infraduodenal part*, from left vitelline vein (between the point at which splenic and superior mesenteric veins open and point where dorsal anastomatic channel joins the left vitelline vein.
- *Retroduodenal part*, from dorsal venous anastomosis.
- *Supraduodenal part*, from right vitelline vein between cephalic ventral venous anastomosis and dorsal venous anastomosis.

N.B.

- *Left branch* is derived from cephalic ventral anastomosis and part of left vitelline vein cephalic to the ventral anastomosis.
- *Right branch* is derived from part of right vitelline vein cephalic to the ventral anastomosis.

CHAPTER 13

Small and large intestines

Small intestine

❖ Discuss the general features, parts, and functions of the small intestin in brief.

General features

- The small intestine is the longest part of the gastrointestinal tract (6 m long) being greater in males than in females.
- It extends from the pylorus to the ileocecal junction.

Parts

- *Upper fixed part* is called *duodenum*, 25 cm long.
- *Lower mobile part* is further divided into 2 parts:

❒ Upper 2/5th is called *jejunum*.

❒ Lower 3/5th is called *ileum*.

Functions

The structure of the small intestine is adapted to:

- Digestion of food
- Absorption of nutrients

❖ Give the differences between jejunum and ileum in the tabular form.

The differences are given in Table 13.1.

Table 13.1

Differences between jejunum and ileum

Features	Jejunum	Ileum
Location	Occupies upper and left part of intestinal area	Occupies lower and right part of intestinal area
Walls	Thicker and more vascular	Thinner and less vascular
Lumen	Wider and often found empty (diameter = 4 cm)	Narrower and often found full (diameter = 3.5 cm)
Circular folds/plicae circulares (valves of Kerckring)	Longer and closely set	Smaller and sparsely set
Villi	More, larger, thicker, and leaf-like	Lesser, shorter, thinner, and fingerlike
Aggregated lymph follicles (Peyer's patches)	Absent	Present
Mesentery	Peritoneal windows present and contains less fat	Peritoneal window absent and contains more fat
Arterial arcades	One or two rows with long vasa recta	Four or five rows with short vasa recta

❖ Write a short note on mesentery.

The mesentery is a broad fan-shaped fold of peritoneum, which suspends the coils of jejunum and ileum from the posterior abdominal wall. The breadth of mesentery is maximum (8″) in its central part and gradually diminishes toward the ends (Fig. 13.1).

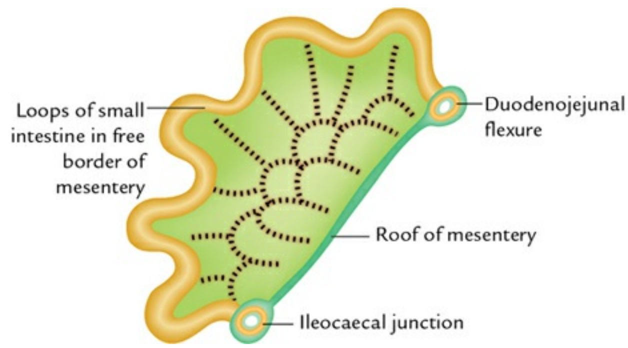


FIG. 13.1 Mesentery.

Features

- *Two borders* – attached and free
- Number of pleats

Borders

- *Attached border* (root of mesentery) is 15 cm (6″) long.

❒ Directed obliquely downward and to the right.

❒ Extends from duodenojejunal flexure (located on the left side of L2 vertebra) to the right sacroiliac joint.

- *Free border/intestinal border* is 6 m long.

❒ Forms fold or pleats.

N.B.

The root of mesentery is 15 cm (6″) long, while its free border is 6 m long; hence, it is thrown into number of pleats like that of a full spirit.

Contents

- Jejunum and ileum
- 100–200 lymph nodes

- Lacteals (lymphatics)
- Autonomic nerves
- Connective tissue and fat

Development

The small intestine develops from midgut loop. The apex of midgut loop communicates with the yolk sac through narrow vitellointestinal duct (stalk of yolk sac). The midgut loop is divided into pre- and post-arterial segments by the superior mesenteric artery.

The parts of small intestine derived from midgut loop are as under:

- Whole of jejunum, from *pre-arterial segment*
- Whole of ileum except its terminal part, from *pre-arterial segment*
- Terminal part of ileum, from *post-arterial segment*

❖ Give the histological differences between the jejunum and ileum in a tabular form.

These are given in Table 13.2.

Table 13.2

Histological differences between jejunum and ileum

	Jejunum	**Ileum**
Epithelium	Few goblet cells interspersed in columnar epithelium	More goblets cells interspersed in columnar epithelium
Villi	Tongue-shaped with swollen end Abundant with different heights	Finger-shaped Fewer with variable upper level
Lamina propria	Diffuse infiltration of lymphocytes	Nodular aggregation of lymphocytes (lymph nodules/*Peyer's patches*) that break through muscularis mucosae into submucosa

❖ Write a short note on Meckel's diverticulum (diverticulum ilei).

- It is small diverticulum (if present) seen at the antimesenteric border of ileum. Its caliber is equal to that of ileum.
- Its apex may be free/attached to umbilicus by a fibrous band.
- It is the most common congenital anomaly of the gastrointestinal duct.
- It is a persistent proximal part of the vitellointestinal duct, which normally disappears during 6th week of intrauterine life (IUL).

General features (fig. 13.2)

They follow the rule of "2".

- *Length:* 2″ long.
- *Location:* 2 feet away from ileocecal junction.
- *Occurrence:* 2% of subjects.

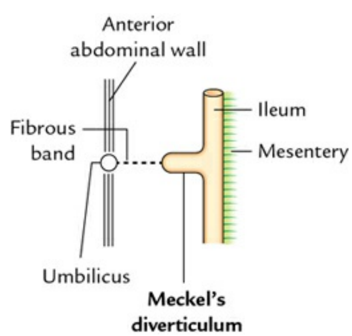


FIG. 13.2 Meckel's diverticulum.

Applied anatomy

When connected to umbilicus by a fibrous band, the intestine may rotate around it and gets obstructed. It is often the site of heterotrophic pancreatic tissue and gastric mucosa with oxyntic cells. It may enter into hernia sac. It may present a discharge from umbilicus/bulging umbilicus/cystic umbilical tumor. If remains patent, the contents of small intestine are being discharged at the umbilicus.

Large intestine

❖ Describe parts and functions of the large intestine. Give its cardinal features.

The large intestine

- Is 1.5 m long
- Extends from ileocecal junction to the anus.

Parts

The large intestine is divided into 7 parts:

- Caecum
- Ascending colon
- Transverse colon
- Descending colon
- Sigmoid colon
- Rectum
- Anal canal

Functions

- Absorption of water and electrolytes
- Lubrication of feces by mucus
- Normal bacterial flora of colon synthesise vitamin B
- Mucus of colon contains IgA antibodies, which protects it from invasion by microorganisms
- Storage of feces
- Microvilli of columnar cells of lining epithelium serve as a sensory function

Cardinal features

The large intestine presents 3 cardinal features:

- *Presence of appendices epiploicae*: These are peritoneal sacs filled with fat.
- *Presence of the taeniae coli*: These are three longitudinal muscular bands.
- *Presence of sacculations*: These are sacculated dilatations in the wall. They are formed taeniae coli are shorter in length than the intestine itself.

❖ What are differences between the small and large intestines?

These are given in Table 13.3.

Table 13.3

Differences between small and large intestine

Features	Small intestine	Large intestine
Length	6 m	1.5 m
Lumen	Narrower	Wider
Appendices epiploicae	Absent	Present
Taenia coli	Absent	Present
Sacculations	Absent	Present
Distensibility	Less	More
Mobility	Greater part is freely mobile	Greater part is fixed
Villi	Present	Absent
Transverse mucosal folds	Permanent	Obliterated when longitudinal muscle coat relaxes
Peyer's patches	Present	Absent
Common site for	Worms infestation Typhoid ulcer Tubercular ulcer	Entamoeba histolytica Dysentery organisms Carcinoma
Effects of infection and irritation	Diarrhea	Dysentery

❖ Describe the appendix under the following headings: (a) general features, (b) positions, (c) relations, (d) blood supply, (e) development, and (f) applied anatomy.

General features

- It is a narrow worm-like tubular diverticulum arising from posteromedial wall of the caecum, about 2 cm below the ileocecal valve.
- It resembles round worm, hence called vermiform appendix.
- It is located in the right iliac fossa.
- Its length varies from 2 to 20 cm with an average length of 9 cm.
- Its length increases in young adults but gradually diminishes after the middle age.
- All the taenia of the colon converge on the base of the appendix.
- Appendix is suspended by a small triangular fold of peritoneum called *mesoappendix*.

Positions (fig. 13.3)

The appendix lies in the right iliac fossa with base fixed/attached to the posteromedial wall of the caecum. The location of the base corresponds to a point 2 cm below the intersection of transtubercular and right lateral planes.

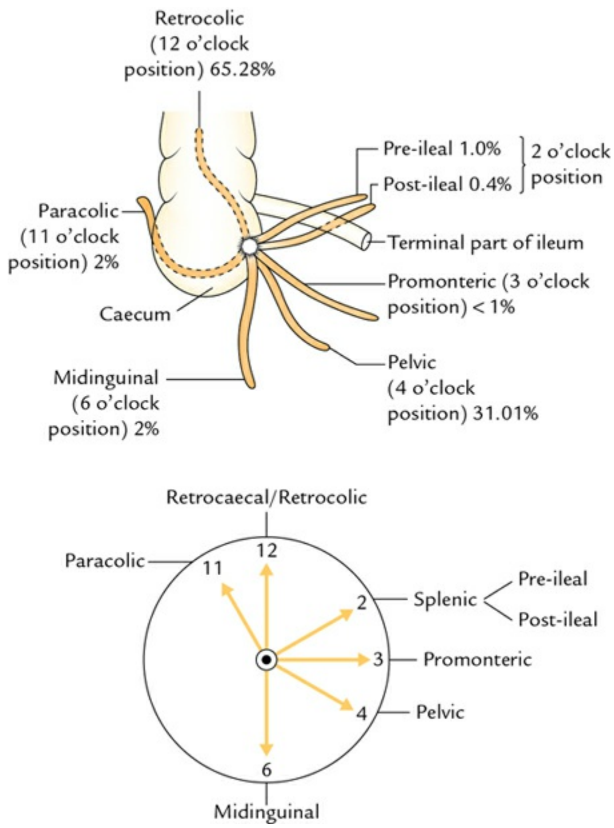


FIG. 13.3 Positions of the appendix.

Although the base of appendix is fixed, its tip may point in any direction, thus defining the position of the appendix. These positions are often compared to those of the hour needle of a time clock. The positions are as follows:

- *Paracolic (11 o'clock) position*: Appendix lies in the paracolic gutter, right to the ascending colon.
- *Retrocaecal/retrocolic (12 o'clock) position*: Appendix lies behind the caecum or ascending colon (commonest position, 65%).
- *Splenic (2 o'clock) position*: Appendix lies in front of or behind the terminal ileum and directed toward the spleen. It is the most dangerous position because if inflamed, its infection spreads to general peritoneal cavity.
- *Promontoric (3 o'clock) position*: Appendix passes horizontally to the left towards the sacral promontory.
- *Pelvic (4 o'clock) position*: Appendix passes over the pelvic brim to descend into pelvis near the ovary in female (2nd commonest position, 30%).
- *Subcecal (6 o'clock) position:* Appendix lies below the caecum.

N.B.

The *appendicular orifice* is situated on the posteromedial wall of the caecum 2 cm below the ileocecal orifice.

Arterial supply

By appendicular artery, a branch of inferior division of ileocolic artery. It runs behind the terminal part of ileum and enters the mesoappendix. Here, it gives a recurrent branch which forms anastomosis with the posterior cecal artery. The tip of appendix is least vascular.

Development

The appendix develops from narrow part of caecal diverticulum of the midgut loop.

Applied anatomy

Appendicitis

It is the inflammation of the appendix. It usually occurs due to obstruction of its lumen by a fecolith. Clinically, it is present as:

- Pain in umbilical region, which later gets localized in the right iliac fossa
- Vomiting
- Fever
- Tenderness of McBurney's point
- Muscle guarding and rebound tenderness over appendix

N.B.

The appendicitis is rare at the extreme ages because in children lumen of appendix is wide, while in old age it gets obliterated. Thus, it cannot be obstructed by a fecolith.

Appendectomy

It is surgical removal of appendix, which is often required in chronic appendicitis.

Mcburney's point

It is the point that lies at the junction of lateral 1/3rd and medial 2/3rd of the line joining the umbilicus with the right anterior superior iliac spine (*spinoumbilical line*). For exposure of appendix, *gridiron incision* is given at right angle to this line at this point.

Referred pain of appendix

The appendicular pain is referred to the umbilicus because both appendix and umbilicus are supplied by T10 spinal segment (appendix by sympathetic fibers and umbilicus by somatic fibers).

❖ Give the histological features of the appendix.

The histological features of appendix are (Fig. 13.4):

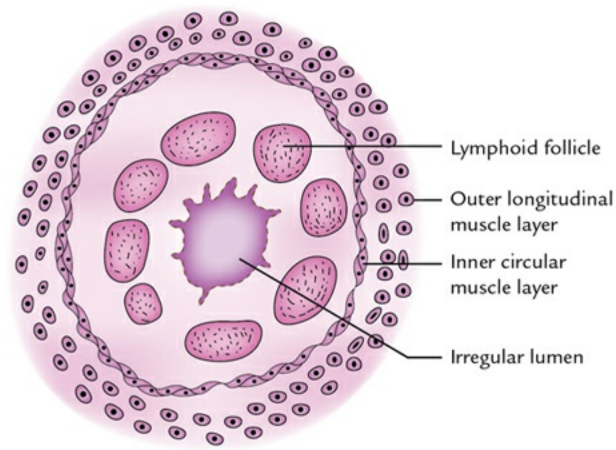


FIG. 13.4 Histological features of the appendix.

The appendix shows small angulated lumen and its wall consists of four coats, viz. mucosa, submucosa, muscularis externa, and serosa.

- *Mucosa*:

❒ Lined by the simple columnar cells with numerous goblet cells.

❒ Is devoid of villi

The intestinal glands (crypts of Lieberkühn) are few and short. Muscularis mucosae is disrupted by lymphatic nodules.

- *Submucosa*: It contains a *ring of large lymphoid follicles* with germinal centers. Hence, the appendix is commonly considered as an *abdominal tonsil*.
- *Muscularis externa*: It consists of outer longitudinal and inner circular layers of smooth muscle.
- *Serosa*: It is made up of visceral peritoneum.

Large vessels of the gut

❖ Write a short note on coeliac trunk.

It is the artery of foregut. It is short trunk (1.25 cm long) and supplies alimentary canal up to the opening of bile duct and its derivatives.

Origin

It arises from the front of aorta just below the aortic orifice of the diaphragm, at the level of L1 vertebra (Fig. 13.5).

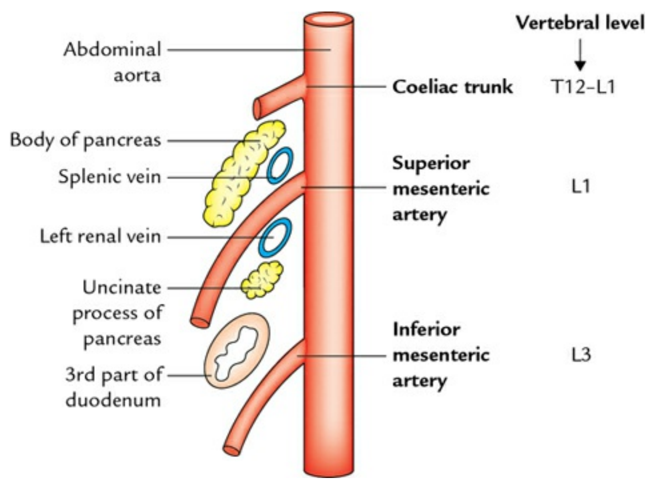


FIG. 13.5 Origins of the ventral branches of abdominal aorta.

Branches

It gives 3 branches:

- *Left gastric artery*, smallest branch.
- *Common hepatic artery*, larger than left gastric artery.
- *Splenic artery*, largest and remarkably tortuous.

Left gastric artery

It is the smallest branch of coeliac trunk but supplies largest areas of the stomach.

Branches

- Esophageal branch
- Gastric branches

Common hepatic artery

It passes to the right over the upper border of pancreas.

Branches

- Gastroduodenal artery
- Right gastric artery
- Duodenal branch
- Right hepatic artery
- Left hepatic artery

} Terminal branches

N.B.

The gastroduodenal artery passes behind the first part of duodenum and is divides into:

• Right gastroepiploic artery

• Superior pancreaticoduodenal artery

Splenic artery

It is the largest branch of the coeliac trunk. It is remarkably tortuous and runs toward the left behind the stomach to reach the hilum of spleen where it ends by dividing into 5–7 *splenic branches*.

N.B.

It is the main source of arterial supply to the pancreas.

Branches and distribution (fig. 13.5)

• Pancreatic branches to body of pancreas

• Five to six short gastric arteries to fundus of the stomach

• Left gastroepiploic artery to left half of body of the stomach near the greater curvature and to greater omentum

• Five to six splenic branches to spleen

❖ Give a brief account of the superior mesenteric artery.

It is the artery of midgut.

Origin

From front of aorta at the lower border of L1 vertebra. It courses downward and to the left to reach right iliac fossa where it terminates by anastomosing with a branch of ileocolic artery.

Branches and distribution

- *Twelve or more jejunal and ileal arteries* from its convex aspect to jejunum and ileum.
- *Inferior pancreaticoduodenal artery* to lower half of head of pancreas and adjoining part of duodenum.
- *Middle colic artery* to transverse colon.
- *Right colic artery* to ascending colon, right colic flexure, and proximal part of transverse colon.
- *Ileocolic artery* to caecum, vermiform appendix, beginning of ascending colon, and termination of ileum.

❖ Give a brief account of the inferior mesentery artery.

It is the artery of hindgut.

Origin

From front of aorta at the level of L3 vertebra. It courses downward left to aorta, crosses left common iliac artery, and then continues as the superior rectal artery.

Branches and distribution

- *Left colic artery* to the terminal part of transverse colon, left colic flexure, and upper part of descending colon.
- *Sigmoid arteries (2 to 4 in number)* to the lower part of descending colon and sigmoid (pelvic) colon.
- *Superior rectal artery* to the upper part of rectum.

❖ Describe the caecum under the following headings: (a) introduction, (b) shapes, (c) relations, (e) arterial supply, and (g) applied anatomy.

Introduction

It is the dilated proximal end/cul-de-sac of the large intestine below ileocolic junction. It is situated in the right iliac fossa above the lateral half of the inguinal ligament. It has greater width than length. Size: length, 6 cm; breadth, 7.5 cm.

It communicates:

- Superiorly with ascending colon
- Medially with ileum
- Posteromedially with appendix

Shapes

There are 3 types of the caecum according to shape:

- Conical type
- Ampullary type (commonest)
- Intermediate type

Relations

Anterior

- Coils of small intestine
- Anterior abdominal wall

Posterior

- Right psoas major and iliacus muscles
- Retrocaecal peritoneal recess
- Right gonadal vessels
- Right external iliac vessels
- Genitofemoral, femoral, and lateral cutaneous nerves of the thigh

Arterial supply

By the anterior and posterior caecal arteries from ileocecal artery (terminal branch of the superior mesenteric artery).

Applied anatomy

Caecum acts as a guide to localize the site of intestinal obstruction in barium enema study. The dictum is that:

- If caecum is distended, the obstruction is in the large intestine.
- If caecum is empty, the obstruction is in the small intestine.
- *Tuberculosis of intestine* is common at the ileocecal junction.
- *Intussusception*: It is telescopic invagination of ileum into caecum and ascending colon. It is not uncommon.

CHAPTER 14

Kidney, ureter, and suprarenal glands

❖ Describe kidney under the following headings: (a) introduction, (b) external features, (c) coverings/capsules, (d) relations, (e) arterial supply, (f) venous drainage, and (g) applied anatomy.

Introduction

- The kidneys are paired excretory organs.
- They are located on posterior abdominal wall on each side of vertebral column, behind peritoneum in the lumbar region.
- Each kidney is about 11 cm long, 6 cm broad, and 3 cm thick.
- Each kidney weighs about 150 gm in males and 135 gm in females.
- Each kidney extends from upper border of T12 to the center of L3 vertebra.
- Right kidney is slightly lower than the left kidney (due to the presence of liver on the right side).
- Lower poles of kidneys lie about 2.5 cm above the iliac crest.

External features

Two poles

- *Upper pole* is broad and in close contact with the suprarenal gland.
- *Lower pole* is pointed.

Two surfaces

- *Anterior surface* is slightly irregular and partly covered with peritoneum.
- *Posterior surface* is flat and entirely nonperitoneal.

Two borders

- *Medial border* is concave and shows a depression in its middle called *hilum*.
- *Lateral border* is convex.

One hilum

Three structures enter/leave the hilum. From anterior to posterior, these are:

- Renal vein
- Renal artery
- Renal pelvis

Accessory renal artery (in 30% cases)

Relations

Anterior relations

These are given in the box below and shown in Figure 14.1.

Right kidney	Left kidney
Right suprarenal gland	Left suprarenal gland
Right lobe of the liver	Spleen
Right colic flexure	Stomach
Second part of the duodenum	Pancreas
Loops of jejunum	Left colic flexure and descending colon Loops of jejunum

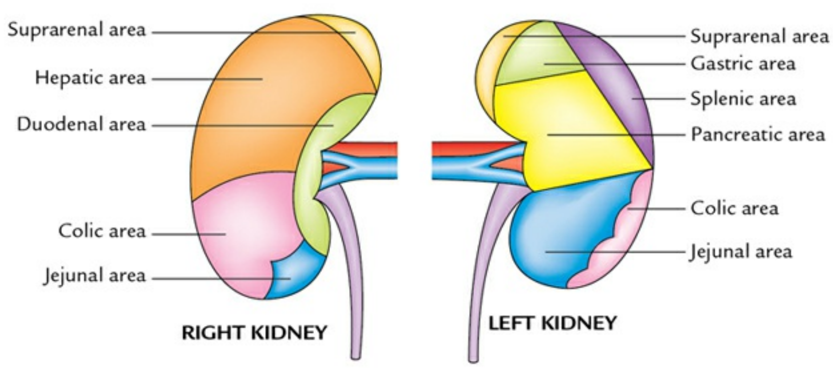


FIG. 14.1 Anterior relations of the kidneys.

N.B.

In right kidney hepatic and intestinal surfaces are covered by peritoneum. While in left kidney gastric splenic and jejunal surfaces are covered by peritoneum.

Posterior relations

The posterior relations of both kidneys are (Fig. 14.2):

- *Four muscles*

❒ Diaphragm

❒ Psoas major

❒ Quadratus lumborum

❒ Transversus abdominis

- *Three nerves*

❒ Subcostal

❒ Iliohypogastric

❒ Ilioinguinal

• *One set of vessels*

❒ Subcostal vessels

• *One or two ribs*

❒ 12th rib in case of right kidney

❒ 11th and 12th ribs in case of left kidney

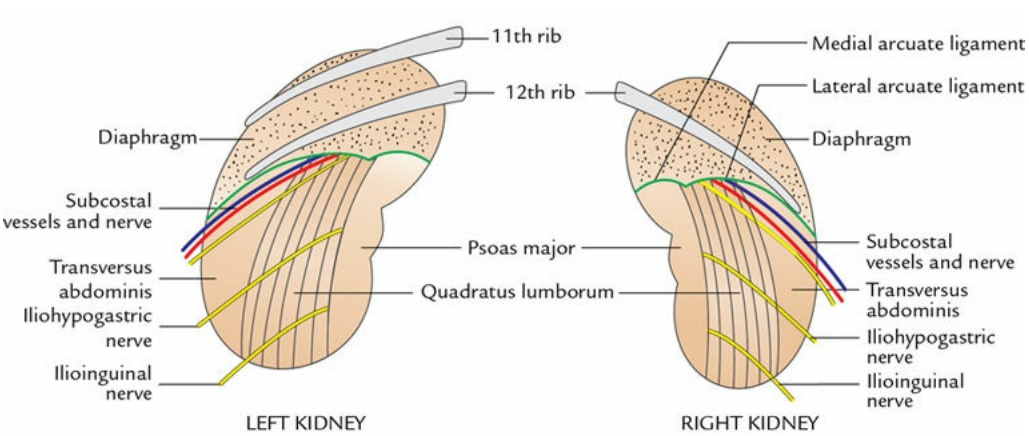


FIG. 14.2 Posterior relations of the kidneys.

Capsules/covering

There are 4 coverings of the kidney. From within outward these are (Fig. 14.3):

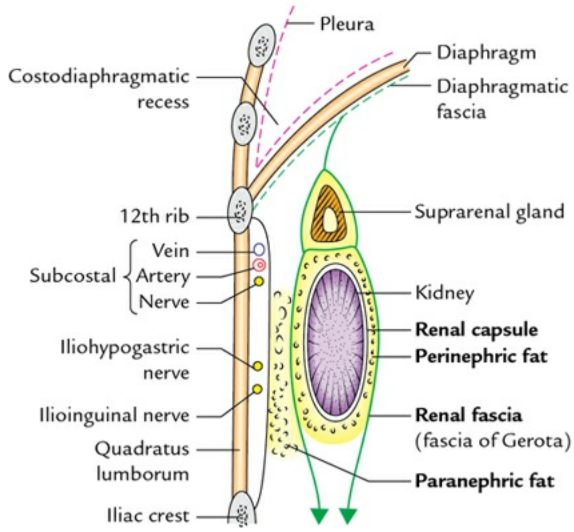


FIG. 14.3 Capsules of the kidney.

Fibrous capsule (true capsule)

It is a thin membrane, which closely invests the kidney and lines the renal sinus. Normally, it can be easily stripped off from the kidney, but in certain diseases, it becomes adherent to kidney and cannot be stripped off.

Perirenal/perinephric fat

It is a layer of adipose tissue lying outside the fibrous capsule. It is thickest at the borders and fills up the extra space in the renal sinus.

Renal fascia/fascia of zerota (false capsule)

It has anterior and posterior layers. The *anterior layer* is called *fascia of Toldt*, and posterior layer is called *fascia of Zuckerkandl.*

Pararenal/paranephric fat

It is a variable amount of fat lying outside the renal fascia especially posteriorly. It fills up paravertebral gutter and acts as a cushion for the kidney.

Fate of renal fascia

- *Superiorly*, the two layers first enclose the suprarenal gland in a separate compartment and then fuse with each other to continue with the *diaphragmatic fascia*.
- *Inferiorly*, *anterior and posterior layers* remain separate and enclose the ureter. Then, the anterior layer is lost in the extraperitoneal tissues of iliac fossa, while the posterior layer blends with fascia iliaca.
- *Laterally*, two layers merge with fascia transversalis.
- *Medially*, anterior layer passes in front of renal vessels and merges with the connective tissue surrounding the aorta and inferior vena cava, while posterior layer covers the fascia covering the quadratus lumborum and psoas major.

Arterial supply

Each kidney is supplied with a renal artery, which arises from the abdominal aorta at the level of intervertebral disc between L1 and L2 vertebrae. Each artery divides into anterior and posterior branches near the hilum which in turn divides into segmental arteries to supply renal segments viz. apical, upper, lower, middle, and posterior.

Venous drainage

Each kidney is drained by renal vein, which opens into inferior vena cava. The left renal vein is longer than the right renal vein and lies superficial to the abdominal aorta.

Applied anatomy

- *Renal angle*: It is an angle between the lower border of 12th rib and outer border of the erector spinae muscle. The renal pain is usually felt here, as dull ache and pressure applied here may elicit tenderness in kidney lesion. The oblique incision in kidney exposure commences here. The danger of opening the pleural sac should be kept in mind, while exposing the kidney from the behind.

- *Bimanual palpation*: Kidney can be palpated bimanually with one hand placed in front of the anterior abdominal wall and other hand behind the flank. When enlarged, the lower pole of the kidney can be palpated on deep inspiration.

- *Floating kidney/nephroptosis*: Normally, the kidney more or less remains in place because it lies in the abundant fat within renal fascia. But in chronic debilitating disease, this fat disappears and kidney becomes hypermobile and can move up and down within the renal fascia, but not from side to side. This may cause kinking of ureter and urinary obstruction.

❖ Discuss histological features of the kidney.

The histological section through kidney presents an outer *cortex* and an inner *medulla*.

Cortex

The cortex presents the following features (Fig. 14.4):

- Presence of darkly, stained, small, dense, rounded structures arranged in parallel rows at right angle to the capsule of kidney. These are *renal corpuscles/glomeruli*.
- Pale stained lines running vertically towards medulla, the *medullary rays*.
- Presence of many sections of proximal convoluted tubules and some sections of distal convoluted tubules.

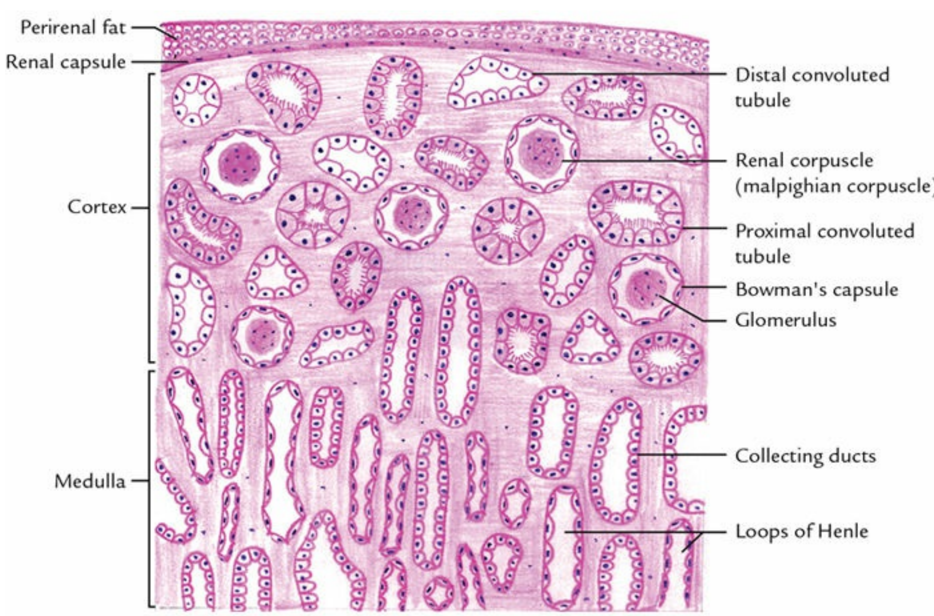


FIG. 14.4 Histological features of the kidney: cortex and medulla.

The differences between the sections of proximal and distal convoluted tubules are given in Table 14.1.

Table 14.1

Differences between the sections of proximal and distal convoluted tubules

	Proximal convoluted tubule	Distal convoluted tubule
Lining cells	Truncated low columnar with brush border	Cuboidal with no brush border
Nucleus	Large, spherical, and basal	Small and central
Lumen	Small, not clearly visible	Large, clearly visible
Cytoplasm	Stained bright pink	Stained lightly
Cell outline	Not distinct	Distinct

Medulla

The medulla presents the following features (Fig. 14.4):

- Numerous light staining tubular structures running vertically, the *collecting ducts*.
- Sections of *loop of Henle*.
- Capillaries and connective tissues.

❖ Describe development of the kidney and associated common congenital anomalies in brief.

Development

Kidney develops from intermediate mesoderm in the pelvis during the 5th week of IUL. It ascends in the lumbar region and becomes functional in the 9th week of IUL.

Sources (fig. 14.5)

- *Secretory part* develops from **metanephric blastema**.
- *Collecting part* develops from **ureteric bud**, which arises from mesonephric duct.

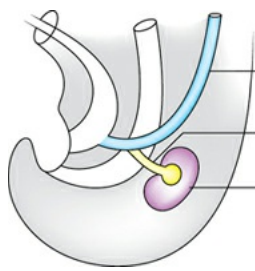


FIG. 14.5 Development of the kidney.

The components of secretory and collecting parts of kidney are given in the box below:

Secretory part	Collecting part
Renal glomerulus	Ureter
Bowman's capsule	Renal pelvis
Proximal convoluted tubule	Major calyces
Loop of Henle	Minor calyces
Distal convoluted tubule	Collecting ducts Collecting tubules

Congenital anomalies

Renal agenesis (absence of kidney)

It is unilateral and occurs in 1/2400 births.

Horseshoe kidney

In this type usually inferior poles of two kidneys are fused to each other across the midline.

Polycystic kidney

In this type, numerous cysts filled with urine are present within the kidney.

It occurs due to:

- Failure of connection between excretory and collecting components (old view).
- Abnormal dilatation of different parts of uriniferous tubules especially loops of the Henle (recent view).

❖ Describe ureter under the following headings: (a) introduction, (b) course (c) constrictions, (d) arterial supply, (e) nerve supply, (f) development, and (g) applied anatomy.

Introduction

The ureter is a narrow (3 mm in diameter) thick-walled muscular tube that conveys urine from kidney to the urinary bladder. It is 25 cm (10″) long, of which 5″ lies in the abdomen and 5″ in the pelvis.

Course (fig. 14.6)

- It begins within renal sinus as a funnel-shaped dilatation termed *renal pelvis*. The renal pelvis gradually narrows and descends along the medial margin of kidney. At the lower of kidney, it becomes *ureter proper*.
- Ureter proper passes downward and lies on tips of transverse processes of lumbar vertebrae and psoas major.
- It crosses the pelvic brim (in front of termination of common iliac artery) to enter true pelvis.
- In pelvis at first, it passes in front of ischial spine and then runs forward and medially to enter urinary bladder.

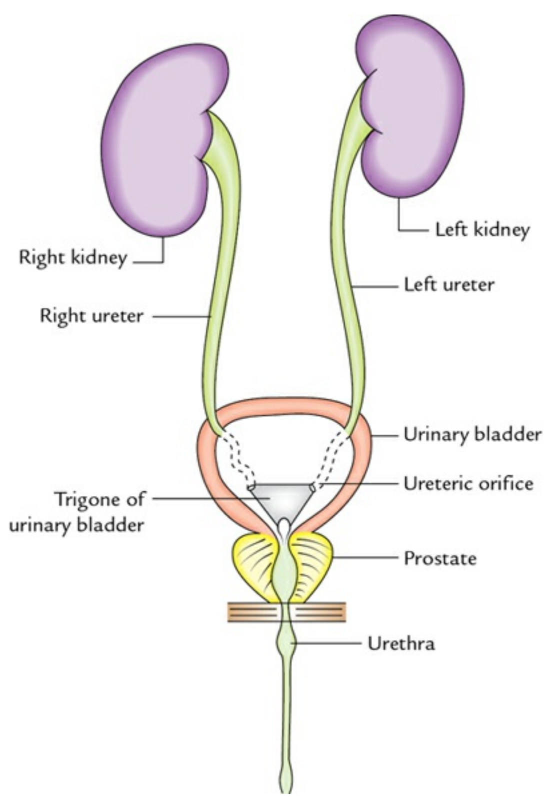


FIG. 14.6 Ureters.

Constrictions

The ureter presents 5 normal anatomical constrictions at the following sites (Fig. 14.7):

- **Pelviureteric junction**
- **Pelvic brim**
- Juxtaposition of vas deferens or broad ligament
- **Uretero-vesical junction** (i.e., point *where it pierces the wall of urinary bladder*)
- Ureteric orifice, i.e., opening into the urinary bladder

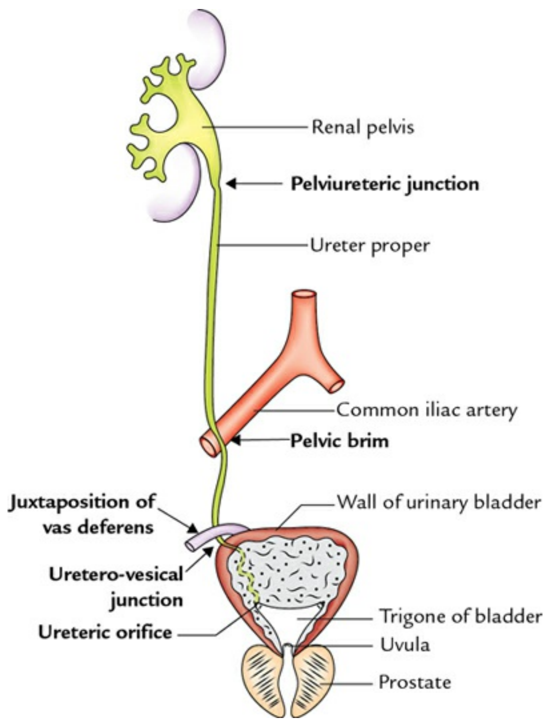


FIG. 14.7 Ureteric constrictions.

N.B.

Most of anatomy textbooks describe only 3 constrictions (pelviureteric junction, pelvic brim, and uretero-vesical junction).

Arterial supply

The ureter is supplied by the following three sets of arteries:

- *Upper part*, by the branches from renal artery.
- *Middle part*, by the branches from abdominal aorta.

- *Pelvic part*, by the branches from vesical (superior and inferior) middle rectal/uterine arteries.

Nerve supply

By the sympathetic (T10–L1) and parasympathetic (S2, S3, and S4) fibers through renal, aortic, and hypogastric plexuses.

Development

The ureter develops during 5th to 9th weeks of IUL from the **ureteric bud**.

Applied anatomy

Ureteric colic (also called renal colic)

It is a severe spasmodic pain arising from ureter when the ureteric stone is lodged in its lumen. Pain typically starts in loin and radiates down to grain (scrotum/labium majora) and inner side of the upper part of the thigh. Note pain is referred to the cutaneous areas supplied by T10 to L1 spinal segments, which also supply the ureter.

Impaction of ureteric stone

Ureteric stone is likely to be impacted at one of the sites of normal anatomical constrictions. Ureteric stone lodged in the lower part of the ureter in female can be palpated per vaginum because of close relationship of ureter to the lateral fornix of the vagina.

❖ Give histological features of the ureter (fig. 14.8).

Histological section of ureter presents a star-shaped lumen and a thick wall. The thick wall consists of 3 coats. From within outward, these are: mucous coat, muscular coat, and fibrous coat.

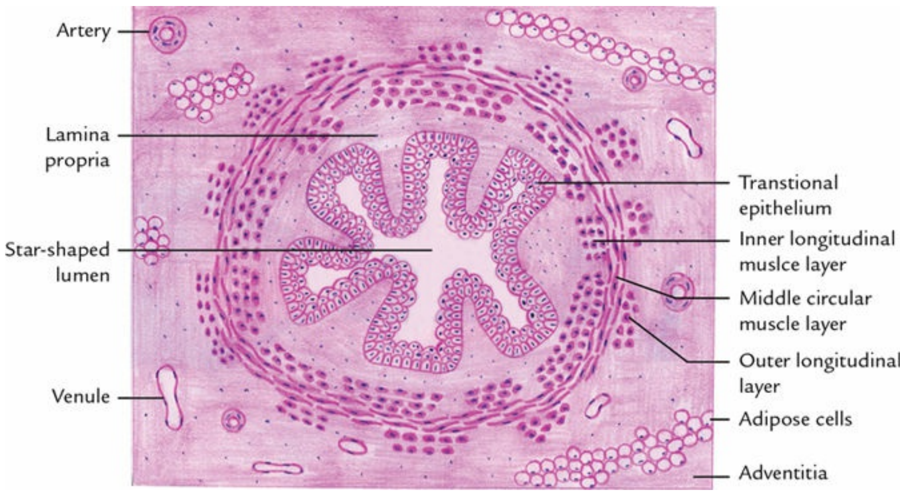


FIG. 14.8 Histological features of the ureter.

Mucous coat

- Mucous membrane is lined by transitional epithelium with no glands.
- Lamina propria is wide and made up of fibroelastic tissue, which is thrown into 5–6 longitudinal folds.

Muscular coat

It is made up of smooth muscle fibers.

- *In upper 2/3rd*, it consists of 2 layers:

❒ Outer layer of circular muscle fibers

❒ Inner layer of longitudinal muscle fibers

- *In lower 1/3rd*, it consists of 3 layers:

❒ Outer layer of longitudinal muscle fibers

❒ Intermediate layer of circular muscle fibers

❒ Inner layer of longitudinal muscle fibers

Adventitia (fibrous coat)

It is made up of loose connective tissue containing many elastic fibers, blood vessels, lymphatics, and nerves.

N.B.

There is no submucous coat in the ureter.

❖ Describe the suprarenal gland in brief: (a) external features, (b) arterial supply, and (c) venous drainage.

External features

- The suprarenal glands are a pair of endocrine glands situated over the upper pole of the kidneys.
- It consists of outer *cortex* and an inner *medulla*. The cortex secretes number of steroid hormones and medulla secretes adrenalin and noradrenalin.
- Each gland weighs about 5 gm.
- Right gland measures about 4 × 4 × 1 cm.
- Left gland measures about 5 × 3 × 1 cm.
- Right gland is triangular/pyramidal in shape, while left gland is semilunar in shape.

Arterial supply (fig. 14.9)

Each suprarenal gland is supplied by 3 arteries:

- *Superior suprarenal artery*, a branch of inferior phrenic artery.
- *Middle suprarenal artery*, a direct branch from abdominal aorta.
- *Inferior suprarenal artery*, a branch of renal artery.

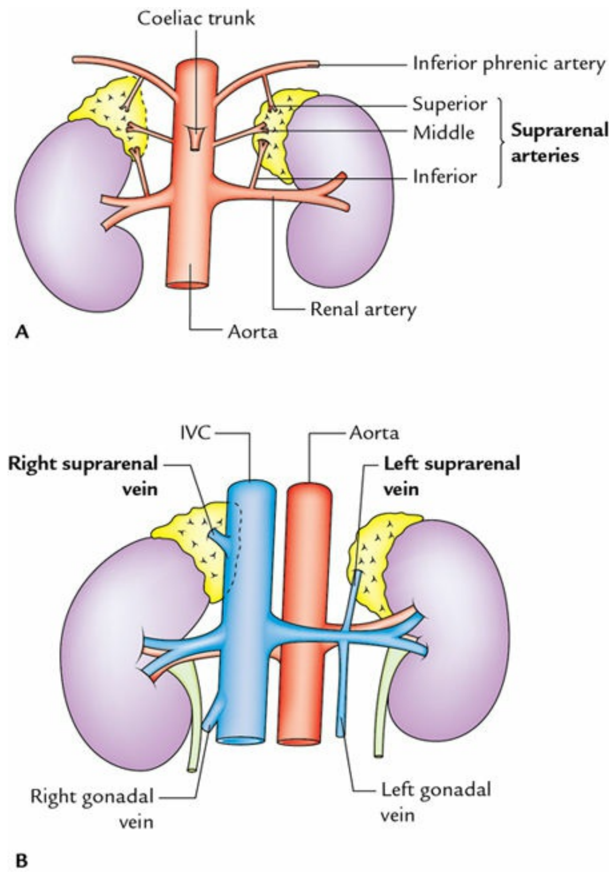


FIG. 14.9 Blood supply of the suprarenal gland: A, arterial supply; B, venous drainage.

Venous drainage (fig. 14.9)

Each gland is drained by one vein. The vein from right gland drains into IVC, while vein from left gland drains into left renal vein.

❖ Give differences between the right and left suprarenal glands.

The differences between right and left suprarenal glands are given in the box below:

Right suprarenal gland	Left suprarenal gland
Triangular or pyramidal in shape (like a top hat)	Semilunar in shape (like a cocked hat)
Does not reach hilum of kidney	Reaches hilum of kidney
Its hilu m is directed upward	Its hilum is directed downward
Its vein drains into IVC	Its vein drains into renal vein
It lies at higher level	It lies at lower level

❖ Give histological features of the suprarenal/adrenal gland.

Histological section of suprarenal gland presents cortex (outer 2/3rd) and medulla (inner 1/3rd) (Fig. 14.10).

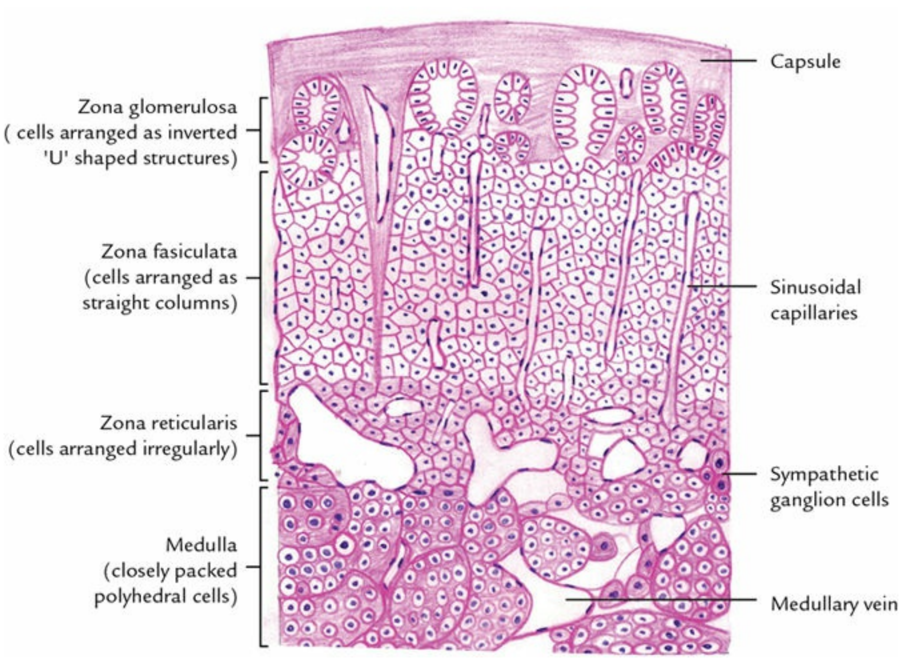


FIG. 14.10 Histological features of the suprarenal gland.

Cortex

The cortex from superficial to deep consists of 3 zones.

- *Zona glomerulosa* forms 15% of thickness. It is made up of inverted U-shaped arches of cells with intervening sinusoids. The cells are columnar with dark staining spherical nuclei.
- *Zona fasciculata* forms 75% of thickness. It consists of vertical columns, usually 2–3 cells thick which are separated by sinusoids. The cells are cuboidal or polygonal, giving foamy or spongy appearance hence also called *spongiocytes.*
- *Zona reticularis* forms 10% of thickness. It consists of irregular network of branching cords and clumps of cells separated by wide sinusoids. The cells are much smaller than the cells in zona fasciculata.

Medulla

The medulla consists of closely packed clumps of polyhedral chromaffin cells separated by wide sinusoids. The prominent medullary vein is characteristically located in the center of the medulla.

N.B.

- *Zona glomerulosa* secretes **mineralocorticoids**, zona fasciculata secretes **glucocorticoids**, and zona reticularis secretes **hormones**.

- *Medulla* secretes **epinephrine** (adrenalin) and **norepinephrine** (noradrenaline).

CHAPTER 15

Diaphragm, muscles of posterior abdominal wall, and great vessels of abdomen

Diaphragm

❖ Describe diaphragm under the following headings: (a) introduction, (b) origin and insertion, (c) openings of diaphragm and structure passing through them, (d) nerve supply, (e) actions, and (d) development.

Introduction

The diaphragm is a large musculotendinous structure, which separates thoracic cavity from the abdominal cavity.

Origin

It is divided into 3 parts: sternal, costal, and lumbar (Fig. 15.1).

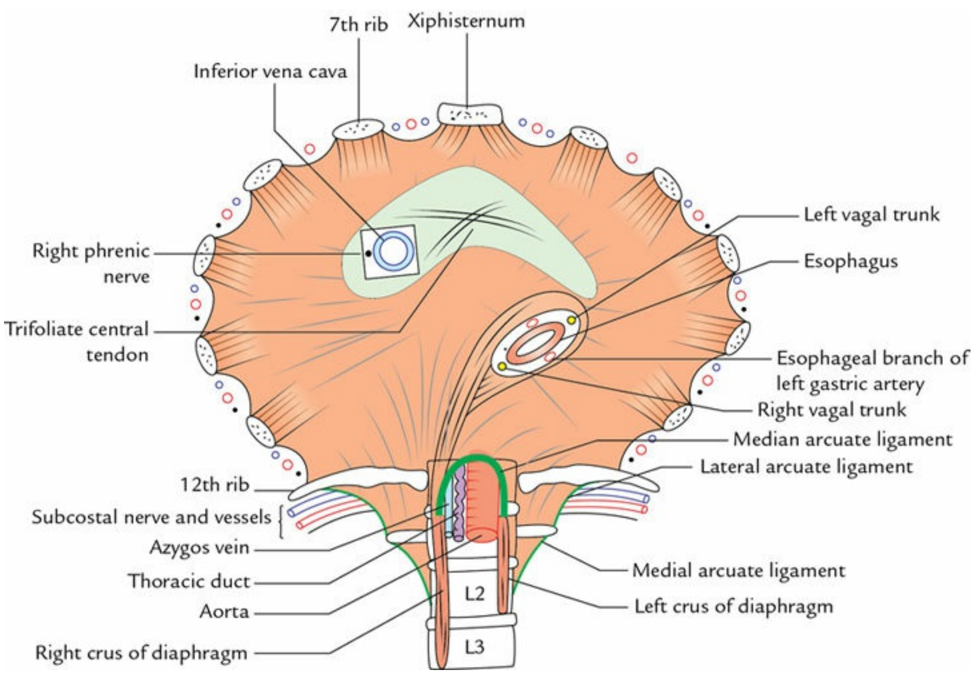


FIG. 15.1 Origin, insertion, and openings of the diaphragm.

Sternal origin

By 2 fleshy slips from the back of xiphoid process.

Costal origin

By 6 fleshy slips from the inner surfaces of the lower 6 costal cartilages and adjacent parts of ribs.

Vertebral origin

From upper 3 lumbar vertebrae by a pair of crura and associated median, medial, and lateral arcuate ligaments.

- The *crura* (two in number) are tapering longitudinal musculotendinous structures attached to the upper 2 or 3 lumbar vertebrae.

- *Right crus* is longer and stronger and attached on anterolateral surfaces of upper 3 lumbar vertebrae and intervening intervertebral discs.

- *Left crus* is shorter and attached on anterolateral surfaces of upper two lumbar vertebrae and intervening intervertebral discs.

- *Medial arcuate ligament* is a tendinous band that arches in front of the upper part of the psoas major from the body of the 2nd lumbar vertebra to the first lumbar transverse process.

- *Lateral arcuate ligament* is a tendinous band that arches in front of the upper part of quadratus lumborum from the first lumbar transverse process to the 12th rib.

- *Median arcuate ligament* connecting the upper ends of two crura is tendinous and arches across the aorta.

Insertion

Into central tendon, a trifoliate tendinous structure.

Openings of diaphragm

There are three main openings in the diaphragm: vena caval, esophageal, and aortic.

The vertebral level, shape, and location of these openings are given in the box below:

Opening	Vertebral level	Shape	Location
Vena caval	T8	Square	One inch to the right of median plane between the median and right folia of the central tendon.
Esophageal	T10	Oval	One inch to the left of median plane behind the central tendon between the medial fleshy fibers of right crus.
Aortic	T12	Round	In the median plane between the right and left crura and behind the median arcuate ligament.

Structures passing through 3 major openings of the diaphragm are given in the box below:

Opening	Structures passing through
Aortic opening (an osseoaponeurotic opening)	Aorta Thoracic duct Azygos vein
Esophageal opening	Esophagus Right and left vegal trunks Esophageal branches of left gastric artery
Vena caval opening	Inferior vena cava Branches of right phrenic nerve Few lymph vessels

Nerve supply

Motor

By phrenic nerves (derived from ventral rami of C3, C4, and C5).

Sensory

- Phrenic nerves provide sensory innervation to the central part.

- Lower 6 thoracic nerves provide sensory innervation to the peripheral part.

Actions

The diaphragm is a principle muscle of respiration. It contracts during expulsive acts such as micturition and defecation.

Development

The diaphragm develops from the following 4 sources:

- Septum transversum
- Pleuroperitoneal membranes
- Lateral thoracic walls
- Dorsal mesentery of esophagus

Muscles of posterior abdominal wall

❖ What are muscles of the posterior abdominal wall?

They are 3 in number:

- Psoas major
- Iliacus
- Quadratus lumborum

❖ Give the origin, insertion, nerve supply, and actions of the psoas major muscle.

Psoas major muscle is a large fusiform muscle placed along the side of lumbar vertebral column and pelvic brim (Fig. 15.2).

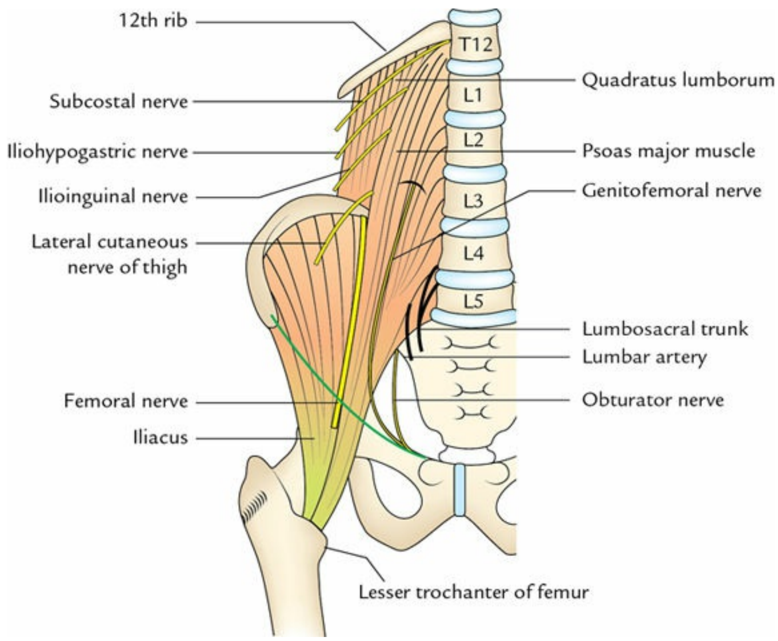


FIG. 15.2 Origin and insertion of the psoas major muscle.

Origin

- By 5 slips from the anterior surfaces and lower borders of transverse processes of all the lumbar vertebrae.
- By 5 slips, from each intervertebral disc and the adjacent margins of two vertebrae between T12 to L5 vertebrae.
- From 4 fibrous arches that bridge across the sides of upper 4 lumbar vertebral bodies.

Insertion

By a rounded tendon into the tip and anterior surface of lesser trochanter of the femur.

Nerve supply

By the branches from roots of lumbar plexus (ventral rami of L2, L3, and sometimes L4).

Actions

Medial rotation, flexion, and lateral rotation of the thigh in sequence.

- It flexes the trunk on the lower limb as in stooping position.
- It flexes the vertebral column forward and sideward.
- It along with iliacus is a powerful flexor of hip joint as in raising the trunk from recumbent to sitting position.

❖ Write a short note on psoas sheath and discuss its clinical significance.

The psoas major muscle is enclosed in the fascial sheath called *psoas sheath*. It is formed by the psoas fascia.

The pus from tubercular lumbar spine cannot spread anteriorly due to attachment of anterior longitudinal ligament on vertebral column, and therefore, it passes laterally into the psoas sheath. Pus from tubercular thoracic spine may also enter the psoas sheath by tracking down from the posterior mediastinum, as the sheath is open above and communicates with posterior mediastinum. Sometimes pus spreads under the inguinal ligament into the femoral triangle where it produces a soft swelling (Fig. 15.3).

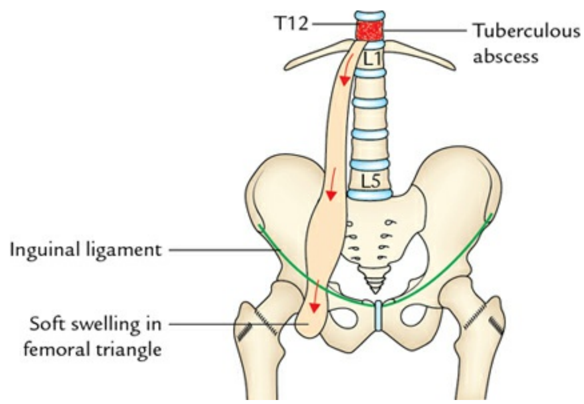


FIG. 15.3 Psoas abscess.

Occasionally, in neglected cases, pus tracks along the femoral vessels into the subsartorial canal and eventually may produce a swelling in the popliteal fossa.

❖ Enumerate the nerves that appear in relation to the psoas major muscle.

7 nerves appear in relation to the psoas major muscles (Fig. 15.2).

- *One Anteriorly*: Genitofemoral nerve (L1, L2).
- *Two Medially*: Obturator nerve and the lumbosacral trunk.
- *Four Laterally*: From above downward; iliohypogastric nerve, ilioinguinal nerve, lateral cutaneous nerve of the thigh, and femoral nerve.

Great blood vessels of abdomen

❖ Describe abdominal aorta under the following headings: (a) introduction, (b) branches, (c) development, and (d) applied anatomy.

Introduction (fig. 15.4)

- It is the continuation of descending thoracic aorta at the aortic orifice of the diaphragm at the level of the lower border of T12 vertebra and terminates at the lower border of L4 vertebra by dividing into two common iliac arteries.
- It lies in front of upper 4 lumbar vertebrae behind the peritoneum.

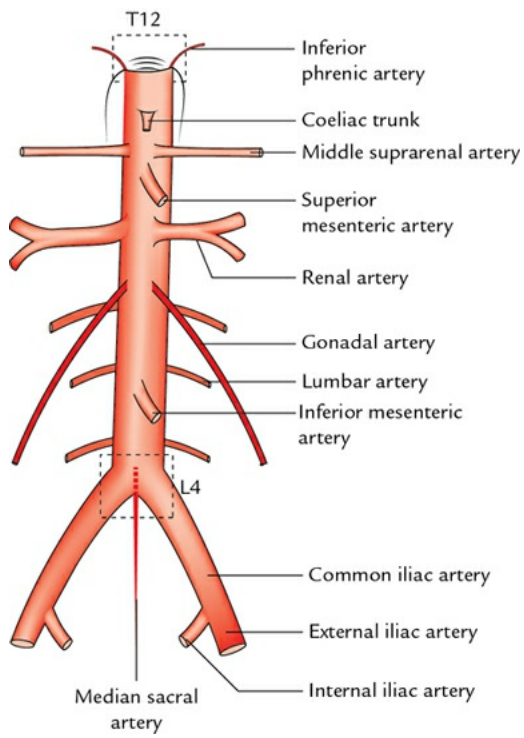


FIG. 15.4 Abdominal aorta.

Branches (fig. 15.4)

These are in 4 sets:

- *Three unpaired anterior branches*, to the viscera:

❒ *Coeliac artery*, also called coeliac axis/coeliac trunk, at the level of T12.

❒ *Superior mesenteric artery*, at the level of L1.

❒ *Inferior mesenteric artery*, at the level of L3.

- *Three paired lateral branches*, to the viscera:

❒ Middle suprarenal arteries, at the level of L2.

❒ Renal arteries, at the level of L1.

❒ Gonadal arteries (testicular or ovarian), at the level of L2.

- *Five paired lateral branches*, to the parities:

❒ Inferior phrenic arteries, at the level of T12.

❒ Four lumbar arteries (arising from the posterior aspect of the aorta).

- *Two terminal branches*:

❒ Right and left common iliac arteries, at the level of L4.

- *One unpaired posterior branch:* Median sacral artery arises slightly above the bifurcation of aorta, at the level of L4.

Development

The abdominal aorta develops in the 3rd week of IUL by the fusion of two primitive dorsal aortae.

Applied anatomy

Aortic pulsations

They can be felt just below and slightly to the left of the umbilicus in the thin individuals with abdominal muscles relaxed.

Aortic aneurysm (localized dilatation of aorta)

It commonly (95%) occurs below the origin of renal arteries.

Coarctation of abdominal aorta (stenosis)

If occurs, it is fatal because of less blood supply to the kidneys.

❖ Describe inferior vena cava under the following headings: (a) introduction, (b) tributaries, and (c) development.

Introduction (fig. 15.5)

• It is largest vein of the body, which drains venous blood from body below the diaphragm.

• It extends (below upward) from L5 to T8 vertebra.

• It forms on the right side of the front of L5 vertebra and terminates by opening into the right atrium.

• It is 9" long and 1" in breadth.

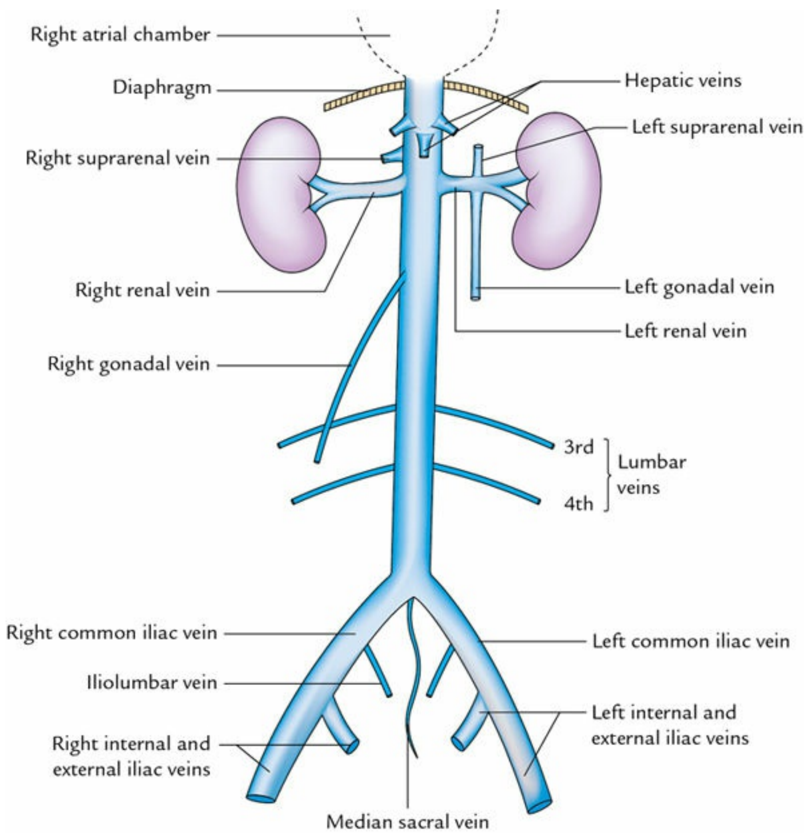


FIG. 15.5 Inferior vena cava.

Tributaries (fig. 15.5)

There are 12 tributaries:

• 2 common iliac veins

• 2 renal veins

• 2 hepatic veins

• 2 phrenic veins

• 2 lumbar veins (3rd and 4th)

• Right suprarenal vein

• Right testicular (or ovarian) vein

N.B.

Tributaries of inferior vena cava do not correspond to branches of the abdominal aorta.

Development

It is composite vessel and develops in the 8th week of IUL from the following sources. From below upward, these are (Fig. 15.6):

• Persistent caudal part of right posterior cardinal vein.

• Right supracardinal vein.

• Anastomosis between right supracardinal and right subcardinal veins.

• Upper part of right subcardinal vein.

• Anastomotic channel between right subcardinal and right hepatocardiac channel.

• Right hepatocardiac channel.

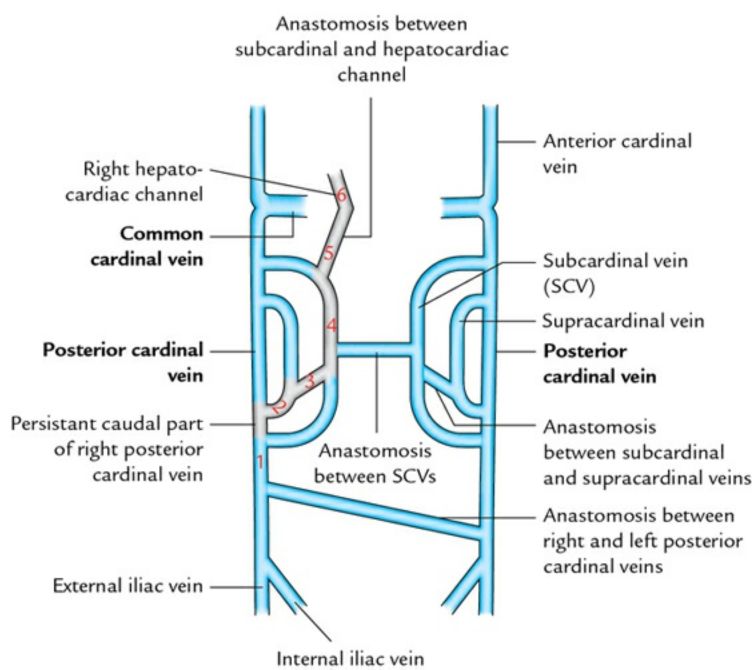


FIG. 15.6 Development of the inferior vena cava.

N.B.

Common developmental anomalies of the inferior vena cava are: (a) double inferior vena cava and (b) preureteric inferior vena cava/retrocaval ureter.

CHAPTER 16

Pelvic muscles and vessels

Pelvic muscles

❖ Enumerate muscles of the pelvis.

These are 4 pairs of pelvic muscles:

- Levator ani
- Coccygeus
- Piriformis
- Obturator externus

❖ Describe pelvic diaphragm under the following headings: (a) introduction, (b) formation, (c) openings, (d) relations, (e) functions, and (f) applied anatomy.

Introduction

The pelvic diaphragm is a gutter shaped muscular partition between the pelvis and perineum.

Formation

It is formed by 4 muscles, two from each side (Fig. 16.1):

- *Levator ani*
- *Coccygeus*

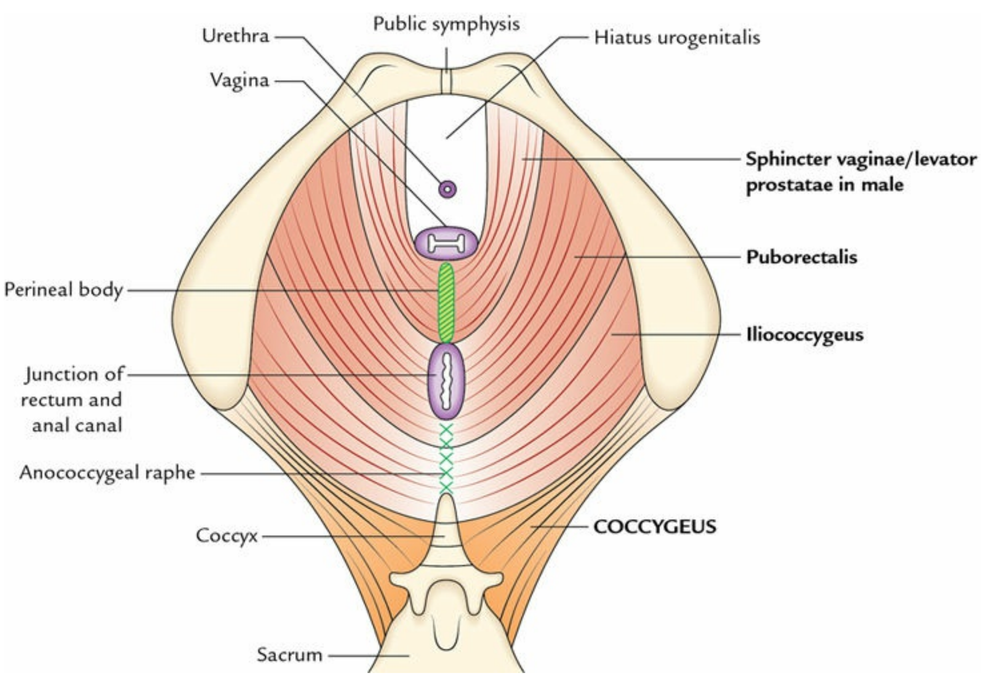


FIG. 16.1 Pelvic diaphragm.

Levator ani

It consists of two parts: *pubococcygeus* and *iliococcygeus*.

Pubococcygeus

Origin

- *Anterior fibers*: From medial part of pelvic surface of the body of the pubis.
- *Posterior fibers*: From lateral part of the pelvic surface of the body of pubis and anterior half of the

tendinous arch of the pelvic fascia (also called white line of the obturator fascia).

Insertion: The fibers run backward, downward, and medially with different degrees of obliquity and are inserted as follows:

- *Puboprostate or pubovaginalis (anteriormost fibers)*: These fibers pass by the sides of the prostate in male (*levator prostate*) or vagina in female (*sphincter vaginae*) to insert into the perineal body.

- *Puborectalis*: These fibers wind around the posterior aspect of the anorectal junction and continue with the similar fibers of the opposite muscle forming a U-shaped loop termed *puborectal sling*.

- *Iliococcygeus proper (posteriormost fibers)*: These fibers pass are inserted into the anococcygeal raphe and tip of the coccyx.

Iliococcygeus

Origin From posterior half of the tendinous arch/white line on the obturator fascia and pelvic surface of the ischial spine.

Insertion The fibers pass downward, backward, and medially are inserted into the sides of the lower two pieces of the coccyx and anococcygeal raphe.

Nerve supply Anterior half of the levator ani is supplied from the perineal surface via perineal branch of *pudendal nerve* (S2 and S3), and the posterior half is supplied from the pelvic surface by the *4th sacral nerve*.

Actions

- It closes the posterior part of the pelvic outlet.

- It fixes the perineal body and supports the pelvic viscera.

- It resists any rise in intra-abdominal pressure as in coughing, sneezing, defecation, and micturition.

- It maintains the continence of the bladder and the rectum.

Coccygeus (ischiococcygeus)

It is a triangular muscle situated behind the levator ani.

Origin Ischial spine and sacrospinous ligament.
Insertion Sides of upper two pieces of the coccyx and last piece of the sacrum.
Nerve supply By ventral rami of the 4th and 5th sacral nerves.

Openings of the pelvic diaphragm

- *Hiatus urogenitalis:* It is a triangular gap between the anterior fibers of the two levator ani muscles. It provides passage to the urethra in male and the urethra and vagina in female. This gap is closed from below by the urogenital diaphragm.

- *Hiatus rectalis:* It is a round opening between the perineal body and the anococcygeal raphe. It provides a passage to the anorectal junction.

N.B.

Hiatus of Schwalbe: It is an abnormal opening present in the pelvic diaphragm when levator ani fails to arise from the obturator fascia. Through, this gap between obturator fascia and tendinous arch of obturator fascia, the pelvic viscera may herniate into ischiorectal fossa of the corresponding side.

Relations of the pelvic diaphragm

- *Superior/pelvic surface*

❒ Pelvic fascia

❒ Urinary bladder

❒ Prostate

❒ Rectum

- *Inferior/perineal surface*

❒ Anal fascia

Functions of the pelvic diaphragm

- It supports the pelvic viscera by counteracting the downward thrust of the diaphragm during increased intra-abdominal pressure.
- In male, anterior fibers of levator ani elevate the prostate, hence called *levator prostrate*.
- In female, anterior fibers constrict the vagina and acts as the *sphincter vaginae*. It prevents downward displacement of the uterus through the vaginal canal.
- *Coccygeus muscle* pulls the coccyx forward after it is displaced backward during defecation or parturition.
- During defecation the puborectal sling relaxes and as a result rectum and anal canal form a straight tube to facilitate the act.
- *In parturition*, the puborectal sling upon which the fetal head rests allows forward rotation of the head into the lower part of birth canal.
- *In micturition*, the pubococcygeus relaxes as the intra-abdominal pressure rises and the neck of the bladder descends. This descent stimulates the detrusor muscle of the urinary bladder to help void the urine.

Applied anatomy

The pelvic diaphragm may be injured during parturition. This may cause uterine or rectal prolapse.

Arteries of the pelvis

❖ Write a short note on the internal iliac artery.

Origin

It is one of the two terminal branches of the common iliac artery.

Termination

It terminates by dividing into *anterior* and *posterior divisions* at the upper margin of greater sciatic foramen.

Branches (fig. 16.2)

Anterior divisions

It gives off 6 branches in the male/female:

- Superior vesical artery
- Obturator artery
- Middle rectal artery
- Inferior vesical artery (replaced by the vaginal artery in female)
- Internal pudendal artery
- Inferior gluteal artery
- Uterine artery (in female only)

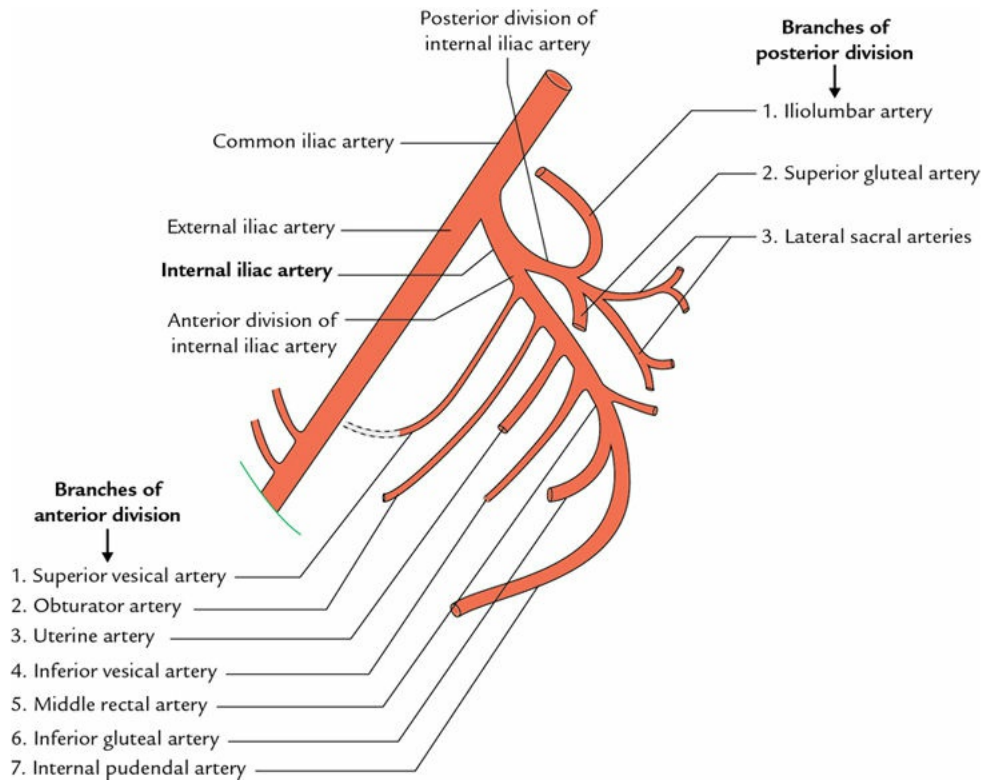


FIG. 16.2 Branches of the internal iliac artery.

N.B.

All the branches from anterior division are visceral branches except inferior gluteal and obturator arteries, which are parietal branches.

Posterior divisions

It gives off 3 branches:

- Iliolumbar
- Lateral sacral (usually 2 in number)
- Superior gluteal artery

N.B.

All the branches of posterior division are parietal branches.

CHAPTER 17

Pelvic viscera

The pelvis is a large, basin–shaped region of the body at the junction of the trunk and lower limbs. It contains the following organs:

- Urinary bladder
- Prostate (in male only)
- Uterus (in female only)
- Rectum

These organs are called pelvic viscera, and pelvis protects them.

Urinary bladder and urethra

❖ Describe urinary bladder under the following headings: (a) introduction, (b) external features, (c) relations, (d) supports, (e) arterial supply, (f) venous drainage, (g) lymphatic drainage, (h) nerve supply, and (i) applied anatomy.

Introduction

The urinary bladder is a hollow muscular organ, which lies in the anterior part of pelvic cavity behind the pubic symphysis. It acts as a reservoir of urine. Its capacity is 220 ml but varies from 120 ml to 320 ml.

N.B.

- When bladder is filled up to 120 ml, one gets sense of filling of the bladder
- When bladder is filled beyond 240 ml, one gets desire to micturate.
- When capacity of the bladder reaches 480 ml, one starts feeling pain.

External features (fig. 17.1)

An *empty bladder* is tetrahedral in shape and presents: (a) apex, (b) base, (c) neck, (d) 3 surfaces (superior and two inferior lateral surfaces), and (e) 4 borders (left lateral, right lateral, posterior, and anteroinferior).

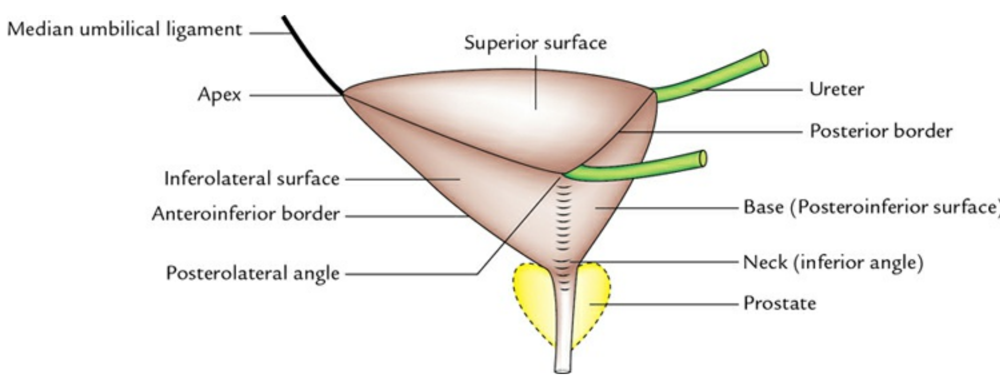


FIG. 17.1 External features of the urinary bladder.

N.B.

A full bladder is ovoid in shape and presents: apex base, neck, and 2 surfaces (anterior and posterior).

Apex

It lies just below behind the upper border of pubic symphysis. It is directed forward and upward and connected to umbilicus by median umbilical ligament.

Base (fundus/posteroinferior surface)

It is directed backward and downward.

Neck

It is the lowest and most fixed part. It lies 3–4 cm behind the lower border of the pubic symphysis and is pierced by internal urethral orifice.

Surfaces

- *Superior surface*: It is covered by peritoneum.
- *Inferolateral surfaces*: They are devoid of peritoneum.

Borders

- *Anterior border*: It extends from the apex to the neck and separates inferolateral surfaces from each other.
- *Lateral borders (left and right)*: Each of them separates superior surface from inferolateral surface on the corresponding side and extends from entrance of ureter to the apex.
- *Posterior border*: It separates superior surface from base and extends between the entrances of ureters.

Relations

Apex

Connected to umbilicus by median umbilical ligament.

Base/posteroinferior surface

- *In female*: Cervix of uterus and vagina.
- *In male* (Fig. 17.2): Rectovesical pouch containing coils of intestine (in upper part); seminal vesicles and vasa deferentia (in lower part).

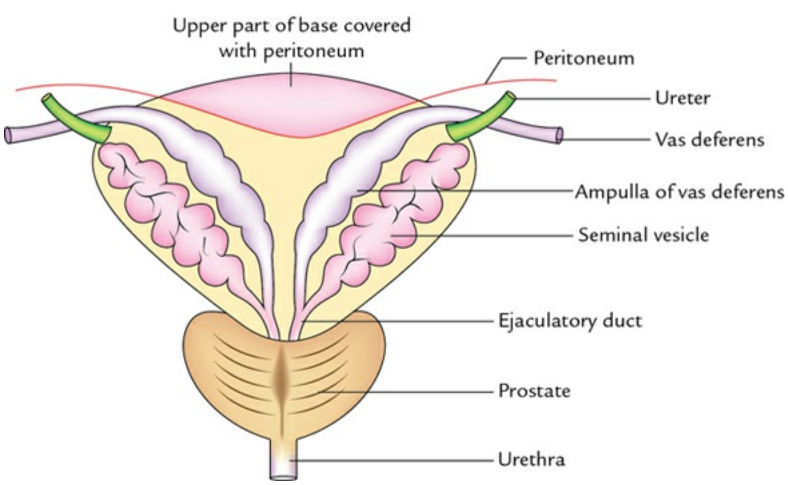


FIG. 17.2 Relations of the base of urinary bladder.

Neck

- *In female*: Pelvic fascia.

- *In male* (Fig. 17.2): Base of prostate.

Superior surface

- *In female*

❒ Covered by peritoneum except small area near the posterior border

❒ Vesicouterine pouch

❒ Sigmoid colon

❒ Coils of ileum

- *In male*

❒ Completely covered by peritoneum

❒ Sigmoid colon

❒ Coils of ileum

Inferolateral surfaces

- Pubis
- Pubovesical ligaments in female and puboprostatic ligaments in male
- Retropubic fat
- Levator ani muscle
- Obturator internus muscle

Supports/ligaments

Median umbilical ligament

It is a remnant of urachus (i.e., obliterated urachus).

Puboprostatic ligaments/pubovesical ligaments (4 in number)

These are fibromuscular bands extending from bladder neck to pubic symphysis.

Lateral ligaments (2 in number)

These are fibromuscular bands extending from inferolateral surface of the bladder to the tendinous arch of pelvic fascia.

Posterior ligaments (2 in number)

These are fibromuscular bands extending from base of bladder to the pelvic wall.

Arterial supply

Major blood supply by:

- *Superior vesical artery*
- *Inferior vesical artery*

Branches of the anterior division of internal iliac artery

Minor blood supply by:

- Obturator artery
- Inferior gluteal artery
- Uterine artery
- Vaginal artery

Branches of the anterior division of internal iliac artery

Venous drainage

By *vesicoprostatic venous plexus* in male and *vesical venous plexus* in female, which drain backward into internal iliac vein.

Lymphatic drainage

Lymphatics from bladder follow the arteries and drain into external (most) and internal iliac nodes.

Nerve supply

Sympathetic supply

From T11, T12, L1, and L2 spinal segments. It is inhibitory to the detrusor muscle of bladder wall and motors to (i.e., constricts) the internal urethral sphincter (sphincter vesicae), thus allowing the filling of the bladder.

Parasympathetic supply

From S2, S3, and S4 spinal segments. It is motor to (i.e., constricts) the detrusor muscle of the bladder wall and inhibitory to the internal urethral sphincter (i. e., relaxes), thus allowing the evacuation of urine from the bladder.

Somatic supply

From pudendal nerve to external urethral sphincter.

Sensory supply

From parasympathetic fibers to S2–S4.

Applied anatomy

Distended bladder

It occurs due to obstruction of urine outflow by enlarged prostate or stricture. It may be ruptured by injuries to the lower abdominal wall.

Reflex (automatic) bladder

In this condition, the voluntary inhibition and initiation of micturition is lost. As a result, bladder empties reflexly every 1 to 4 h. It occurs in transection of spinal cord above S2 spinal segment.

Atonic bladder

In this condition, the wall of urinary bladder becomes thin and hypotonic following interruption of sensory fibers of the reflex arch of micturition. It results in overflow incontinence.

❖ Enumerate the histological features of the urinary bladder.

In a histological section, the wall of the bladder presents 3 coats; from inward to outside, these are: (a) mucosa, (b) muscular coat, and (c) adventitia (Fig. 17.3).

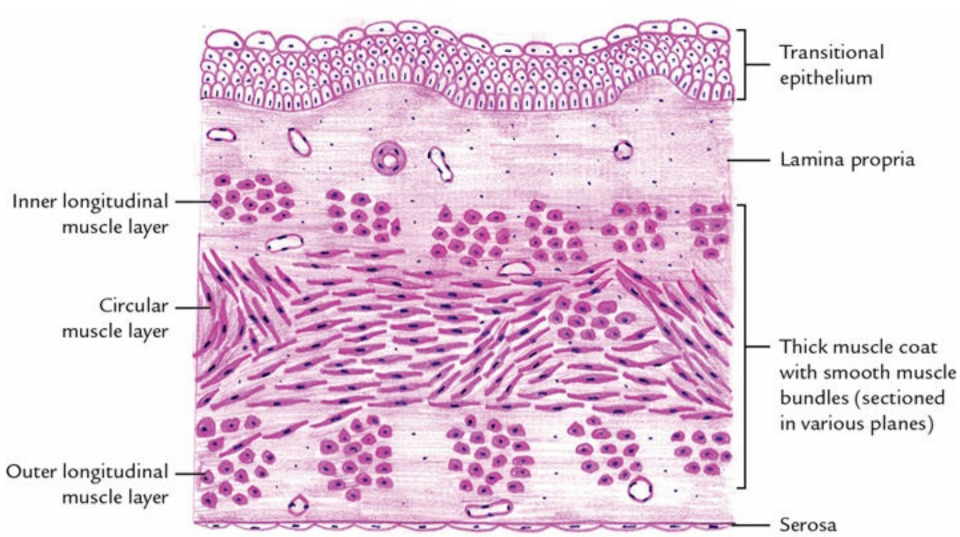


FIG. 17.3 Histological features of the urinary bladder.

Mucosa

- *Epithelium* consists 6–8 cells thick transitional epithelium with no glands.
- *Lamina propria* is made up of loose connective tissue containing lymph and blood vessels.

Muscular coat

It is thick and made up of smooth muscle fibers running in all directions, viz. transverse, longitudinal, and oblique. The spaces between bundles of muscle fibers are occupied by loose connective tissue, without forming distinct layers. At neck, it presents 3 distinct layers: (a) inner longitudinal, (b) middle circular, and (c) outer longitudinal.

Adventitia

It is well defined fibrous layer.

❖ Write a brief note on the development of the urinary bladder and enumerate common congenital anomalies associated with it.

Development

The urinary bladder develops in the 4–7 weeks of IUL, from upper part of *vesicourethral canal*. The small part near the apex is derived from allantois (Fig. 17.4).

Points to note

- *Epithelium* of whole of bladder is endodermal in origin (derived from vesicourethral canal) except that of trigone, which is mesodermal in origin (derived from absorbed mesonephric ducts).
- *Muscle coat* (detrusor muscle) of bladder develops from splanchnopleuric mesoderm.

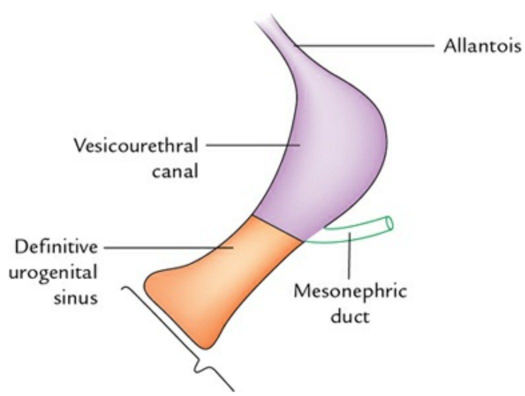


FIG. 17.4 Development of the urinary bladder.

Congenital anomalies

Ectopia vesicae

In this condition, the lower part of anterior abdominal wall and anterior wall of bladder are absent, and posterior wall of bladder is exposed to the exterior.

Urachal sinus, urachal fistula, and urachal cyst (fig. 17.5)

The urachus may remain patent only in the upper part (**urachal sinus**) or along entire extent (**urachal fistula**) or only a small part in the middle remains patent and forms cyst (**urachal cyst**).

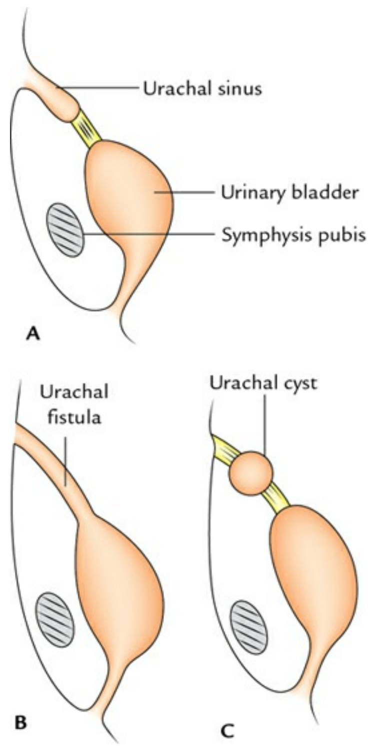


FIG. 17.5 Urachal sinus, fistula, and cyst.

❖ Describe male urethra under the following headings: (a) introduction, (b) parts, and (c) applied anatomy.

Introduction

The male urethra is a long narrow membranous canal for discharging urine and semen.

- It is 18–20 cm long.
- It is S-shaped, i.e., presents two curvatures.
- It extends from internal urethral orifice at the neck of bladder to external urethral orifice at the tip of glans penis.

Parts/divisions (fig. 17.6)

The male urethra is divided into the following 3 parts:

- Prostatic part
- Membranous part
- Spongy part

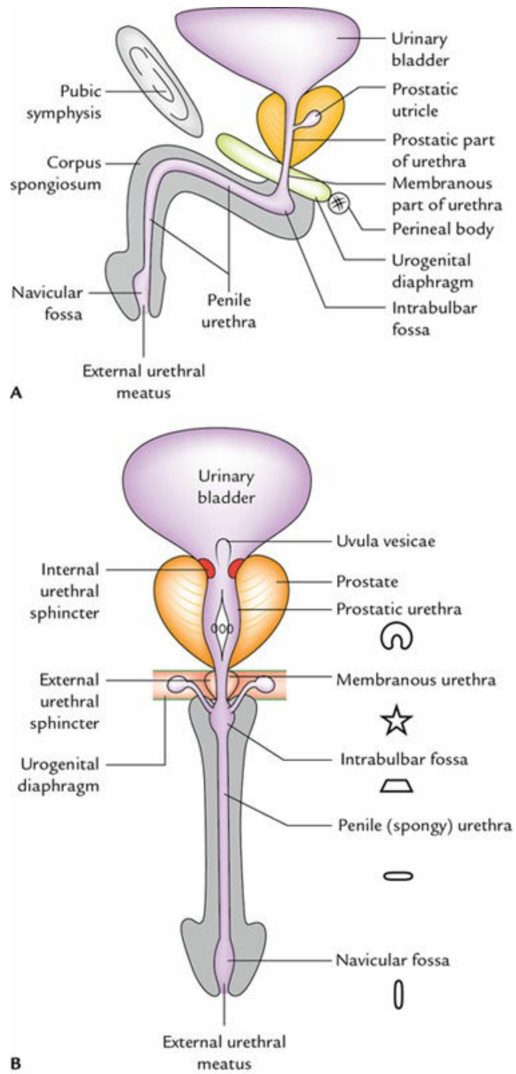


FIG. 17.6 Male urethra: A, shape; B, parts and their shapes.

The details of three parts are given in Table 17.1.

Table 17.1
Parts of the male urethra

Features	Prostatic part	Membranous part	Spongy part
Location	Within prostate	Within urogenital diaphragm	Within penis (corpus spongiosum)
Length	3 cm	1.5–2 cm	15 cm
Shape in cross section	Horseshoe shaped	Star-shaped	In the bulb-trapezoid In the body-transverse slit At external urethral orifice-vertical slit
Diameter and dilatability	Widest and most dilatable	Narrowest and least dilatable	Mostly uniform in diameter with medium dilatation
Other features	Presents: Urethral crest Prostatic sinus Verumontanum	Surrounded by external urethral sphincter	Presents: Intrabulbar fossa in bulb of penis Fossa terminalis/navicularis in glans penis
Openings	Prostatic utricle Ejaculatory ducts Prostatic glands	Minute mucous glands	Urethral glands (Littre's glands) Bulbourethral glands

Applied anatomy

Catheterization

During catheterization/instrumentation of male urethra to empty the distended and painful bladder, the normal curvatures should be kept in mind. Otherwise, the forceful insertion of metallic instrument may cause urethral rupture and create false passages.

Urethritis and stricture

The infection of urethra is called urethritis. The chronic urethritis may lead to urethral stricture.

Rupture of the urethra

It may occur when person falls astride with perineum hitting a sharp object.

- *Rupture of urethra below the perineal membrane* leads to **extravasation of urine** in the superficial perineal pouch, scrotum, penis, and lower part of anterior abdominal wall deep to Scarpa's fascia.
- *Rupture of urethra above the perineal membrane* leads to *extravasation of urine* in the extraperitoneal space of pelvis and lower part of anterior abdominal wall.

❖ Give a brief account of development of the male urethra.

Male urethra develops at the end of the 3rd month of IUL as follows:

Prostatic part

• Above the opening of ejaculatory ducts

❒ Anterior and lateral walls, from vesicourethral canal

❒ Posterior wall, from absorbed mesonephric ducts

• Below the opening of ejaculatory ducts, from pelvic part of definitive urogenital sinus.

Membranous part

From pelvic part of definitive urogenital.

Penile part

From phallic part of definitive urogenital sinus.

Terminal part

From surface ectoderm.

❖ Write a short note on the female urethra.

The female urethra is 4 cm long and 6 mm in diameter. It begins at the internal urethral meatus of bladder, opposite middle of pubic symphysis. It passes anteroinferiorly behind pubic symphysis, embedded in the anterior wall of vagina to open into vestibule of vagina above the vaginal orifice.

❖ Give differences between the male and female urethra.

	Male urethra	**Female urethra**
Length	18–20 cm	4 cm
Shape	S-shaped	Straight
Catheterization	Difficult	Easy
Location of external urethral orifice	Away from the surface of body at the tip of penis	At the surface of the body in vestibule of vagina

❖ Discuss histological features of the male urethra.

Histological features

In a histological section the wall of urethra presents 3 coats. From outside inward, these are: muscular coat, submucous coat, and mucosa.

Muscular coat

It consists of inner longitudinal and outer circular layer of smooth muscle fibers.

Submucous coat

It consists of erectile vascular tissue.

Mucosa

It presents regional variations:

- *Above the colliculus seminalis*, it is lined by transition epithelium.
- *Between colliculus seminalis and navicular fossa*, it is lined by stratified columnar epithelium.
- *Distal to navicular fossa*, it is lined by stratified squamous nonkeratinized epithelium.

Prostate

❖ Describe prostate under the following headings: (a) introduction, (b) external features, (c) relations, (d) lobes, (e) structural zones, (f) capsules (g) arterial supply, (h) venous drainage, and (i) applied anatomy.

Introduction

It is an accessory gland of male reproductive system and adds about 30% bulk to the semen.

• It is a conical (inverted cone) fibromuscular glandular organ surrounding the proximal part of the male urethra.

• It is located in the lesser pelvis below the neck of urinary bladder behind the lower part of the pubic symphysis.

• Its breadth is more than its length with following dimensions:

❒ Anteroposterior = 2 cm

❒ Vertical = 3 cm

❒ Transverse = 4 cm

External features (fig. 17.7)

The prostate presents: apex, base, and 4 surfaces.

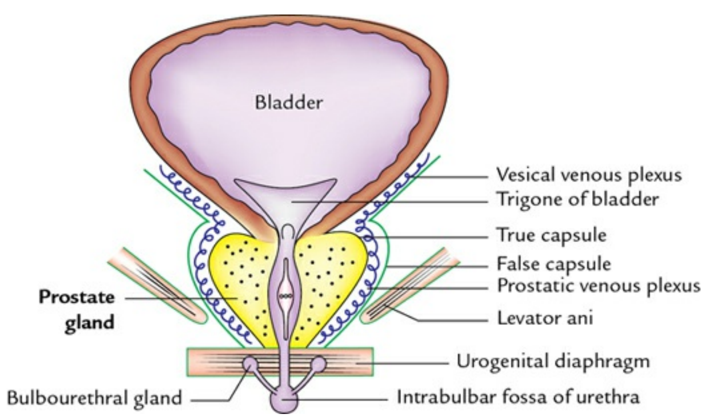


FIG. 17.7 Location of the prostate.

Apex

It is blunt, and prostatic urethra emerges from its front aspect.

Base

It is fused with the neck of bladder and perforated by urethra.

4 surfaces

- *Anterior*: It is narrow, convex, and situated 2 cm behind the lower part of pubic symphysis.
- *Posterior*: It is broad, flat and presents a transverse groove in the upper part.
- *Right and left inferolateral surfaces*: They are related to levator ani on the corresponding side.

Relations

Superiorly

Base of prostate is fused with the neck of urinary bladder. It is pierced by urethra near its anterior border.

Inferiorly

Apex of prostate blunt and rests on the urogenital diaphragm. The prostatic urethra emerges from its anterior aspect.

Anteriorly

Anterior surface of prostate is separated from pubic symphysis by **retropubic space** (cave of Retzius) filled with retropubic fat.

Laterally

Inferolateral surfaces are related to that part of levator ani, called **levator prostatae.**

Posteriorly

Posterior surface is separated from the rectum by **fascia of Denonvilliers.**

Lobes of the prostate (fig. 17.8)

The prostate is divided into 5 lobes: median/middle lobe, posterior lobe, anterior lobe, and lateral (right and left) lobes.

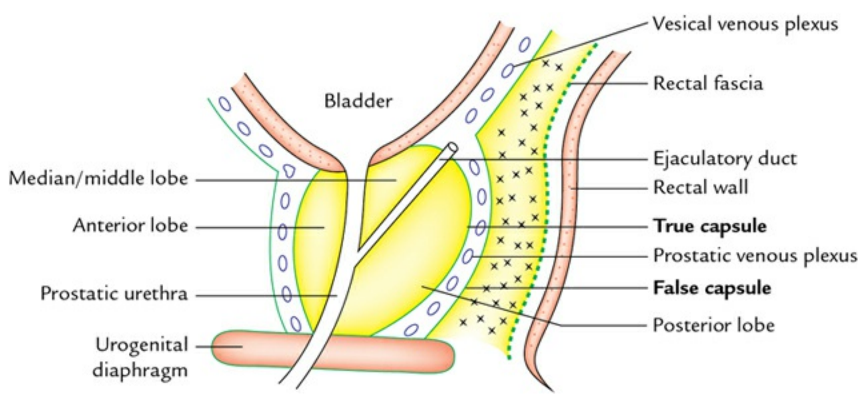


FIG. 17.8 Lobes and capsules of the prostate.

Median or middle lobe

It lies behind the upper part of the urethra and infront of ejaculatory ducts. It produces a slight elevation in the lower part of the trigone of bladder called *uvula vesicae*.

Median lobe is wedge-shaped and contains much glandular tissue; hence, it is a common site for an adenoma. The glandular tissue consists of *subtrigonal glands* and *subcervical glands of Albarran*. These mucous glands are clinically important because owing to their intimate relation to the bladder neck, even a slight degree of their enlargement may lead to obstruction of urine outflow causing urinary retention. The middle lobe also projects into the urethra, raising a median ridge in its floor called *urethral crest* or *verumontanum.*

Posterior lobe

It lies behind the middle lobe and connects the two lateral lobes. It is a common site of *primary carcinoma of prostate*.

Anterior lobe

It lies in front of urethra and does not contain glandular tissue. It is, in fact, a small isthmus connecting two lateral lobes.

Right and left lateral lobes

They lie one each side of urethra and contain some glandular tissue; hence, adenoma may occur rarely in these lobes in old age.

Structural zones of prostate

According to McNeal, structurally the prostate gland presents 3 concentric zones: peripheral, central, and periurethral.

Peripheral zone

It is a larger zone and situated posteriorly. It consists of long branching glands and forms 70% of the glandular tissue.

Central zone

It is situated posterior to the urethral lumen and above the ejaculatory ducts. It consists of submucosal gland and constitutes 25% of the glandular tissue.

Periurethral zone

It is transitional zone (5%), which along with central zone forms the *central gland*. The central zone consists of mucosal (suburethral glands).

Capsules of prostate

True capsule

It is a thin sheath that surrounds the gland intimately. It is formed by the condensation of peripheral fibrous stroma of the gland.

False capsule (or prostatic sheath)

It lies outside the true capsule and is derived from visceral layer of pelvic fascia. It continues with fascia surrounding the bladder above and with the fascia of Denonvilliers posteriorly.

The prostatic venous plexus lies between the true and false capsules.

N.B.

Pathological capsule (or *surgical capsule*) When benign (adenomatous) hypertrophy of the prostate (BHP) takes place, the peripheral part of the gland becomes compressed to form a capsule around the adenoma termed as pathological capsule.

While performing an enucleation of the prostatic adenoma, plane of cleavage should be between the adenomatous mass and surgical capsule so that prostatic venous plexus lying external to true capsule is not injured/damaged inadvertently.

Arterial supply

The prostate is supplied by the branches of:

- Inferior vesical artery
- Middle rectal artery
- Internal pudendal artery

Venous drainage

The veins draining prostate form rich venous plexus, which lies between the true and false capsules.

- It receives deep dorsal vein of penis and communicates above with the vesical venous plexus to form the *vesicoprostatic plexus*.
- It drains into internal iliac veins.

N.B.

Valveless communications exist between the prostatic venous plexus and vertebral venous plexus. Consequently, malignant cells of carcinoma prostate may spread into vertebral column, skull, and CNS.

Applied anatomy

Benign hypertrophy of prostate (BHP)

It is common after 50 years of age, hence also called *senile enlargement of prostate*. It mostly occurs in middle lobe due to hypertrophy of mucosal/periurethral glands of central zone. Clinically, it presents as increased frequency and urgency of the urination.

Carcinoma prostate

It commonly occurs after 55 years of age mostly in the posterior lobe/outer peripheral zone of prostate. Clinically, it presents as irregular fixed prostate with pain in perineum, urinary obstruction, and difficulty in urination.

Prostatectomy [surgical removal/enucleation of adenoma]

The adenoma is enucleated leaving behind all the capsules.

❖ Give histological features of the prostate gland.

The prostate is a compound tubuloalveolar/tubuloacinar gland. A histological section through it presents two components: stroma and parenchyma (Fig. 17.9).

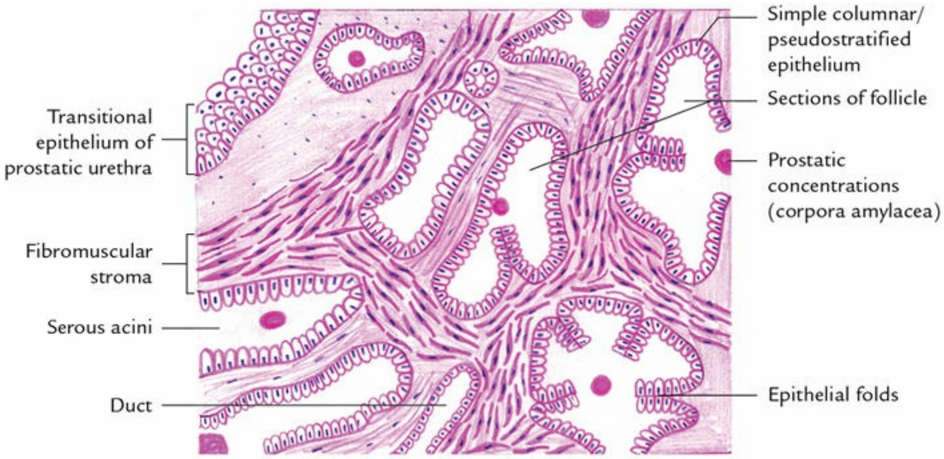


FIG. 17.9 Histological features of the prostate.

Stroma

It is fibromuscular and forms:

- Discrete bundles of muscle fibers surrounding serous alveoli and run in many directions.
- Thin capsule of collagen and smooth muscle fibers.

Parenchyma

It consists of serous acini and ducts.

- *Serous acini*

❒ Are large, irregular, and of different shapes.

❒ Have wide lumen, in old age some of them may contain small colloidal mass (amorphous eosinophilic mass) called *prostatic concretions/corpora amylacea* (*amyloid bodies*).

❒ Are lined by secretory tall columnar cells. The lining *epithelium shows aggressive infolding*.

- *Ducts*

❒ They may be seen between the acini.

- They are lined by bilaminar epithelium, an inner layer of columnar cells, and outer layer of cuboidal cells.

Uterus

❖ Describe uterus under the following headings: (a) introduction, (b) parts and cavities, (c) relations, (d) axis, (e) supports, (f) arterial supply, (g) lymphatic drainage, and (h) applied anatomy.

Introduction

The uterus is a childbearing thick-walled hollow muscular organ. It is situated in the lesser pelvis between the urinary bladder in front and rectum behind.

Parts (fig. 17.10)

It is piriform in shape (i.e., looks like an upside down pear) and subdivided into 3 parts. From above downward, these are: fundus, body, and cervix.

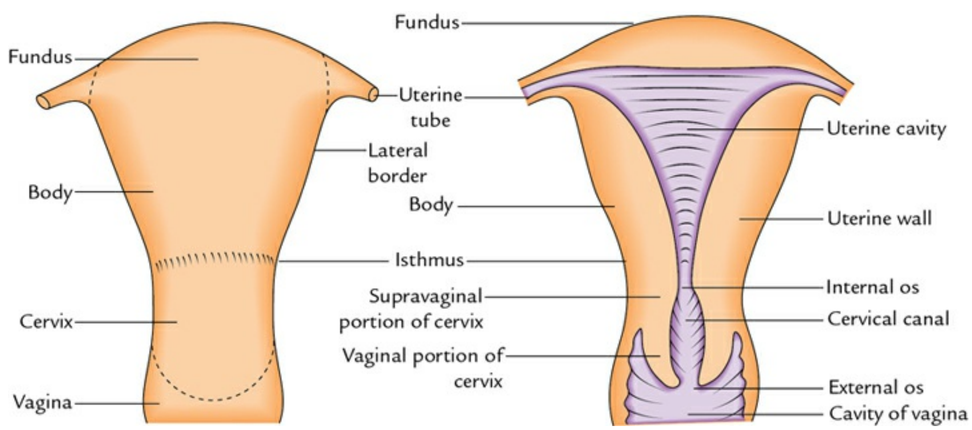


FIG. 17.10 Parts and cavities of the uterus.

Fundus

Upper dome-shaped part above the openings of uterine tubes.

Body

Part of uterus, which extends from fundus to isthmus. It has triangular cavity.

Cervix

Part of uterus below the isthmus having spindle-shaped cavity called cervical canal.

Relations

Fundus

Covered by the peritoneum.

Body

- *Anterior surface* is separated from urinary bladder by uterovesical pouch.
- *Posterior surface* is separated from rectum by rectouterine pouch containing sigmoid colon and coils of terminal part of ileum.

Cervix

- *Supravaginal part*

❒ *Anterior:* Urinary bladder

❒ *Posterior:* Rectouterine pouch and rectum

❒ *On each side:* Ureter and uterine artery

- *Vaginal part*

❒ *Anterior:* Base of urinary bladder

❒ *Posterior:* Rectouterine pouch

❒ *On each side:* Ureter crossed by the uterine artery

Axis (fig. 17.11)

The axis of uterus is defined by two terms: anteversion and anteflexion.

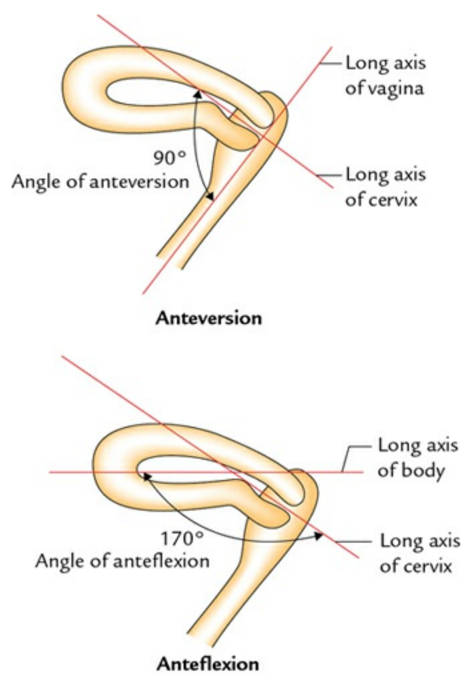


FIG. 17.11 Axis (angles of anteversion and anteflexion) of the uterus.

Anteversion

It is a forward angle between the long axis of cervix and long axis of vagina. It measures about 90°.

Anteflexion

It is a forward angle between the long axis of body and long axis of cervix. It measures about 120–170°.

Supports

The uterus undergoes extensive change in size and shape during reproductive period of life of the women. It is supported and prevented from sagging down by a number of factors called supports. The supports are classified into two types: primary and secondary.

Primary supports

- *Muscular or active supports*

❒ Pelvic diaphragm

❒ Urogenital diaphragm

❒ Perineal body

- *Ligamentous/fibromuscular/mechanical supports* (Fig. 17.12)

❒ Transverse cervical ligaments of Mackenrodt (most important)

❒ Round ligament of uterus

❒ Uterosacral ligament

❒ Pubocervical ligament

- *Visceral*

❒ Urinary bladder

❒ Vagina

❒ Uterine axis

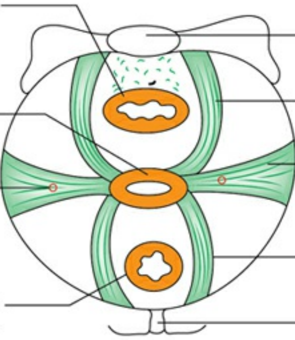


FIG. 17.12 Ligamentous supports of the uterus.

Secondary supports (formed by peritoneal ligaments)

- *Broad ligaments*
- *Uterovesical fold of peritoneum*
- *Rectovaginal fold of peritoneum*

The details of important supports are as follows:

- *Pelvic diaphragm*: It supports the pelvic viscera and resists any rise in intra-abdominal pressure.
- *Urogenital diaphragm*: It is formed by sphincter urethrae and deep transverse perinei muscles and enclosed between superior and inferior fasciae of the urogenital diaphragm.
- *Perineal body*: It is a fibromuscular node situated in the midline at the center of perineum. It provides attachment to nine muscles. It acts as an anchor to pelvic diaphragm and maintains the integrity of pelvic diaphragm.
- *Transverse cervical ligaments* (Mackenrodt's ligaments): These are formed by the condensation of the pelvic fascia on each side of the cervix above the levator ani around the uterine vessels. They are fan-shaped and connect the lateral aspects of the cervix and upper part of vaginal wall to the lateral pelvic wall. They keep the cervix in the midline and prevent the downward displacement of uterus through vagina.
- *Round ligaments of uterus*: These are two 10–12 long, flat fibromuscular bands lying between the two layers of the broad ligament, anteroinferior to the uterine tube. Each ligament begins at the lateral angle of uterus, runs forward and laterally, passes through the deep inguinal ring, transverses the inguinal canal, emerges through the superficial inguinal ring, and finally merges with the areolar tissue of the labium majus after breaking into thin filaments. It keeps the funds pulled forward and maintains the anteversion and anteflexion of uterus.
- *Uterosacral ligaments*: These are the condensation of the pelvic fascia, which connect the cervix to the periosteum of the sacrum and are enclosed within the rectouterine folds of peritoneum. They keep the cervix braced backward against the forward pull of the round ligaments on fundus and thus maintain the body of uterus in anteflexion.
- *Pubocervical ligaments*: These are a pair of fibrous bands derived from the pelvic fascia and connect the cervix to the posterior surface of the pubis. They keep the cervix in position by counteracting the pull of uterosacral ligaments.

Arterial supply

- Chiefly by the uterine arteries
- Partly by the ovarian arteries

Lymphatic drainage (Fig. 17.13) The lymph from the uterus is drained as follows:

- From *fundus and upper part of the body*, most of the lymph vessels pass along the ovarian vessels to drain into *para-aortic pre-aortic lymph nodes*. However, some lymph vessels from the region of lateral angle of uterus pass along the round ligament to drain into *superficial inguinal lymph nodes*.
- From *lower part of the body*, lymph vessels travel via broad ligament to drain into the external iliac lymph nodes.

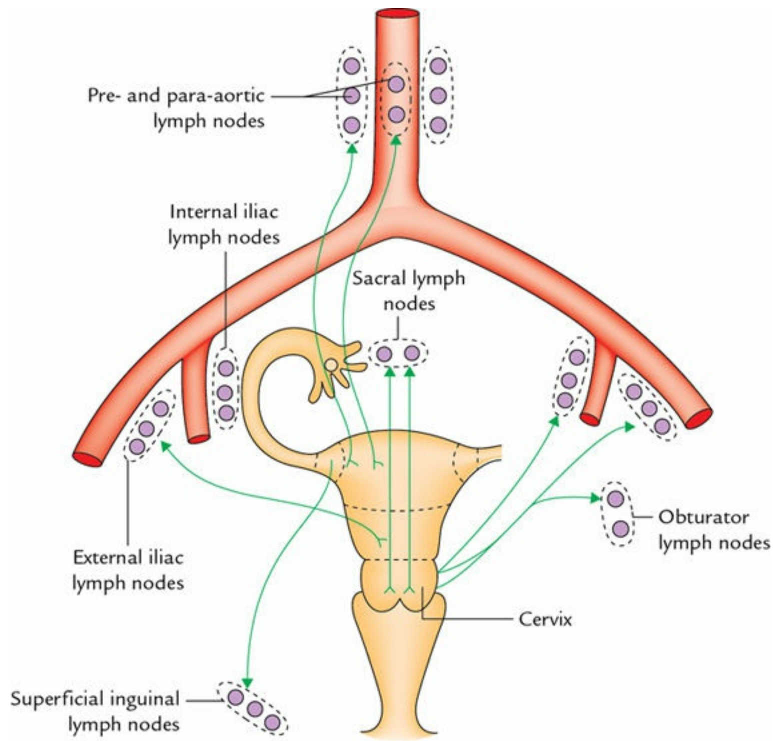


FIG. 17.13 Lymphatic drainage of the uterus.

From the *cervix*, lymph vessels pass:

❐ *Laterally* into broad ligament to drain into *external iliac lymph nodes*.

❐ *Posterolaterally* along the uterine vessels to drain into *internal iliac lymph nodes.*

❐ *Posteriorly* along the uterosacral ligaments to drain into *sacral lymph nodes*.

Applied anatomy

Carcinoma cervix

It is the second commonest cancer in females and often occurs in age group between 40 to 45 years. It is squamous cell carcinoma and spreads directly to adjacent structures.

Prolapse of uterus

In this condition, the uterus descends into the vagina. It occurs due to weakness of various supports of the uterus.

Hysterectomy

It is the surgical removal of uterus.

Caesarean section

It is the surgical procedure to deliver baby by incising the uterus in cases where vaginal delivery is difficult or not possible.

❖ Write a short note on broad ligament of the uterus.

It is a fold of peritoneum passing from the side of uterus to the lateral wall of the pelvis.

Contents

These are (Fig. 17.14):

- Uterine tube
- Round ligament of uterus
- Uterine vessels
- Ovarian vessels
- Ligament of ovary
- Some lymph vessels
- Uterovaginal and ovarian nerve plexuses
- Vestigial remnants of mesonephric duct and its tubules, viz.

❒ *Epoophoron*, a remnant of proximal mesonephric tubules.

❒ *Duct of Gartner*, a remnant of cephalic part of the mesonephric duct.

❒ *Paroophoron*, a remnant of distal mesonephric tubules.

- Extraperitoneal tissue

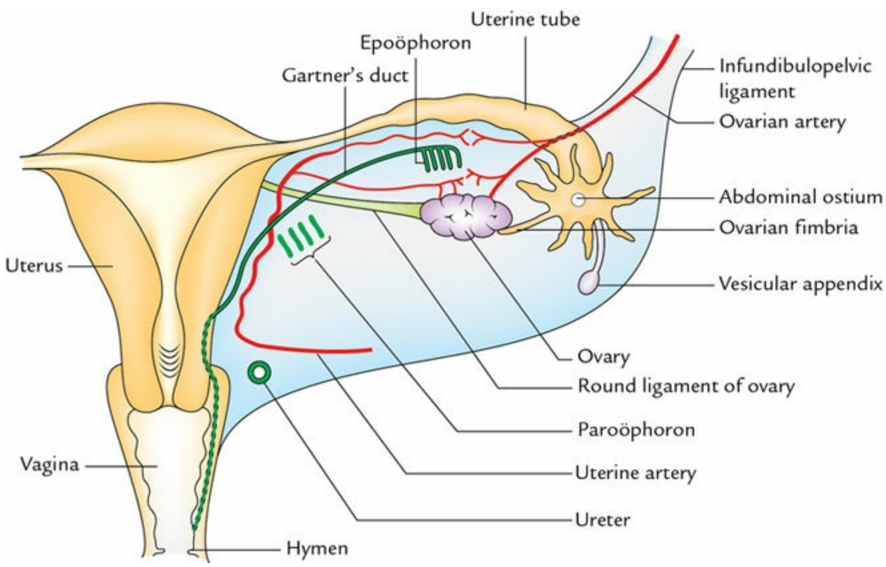


FIG. 17.14 Broad ligament of the uterus.

N.B.

The ureter as a rule is not a content of broad ligament.

Applied anatomy

The ureteric stone can be palpated on vaginal examination at the site, where ureter is in close relationship to the lateral fornix of vagina.

❖ Give a brief account of development of the uterus and associated common congenital anomalies.

Development (fig. 17.15)

The uterus develops from the following sources:

- *Most of uterus* develops from cephalic part of *uterovaginal canal* formed by the fusion of the caudal parts of the *paramesonephric ducts*.
- *Funds of uterus* is formed by the incorporation of segments of horizontal parts of the paramesonephric ducts.
- *Myometrium* is derived from surrounding mesoderm.

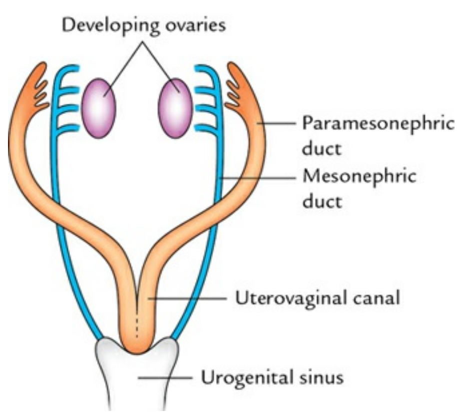


FIG. 17.15 Development of the uterus.

Congenital anomalies

These are as follows (Fig. 17.16):

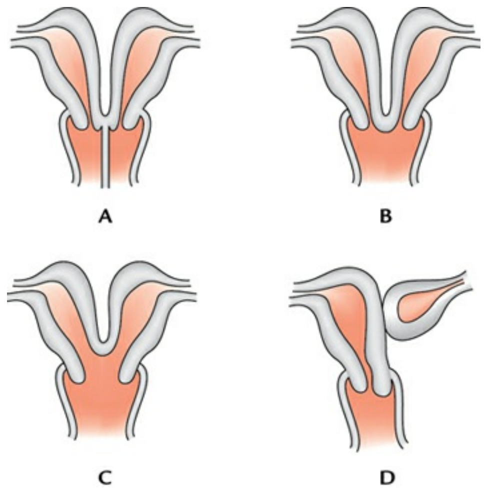


FIG. 17.16 Congenital anomalies of the uterus.

Double uterus (uterus didelphys) and double vagina (fig. 17.16a)

It occurs due to lack of fusion of paramesonephric duct and sinovaginal bulbs.

Double uterus with single vagina (fig. 17.16b)

It occurs when paramesonephric ducts fail to fuse.

Bicornuate uterus (fig. 17.16c)

In this case, the vagina and cervix are single, but the body of uterus is duplicated.

Unicornuate (fig. 17.16d)

In this case, half of the uterus is missing due to degeneration of one of the paramesonephric ducts.

Infantile uterus

In this condition, uterus remains rudimentary.

Agenesis of uterus (complete absence of uterus)

It occurs when paramesonephric ducts fail to develop.

❖ Describe histological features of the uterus.

In a histological section, wall of uterus presents 3 layers: from inside outward, these are: endometrium, myometrium (thickest coat), and perimetrium (Fig. 17.17).

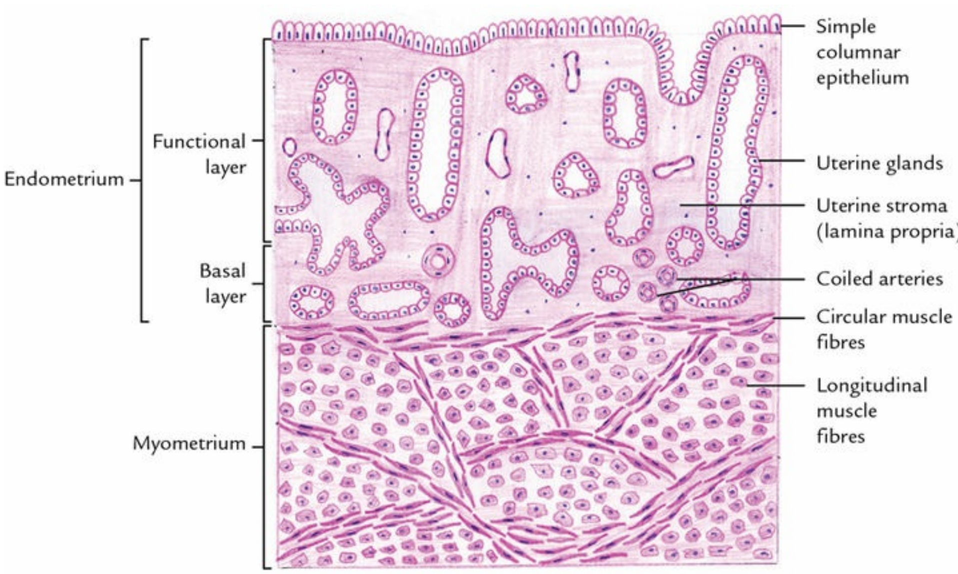


FIG. 17.17 Histological features of the uterus.

Endometrium/mucosa

Epithelium

Simple columnar epithelium with mixture of secretory and ciliated cells.

Lamina propria

It is thick and contains simple tubular glands lined by a layer of columnar cells with abundant interglandular stroma.

Uterine glands and stroma

They undergo changes in different phases of menstrual cycle.

- *Secretory phase*

❒ Glands become tortuous and dilated exhibiting saw-tooth appearance

❒ Stroma becomes oedematous

- *Proliferative phase*

❒ Glands are straight in upper parts and have narrow lumen with slight wavy appearance

❒ Stroma abundant with coiled arteries in deeper parts

• *Menstrual phase*

❒ Loss of epithelium

❒ Necrosis of walls of vessels

❒ Necrotic stroma, spiral arteries, and glands are sloughed off

❒ Presence of blood cells

❒ Presence of blood in uterine lumen

Myometrium/muscular layer (thickest layer)

• Consists of interlacing bundle of long smooth muscle fibers, which are arranged 3 ill-defined layers separated by connective tissue. The inner and outer layers are longitudinal, and middle layer is circular.

• Presence of large blood vessels in middle layer giving it a spongy appearance.

Perimetrium/serosa

Consists of a single layer of a mesothelial lining and a connective tissue layer.

N.B.

The **section through cervix** presents different histological features than fundus and body:

• It is not lined by endometrium.

• It is lined by tall columnar mucous secreting epithelium.

• The lamina propria contains branched tubular mucous secreting cervical glands.

• The vaginal portion of cervix is lined by stratified squamous epithelium.

❖ Write a short note on the uterine/fallopian tube.

The uterine tubes are a pair of ducts that convey the ova from the ovary to the uterus. Each tube is about 10 cm (4 inches) long and lies in the upper border of broad ligament. It is the site of fertilization of the ovum.

Parts

From lateral to medial, each tube is divided into 4 parts (Fig. 17.18):

- *Infundibulum*, 1 cm long
- *Ampulla*, 5 cm long
- *Isthmus*, 2.5 to 3 cm long
- Interstitial/intramural part, 1 cm long

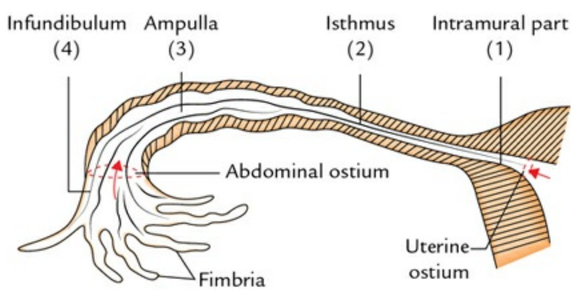


FIG. 17.18 Parts of the uterine tube.

Infundibulum

It is a funnel-shaped lateral end of uterine tube, which projects beyond the broad ligament. It bears finger like processes called *fimbriae*. One of the fimbriae which is longer than the others and remains in contact with the tubal pole of the ovary is called as *ovarian fimbria.* At the lateral end, the uterine tube opens into the peritoneal cavity through its *abdominal ostium*. It is about 3 mm in diameter.

Ampulla

It is thin-walled, dilated and tortuous, forming approximately lateral 2/3rd of the tube. It is about 4 mm in diameter. It is the commonest site of the fertilization.

Isthmus

It is thick, narrow, rounded, and cord-like. It is the narrowest part of the tube.

Interstitial part (intramural part)

It lies within the wall of the uterus.

Arterial supply

- Medial 2/3rd by uterine artery

- Lateral 1/3rd by ovarian artery

Applied anatomy

Salpingitis

It is inflammation of uterine tube. The chronic salpingitis can lead to tubal blockage.

Sterility

The most common cause of secondary sterility is the tubal blockage, which usually caused by infection, but may be congenital. The patency of the tube can be tested by:

- *Insufflation test (Rubin's test)*: If the tube is patent, when the air pushed into uterus, it passes through uterine tube and leaks into peritoneal cavity. The leakage of air into peritoneal cavity produces bubbling/hissing sound, which can be auscultated over the iliac fossae.

- *Hysterosalpingography*: It is a radiological technique, in which the cavities of uterus and fallopian tubes are visualized by injecting a radiopaque substance into the uterine cavity.

❖ Describe histological features of the fallopian tube.

The wall of fallopian tube consists of 3 coats. From inside outward, these are mucosa, muscular coat, and serous coat (Fig. 17.19).

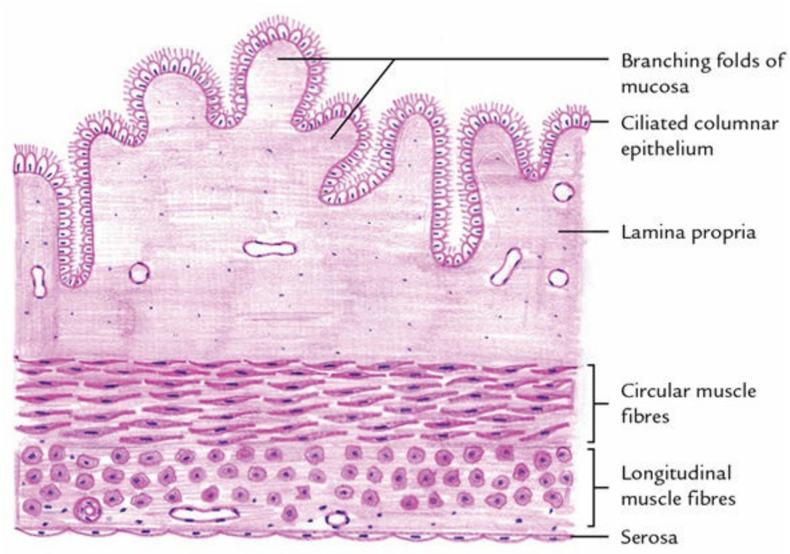


FIG. 17.19 Histological features of the fallopian tube.

Mucosa

- Is lined by both ciliated and nonciliated columnar cells.
- *Lamina propria* consists of loose connective tissue (highly vascular). It is thrown into numerous longitudinal folds, which branch but do not anastomose. However, they form labyrinth. Because of these folds, the *lumen* is highly irregular.

Muscular coat

It is made up of inner circular and outer longitudinal layer of smooth muscle fibers.

Serous coat

It is outermost layer lined by mesothelial cells.

❖ Write a short note on vagina.

- It is fibromuscular canal extending from cervix of uterus to the vestibule of the vagina.
- It is situated behind the urinary bladder and urethra and in front of rectum and anal canal.
- Its diameter gradually increases from below upward.
- Its lumen is circular at the upper end, a transverse slit in the middle, and H-shaped in the lower part.
- Its anterior wall is 7.5 cm long, while its posterior wall is 9 cm long.
- Its lower end is closed by a thin annular fold of mucous membrane, the *hymen*, in married women it ruptures and is represented by rounded tags around the vagina orifice called *caruncuIae hymenales.*
- Its upper end forms a circular recess around the cervix called *fornix.*

Functions

- Acts as an organ of copulation in female
- Forms the longest part of the birth canal during childbirth

Arterial supply

- Vaginal artery, a branch of internal iliac artery
- Branches of uterine and internal pudendal arteries

❖ Give the histological features of the vagina.

The wall of vagina from inside outward consists of 3 coats: mucosa, muscular coat, and adventitia.

Mucosa

It is lined by stratified squamous nonkeratinized epithelium consisting of 16–18 layers of cells.

Lamina propria It is made up of dense connective tissue with many elastic fibers (highly vascular).

N.B.

Lamina propria does not contain glands; the vaginal epithelium is kept moist by glands of the cervix.

Muscular coat

It consists of ill-defined inner circular and outer longitudinal layers of smooth muscle fibers intermingled with elastic fibers.

Adventitia

It is made up of fibrous tissue containing numerous thick elastic fibers.

❖ Describe ovary under the following headings: (a) introduction, (b) external features, (c) relations, (d) arterial supply, (e) venous drainage, (f) lymphatic drainage, (g) nerve supply, and (h) applied anatomy.

Introduction

- They are a pair of female gonads, which produce ova and female sex hormones viz. estrogen and progesterone.
- Each ovary is almond-shaped and situated in ovarian fossa in the lateral wall lesser pelvis below the pelvic brim.
- It lies on each side of uterus and attached to the posterior layer of broad ligament by a short peritoneal fold called *mesovarium*.

External features

- *Two surfaces*: medial and lateral.
- *Two borders*: anterior (mesovarian) and posterior (free).
- *Two poles*: upper (broader) and lower (narrower).

Relations (fig. 17.20)

Peritoneal relations

Ovary is covered by a single layer of low cuboidal epithelium called – *germinal epithelium* (modified peritoneum). Along the mesovarian border peritoneum forms *mesovarium*.

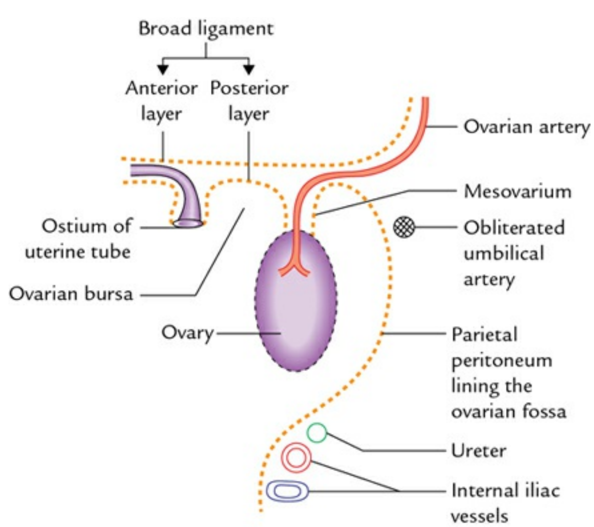


FIG. 17.20 Relations of the ovary.

Visceral relations

- *Poles*

❒ *Upper or tubal pole*: It is directed upward and is related to the distal end of uterine tube.

❒ *Lower or uterine pole*: It is directed downward and is connected to the lateral angle of the uterus by the ligament of the ovary.

- *Borders*

❒ *Anterior or mesovarian border*: It is straight and is related to uterine tube and the obliterated umbilical artery. It presents hilum.

❒ *Posterior or free border*: It is convex and is related to uterine tube in the upper part and ureter in the lower part.

- *Surfaces*

❒ *Lateral surface*: It is convex and lies in the ovarian fossa. It is related to obturator vessels and nerves separated by a peritoneum.

❒ *Medial surface*: It is related to the terminal part of the uterine tube separated by ovarian bursa, a peritoneal recess between the mesosalpinx and the ovary.

Arterial supply

- *Ovarian artery (main artery)*, a branch of the abdominal aorta which reaches the ovary through suspensory ligament of the ovary.

- *Uterine artery*, a branch of the internal iliac artery which reaches the ovary via mesovarium.

Venous drainage

Right ovarian vein drains into the inferior vena cava, while the left ovarian vein drains into the left renal vain.

Lymphatic drainage

Lymphatics from ovary drain into the **preaortic** and **paraaortic** nodes along the side of origin of ovarian artery.

Nerve supply

By both sympathetic and parasympathetic fibers.

Sympathetic fibers

Derived from T10–T11 segments. These are vasoconstrictors and form afferent pathway to pain; hence, ovarian pain is referred to the loin and groin.

Parasympathetic fibers

Derived from S2, S3, and S4 segments. These are vasodilators.

Applied anatomy

Oophoritis

It is an inflammation of the ovary. It may produce localized peritonitis of ovarian fossa and an eventual irritation of obturator nerve, which may lead to pain that is referred to medial aspect of the thigh.

Ovarian tumors

The ovary is a common site for carcinoma, teratoma, and secondaries.

- Carcinoma of ovary is common and accounts for 15% of all cancers and 20% of gynecological cancers.
- Commonest secondary tumor of ovary is *Krukenberg's tumor*, which occurs via transcoelomic migration of cancer cells from carcinoma breast.

Ovarian cysts

Are common and occur as a result of developmental arrest of ovarian follicles.

Prolapse of ovary

Ovary is frequently displaced into the recto-uterine pouch (pouch of Douglas).

❖ Give histological features of the ovary.

The ovary is solid ovoid organ covered by cuboidal epithelium (germinal epithelium). Beneath, this is a thin layer of connective tissue called tunica albuginea. Part deep to tunica albuginea is demarcated into 2 zones: (a) outer cortex and (b) inner medulla (Fig. 17.21).

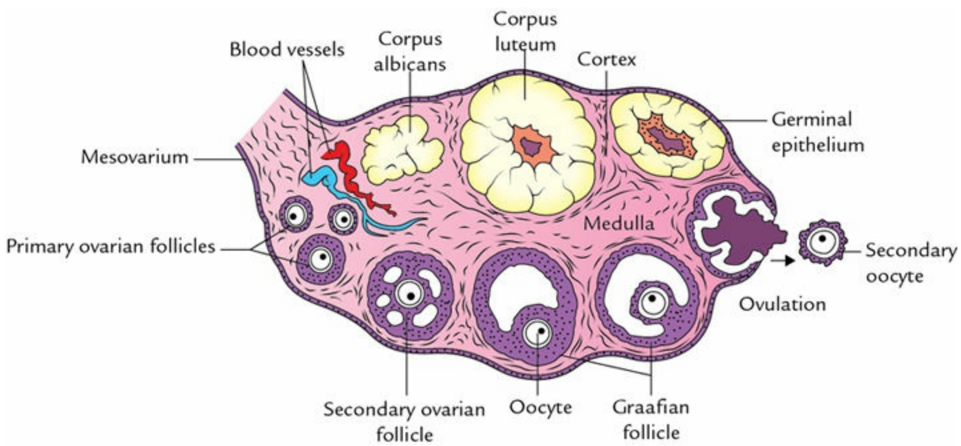


FIG. 17.21 Histological features of the ovary.

Cortex

It contains numerous ovarian follicles in various stages of the development:

- *Primordial follicles*, consisting of primary oocyte covered by a single layer of flat cells.
- *Primary follicles*, consisting of primary oocyte covered by a single layer of cuboidal cells.
- *Secondary follicles*, consisting of oocyte covered by zona pellucida and membrana granulosa.
- *Graafian follicles* are fluid filled follicles with ovum at one side embedded in a mass of cells called *cumulus oophorus.*

Medulla

It consists of connective tissues presenting *swirly appearance*. It contains several blood vessel (mostly veins) and smooth muscle fibers.

❖ Write a short note on the ovarian fossa.

The ovarian fossa is a peritoneal depression in the lateral pelvic wall where the ovary lies.

Boundaries (fig. 17.22)

Anterior

Obliterated umbilical artery.

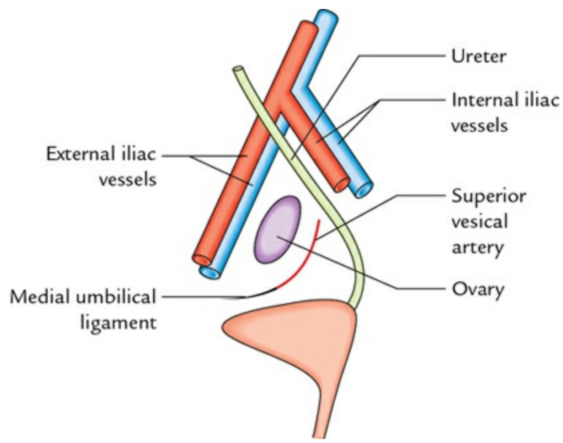


FIG. 17.22 Boundaries of the ovarian fossa.

Posterior

Ureter, internal iliac artery.

Superior

External iliac vein.

Floor

Peritoneal depression beneath which passes obturator nerve and vessels.

Applied anatomy

- In case of ovarian cyst rupture, the fluid may be collected in this fossa.
- *Oophoritis* (inflammation of ovary) may cause localized peritonitis of ovarian fossa and eventually irritate the obturator nerve. This manifests as pain on the medial aspect of the thigh.

❖ Describe rectum under the following headings: (a) introduction, (b) curvatures, (c) relations, (d) arterial supply, (e) venous drainage, (f) lymphatic drainage, and (g) applied anatomy.

Introduction

- It is a distal part of the large intestine between the sigmoid colon and anal canal.
- It joins the anal canal at an angle of 90° angle forming an *anorectal flexure.*
- It is 12 cm long and lies in the lesser pelvis in front of last 3 pieces of sacrum and coccyx.
- Its lower dilated part is called *ampulla,* which initiates an urge to defecate when feces enter into it.

Curvatures (fig. 17.23)

The rectum lies in the median plane at the beginning as well as at the end, but it shows two types of curvature in its course.

- *Two anteroposterior curvatures*

❒ *Sacral flexure:* It follows the concavity of sacrum and coccyx.

❒ *Perineal flexure:* It is the backward bend at the anorectal junction.

- *Three lateral curvatures*

❒ Upper lateral curvature is convex to the right.

❒ Middle lateral curvature is convex to the left.

❒ Lower lateral curvature is convex to the right.

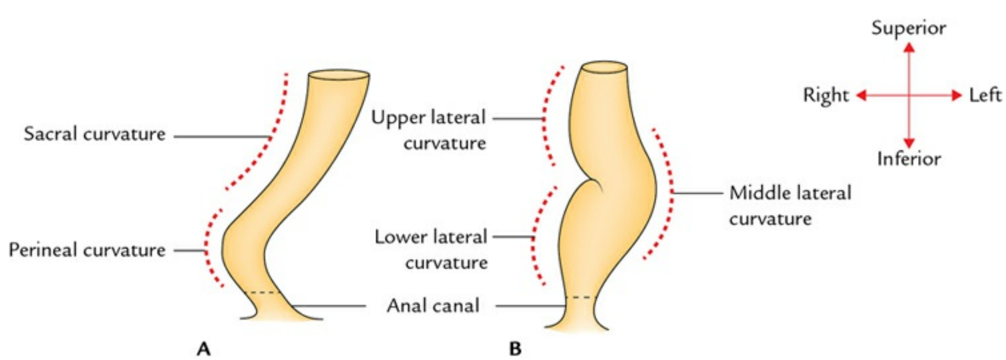


FIG. 17.23 Curvatures of the rectum.

Relations (fig. 17.24)

Peritoneal relations

- *Upper 1/3rd* of rectum is covered by peritoneum anteriorly and at the sides.
- *Middle 1/3rd* of rectum is covered by peritoneum only anteriorly.
- *Lower 1/3rd* of rectum is not covered by peritoneum.

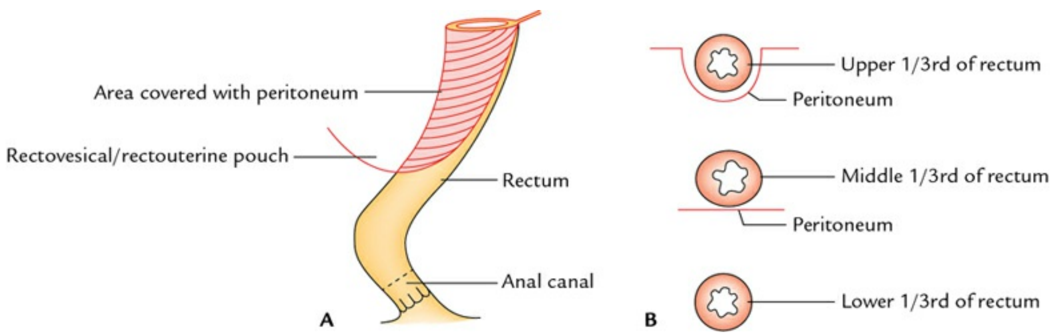


FIG. 17.24 Peritoneal relations of the rectum.

Visceral relations

In male

- *Upper 2/3rd*

❒ Recto-vesical pouch

❒ Coils of ileum and sigmoid colon

- *Lower 1/3rd*

❒ Base of urinary bladder

❒ Terminal parts of ureters

❒ Seminal vesicles

❒ Ampullae of ducti deferens

❒ Prostate

In female

- *Upper 2/3rd*: Rectouterine pouch containing coils of ileum.
- *Lower 1/3rd*: Lower part of the vagina.

Posterior relations

They are same in male and female as follows:

- Lower 3 pieces of the sacrum, coccyx, and anococcygeal body.
- Piriformis, coccygeus, and levator ani muscles.
- Median sacral, superior rectal, and lateral sacral arteries.
- Sympathetic trunks with the ganglion impar, anterior primary rami of sacral and coccygeal nerves, and pelvic splanchnic nerves.

Arterial supply

The rectum is supplied by 4 arteries: one superior rectal, two middle rectal, and one median sacral.

- *Superior rectal artery* provides the main supply. It is the continuation of the inferior mesenteric artery.
- *Middle rectal arteries* are the branches of the anterior divisions of the internal iliac arteries.
- *Median sacral artery* is a direct continuation of aorta.

N.B.

The two inferior rectal arteries, the branches of the internal pudendal arteries (from the anterior division of internal iliac arteries), are said to supply rectum, but strictly speaking, they supply anal canal.

Venous drainage (fig. 17.25)

- *Superior rectal veins* that continue upward as inferior mesenteric vein and drain into portal system.
- *Middle rectal veins* drain into internal iliac veins.
- *Inferior rectal veins* drain into internal pudendal veins.

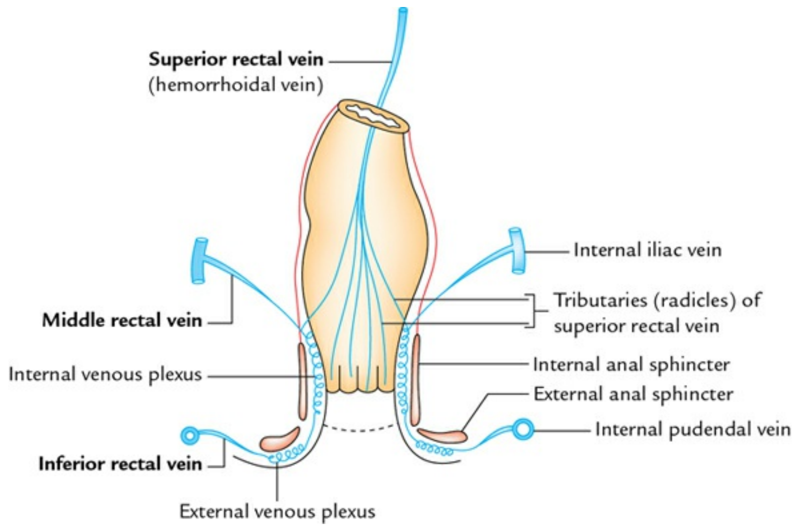


FIG. 17.25 Venous drainage of the rectum.

N.B.

There are free anastomoses between the tributaries of these veins in the rectal wall.

Lymphatic drainage (fig. 17.26)

- *Lymphatics from the upper half* accompany the superior rectal vessels and drain into the **inferior mesenteric nodes**. A few of these vessels are intercepted by the **pararectal lymph nodes** situated on each side of the rectosigmoid junction.
- *Lymphatics from the lower half* accompany the middle rectal vessels and drain into the **internal iliac nodes.**

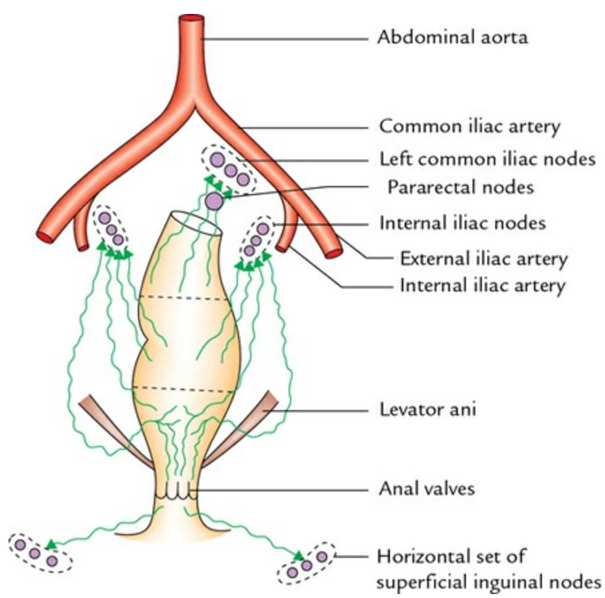


FIG. 17.26 Lymphatic drainage of the rectum.

Applied anatomy

Per-rectal examination

It is commonly done in clinical practice to palpate following structures:

- *In male*

❐ Posterior surface of prostate

❐ Seminal vesicles

❐ Vasa deferentia

- *In female*

❐ Perineal body

❐ Cervix

Prolapse of rectum (procidentia)

It is the protrusion of rectum through anus. It can be incomplete or complete.

In incomplete prolapse, there is protrusion of only mucosa while in complete prolapse, the whole thickness of rectal wall protrudes through the anus.

CHAPTER 18

Perineum

❖ Write a short note on the perineum.

It is the lowest part of the trunk below the pelvic diaphragm. It is traversed by urethra and anal canal in the male and vagina and anal canal in the female. The external genitalia are located on the surface of perineum.

Boundaries

Superficial

- *Anterior*: Scrotum in the male and mons pubis in the female.
- *Posterior*: Buttocks.
- *On each side*: Upper part of medial aspect of the thigh.

Deep

- *Anterior*: Inferior margin of pubic symphysis.
- *Posterior*: Coccyx.
- *On each side*: From before backward, ischiopubic ramus, ischial tuberosity, and sacrotuberous ligament.

Divisions

A transverse line passing through anterior ends of two ischial tuberosities divides the perineum into two triangular areas:

- *Anterior triangle*, the urogenital region.
- *Posterior triangle*, the anal region.

❖ Write a short note on the perineal body.

It is fibromuscular node situated in the midline of perineum at the junction of urogenital and anal triangles. In the male, it lies close to the bulb of penis, while in female it lies between canal and pudendal cleft. It develops from the tip of urorectal septum.

Formation (fig. 18.1)

It is formed by 10 muscles: 4 paired and 2 unpaired.

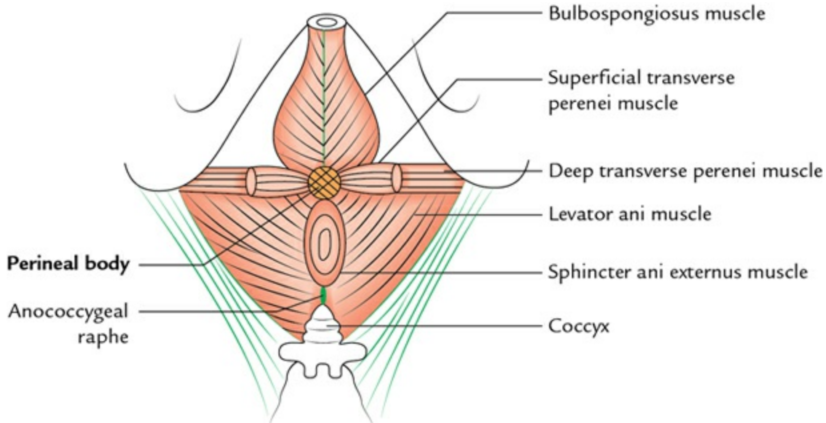


FIG. 18.1 Perineal body.

Paired

- Bulbospongiosus
- Superficial transverse perinei
- Deep transverse perinei
- Levator ani

Unpaired

- Sphincter ani externus (external anal sphincter)
- Conjoint longitudinal muscle coat of anal canal

Applied anatomy

- *Damage of perineal body, viz. during parturition*: It weakens the pelvic floor and leads to prolapse of the uterus and vagina.
- *Episiotomy (incision of vulva)*: It is given to facilitate the childbirth and prevent rupture of the perineal body in primiparous females.

❖ Write a short note on the perineal membrane.

It is a strong triangular membrane (fascial sheath) that stretches across the urogenital triangle between the ischiopubic rami at the sides. It intervenes between the deep perineal pouch above and the superficial perineal pouch below, thus forming the inferior boundary of deep perineal pouch and the superior boundary of superficial perineal pouch.

- In front, it is thickened to form the *transverse perineal ligament* and is continuous with the superior fascia of the urogenital diaphragm.

- Behind, it is fixed to the perineal body in the midline and splits into two layers. The upper layer is continuous with the superior fascia of urogenital diaphragm, while inferior layer is continuous as Colles' fascia.

❖ Enumerate the structures piercing the perineal membrane.

The structures piercing the perineal membrane are given in the box below and shown in Figure 18.2.

In male	In female
Urethra	Urethra
Ducts of bulbourethral glands	Vagina
Artery and nerve to the bulb of penis	Artery and nerve to the bulb of vestibule of vagina
Dorsal artery of penis	Dorsal artery of clitoris
Deep artery of penis	Deep artery of clitoris
Posterior scrotal nerve and vessels	Posterior labial nerve and vessels
Branches of the perineal nerve to superficial perinei muscles	Branches of the perineal nerve to superficial perinei muscles

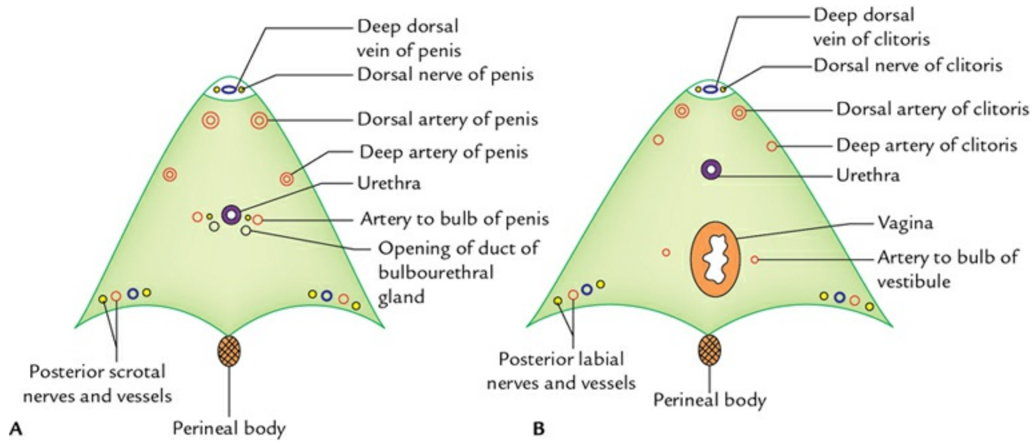


FIG. 18.2 Structures piercing perineal membrane.

❖ Write a short note on the urogenital diaphragm.

The urogenital diaphragm (UD) is musculofascial partition across the pubic arch below the pelvic diaphragm separates the true pelvic cavity from the anterior part of the pelvic outlet.

Formation

It is a triangular muscle sheet formed by sphincter urethrae and deep transverse perinei muscles. On the deeper aspect, it is covered by a thin layer of endopelvic fascia called *superior fascia of the urogenital diaphragm*, and on the superficial aspect, it is covered by the perineal membrane called *inferior fascia of the urogenital diaphragm* (for details, see textbook of Anatomy Vol. II by Vishram Singh).

This triangular diaphragm occupies the urogenital triangle with its apex behind the pubic symphysis and its sides are attached to the ischiopubic rami. It contains bulbourethral glands in the male.

Structures piercing UD

- *In male*: Urethra.
- *In female*: Urethra and vagina.

Relations

Below

Superficial perineal pouch.

Above

- Apex of prostate in male/neck of bladder in female.
- Anterior fibres of levator ani muscles.
- Anterior recesses of ischiorectal fossa.

In front

Triangular gap between arcuate pubic ligament and transverse perineal ligament. This gap transmits deep dorsal vein of penis/clitoris.

Actions

- Supports prostate/bladder
- Constricts vagina in female
- Fixes perineal body
- Constricts urethra

❖ Write a short note on the superficial perineal pouch.

The superficial perineal pouch is a space between Colles' fascia and perineal membrane.

Boundaries

- *Inferior/floor* Colles' fascia.
- *Superior (roof)* Perineal membrane.
- *On each side* Ischiopubic ramus.
- *Posterior* Posteriorly, the space is closed by the fusion of Colles' fascia and perineal membrane.
- *Anterior* Anteriorly, it remains open and is continuous with spaces of scrotum, penis, and lower anterior abdominal wall.

Contents

Table 18.1 shows the contents of superficial pouch in the male and female.

Table 18.1

Structures within the superficial perineal pouch (see Fig. 18.3)

In male	In female
Root of the penis • Bulb of penis covered by the bulbospongiosus muscles • Crura of penis covered by the ischiocavernosus muscles	Root of the clitoris • Bulbs of vestibule covered by the bulbospongiosus muscles • Crura of clitoris covered by the ischiocavernosus muscles
Superficial transverse perinei muscles	Superficial transverse perinei muscles
Ducts of bulbourethral glands	Greater vestibular glands (Bartholin glands)
Urethra (within the bulb of penis)	Urethra
Branches of the internal pudendal artery • Perineal artery • Dorsal artery of penis • Deep artery of penis	Branches of the internal pudendal artery • Perineal artery • Dorsal artery of clitoris • Deep artery of clitoris
Branches of the pudendal nerve • Perineal nerve • Dorsal nerve of penis	Branches of the pudendal nerve • Perineal nerve • Dorsal nerve of clitoris

Applied anatomy

Rupture of urethra The rupture of urethra superficial to perineal membrane leads to **extravasation of urine in superficial perineal pouch** which subsequently accumulates in the scrotum, penis, and anterior abdominal wall deep to Scarpa's fascia, and may extend up to the axilla.

❖ Write a short note on the deep perineal pouch.

The deep perineal pouch is an interfascial space between the superior and inferior fascia of the urogenital diaphragm (Fig. 18.3). It is situated deep to perineal membrane in the region of urogenital triangle.

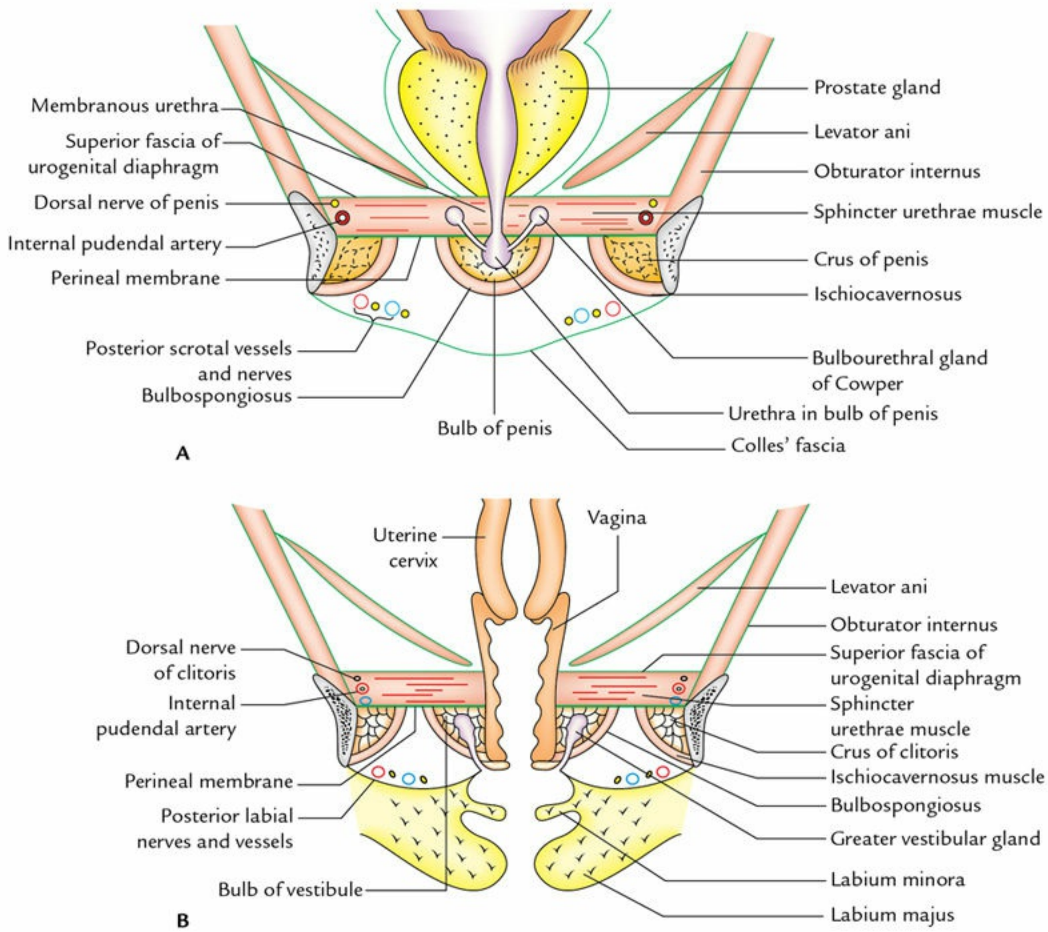


FIG. 18.3 Boundaries and contents of the deep and superficial perineal pouches.

Boundaries repetition

- *Below*: Perineal membrane/inferior fascia of urogenital diaphragm.
- *Above*: Superior fascia of urogenital diaphragm.
- *On each side*: Ischiopubic ramus.
- *Posteriorly*: Space is closed by the union of perineal membrane with the superior fascia of the urogenital diaphragm.

- *Anteriorly*: Space is closed by the union of perineal membrane with the superior fascia of the urogenital diaphragm at transverse perineal ligament.

Contents

In male

- Membranous urethra
- Bulbourethral glands
- Dorsal nerve of penis
- Artery of penis
- Muscular branches of perineal nerve
- Sphincter urethrae muscle
- Deep transverse perinei muscle

In female

- Urethra
- Vagina
- Dorsal nerve of clitoris
- Sphincter urethrae muscle
- Deep transverse perinei muscle

Applied anatomy

The rupture of urethra, deep to perineal membrane, leads to extravasation of urine in the extraperitoneal space of the pelvis, which subsequently accumulates in the anterior abdominal wall.

❖ Describe the ischiorectal/ischioanal fossa in brief.

Introduction

- It is a wedge-shaped space on each side of anal canal below the pelvic diaphragm. The two fossae communicate with each other behind the anal canal. They are filled with fat, which help in dilatation of rectum and anal canal, during defecation (i.e., passage of feces).
- *Dimensions*: Length, width, and depth = 2" × 1" × 2".

Boundaries (fig. 18.4)

Lateral

Fascia covering obturator internus and medal surface of ischial tuberosity.

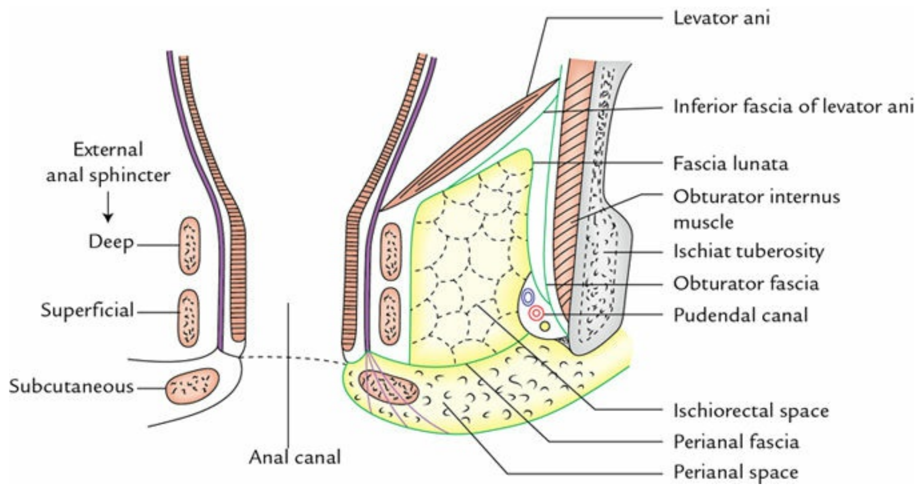


FIG. 18.4 Boundaries of the ischiorectal fossa.

Medial

Fascia covering levator ani in the upper part and external anal sphincter in the lower part.

Posterior

Sacrotuberous ligament.

Anterior

Posterior border of perineal membrane.

Floor (base)

Perinea skin.

Roof (apex)

Meeting point of fascia covering obturator internus and anal fascia (inferior fascia of pelvic diaphragm).

Recesses

Anterior recess

It extends above the urogenital diaphragm and reaches up to the posterior surface of body of the pubis.

Posterior recess

It is small and present deep to the sacrotuberous ligament.

Horseshoe recess

It connects 2 ischiorectal fossae behind the anal canal.

Contents (fig. 18.5)

- Ischiorectal pad of fat
- Inferior rectal nerve and vessels
- Perineal branch of the 4th sacral nerve (S4)
- Posterior scrotal (or labial) nerves and vessels
- Perforating cutaneous branch of S2 and S3
- Pudendal canal and its contents

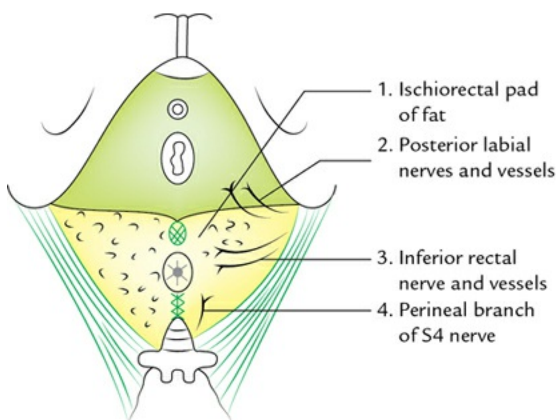


FIG. 18.5 Contents of the ischiorectal fossa.

Applied anatomy

- Loss of fat in the fossa may lead to rectal prolapse, especially in the young children.
- *Ischiorectal abscess*: Ischiorectal fossa is the common site of infection due to its location and often leads to ischiorectal abscess. This abscess may either burst into anal canal or on the surface of perineum or both. In last case track may form connecting surface of perineum to anal canal called a *fistula in ano*. The unilateral abscess may become bilateral through horseshoe recess.

❖ Describe the pudendal canal (Alcock's canal) in brief.

- It is a fascial tunnel situated in the lateral wall of the ischiorectal fossa about 2.5 cm above the ischial tuberosity.
- It extends from the lesser sciatic notch to the deep perineal pouch.
- It conveys pudendal nerve and internal pudendal vessels from lesser sciatic notch to the deep perineal pouch.

Formation

It is formed either by splitting of the fascia lunata or by splitting of obturator fascia or by separation between lunata and obturator fascia.

Contents

- Pudendal nerve, which divides within the canal into the dorsal nerve of penis and perineal nerve.
- Internal pudendal vessels.

The arrangement of structures within the canal from above downward is as follows:

- Dorsal nerve of penis or clitoris
- Internal pudendal vein
- Internal pudendal artery
- Perineal nerve

❖ Describe the pudendal nerve in brief.

The pudendal nerve provides principal innervation to the perineum.

Origin, course, and distribution (fig. 18.6)

The pudendal nerve arises from ventral rami of S2, S3, and S4 in the pelvis. It leaves the pelvis through greater sciatic foramen below the piriformis muscle, medial to internal pudendal vessels. It crosses the dorsum of ischial spine and immediately disappears through the lesser sciatic foramen to enter the pudendal canal (Alcock's canal).

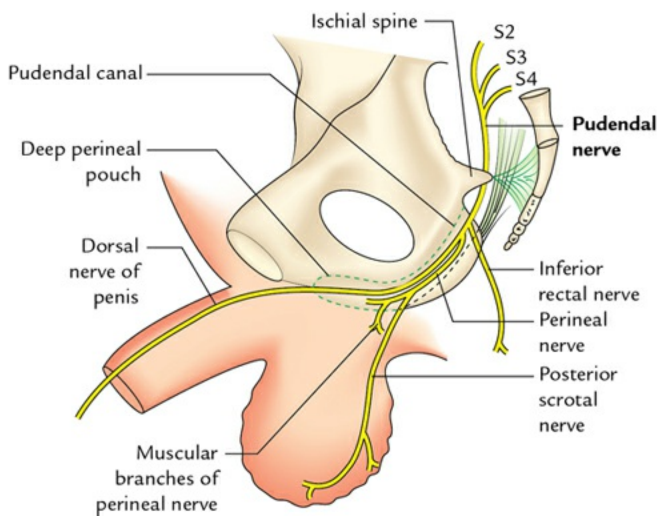


FIG. 18.6 Course and branches of the pudendal nerve.

In the posterior part of the canal, it gives off: (a) *inferior rectal nerve*, which crosses the fossa to innervate the external anal sphincter, perianal skin, and anal canal, (b) a large perineal nerve, and (c) a small dorsal nerve of the penis (or clitoris).

The *perineal nerve* bifurcates almost at once into deep and superficial branches. The deeper branch supplies the sphincter urethrae and other muscle of urogenital triangle, viz. superficial and deep transverse perinei, ischiocavernosus and bulbospongiosus. Its superficial branch innervates the posterior 2/3rd of scrotum (or labium majus) through posterior scrotal (or labial nerves).

The *dorsal nerve of penis (or clitoris)* runs in the pudendal canal and in the deep perineal pouch close to the pubic arch, then traverses through a gap below the arcuate pubic ligament to reach on the dorsum of penis.

Branches

- Inferior rectal nerve
- Perineal nerve
- Dorsal nerve of penis/clitoris

Applied anatomy

Pudendal nerve block

It is given to anesthetize the perineum. In this, the pudendal nerve is infiltrated with local anesthetic agent where it crosses the ischial spine. The needle is passed through vaginal wall and then guided by finger near to the ischial spine.

❖ Describe anal canal under the following headings: (a) introduction, (b) relations, (c) interior, (d) anal sphincters, (e) arterial supply, (f) venous drainage, (g) nerve supply, (h) lymphatic drainage, and (i) applied anatomy.

Introduction

The anal canal is about 3.8 cm long terminal part of the large intestine. It is situated below the pelvic diaphragm in the anal triangle between the ischiorectal fossae. It extends downward and backward from anorectal flexure (½" below and 1" in front of the coccyx) to anus.

Relations

Anterior

- *In male*

❐ Perineal body

❐ Membranous urethra

❐ Bulb of the penis

- *In female*

❐ Perineal body

❐ Lower part of the vagina

Posterior

- Anococcygeal ligament
- Tip of the coccyx

Interior of anal canal

The interior of anal canal is divided into upper and lower parts by the *pectinate line*, which represents the site of attachment of anal membrane in embryonic life.

Characteristic features of the upper part

- Lined by the mucous membrane with simple columnar epithelium. It is reddish in color due to rich blood supply.
- Mucous membrane shows 6–10 longitudinal folds called *anal columns of Morgagni*.

- Lower ends of anal columns are united to each other by transverse folds of mucous membrane called *anal valves.*
- Above these valves, there are small pockets (vertical depressions) called *anal sinuses*. The anal glands open into these sinuses.

Characteristic features of the lower part

- *Upper 15 mm called pecten/transitional zone*

❒ Lined by mucous membrane, which is bluish in appearance due to the presence of rich venous plexus underneath.

❒ Mucosa is less mobile as compared to that above the pectinate line.

❒ Limited below by *Hilton's line*, which corresponds to intersphincteric groove.

❒ Lined by stratified squamous epithelium without sebaceous or sweat glands.

- *Lower 8 mm called cutaneous part*

❒ Lined by true skin containing sweat glands, sebaceous glands, and hair.

❒ Lining epithelium is stratified squamous keratinized.

The differences between the upper and lower parts are given in Table 18.2.

Table 18.2

Differences between the upper and lower parts of anal canal

Features	Upper parts of anal canal	Lower parts of anal canal
Development	From endoderm of the hind gut	From ectoderm of proctodeum
Innervation	Autonomic nerves, hence insensitive to pain and temperature	Somatic nerves, hence sensitive to pain and temperature
Epithelial lining	Simple columnar	Stratified squamous
Arterial supply	Superior rectal artery	Inferior rectal artery
Venous drainage	Superior rectal vein draining into portal system	Inferior rectal vein draining into caval system
Lymphatic drainage	Internal iliac lymph nodes	Superficial inguinal lymph nodes (horizontal set)
Length	15 cm	23 cm

Anal sphincters (fig. 18.7)

They form the powerful sphincteric mechanism at the distal end of gastrointestinal tract. There are two anal sphincters:

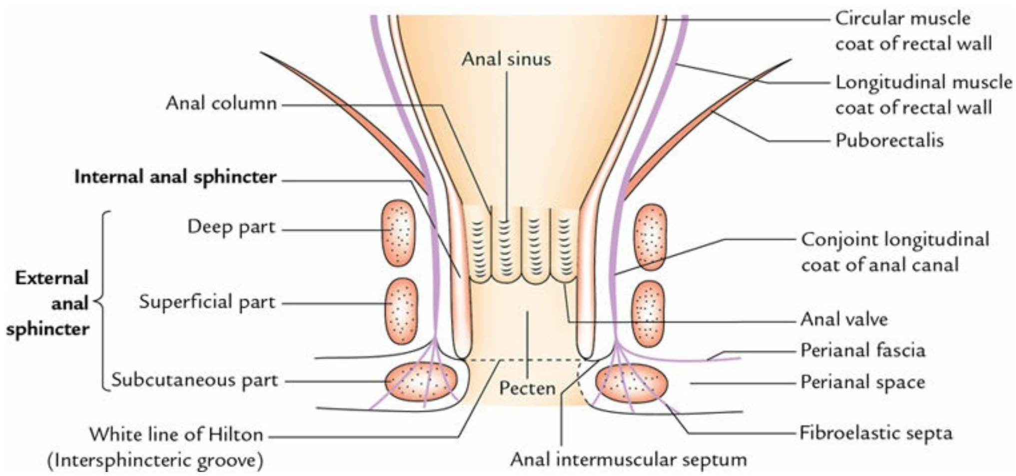


FIG. 18.7 Anal canal and its sphincters.

Internal anal sphincter

- It is formed by the thickened circular smooth muscle coat of rectal wall surrounding the upper 3/4th of the anal canal.
- It extends from anorectal junction to intersphincteric groove (*Hilton's line*) of the anal canal.
- It is surrounded by the deep and superficial parts of the external anal sphincter.
- It is supplied by autonomic fibres, hence involuntary in nature.

External anal sphincter

It is a muscular ring that surrounds the entire length of the anal canal. It is divided into three parts.

- *Deep part*: It completely encircles the upper part of the anal canal and has no bony attachment. The puborectalis blends with the deep part of external sphincter behind and forms a sling around the anorectal junction, which is attached anteriorly to the back of the pubis. In the resting state, the anorectal tube is angled forward at this level, and contraction of puborectalis sling will increase this angle, an important factor in the continence mechanism.
- *Superficial part*: It is elliptical in shape and lies below the deep part. It arises from tip of coccyx and anococcygeal body behind. It sweeps forwards around the sides of lower part of internal sphincter to get inserted into the perineal body.
- *Subcutaneous part*: It lies below the internal sphincter in the perianal space and encircles the anal orifice. It has no bony attachment. It is traversed by fibroelastic septa derived from conjoint longitudinal coat of anal wall.

The external anal sphincter is made up of striated muscle and supplied by somatic nerves, inferior rectal nerve, and perineal branch of the 4th sacral. It is therefore under voluntary control.

Arterial supply

- Above the pectinate line, by the *superior rectal artery*, a continuation of inferior mesenteric artery.
- Below the pectinate line, by the *inferior rectal artery*, a branch of the internal pudendal artery.

Venous drainage

- Venous blood from above the pectinate line is passed through internal rectal venous plexus into superior rectal vein, a tributary of portal vein.
- Venous blood from below the pectinate line is drained into *inferior rectal vein*, a tributary of systemic vein.

Nerve supply

- Above the pectinate line by autonomic nerve; hence, anal canal above this line is insensitive to pain.
- Below the pectinate line by inferior rectal nerve, a branch of pudendal nerve (somatic nerve); hence, anal canal below the pectinate line is sensitive to pain.

Lymphatic drainage

- Above the pectinate line into *internal iliac lymph nodes*.
- Below the pectinate line into *superficial inguinal lymph nodes* (horizontal set).

Applied anatomy

Internal piles

These are *saccular dilatations of internal rectal venous plexus*. They occur above the pectinate line and painless. For this reason, internal piles remain asymptomatic for a long time till they become big enough to rupture and cause painless bleeding per rectum.

External piles

These are dilatations of external venous plexus. They lie below the pectinate line and are sensitive to touch, pain and temperature.

Anal fissure

The faecolith catching on the fold of the mucous membrane (anal valves) and dragging it down rupture the valves and form an elongated ulcer called anal fissure.

Anal fistulae

The infection of anal sinus due to impaction of fecal matter may cause on abscess in the wall of the anal canal. Which finds its way both into ischiorectal fossa and perianal skin, forming *anal fistula.*

❖ Write a short note on the development of the anal canal.

The anal canal develops in the 7th week of intrauterine life (IUL) from two sources (Fig. 18.8).

- *Upper 2/3rd* develops from primitive rectum, hence endodermal in origin.
- *Lower 1/3rd* develops from anal pit/proctodeum, hence ectodermal in origin.

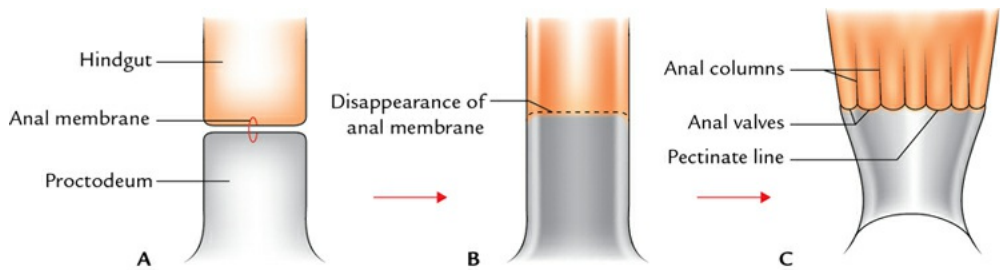


FIG. 18.8 Development of the anal canal.

N.B.

The line of junction between the two parts is represented by the *pectinate line*.

Congenital anomalies

- *Imperforate anus*, it occurs when the membrane fails to break down due to abnormal development of urorectal septum.
- *Anal agenesis*, in this condition, the anal canal ends blindly.

SECTION III
Lower limb

OUTLINE

CHAPTER 19

Osteology

❖ Write a short note on iliac crest.

- It is S–shaped, flattened upper border of the ilium.
- It is subdivided into two segments:

❒ Larger ventral segment (anterior 2/3rd)

❒ Smaller dorsal segment (posterior 1/3rd).

Attachments

These are given in the box below and shown in Figure 19.1:

Segment	Attachments
Ventral segment	
Anterior 2/3rd	From outside to inside External oblique Internal oblique Transversus abdominis
Posterior 1/3rd	From outside to inside Latissimus dorsi Quadratus lumborum
Dorsal segment	
Outer sloping area	Gluteus maximus
Inner sloping surface	Erector spinae

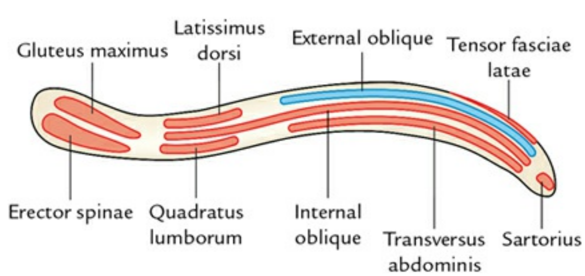


FIG. 19.1 Attachments on iliac crest (right side).

Applied anatomy

Bone grafting

The iliac crest is often used for bone grafting.

Bone marrow examination

The iliac crest is the preferred site for bone marrow aspiration in the children.

❖ Write a short note on greater sciatic notch.

It is a large bony notch on the posterior border of ilium, above the ischial spine. It is divided into upper and lower parts by the piriformis muscle.

Structures

Structures passing through the greater sciatic notch (Fig. 19.2):

• Piriformis passes through the middle of the notch

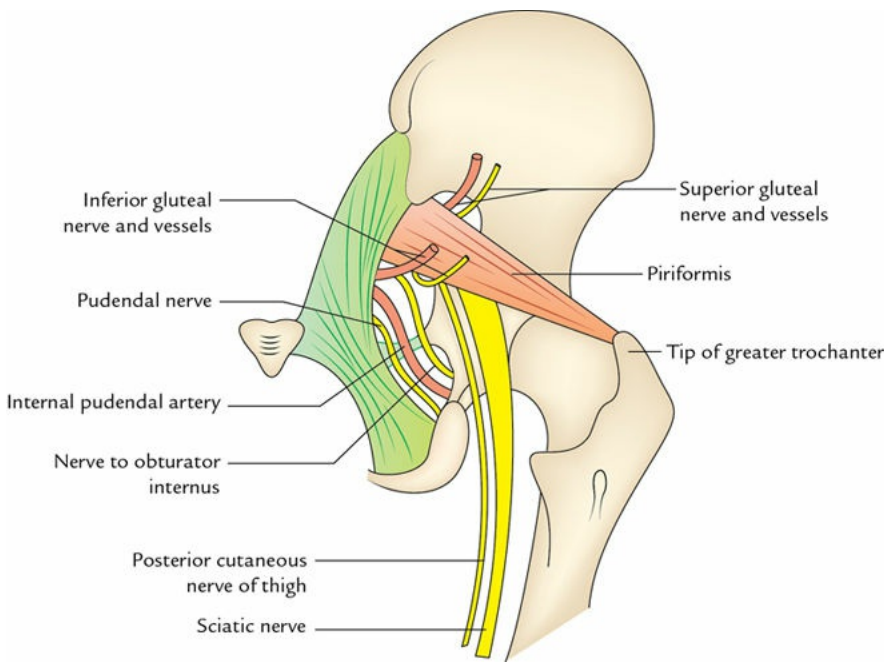


FIG. 19.2 Structure passing through greater and lesser sciatic notches.

Structures passing above piriformis:

• Superior gluteal vessels

• Superior gluteal nerve

Structures passing below piriformis:

• Sciatic nerve

• Pudendal nerve

❐ Internal pudendal vessels

❐ Nerve to obturator internus

❐ Inferior gluteal nerve and vessels

❒ Posterior femoral cutaneous nerve

❖ Write a short note on lesser sciatic notch.

It is a small bony notch on the posterior border of ilium below the ischial spine.

Structures passing through the lesser sciatic notch (Fig. 19.2):

- Tendon of obturator internus
- Pudendal nerve – PIN structures
- Internal pudendal vessels – PIN structures
- Nerve to obturator internus – PIN structures

❖ Write a short note on ischial tuberosity.

It is a rough tuberosity present on the lower end of dorsal surface of the ischium.

Subdivisions (fig. 19.3)

It is divided by a transverse ridge into upper quadrilateral and lower triangular areas. The upper quadrilateral area is further subdivided by an oblique ridge into upper lateral and lower medial parts. The lower triangular area is subdivided by a longitudinal ridge into lateral and medial parts.

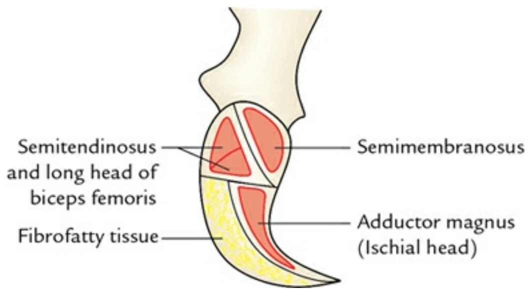


FIG. 19.3 Attachments of ischial tuberosity.

Attachments (fig. 19.3)

These are given in the box below:

Parts	Attachments
Upper quadrangular area	
Upper lateral part Lower medial part	Tendon of semimembranosus (origin) Common tendon of semitendinosus and long head of biceps femoris (origin)
Lower	
Lateral part Medial part	Ischial part of adductor magnus (origin) Sacrotuberous ligament along the medial margin

❖ Enumerate muscles attached to the greater trochanter.

Six muscles attached to the greater trochanter are:

- *Gluteus minimus*: On the anterior surface.
- *Gluteus medius*: On the lateral surface into an oblique ridge.
- *Obturator internus*: On the trochanteric fossa.
- *Obturator externus*: In the medial surface.
- *Piriformis*: On the apex.
- *Quadratus femoris*: On the quadrate tubercle.

❖ Enumerate structures attached to the linea aspera.

It is a thick posterior border of femur presenting medial and lateral lips. It provides attachment to 9 structures: 2 intermuscular septa and 7 muscles (Fig. 19.4).

- *Medial intermuscular septum* } Two septa
- *Lateral intermuscular septum* }
- *Vastus intermedius* } Three vasti
- *Vastus lateralis* }
- *Vastus medialis* }
- *Adductor magnus* } Three adductors
- *Adductor brevis* }
- *Adductor longus* }
- *Short head of biceps femoris* – One other muscle

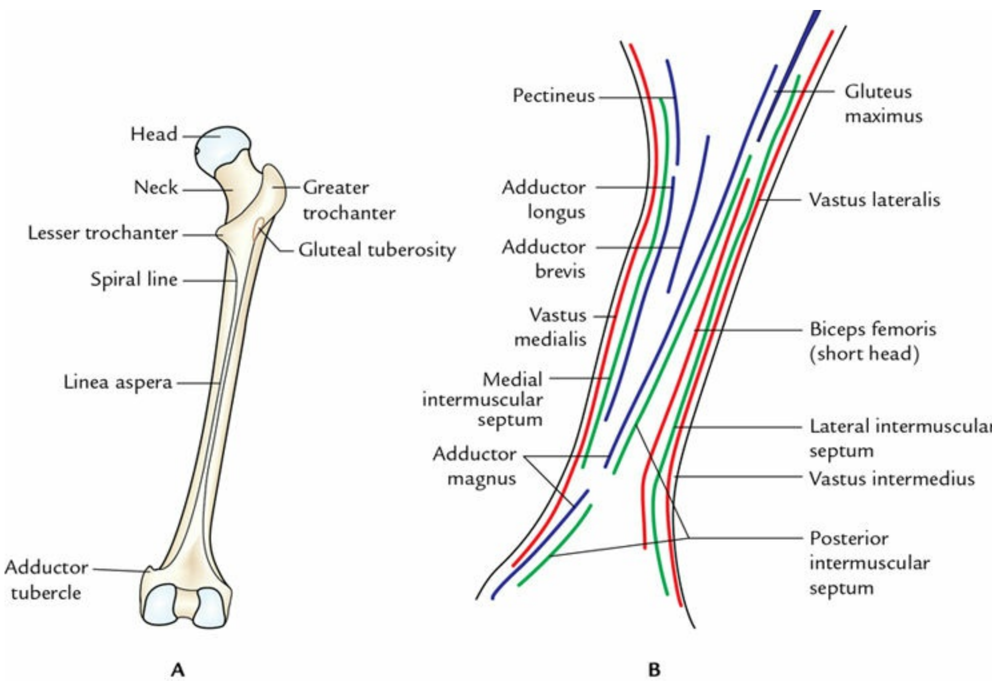


FIG. 19.4 Structures attached to linea aspera.

❖ Write a short note on the adductor tubercle.

It is a conical bony projection at the lower end of femur posterosuperior to the medial epicondyle.

Attachments

- Tendon of ischial/hamstring part of the adductor magnus
- Tibial collateral ligament

Applied anatomy

The lower epiphyseal plate of the femur in children passes through the adductor tubercle. The growth in length of femur is essentially due to activity at this plate. Therefore, any interference with it in children will affect the growth of femur in length causing shortening of the limb.

❖ Avascular necrosis of the head of femur is common in intracapsular fracture neck of femur. Give the anatomical basis.

The head of femur is supplied in 3 sets of vessels (Fig. 19.5):

- *Artery of head of femur*, a branch of the ascending branch of medial circumflex femoral artery
- *Nutrient artery*, a branch of the 2nd perforating branch of profunda femoral artery
- *Retinacular arteries*, derived from medial and lateral circumflex femoral arteries (most important source of blood supply)

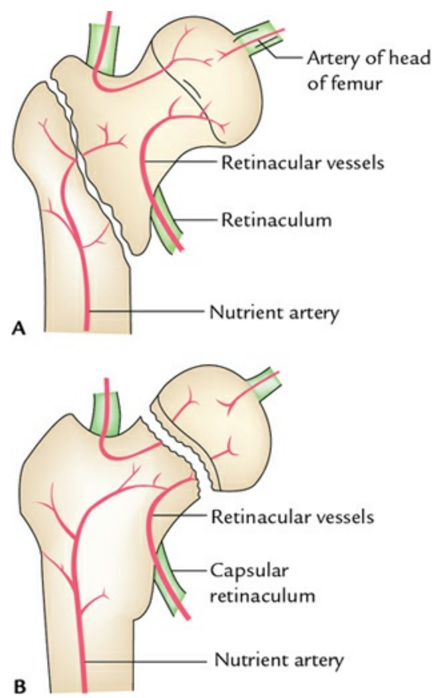


FIG. 19.5 Blood supply and fractures of the neck of femur: A, extracapsular fracture of the neck; B, intracapsular fracture of the neck.

The avascular necrosis of head of femur commonly occurs in intracapsular fracture neck of femur due to because of the involvement/damage of the retinacular vessels.

❖ Write a note on the ossification center at the lower end of the femur.

The ossification center of the lower end of femur occurs at birth (9 months). Therefore, the presence of this center in radiograph of a newly born child found dead suggests that the baby was full term and viable (Fig. 19.6).

FIG. 19.6 Radiograph showing ossification at the lower end of femur (arrow).

❖ Enumerate the sites of sesamoid bones in the lower limb.

- *Patella*: In the tendon of quadriceps femoris.
- *Fabella*: In the lateral head of the gastrocnemius.
- *A sesamoid bone*: In the tendon of peroneus longus where it winds around the cuboid.
- *Two sesamoid bones* below the head of the 1st metatarsal; one in each half of the tendon of *flexor hallucis brevis*.

N.B.

Patella is the largest sesamoid bone in the body.

CHAPTER 20

Thigh

❖ Describe great saphenous vein under the following headings: (a) formation and course, (b) tributaries, (c) perforators, and (d) applied anatomy.

The great saphenous (in Greek saphês = easily seen) vein is the longest vein of the body. It drains the venous blood from whole of lower extremity, except the medial side of leg. It represents the preaxial vein of the lower limb.

Formation and course (fig. 20.1)

It is formed on dorsum of the foot, by the union of medial end of dorsal venous arch and medial marginal vein of the foot. It runs upward in front of medial malleolus and crosses obliquely on medial surface of lower third of tibia. It ascends a little behind the medial border of tibia to reach knee about one hand's breadth posterior to patella. Then, it runs along the medial side of thigh to drain into the femoral vein after piercing cribriform fascia of saphenous opening.

- *Peculiarities*: It contain 10 to 15 valves, which prevent backflow of venous blood. One of the valves is always present at saphenofemoral junction.

- *Perforating veins* (perforators) connect saphenous vein to deep vein.

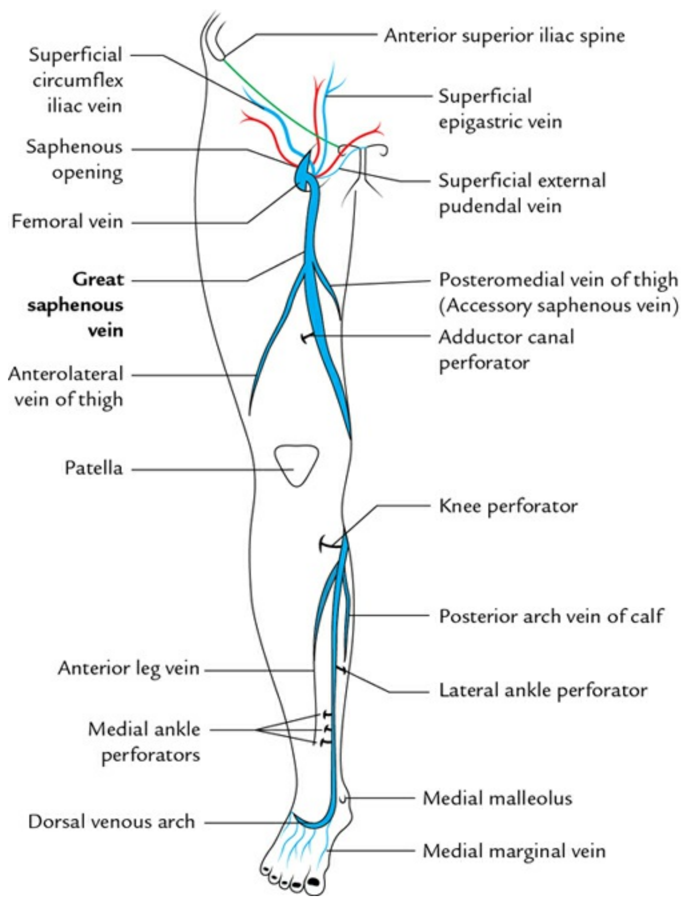


FIG. 20.1 Saphenous vein.

Tributaries

Medial marginal vein.

- Anterior leg vein
- Posterior arch vein of calf
- Posteromedial vein of thigh (accessory saphenous vein)
- Anterior lateral vein of thigh
- Superficial epigastric vein
- Superficial circumflex iliac vein
- Superficial external pudendal vein
- Deep external pudendal vein

Communicating vein to small saphenous vein.

Perforators

These are communicating channels that connect the superficial long saphenous vein with the deep veins. They are provided with the valves that permit the flow of blood only from superficial to deep veins.

Sites of perforators

Location of the perforators is fairly constant. These are:

- *Adductor canal perforator*, in the lower part of adductor canal.
- *Knee perforator*, just below the knee, close to the medial border of the tibia.
- *Lateral ankle perforator*, at the junction of middle and lower 1/3rd of lateral leg.
- *Three medial angle perforators*, close to the medial border of the lower third of the tibia.

Applied anatomy

Varicose veins

These are dilated tortuous and enlarged veins commonly seen in the lower limb. They often occur in people who are standing for long time (e.g. traffic police personnels). The valve within perforators and one at saphenofemoral junction become incompetent. As a result, the flow of the blood is reversed. The defective veins become 'high pressure leaks'. Consequently, the superficial veins become dilated and tortuous forming *varicose veins*. The blood is stagnated in the superficial veins causing gradual degeneration of their valves and subsequent formation of *varicose ulcers.*

Great saphenous vein graft

The great saphenous vein is commonly used for arterial grafting in coronary artery bypass surgery. Due to the presence of valves, a segment of vein to be used for grafting is reversed.

❖ Write a short note on superficial inguinal lymph nodes.

The superficial inguinal lymph nodes (4 to 5 in number) are arranged in the form of a letter 'T' (Fig. 20.2).

- *Horizontal set* lies along the inguinal ligament.
- *Vertical set* lies along the upper part of the great saphenous vein.

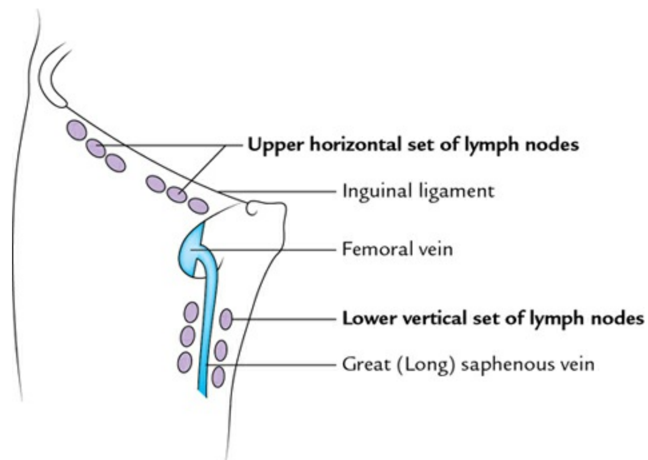


FIG. 20.2 Superficial inguinal lymph nodes.

Areas drained

- *Lower vertical set* receives lymph from whole of the lower limb except from lateral side of the back of the leg and lateral side of the heel and foot.
- *Upper horizontal set*

❐ *Lateral group* receives lymph from buttock, flanks and back.

❐ *Medial group* receives lymph from anterior abdominal wall, below umbilicus, external genitalia except glans penis part of anal canal below the pectineal line, vagina below the hymen, penile part of the male urethra and superolateral angle of the uterus.

N.B.

Lymph from superficial inguinal lymph nodes is drained into deep inguinal lymph nodes.

Applied anatomy

The upper medial group of superficial inguinal lymph node is often enlarged if there is any infection in their drainage area (vide supra).

❖ Write a short note on the saphenous opening.

It is an oval opening in the fascia lata (deep fascia of thigh) and lies about 4 cm below and lateral to the pubic tubercle. The saphenous opening has a sharp crescentic lateral margin, which lies in front of the femoral sheath. The medial margin is ill-defined and formed by the fascia covering the pectineus muscle. It lies at the deep level. The opening is closed by sieve-like fascia – the **cribriform fascia** (Fig. 20.3).

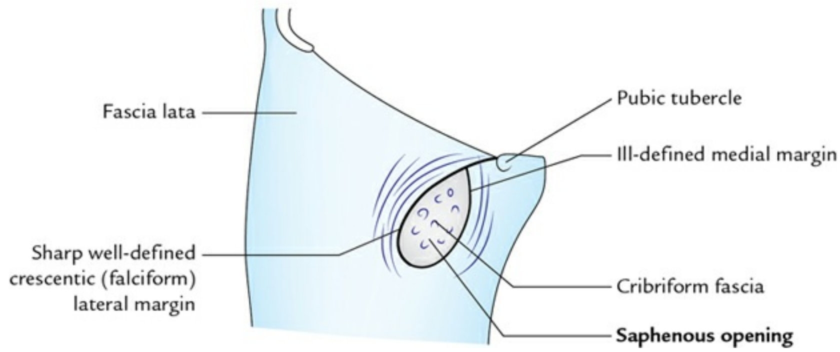


FIG. 20.3 Saphenous opening.

Structures piercing cribriform fascia

- Long saphenous vein
- Superficial external pudendal artery
- Superficial epigastric artery
- Lymph vessels

❖ Write a short note on the femoral triangle.

It is a triangular depression on the anteromedial aspect of the upper 1/3rd of the thigh, with its apex directed downward.

Boundaries (fig. 20.4)

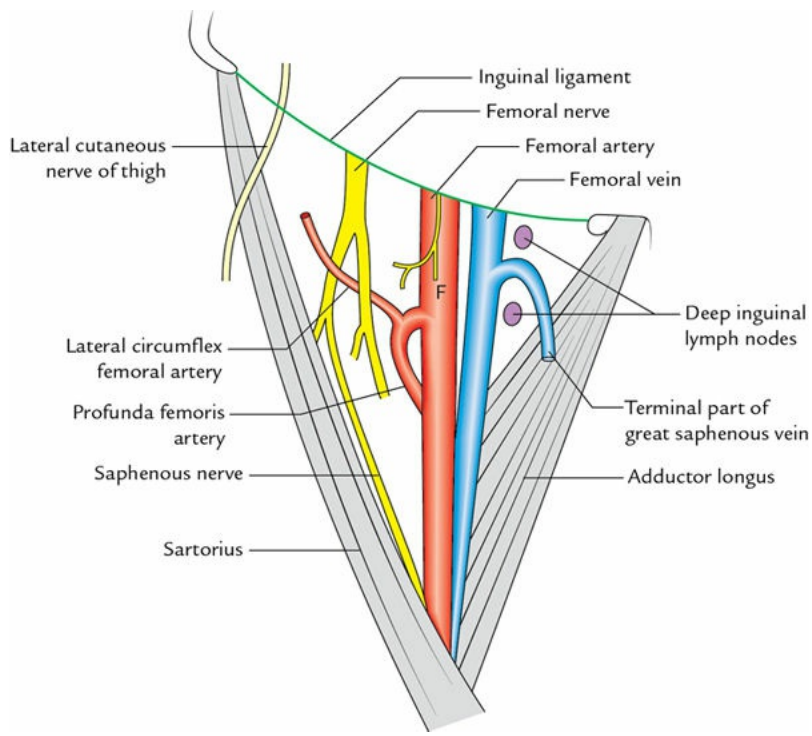


FIG. 20.4 Boundaries and contents of femoral triangle (F = genital branch of genitofemoral nerve).

Lateral

Medial border of sartorius.

Medial

Medial border of adductor longus.

Base

Inguinal ligament.

Apex

Meeting point of medial and lateral boundaries.

Roof

Skin, superficial and deep fasciae.

Floor

From medial to lateral: by adductor longus, pectineus, psoas major and iliacus.

Contents

Mnemonic: VAN (Femoral vein, femoral artery and femoral nerve from medial to lateral side.)

- Lateral cutaneous nerve of the thigh.
- Deep inguinal lymph nodes.
- Profunda femoris artery and its two branches (medial and lateral circumflex femoral arteries).
- Genital branch of the genitofemoral nerve.

Applied anatomy

- *Swelling in the femoral triangle* could be due to:

❒ Enlarged lymph nodes

❒ Psoas abscess

❒ Saphena varix

- *Femoral pulse*: can be felt at the mid-inguinal point against the head of femur.

❖ Enumerate the structures damaged by stabbing at the apex of the femoral triangle. Give its applied importance.

From before backward, these are (Fig. 20.5):

- Femoral artery
- Femoral vein
- Profunda femoris vein
- Profunda femoris artery

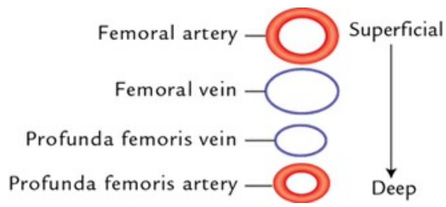


FIG. 20.5 Arrangement of structures at the apex of femoral triangle.

A stab wound at the apex of femoral triangle may be fatal as it cuts all the major vessels of the lower limb.

❖ Write a short on the femoral sheath.

Introduction

It is funnel–shaped fascial sleeve enclosing the upper 1 and ½ inch of femoral vessels. It is 4 cm long. It is conical in shape with vertical lateral wall and oblique medial wall (Fig. 20.6).

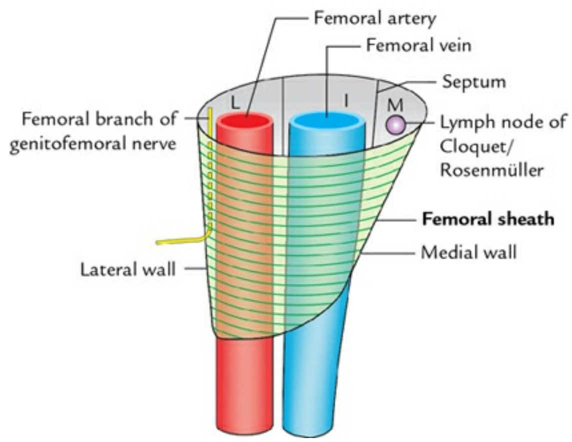


FIG. 20.6 Walls and contents of the femoral sheath.

Formation

It is formed by the downward prolongation of the fascial layers of the abdominal cavity.

- *Anterior wall* by *fascia transversalis.*
- *Posterior wall* by *fascia iliaca.*

Compartments

The femoral sheath is divided by two vertical septa into three compartments:

- *Lateral compartment*: Contains femoral artery and femoral branch of genitofemoral nerve.
- *Intermediate compartment*: Contains femoral vein.
- *Medial compartment* (*femoral canal*)*:* It contains lymph node (lymph node of Cloquet or Rosenmüller).

❖ Write a short note on the femoral canal.

Introduction

• It is the medial compartment of the femoral sheath.

• It does not provide a passage to the large vessels and is filled by fibrofatty tissue.

Femoral ring

The upper end of the femoral canal that opens into the abdomen is called *femoral ring*. The ring is half an inch wide oval opening, which is closed by a condensation of extra peritoneal fat called *femoral septum.*

Boundaries of femoral ring (fig. 20.7)

• *Anteriorly*: Inguinal ligament.

• *Posteriorly*: Pectineal line and pectineus muscle and fascia.

• *Laterally*: Femoral vein.

• *Medially*: Lacunar ligament (concave margin).

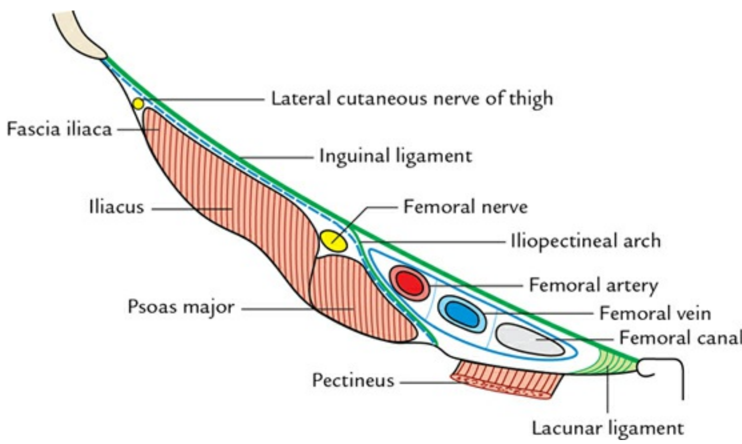


FIG. 20.7 Boundaries of the femoral canal.

Functions of femoral canal

• Provides a dead space for expansion of the femoral vein during increased venous return.

• Provides passage to lymphatics from lower limb to external iliac lymph nodes.

Applied anatomy

The femoral ring is the potential site of weakness in the lower abdomen through which a viscus (intestine) may protrude into femoral canal causing a *femoral hernia*. It is more common in female because:

- Femoral canal is wider in females due to wider pelvis.
- Size of femoral vessels is smaller in females.
- Rise in intra abdominal pressure during pregnancy.

The strangulated femoral hernia is released by incising the lacunar ligament. While doing so, the position of *accessory obturator artery* should always be kept in mind.

Direction of enlarging hernial sac of femoral hernia (fig. 20.8)

- First, it passes downward through the *femoral canal.*
- Then, it passes forward to bulge through the *saphenous opening*.
- Finally, as it enlarges further, it passes upward and laterally along the *superficial epigastric* and *superficial circumflex iliac vessels.*

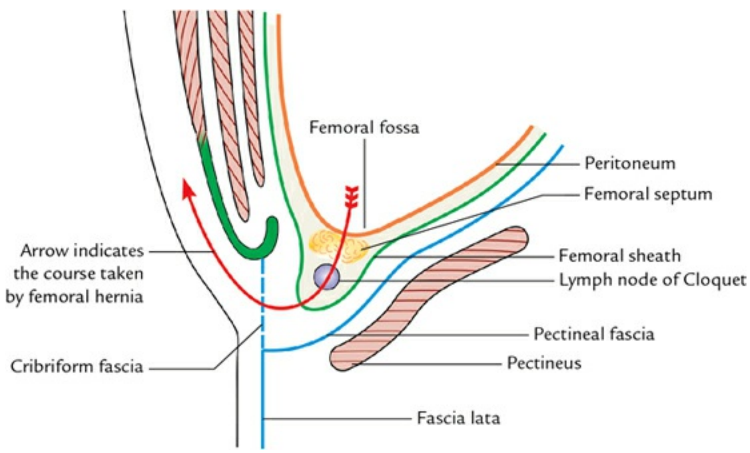


FIG. 20.8 Course of the femoral hernia.

Covering of femoral hernia (fig. 20.9)

From within outward, these are:

- Peritoneum of hernial sac.
- Femoral septum.
- Anterior wall of femoral sheath.
- Cribriform fascia.
- Superficial fascia.

• Skin.

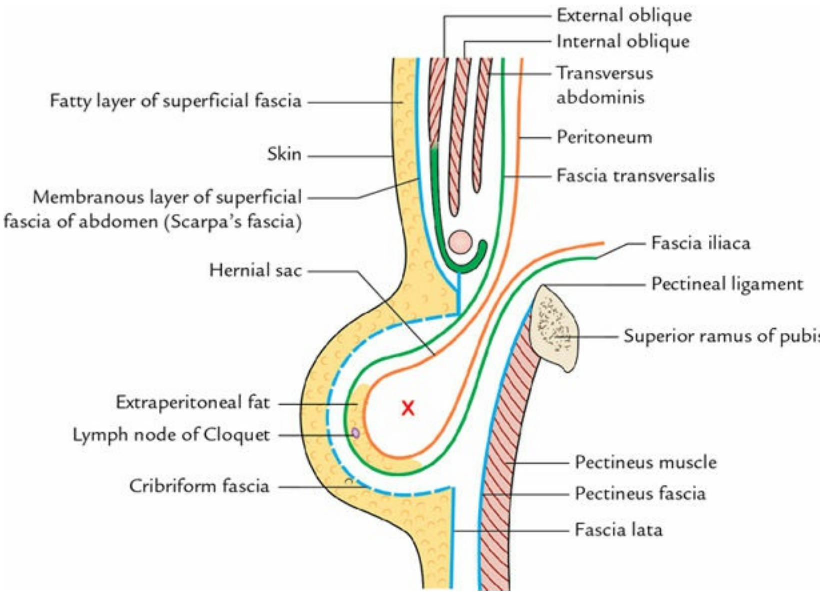


FIG. 20.9 Covering of femoral hernia.

Reduction of femoral hernia

• The thigh is slightly flexed and medially rotated to get laxity of the fasciae and ligaments in the region.

• The hernia is then reduced in a direction opposite to the line of course taken by hernial sac (vide supra).

❖ Write a short note on the femoral artery.

Origin, course, and termination (fig. 20.10)

- It is a continuation of external iliac artery below the inguinal ligament.
- It passes downward and medially, successively in the femoral triangle and adductor canal.
- At the adductor hiatus (apex of adductor canal), it continues as *popliteal artery*.

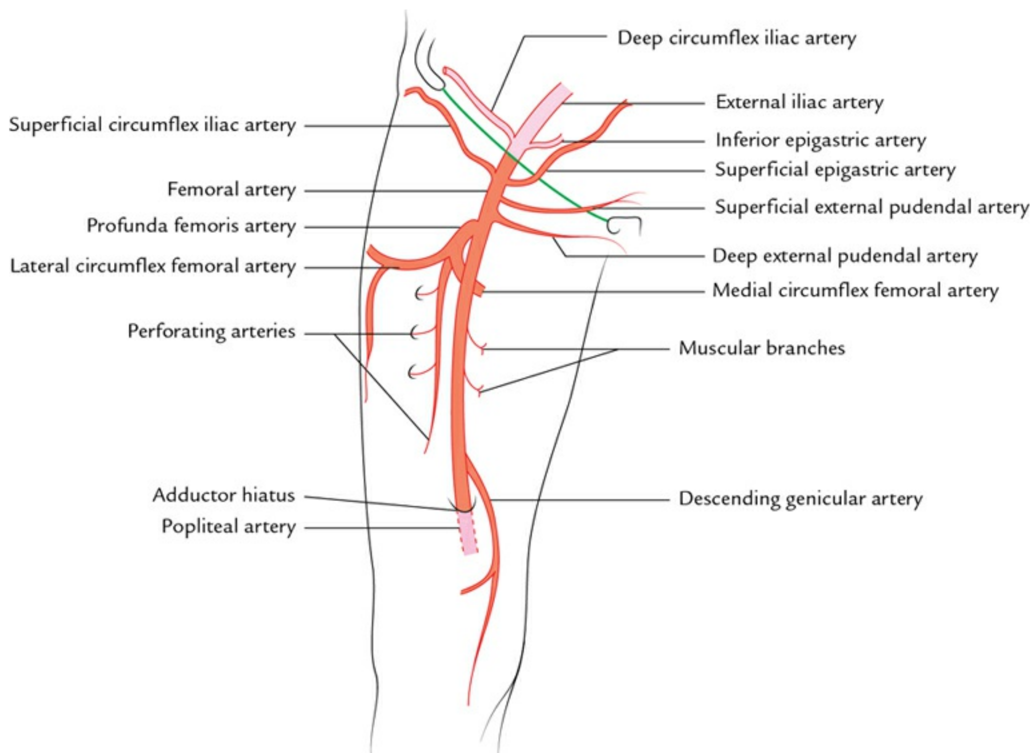


FIG. 20.10 Femoral artery and its branches.

Branches (fig. 20.10)

Superficial (inguinal) branches

- Superficial external pudendal artery
- Superficial epigastric artery
- Superficial circumflex iliac artery

Deep branches

- Deep external pudendal artery

- Profunda femoris artery
- Descending genicular artery
- Muscular

Applied anatomy

- Femoral pulse can be felt at the mid-inguinal point against femoral head.
- Femoral artery is often used for angiography.
- Femoral vein is located by feeling the pulsations of femoral artery and then going medial to it.

❖ Write a short note on the profunda femoris artery (fig. 20.11).

It is the largest branch of the femoral artery. It is the chief source of blood supply to all the compartments of the thigh.

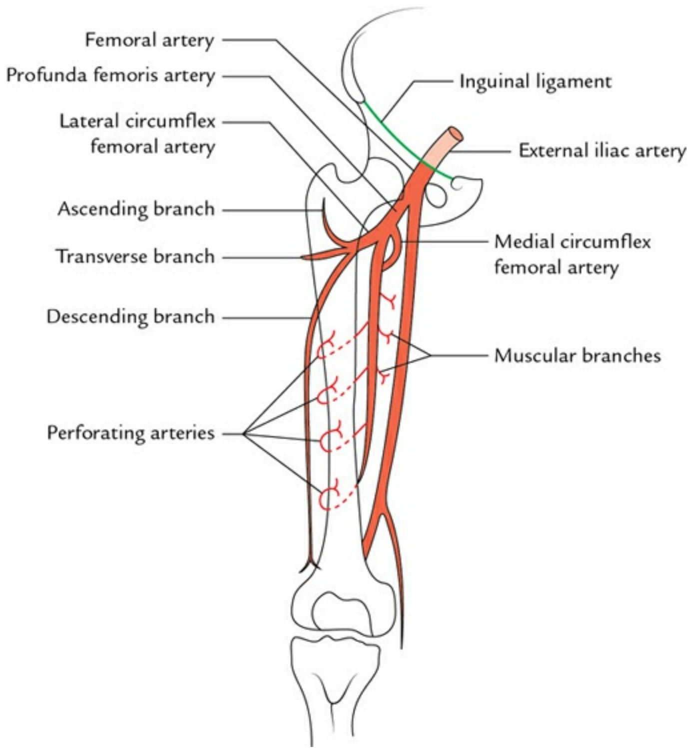


FIG. 20.11 Profunda femoris artery and its branches.

Origin

It arises from lateral side of femoral artery about 4 cm below the inguinal ligament in front of iliacus and spirals medially behind the femoral vessels.

Course

It leaves the femoral triangle by passing between pectineus and adductor longus descends successively first between the adductor longus and brevis and then between the adductor longus and magnus.

Termination

It terminates as the *fourth perforating artery* after piercing the adductor magnus to reach the back of leg.

Branches (fig. 20.11)

In addition to muscular branches, it gives off 3 sets of branches:

• *Medial circumflex femoral artery*: It arises in the femoral triangle. It leaves the femoral triangle by passing posteriorly between pectineus and psoas major. It gives acetabular branch before terminating into transverse and ascending branches.

- *Lateral circumflex femoral artery*: It also arises in the femoral triangle (*the largest branch*). It divides into ascending, transverse and descending branches.

- *Perforating arteries*: These are 4 in number, last being the continuation of the profunda femoris artery itself.

❖ Write a short note on the cruciate anastomosis.

It is an arterial anastomosis on the upper part of the back of thigh at the lower margin of quadratus femoris.

Formation

It is formed by four arteries which anastomose like a red cross:

- Transverse branch of medial circumflex femoral artery
- Transverse branch of lateral circumflex femoral artery
- Descending branch of inferior gluteal artery
- Ascending branch of the first perforating branch of profunda femoris artery

N.B.

This anastomosis forms an indirect connection between the internal iliac and femoral arteries to provide collateral circulation if required.

❖ Write a short note on the trochanteric anastomosis.

It is an arterial anastomosis in the trochanteric fossa.

Formation

It is formed by the following 4 arteries:

- Descending branch of superior gluteal artery.
- A branch from inferior gluteal artery.
- Ascending branch of lateral circumflex femoral artery.
- Ascending branch of medial circumflex femoral artery.

❖ Write a short note on the femoral nerve.

Origin

It arises from lumbar plexus in the substance of psoas major.

Root valve

Posterior divisions of L2, L3 and L4 spinal nerves.

Course

It emerges at the lateral border of psoas major on the posterior abdominal wall and lies between it and iliacus. It enters into the thigh by passing deep to inguinal ligament lateral to the femoral artery. About 4 cm below the ligament, it splits into anterior and posterior divisions.

Branches

These are given in the following box:

Division	Branches
Anterior division	Muscular Sartorius Cutaneous Medial cutaneous nerve of thigh Intermediate cutaneous nerve of thigh
Posterior division	Muscular Rectus femoris Vastus lateralis Vastus medialis Vastus intermedius Cutaneous Saphenous nerve Articular Knee joint Hip joint

Applied anatomy

- *Referred pain*: Pain of hip joint disease is often referred to the knee joint and vice versa. It is also felt on the medial side of the thigh.

- *Injury to femoral nerve*: It causes paralysis of quadriceps femoris causing loss of knee extension.

❖ Write a short note on the adductor canal/Hunter's canal/subsartorial canal.

Introduction

- It is a musculoaponeurotic tunnel situated on the medial side of the middle third of the thigh.
- It provides a passage to the femoral vessels.

Boundaries (fig. 20.12)

- *Anterolateral*: Vastus medialis.
- *Posterior (floor)*: Adductor longus above and adductor magnus below.
- *Anteromedial (roof)*: A fibrous sheet extending between anterolateral and posterior boundaries and is overlapped by sartorius muscle. The subsartorial plexus of nerves lies between fibrous sheet and sartorius muscle.

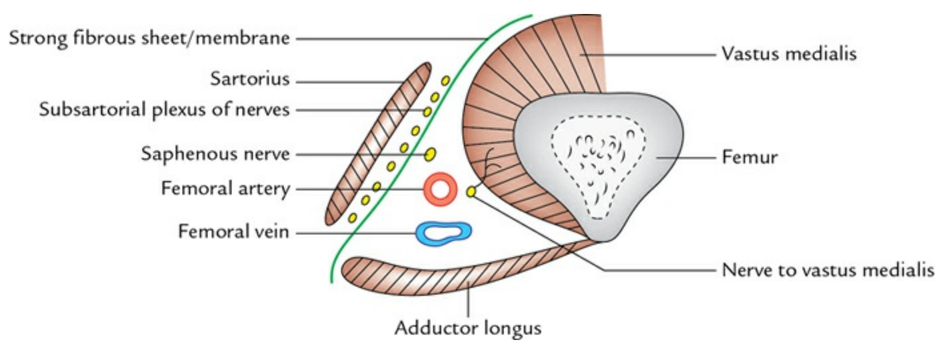


FIG. 20.12 Boundaries and contents of the adductor canal.

Contents

- Femoral artery
- Femoral vein
- Saphenous nerve
- Nerve to vastus medialis
- Descending genicular artery, a branch of femoral artery
- Anterior and posterior divisions of the obturator nerve

Applied anatomy

- Femoral artery is ligated in adductor canal in treatment of *popliteal aneurysm.*

- To control the bleeding following rupture of popliteal aneurysm, a tourniquet is applied on thigh in the region of adductor canal.

❖ Describe the obturator nerve in brief.

It is a nerve of the adductor compartment of thigh and supplies adductor muscles along with skin on the medial aspect of the thigh (Fig. 20.13).

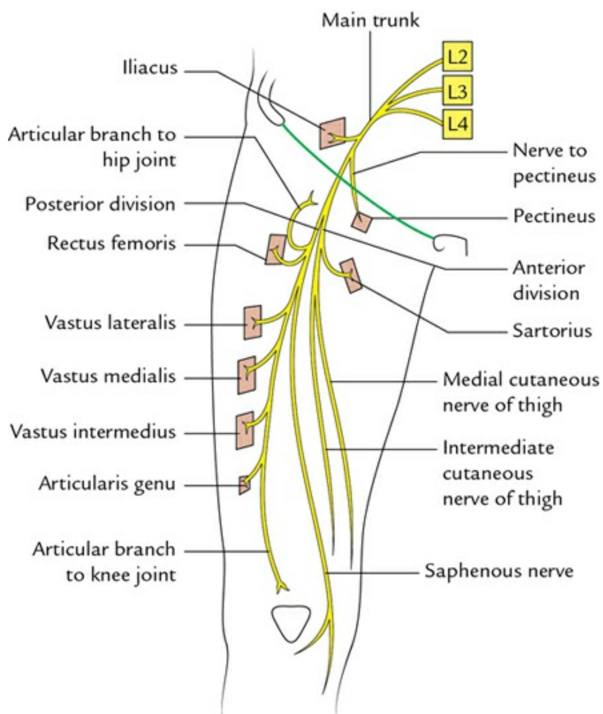


FIG. 20.13 Course and branches of the obturator nerve.

Origin

It arises from ventral divisions of the ventral rami of L2, L3, and L4 within the substance of the psoas major muscle.

Course

- **In pelvis**

❒ It runs medially to emerge at the medial border of psoas, where it lies behind the common iliac vessels.

❒ Now, it runs lateral to internal iliac vessels along the lateral pelvic wall to enter obturator foramen.

❒ At obturator notch, it divides into anterior and posterior division.

• **In thigh**

❒ *Anterior division* passes downward into the thigh in front of obturator externus and then descends behind the pectineus and adductor longus in front of adductor brevis.

❒ *Posterior division* enters the thigh by piercing the anterior part of obturator externus. Then, it descends behind the adductor brevis and adductor magnus.

Branches

These are given in the box below:

Branches	Anterior division	Posterior division
Muscular	Pectineus Gracilis Adductor longus Adductor brevis	Obturator brevis Adductor brevis Adductor magnus
Articular	Hip joint	Knee joint

Applied anatomy

- *Referred pain*: Since obturator nerve supplies both hip and knee joints, the pain of one joint is referred to the other.

- *Surgical division of obturator nerve*: It is sometimes done to relieve the adductor spasm of thigh in *spastic paraplegia*.

❖ Write a short note on the lumbar plexus (fig. 20.14).

The lumbar plexus is formed in the substance of psoas major muscle by the ventral rami of L1 to L4 spinal nerves with a contribution from the subcostal nerve (T12).

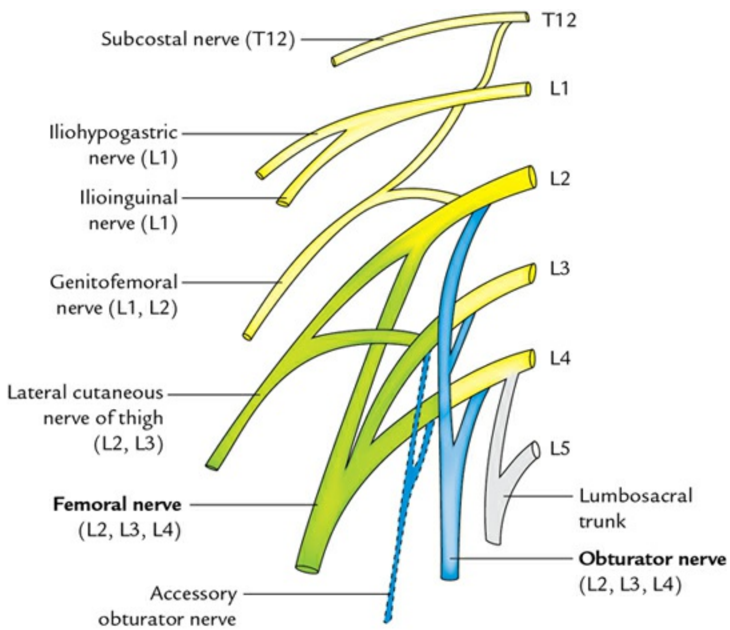


FIG. 20.14 Lumbar plexus of the nerves.

Branches

- Iliohypogastric nerve (L1)
- Ilioinguinal nerve (L1)
- Genitofemoral nerve (L1, L2: ventral divisions)
- Lateral cutaneous nerve of thigh (L2, L3: dorsal divisions)

• Femoral nerve (L2, L3, L4: dorsal divisions) • Obturator nerve (L2, L3, L4: ventral divisions)	}	Terminal branches

N.B.

Sometimes (30% cases), *accessory obturator nerve* may arise from ventral divisions of L3, L4.

❖ Give origin, insertion, nerve supply and actions of the sartorius muscle.

The sartorius is the longest muscle in the body, which crosses front of thigh obliquely from lateral to medial side (Fig. 20.15).

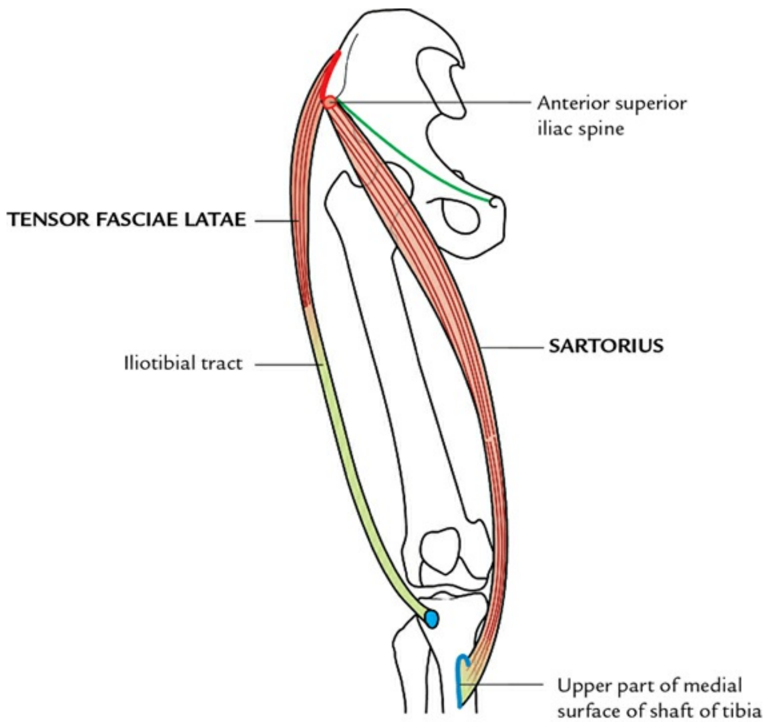


FIG. 20.15 Origin and insertion of sartorius and tensor fasciae latae.

Origin

From anterior superior iliac spine.

Insertion

Into the upper part of the medial surface of the tibia.

Nerve supply

Femoral nerve.

Actions

- Flexion of the thigh at hip joint.
- Flexion of the leg at knee joint.
- Adduction and lateral rotation of the thigh.

N.B.

All of the above actions of sartorius muscle are required in assuming a crossed leg working position as in tailors, hence the name sartorius (L. sartor = tailor).

❖ Give origin, insertion, nerve supply, and actions of the rectus femoris muscle.

The rectus femoris is one of the 4 components of quadriceps femoris muscle. It is bipinnate and lies in midline infront of the thigh. It crosses in front of both hip and knee joints.

Origin

Two heads:

- *Straight head*: From anterior inferior iliac spine.
- *Reflected head*: From groove above the acetabulum.

Insertion

Into tibial tuberosity.

N.B.

The patella is encased in the tendon of rectus femoris before its insertion to tibial tuberosity.

Nerve supply

Femoral nerve (L2, L3, L4: dorsal divisions).

Actions

Hip flexion and knee extension.

❖ Write a short note on extensor apparatus of the knee joint (patello–femoral complex).

It is formed by the following 4 components. From above downward, these are:

- Tendon of quadriceps femoris
- Patella
- Ligamentum patellae
- Tibial tuberosity

CHAPTER 21

Gluteal region, back of thigh, and popliteal fossa

❖ Enumerate major muscles of the gluteal region.

They are 4 in number:

- Gluteus maximus
- Gluteus medius
- Gluteus minimus
- Tensor fasciae latae

N.B.

- The tensor fasciae latae has migrated to the lateral aspect of thigh.
- All the muscles of gluteal region are supplied by *superior gluteal nerve* except gluteus maximus, which is supplied by inferior *gluteal nerve*.

❖ Give the origin, insertion, nerve supply, and actions of gluteus maximus, gluteus medius, and gluteus minimus muscles.

These are given in the following box:

Muscle	Origin	Insertion	Nerve supply	Actions
Gluteus maximus (largest and most superficial) (Fig. 21.1)	Outer slope of dorsal segment of iliac crest Posterior gluteal line Gluteal surface of ilium behind the posterior gluteal line Dorsal surface of lower part of sacrum Side of coccyx Sacrotuberous ligament Fascia over gluteus medius	Iliotibial tract. Gluteal tuberosity	Inferior gluteal nerve (L5, S1, S2)	Powerful extension of the hip joint Lateral rotation of the thigh Abduction of the thigh Stabilization of the knee joint through iliotibial tract Helps in rising from sitting position
Gluteus medius (Fig. 21.2)	Gluteal surface of ilium, between anterior and posterior gluteal lines	Oblique ridge on lateral surface of greater trochanter of femur	Superior gluteal nerve (L5, S1)	Abduction of the thigh at hip joint Medial rotation at hip joint (anterior fibers) Maintains balance when other foot is off the ground, i.e., prevents sagging of the pelvis
Gluteus minimus	Gluteal surface of ilium between anterior and inferior gluteal lines	Ridge on lateral part of anterior surface of greater trochanter of femur	Superior gluteal nerve (L5, S1)	Abduction of the thigh at hip joint Medial rotation at hip joint (anterior fibers) Helps gluteus medius in maintaining balance when other foot is off the ground, i.e., prevents sagging of pelvis

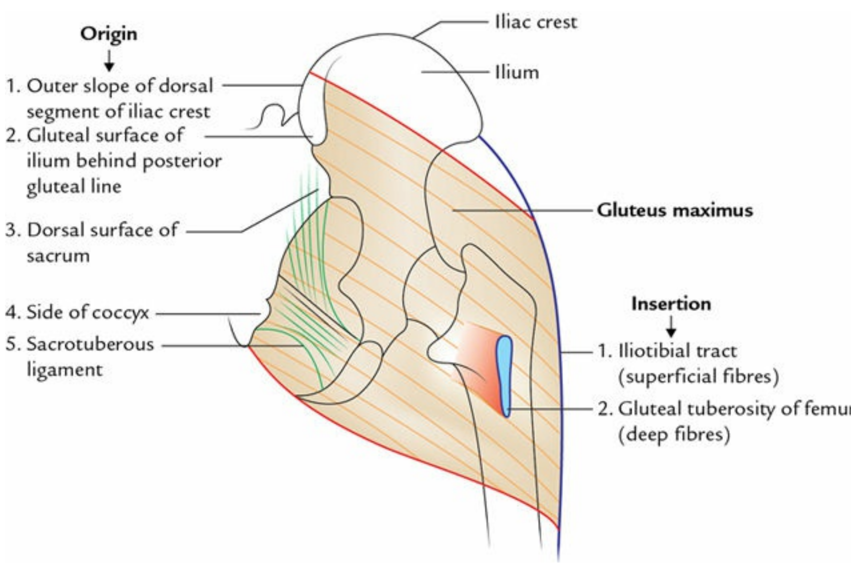


FIG. 21.1 Gluteus maximus muscle.

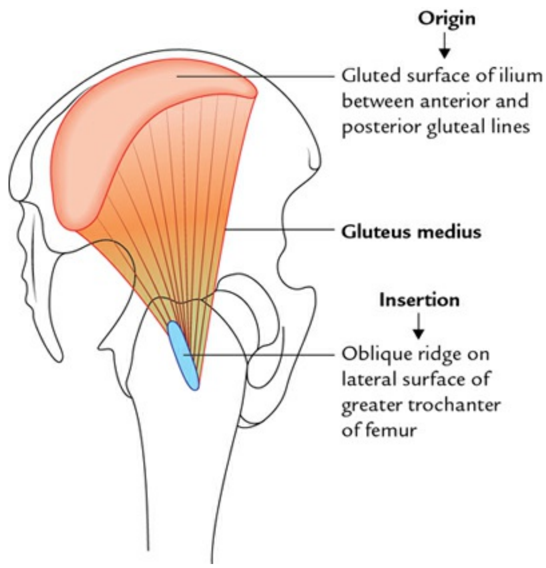


FIG. 22.2 Gluteus medius muscle.

❖ Give the anatomical basis of Trendelenburg's sign.

• When one foot is off the ground, the pelvis is prevented from sagging on the side by the downward pull of opposite gluteus medius (mainly) and gluteus minimus muscles. But if the gluteus medius and minimus muscles are paralyzed on one side and the opposite healthy foot is elevated (i.e., off the ground), the pelvis will sag on that (i.e., healthy) side. This is called *Trendelenburg's sign* (Fig. 21.3).

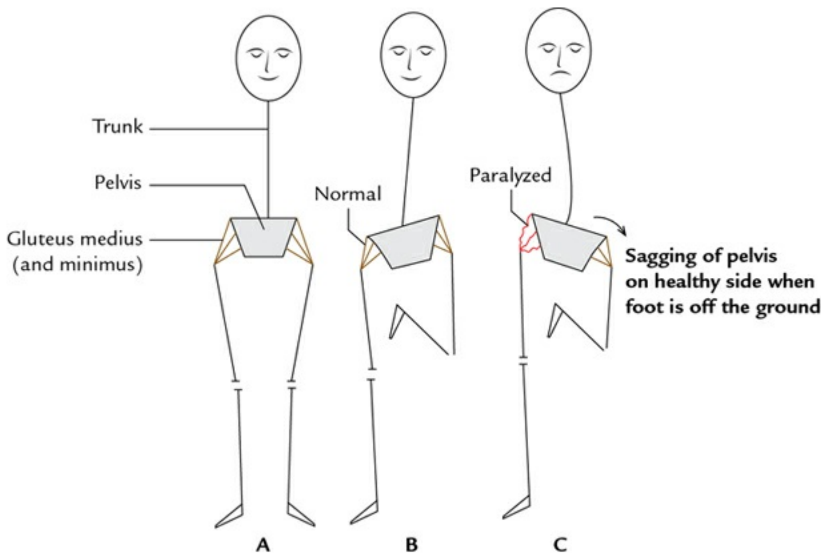


FIG. 21.3 Trendelenburg's sign.

❖ Enumerate the hamstring muscles and give their characteristic features.

They are 4 in number:

• Semitendinosus

• Semimembranosus

• Long head of biceps femoris

• Ischial part of the adductor magnus

Characteristic features

• All arise from ischial tuberosity.

• All are inserted into one of the two leg bones (i.e., tibia or fibula).

• All are supplied by tibial part of the sciatic nerve.

• All extend the hip joint and flex the knee joint.

❖ Give the origin, insertion, nerve supply, and actions of the biceps femoris muscle.

It is the muscle of the back of thigh, which it crosses obliquely from medial to lateral side.

Origin

- *Long head* from inferomedial impression on the upper part of the ischial tuberosity along with semitendinosus.
- *Short head* from (i) lower part of the lateral lip of the linea aspera and (ii) upper 2/3rd of lateral supracondylar line of femur.

Nerve supply

- *Long head* by tibial part of sciatic nerve.
- *Short head* by common peroneal part of sciatic nerve.

Actions

- It is chief flexor of the knee joint.
- It is weak extensor of hip joint white standing and walking.
- It is lateral rotator of leg in semiflexed knee.
- It is lateral rotator of leg when the hip is extended.

❖ Describe the sciatic nerve in brief.

It is the thickest nerve of the body and consists of two components:

- Tibial
- Common peroneal

Origin and root valve

It arises from ventral and dorsal divisions of ventral rami of L4, L5, S1, S2, and S3.

- *Tibial part* from ventral divisions of the anterior primary rami of L4, L5, S1, S2, and S3.
- *Common peroneal part* from dorsal divisions of anterior primary rami of L4 and L5 and S1 and S2.

Course

- *In the pelvis*: The sciatic nerve lies in front of the piriformis under the cover of its fascia.
- *In the gluteal region*: The nerve enters the gluteal region through the greater sciatic foramen below the piriformis. It runs downward with a slight lateral convexity passing between the ischial tuberosity and greater trochanter.
- *In the thigh*: The nerve emerges from lower border of gluteus maximus to enter the back of the thigh where it runs vertically downward up to the superior angle of the popliteal fossa where it terminates by dividing into the **tibial and common peroneal nerves.**

Relations

In the gluteal region

- *Superficial*: Gluteus maximus.
- *Deep*

❒ Body of the ischium.

❒ Tendon of the obturator internus with the gemelli.

❒ Quadratus femoris and obturator externus.

❒ Ascending branch of the medial circumflex femoral artery.

❒ Capsule of the hip joint.

❒ Upper transverse fibers of adductor magnus.

In the thigh

• *Superficial*: Long head of the biceps femoris.

• *Deep*: Adductor magnus.

• *Medial*

❒ Posterior cutaneous nerve of the thigh.

❒ Semimembranosus and semitendinosus.

• *Lateral*: Biceps femoris.

Branches (fig. 21.4)

Articular

To hip joint.

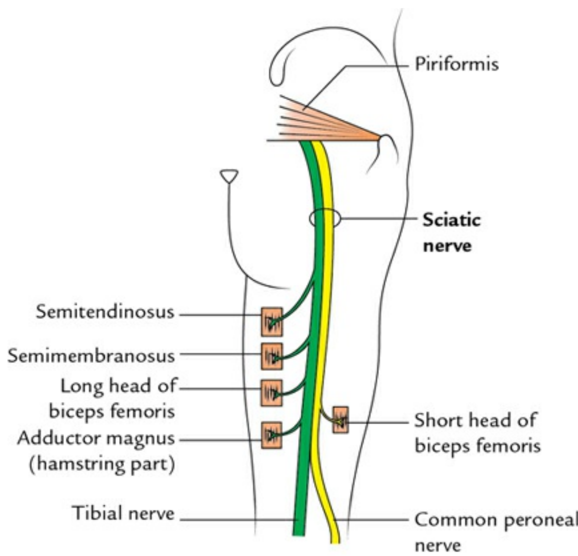


FIG. 21.4 Branches of sciatic nerve.

Muscular

• *Tibial part* supplies hamstring muscles, viz.:

❒ Semitendinosus

❒ Semimembranosus

❒ Long head of biceps femoris

❒ Ischial head of adductor magnus

- *Common peritoneal part* supplies short head of biceps femoris.

Applied anatomy

- *Sleeping foot*: It is the feeling of tingling and numbness in the lower limb. It often occurs due to compression sciatic nerve against femur for long duration, such as sitting on the bicycle rod.
- *Sciatica*: It is a shooting pain along the cutaneous distribution of the sciatic nerve usually due to compression and irritation of one or more of its nerve roots. The pain begins in the gluteal region and radiates successively to back of the thigh, lateral side of the leg, and dorsum of the foot.
- *Any injury to the nerve*, e.g. due to penetrating wounds, hip dislocation, results in loss of all movements below the knee, sensory loss on the back of thigh, whole of leg, and foot except area supplied by the saphenous nerve.

❖ Describe popliteal fossa under the following headings: (a) introduction, (b) boundaries, (c) contents, and (d) applied anatomy.

It is a diamond-shaped fossa on the posterior aspect of the knee, and its lower part is homologous to the cubital fossa in front of the elbow.

Boundaries (fig. 21.5)

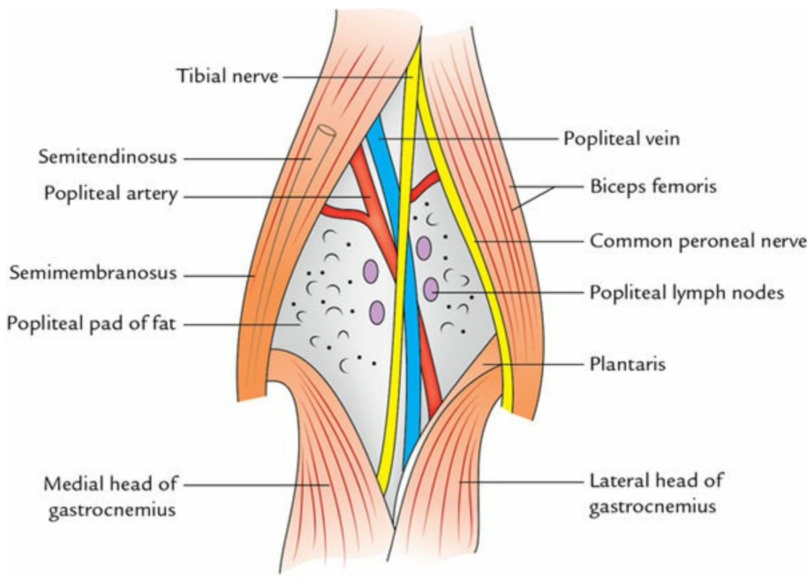


FIG. 21.5 Boundaries and contents of popliteal fossa.

Superolaterally

Biceps femoris.

Superomedially

Semimembranosus and semitendinosus.

Inferolaterally

Lateral head of gastrocnemius supplemented by the plantaris.

Inferomedially

Medial head of gastrocnemius.

Roof

It is formed by popliteal fascia.

Floor

From above downward, it is formed by popliteal surface of femur, capsule of the knee joint, oblique popliteal ligament, and fascia covering the popliteus muscle.

N.B.

- Structures piercing the roof

❒ Sural nerve

❒ Posterior femoral cutaneous nerve

❒ Short saphenous vein

- Structures piercing the floor

❒ Middle genicular vessels

❒ Middle genicular nerve

❒ Genicular branch of the posterior division of obturator nerve

Contents (fig. 21.5)

- Tibial nerve
- Common peroneal nerve
- Popliteal vein
- Popliteal artery
- Popliteal lymph nodes
- Popliteal pad of fat

N.B.

The relationship (relative positions) between nerve and vessels differs in its upper, middle, and lower parts of popliteal fossa.

- In the *upper part* from medial to lateral:

❒ Popliteal artery

❒ Popliteal vein

❒ Tibial nerve

- In the *middle part* from anterior to posterior:

❒ Popliteal artery

❒ Popliteal vein

❒ Tibial nerve

• In the *lower part* from medial to lateral:

Tibial nerve

Popliteal vein

Popliteal artery

Applied anatomy

• *Popliteal aneurysm*: The popliteal artery is the commonest site for aneurysm. Clinically, it presents as a pulsatile swelling in the popliteal fossa.

• *Baker's cyst*: It is cystic swelling in the popliteal fossa which occurs either due to inflammation of synovial bursa underneath semimembranosus or by the protrusion of synovial cavity of knee joint through its capsule.

• *Popliteal pulse*: It can be felt by flexing the knee, so that tight the popliteal fascia is relaxed.

❖ Write a short note on the popliteal artery.

It is the continuation of femoral artery in the popliteal fossa.

Origin and course

It begins at the 5th osseoaponeurotic opening of the adductor magnus (adductor hiatus) and runs downward and laterally in the popliteal fossa to reach the lower border of the popliteus muscle, where it terminates by dividing into anterior and posterior tibial arteries.

Branches

- Genicular branches (5 in number).

❒ Middle genicular artery

❒ Inferior medial and lateral genicular arteries

❒ Superior medial and lateral genicular arteries

- Muscular branches

❒ *Upper muscular* branches to adductor magnus and hamstring muscles.

❒ *Lower muscular* to gastrocnemius, soleus, and plantaris.

- Terminal branches

❒ Anterior tibial

❒ Posterior tibial

Applied anatomy

- Popliteal aneurysm and popliteal pulse (for details see page 228).

CHAPTER 22

Leg and foot

Anterior compartment of leg and dorsum of foot

❖ Enumerate the muscles of anterior compartment of leg.

They are:

- Tibialis anterior
- Extensor hallucis longus
- Extensor digitorum longus
- Peroneus tertius

❖ Give the origin, insertion, nerve supply, and actions of the tibialis anterior muscle.

Origin (fig. 22.1)

Upper 2/3rd of the lateral surface of the tibia and adjacent interosseous membrane.

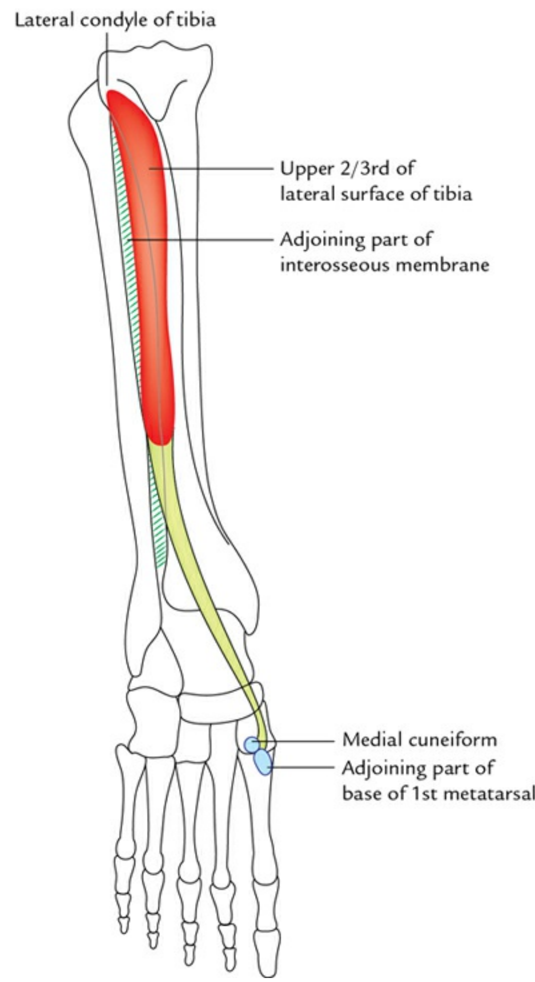


FIG. 22.1 Tibialis anterior muscle.

Insertion (fig. 22.1)

- Medial side of medial cuneiform
- Adjoining part of base of first metatarsal.

Nerve supply

Deep peroneal nerve (anterior tibial nerve).

Actions

- It is dorsiflexor of foot at the ankle joint.
- It is inverter of foot at the subtalar and midtarsal joints.

❖ Write a short note on dorsalis pedis artery.

It is the chief artery of the dorsum of the foot (Fig. 22.2).

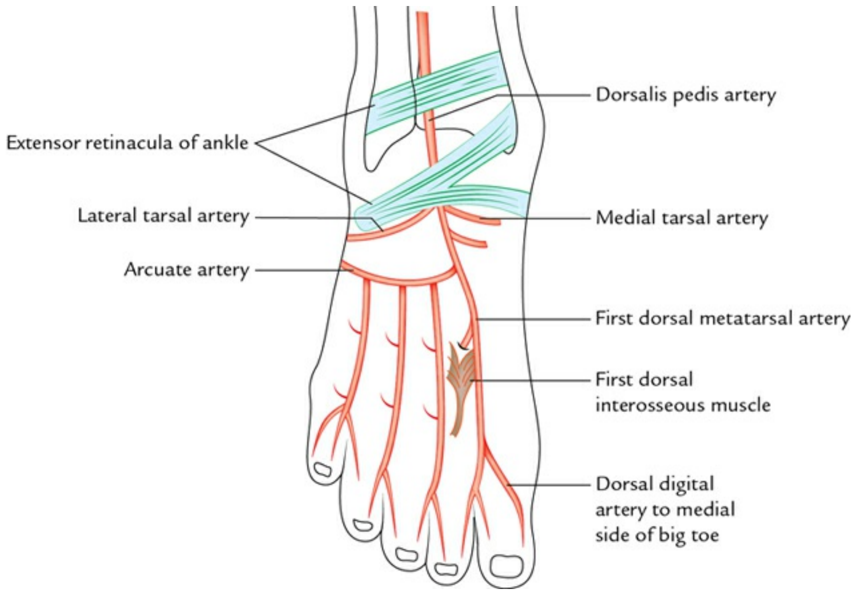


FIG. 22.2 Dorsalis pedis artery.

Origin

It is a continuation of anterior tibial artery in front of ankle joint between medial and lateral malleoli.

Course

It passes forward between tendon of extensor hallucis longus on the medial side, and deep peroneal nerve, and tendons of extensor digitorum longus on the lateral side to reach the proximal end of 1st intermetatarsal space. Here, it pierces the 1st dorsal interosseous muscle to reach the sole where it anastomoses with the lateral plantar artery to complete the *lateral plantar arch.*

Branches

- Medial and lateral tarsal arteries
- Arcuate artery
- First dorsal metatarsal artery

Applied anatomy

Dorsalis pedis pulse

The pulsations of dorsalis pedis artery can be felt on the dorsum of foot distal to ankle joint between tendons of extensor hallucis longus (medially) and extensor digitorum longus (latterly).

Lateral compartment of the leg

❖ Enumerate muscles of the lateral compartment of the leg.

They are:

- Peroneus longus
- Peroneus brevis

❖ Give origin, insertion, nerve supply, and actions of the peroneus longus muscle.

Origin

Head and upper 2/3rd of the lateral surface of the fibula.

Insertion

The tendon enters the sole through groove on the plantar surface of cuboid and crosses it from lateral to medial side to be inserted on the base of the first metatarsal and adjoining part of the medial cuneiform.

Nerve supply

Superficial peroneal nerve.

Actions

- It is evertor of foot at the subtalar and midtarsal joints.
- Its tendon acts as a pulley and supports the arches of foot from above.

❖ Give a brief description of the deep peroneal nerve.

Origin

It is one of the terminal branches of the common peroneal nerve.

Course

It begins at the lateral side of the neck of the fibula and enters the anterior compartment of leg by piercing anterior intermuscular septum. In the anterior compartment, it courses downward first lateral to anterior tibial artery, then in front of the artery, and then again lateral to the artery as if the nerve hesitates to cross the artery. For this region, it is also called *nervus hesitans*. It enters the dorsum of foot by passing deep to the superior extensor retinaculum midway between the medial and lateral malleoli and terminates by dividing into medial and lateral terminal branches.

Branches

In the leg

Muscular branches to supply all four muscles of the anterior compartment of the leg.

On the dorsum of foot

- Medial terminal branch:

❒ *Muscular branch* to 1st dorsal interosseous muscle.

❒ *Dorsal digital nerves* provide sensory innervation to the skin of 1st interdigital cleft.

- *Lateral terminal branch*: Ends by forming a nodule called **pseudoganglion.**

❒ *Muscular branches* to extensor digitorum brevis.

❒ Muscular branch to 2nd dorsal interosseous muscle.

Applied anatomy

Effects of injury to deep peroneal nerve are:

Motor loss

Paralyses of the muscles of anterior compartment of leg (i.e., dorsiflexors of ankle joint), leading to **foot drop.**

Sensory loss

On the dorsum of foot in the first interdigital cleft.

❖ Describe the superficial peroneal nerve in brief.

Origin

It is one of the terminal branches of the common peroneal nerve.

Course

It begins at the lateral aspect of the neck of fibula and travels downward between peroneus longus and peroneus brevis:

- At the junction of upper 2/3rd and lower 1/3rd of the leg, it pierces deep fascia to enter the superficial fascia.
- In the lower part of the leg, it divides into medial and lateral branches that cross in front of extensor retinaculum to reach the dorsum of the foot.

Branches

In the leg

- *Muscular branches* to peroneus longus (PL) and peroneus brevis (PB).
- *Cutaneous branches to*:

❒ Lower 1/3rd of the lateral side of the leg

❒ Medial side of great toe

❒ Interdigital clefts between 2nd, 3rd, 4th, and 5th toes

❒ Most of the dorsum of foot

Applied anatomy

Injury to superficial peroneal nerve leads to:

- Weakness of eversion of foot, due to paralysis of peroneus longus and peroneus brevis.
- Sensory loss on the lateral aspect of the leg.
- Sensory loss on the dorsum of foot and toes except first interdigital cleft and lateral side of 5th toe.

Posterior compartment of the leg

❖ Enumerate the muscles of the posterior compartment of the leg.

They are divided into superficial and deep groups:

Superficial muscles

• Gastrocnemius • Soleus • Plantaris	}	triceps surae

Deep muscles

• Popliteus

• Flexor digitorum longus

• Flexor hallucis longus

• Tibialis posterior

❖ Give origin, insertion, nerve supply, and actions of the gastrocnemius muscle.

The gastrocnemius forms the bulk of the calf (Fig. 22.3).

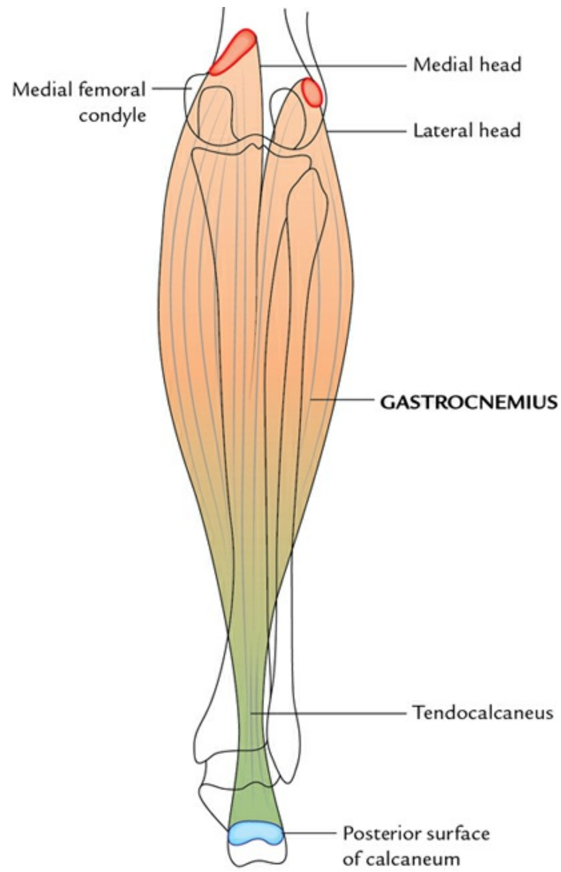


FIG. 22.3 Gastrocnemius muscle.

Origin

Medial head

From upper and posterior part of the medial condyle of femur behind the adductor tubercle and adjacent part of the popliteal surface of the femur.

Lateral head

From lateral aspect of lateral condyle of the femur and adjoining part of the lateral supracondylar line.

Insertion

The gastrocnemius joins the tendon of soleus to form a conjoint tendon – the **tendocalcaneus** that is inserted into the middle 1/3rd of the posterior surface of the calcaneus.

Nerve supply

Tibial nerve.

Actions

Flexion of the knee joint.

❖ Give origin, insertion, nerve supply, and actions of the soleus muscle.

It is a powerful muscle situated deep to gastrocnemius. It is multipennate muscle and shaped like a fish/sole of the foot (Fig. 22.4).

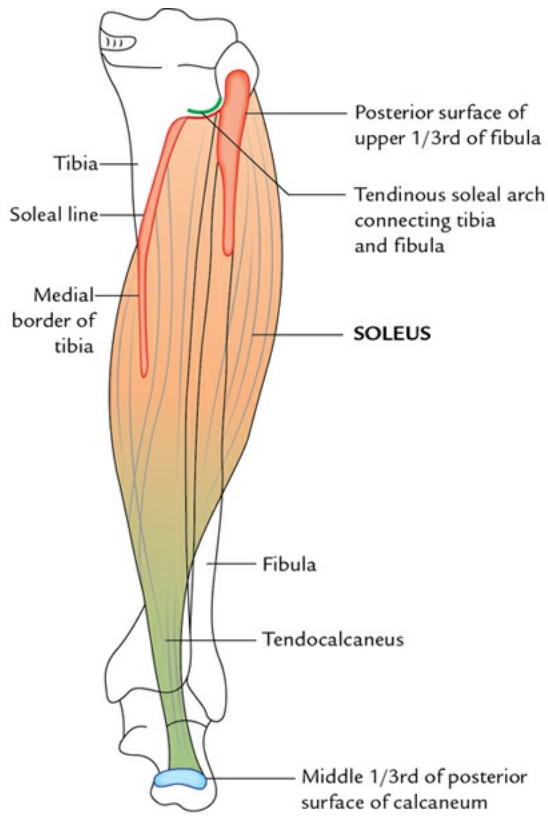


FIG. 22.4 Soleus muscle.

Origin

- Upper 1/3rd of the posterior surface of the fibula
- Tendinous soleal arch
- Soleal line
- Middle 1/3rd of the medial border of the tibia

Insertion

The tendon of soleus fuses with the tendon of gastrocnemius to form **tendocalcaneus** that is inserted into the middle 1/3rd of the posterior surface of the calcaneus.

Actions

- Plantar flexion of the foot at ankle
- Provides main propulsive force during running and walking

❖ Write a short note on the 'calf muscle pump' and 'peripheral heart'.

Calf muscle pump

It is formed by gastrocnemius and soleus muscles together to facilitate the venous return from the lower limb.

Peripheral heart

The soleus muscle is regarded as the peripheral heart because it houses large valveless venous sinuses (**soleal sinuses**), which are connected to both superficial veins (by perforating veins) and deep veins (directly). Therefore, the contraction of the soleus muscle helps in sucking the blood from superficial veins via perforating veins and propelling it to the deep veins of the posterior compartment of the leg, which subsequently drain into the heart.

❖ Give the origin, insertion, nerve supply, and actions of the popliteus muscle.

It is the only short muscle on the back of the leg and forms the lower part of the floor of the popliteal fossa (Fig. 22.5).

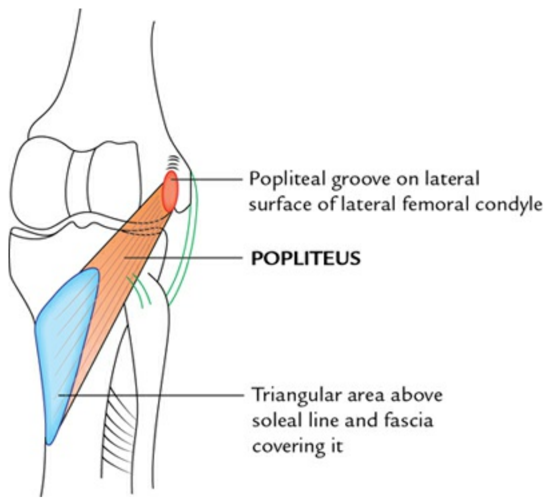


FIG. 22.5 Popliteus muscle.

Origin

Popliteal groove (anterior part) on the lateral surface of the lateral condyle of the femur.

Insertion

Triangular area on the posterior surface of the tibia above the soleal line and fascia covering it.

Nerve supply

Nerve to popliteus, a branch of the tibial nerve.

Actions

• It unlocks the knee in the initial phase of flexion by causing:

❒ *Medial rotation of tibia* on femur when the foot is off the ground or

❒ *Lateral rotation of femur* on tibia when the foot is on the ground.

• It pulls the lateral meniscus posteriorly and prevents it from being trapped at the beginning of the knee flexion, thus preventing from tearing.

N.B.

- Nerve to popliteus winds around the lower margin of popliteus to supply it from its anterior surface.
- Popliteus muscle is important in unlocking the locked knee; hence, it is referred to as **key muscle of the knee joint.**

❖ Describe the tibial nerve (medial popliteal nerve) in brief and give the effects of its injury.

It is the larger terminal branch of the sciatic nerve (root value: L4, L5, S1, S2, and S3).

Origin and course

- It arises from sciatic nerve at the junction of upper 2/3rd and lower 1/3rd of the back of the thigh.
- It enters the popliteal fossa where it crosses popliteal vessels superficially from lateral to medial side.
- From popliteal fossa, it enters posterior compartment of the leg at the level of inferior border of the popliteus undercover of tendinous arch of the soleus.
- In the leg, it crosses tibial artery from medial to lateral side just below the tendinous arch.
- At ankle, it lies lateral to the posterior tibial artery.
- It terminates deep to flexor retinaculum by dividing into lateral and medial plantar nerves.

Branches

In the popliteal fossa

- *Muscular branches* to gastrocnemius (both heads), plantaris, and popliteus
- *Cutaneous branch*, sural nerve
- *Articular*, middle genicular to knee joint

In the leg, below the popliteal fossa

- *Muscular branches* to soleus, flexor digitorum longus (FDL), flexor hallucis longus (FHL), and tibialis posterior.
- *Cutaneous branch*

❒ Medial calcaneal branch.

- *Articular branches* to knee and ankle joints.
- *Terminal branches*

❒ Medial plantar nerve.

❒ Lateral plantar nerve.

Applied anatomy

Effects of injury of tibial nerve in the popliteal fossa

Motor loss

- *Inability to flex the knee*, due to paralysis of gastrocnemius and soleus.
- *Inability to invert foot*, due to paralysis of tibialis posterior.
- *Foot assumes the position of calcaneovalgus*, due to unopposed action of extensors and evertors. As a result, the patient cannot stand on tips of toes and feels difficulty in 'taking off'.
- *Inability to flex the toes*, due to paralysis of long and short flexors of the toes.

Sensory loss

Loss of sensation in the sole of foot.

❖ Describe the common peroneal nerve in brief and give the effects of its injury.

It is the smaller terminal branch of the sciatic nerve (root value: L4, L5, S1, and S2).

Origin and course

It begins at the junction of upper 2/3rd and lower 1/3rd of the back of the thigh. It enters the popliteal fossa through its upper angle and then follows the tendon of biceps tendon to reach the back of the head of the fibula, where it curves forward on the lateral side of the neck fibula and terminates by dividing into superficial and deep peroneal nerves.

Branches

In popliteal fossa

- Superior and inferior lateral genicular nerves
- Lateral cutaneous nerve of calf
- Communicating branch to the sural nerve

In leg below

- Recurrent genicular
- Deep peroneal nerve
- Superficial peroneal nerve

Applied anatomy

Effects of injury to common peroneal nerve

It is the most commonly injured peripheral nerve in the lower limb. It gets injured either due to fracture neck of fibula or due to direct pressure of tightly applied plaster cast. Clinically, it present as (due to the involvement of both deep and superficial peroneal nerves):

- *Foot drop* (foot is inverted and plantar flexed) due to the paralysis of dorsiflexors of ankle and evertors of the foot. As a result, the patient walks on the toes.
- *Sensory loss* on the dorsum of foot and toes except medial and lateral margins of the foot and lateral side of the little toe.

❖ Write a short note on the flexor retinaculum of ankle.

It is a thickened band (about 2.5 cm broad) of deep fascia on the medial aspect of the ankle.

Attachments (fig. 22.6)

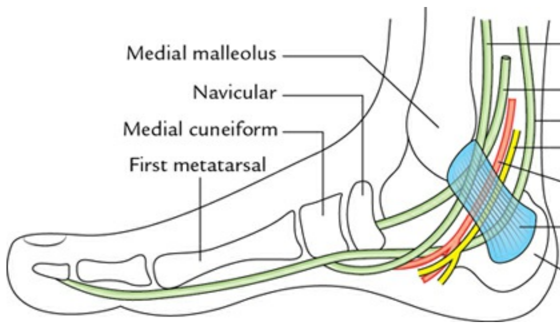


FIG. 22.6 Flexor retinaculum of the ankle.

Anteriorly

Posterior border and tip of the medial malleolus.

Posteriorly

Medial tubercle of the calcaneum.

Structures passing deep to the retinaculum (fig. 22.6):

From medial to lateral

- Tendon of the tibialis posterior
- Tendon of the flexor digitorum longus
- Posterior tibial artery and its terminal branches
- Tibial nerve and its terminal branches
- Tendon of the flexor halluces longus

Functions

It holds the tendons in place (i.e., prevents their bowstring) as they curve to pass forward from back of leg to the sole of the foot.

❖ Write a short note on extensor retinacula of the ankle.

These are two thickened bands of deep fascia, viz. superior and inferior called superior and inferior retinacula (Fig. 22.7).

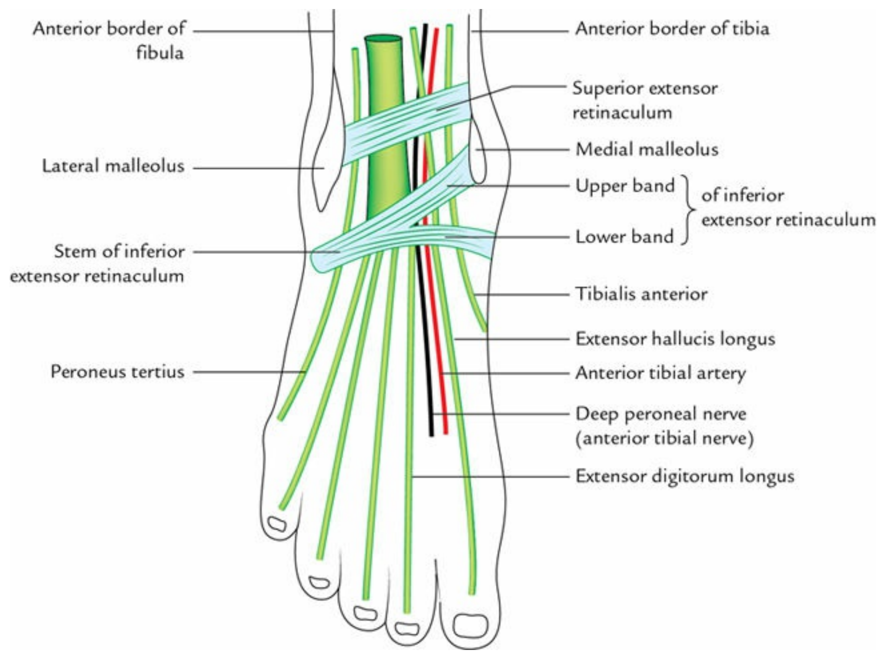


FIG. 22.7 Extensor retinacula of the ankle.

Attachments of superior extensor retinaculum

Medially

Anterior border of tibia.

Laterally

Anterior aspect of fibula.

Attachments of inferior extensor retinaculum (Y-shaped)

Medially

- Upper band of 'Y' to medial malleolus.
- Lower band of 'Y' to deep fascia of sole.

Laterally

Stem of 'Y' to anterior part of calcaneum (upper surface).

Structures passing deep to extensor retinacula of ankle

From medial to lateral, these are:

- **T**ibialis anterior
- Extensor **h**allucis longus
- Anterior tibial **a**rtery
- Deep peroneal **n**erve
- Extensor **d**igitorum longus
- **P**eroneus tertius

Mnemonic: **T**he **H**imalayas **A**re **N**ot **D**ry **P**laces.

Foot

❖ Write a short note on the dorsalis pedis artery.

See pages 234-235.

❖ Draw a labeled diagram to show the sensory innervation of the dorsum of foot.

See Figure 22.8.

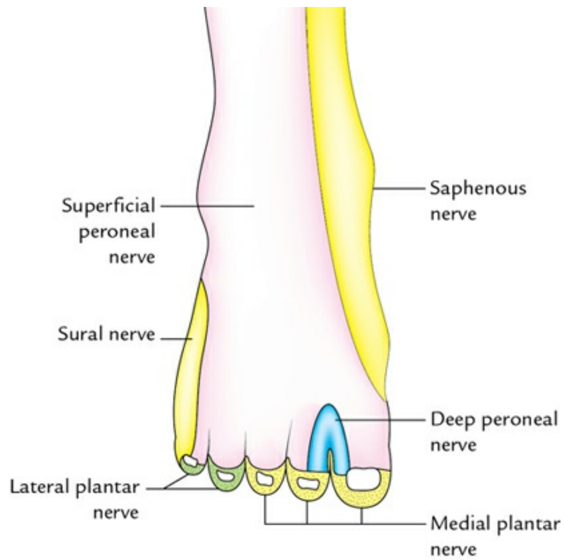


FIG. 22.8 Sensory innervation of the dorsum of the foot.

N.B.

Nail beds of medial 2½ digits are supplied by medial plantar nerve and those of lateral 1½ digits by lateral plantar nerve.

❖ Draw a labeled diagram to show the sensory innervation of the sole.

See Figure 22.9.

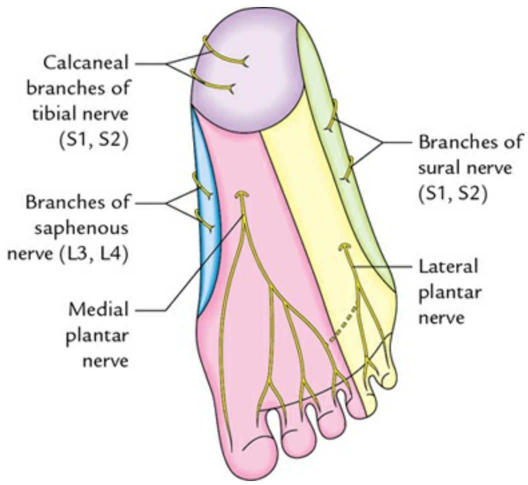


FIG. 22.9 Sensory innervation of the sole.

❖ Write a short note on the plantar aponeurosis.

- It is a central thickened part of the deep fascia of the sole.
- It is triangular in shape, having apex and base.

Attachments (fig. 22.10)

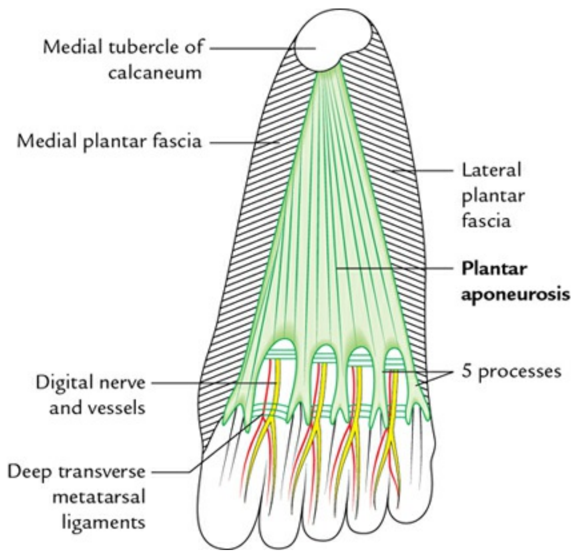


FIG. 22.10 Plantar aponeurosis.

Apex

It is directed proximally and attached to the medial tubercle of the calcaneum.

Base

It is broad distal part that divides into five processes opposite to the heads of the metatarsal bones into 5 processes. These processes are connected by the transverse fibers. The digital nerves and vessels pass through the intervals between the processes.

Each process splits into a superficial and a deep slip. The superficial slip is attached to the skin, and the deep slip divides into two parts that embrace the flexor tendons and blend with the fibrous flexor sheaths and also with the deep transverse metatarsal ligaments.

N.B.

Morphologically, plantar aponeurosis is the detached tendon of the plantaris muscle.

Functions

- It fixes the skin of the sole and protects deeper structures of sole.
- It helps in maintaining the longitudinal arches of the foot by acting as a tie beam.

Applied anatomy

Plantar fasciitis

It is the inflammation or tear of the apical part of the plantar fascia and causes pain in the heal during walking especially on hard surface. It commonly affects the individuals who are supposed to stand for a long period of time, viz. traffic police personnel, hence also called *Policeman's heel*: neglected may lead to the formation of *calcaneal spur*.

❖ Enumerate muscle layers of the sole.

The muscles and tendons of the sole are arranged into the following 4 layers:

First layer

It consists of 3 muscles:

- Abductor hallucis
- Flexor digitorum brevis
- Abductor digiti minimi

Second layer

It consists of 2 tendons and 2 muscles:

- Tendon of flexor hallucis longus
- Tendon of flexor digitorum longus
- Flexor digitorum accessorius
- Lumbrical muscles.

Third layer

It consists of 3 muscles:

- Flexor hallucis brevis
- Adductor hallucis
- Flexor digiti minimi brevis.

Fourth layer

It consists of 2 tendons and 2 muscles:

- Tendon of peroneus longus
- Tendon of tibialis posterior
- Plantar interossei
- Dorsal interossei

N.B.

The 1st *neurovascular plane* lies between the first and second layers of the sole, while the *2nd neurovascular plane* lies between the third and fourth layers of the sole.

❖ Write a short note on the plantar arch.

- It is the name given to the continuation of the distal part of the lateral plantar artery (Fig. 22.11).
- It courses across the sole from lateral to medial side between third and fourth layers of the sole.
- It presents as a concavity proximally and convexity distally.
- It begins at the base of 5th metatarsal bone and extends to the first intercostal osseous where it ends by joining the dorsalis pedis artery.
- The deep branch of lateral plantar nerve lies in its concavity.

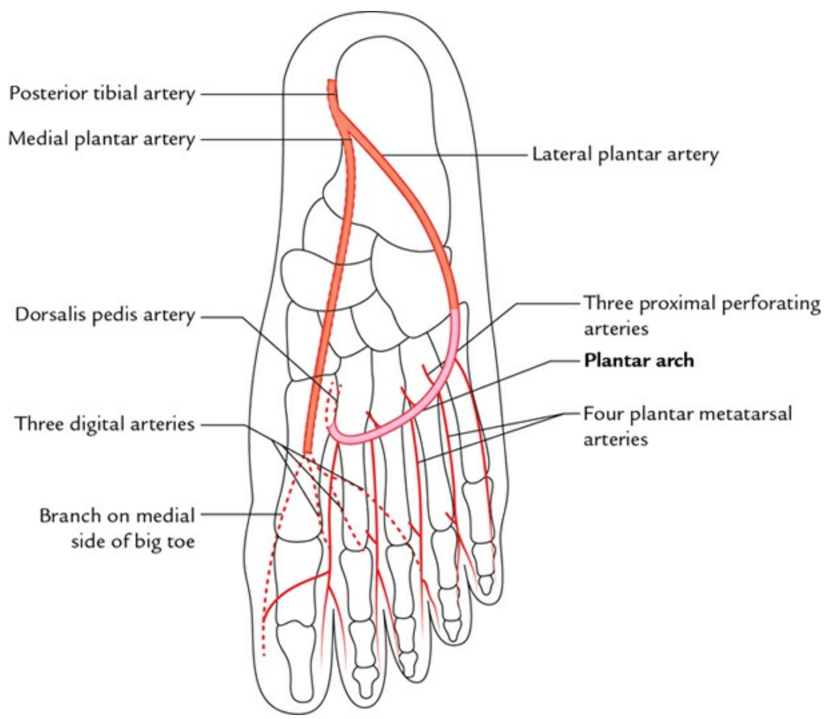


FIG. 22.11 Plantar arch.

Branches

- Three proximal perforating arteries that enter 2nd, 3rd, and 4th intermetatarsal spaces.
- Four plantar metatarsal arteries that run forward in corresponding intermetatarsal spaces.

Applied anatomy

If plantar arch is cut, it is difficult to control the bleeding by direct pressure/ligature due to its deep location. To stop it effectively, one needs to compress the femoral artery.

❖ Describe the arches of foot under the following headings: (a) definition, (b) classification, (c) formation and features, (d) factors responsible for the maintenance of the arches, (e) functions, and (f) applied anatomy.

Definition

The human foot is designed to form segmented arches not only to support the body weight but also to propel the body forward during walking and running. The arches of foot are distinguished features of a human.

Classification

When looked from below, the foot appears arched not only longitudinally, but also transversely. Thus, there are two types of arches.

Longitudinal arches (fig. 22.12)

- Medial
- Lateral

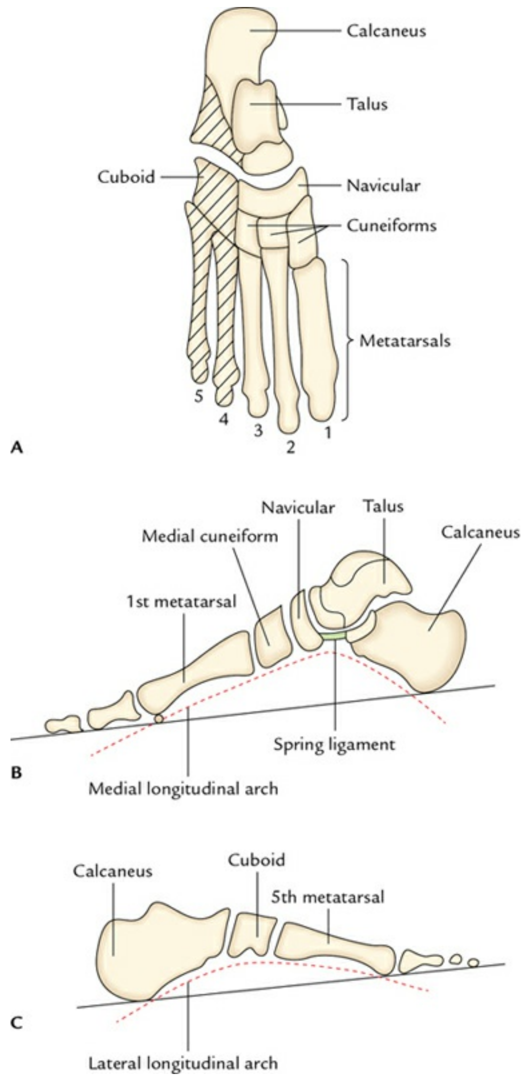


FIG. 22.12 Longitudinal arches of the foot: **A,** formation; **B,** height of medial longitudinal arch; **C,** height of lateral longitudinal arch.

Transverse arches

- Anterior
- Posterior

Formation of medial longitudinal arch

It is considerably higher mobile and resilient. From behind forward, it is formed by:

- Calcaneus
- Talus
- Navicular.
- Three cuneiforms

- Three medial metatarsals

Features of medial longitudinal arch

Ends

- *Anterior end* is formed by the heads of 1st, 2nd and 3rd metatarsals.
- *Posterior end* is formed by medial tubercle of calcaneum.
- *Summit* is formed by superior articular surface of the body of talus.

Pillars

- *Anterior pillar* is long and weak. It is formed by talus, navicular, 3 cuneiforms, and 1st three metatarsals.
- *Posterior pillar* is short and strong. It is formed by medial part of the calcaneum.
- *Joint* The important joint is talocalcaneonavicular joint.

Formation of lateral longitudinal arch

It is low with limited mobility. It is built to transmit weight and thrust to the ground. It acts as shock absorber. From behind forward, it is formed by: calcaneum, cuboid, and two lateral metatarsals.

Joint

The important joint of the arch is the talocalcaneonavicular joint.

Features of lateral longitudinal arch

Ends

- *Anterior end* is formed by heads of fourth and fifth metatarsals.
- *Posterior end* is formed by lateral tubercle of the calcaneus.

Summit

It is formed by the cuboid.

Pillars

- *Anterior pillar* is formed by cuboid and fourth and fifth metatarsals. It is long and weak.
- *Posterior pillar* is formed by lateral half of the calcaneum. It is strong and short.

Joint

The important joint of the arch is the calcaneocuboid joint.

Formation of anterior transverse arch

It is formed by the heads of all the metatarsals.

Formation of posterior transverse arch

It is formed by calcaneum, cuboid, cuneiforms, and metatarsals except their heads. It is like a half dome because only its lateral end comes in contact with the ground.

Factors responsible for the maintenance of the arches of foot

Shapes of the bones

They are very important for maintaining posterior transverse arch where many tarsal bones are involved and interlocked.

Intersegmental ties or ligaments

They hold different segments of arches together like spring ligament for medial longitudinal arch and the long and short plantar ligaments for lateral longitudinal arch.

Tie beams or bowstrings

They connect the two ends of the arch, which prevent the arches from flattening. It is done by plantar aponeurosis and muscles of first layer of sole in case of longitudinal arches and adductor hallucis in case of transverse arch.

Slings

They keep the summit pulled up.

- *Medial longitudinal arch*, by tendons passing from posterior segment of leg into the sole.
- *Lateral longitudinal arch*, tendons of peroneus longus and brevis.
- *Transverse arches*, peroneus longus and tibialis posterior.

Functions of the arches

- Provide rigid support and distribute the body weight to the weight-bearing areas of the sole in standing position.
- Act as a mobile springboard during walking and running.
- Act as a shock absorber during jumping.
- Protect the nerves and vessels of the sole from rubbing against the ground.

Applied anatomy

Flatfoot (pes planus)

It occurs either due to absence or due to collapse of the longitudinal arches, especially the medial longitudinal arch. Clinically, it presents as:

- Clumsy and shuffling gait due to the loss of spring action of foot.
- Foot trauma and osteoarthritis due to the loss of shock absorption.
- Compression of nerves and vessels of the sole due to the loss of concavity.

High-arched foot (pes cavus)

It occurs when longitudinal arches become unduly elevated (i.e., exaggeration of longitudinal arches) due to shortening of plantar aponeurosis or contracture of the intrinsic muscles of the sole.

CHAPTER 23

Joints of the lower limb

❖ Describe hip joint under the following headings: (a) classification, (b) ligaments, (c) relations, (d) movements and muscles producing them, and (e) applied anatomy.

Classification

It is a synovial joint of ball and socket variety. It is formed between rounded head of femur and cup-shaped acetabulum of the hip bone. The acetabulum is deepened at its margins by a fibrocartilaginous rim – the **labrum acetabulare** (Fig. 23.1).

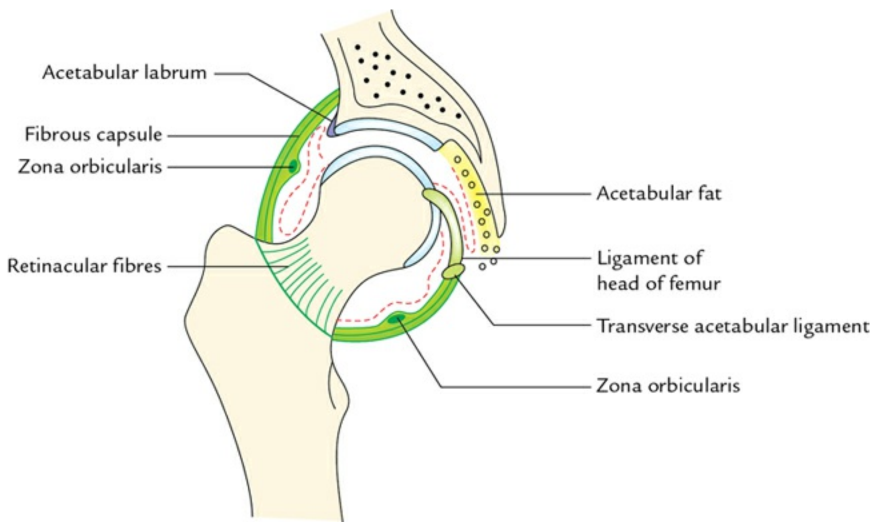


FIG. 23.1 Hip joint (coronal section).

Ligaments

Capsular ligament

Above, it is attached to the acetabular margin and transverse acetabular ligament.

Below, it is attached to the femur on intertrochanteric line anteriorly and on femoral neck about 1 cm above the intertrochanteric crest posteriorly.

The capsular fibers are reflected from their lower attachment upward on the femoral neck to form **retinacula.**

*Iliofemoral ligament (Bigelow's ligament)***:** It is strong inverted 'Y'–shaped ligament. The apex/stem of 'Y' is attached to the anterior inferior iliac spine, while its medial and lateral limbs are attached to the intertrochanteric line (Fig. 23.2).

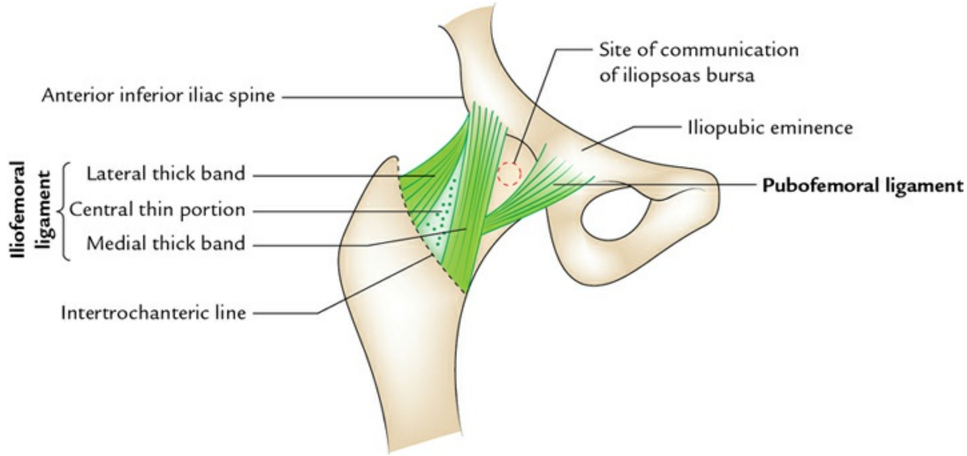


FIG. 23.2 Ligaments providing stability to the hip joint.

Pubofemoral ligament: It is triangular in shape and attached above to the iliopubic junction and below to the anteroinferior part of the capsule, adjacent to intertrochanteric line (Fig. 23.2).

Ischiofemoral ligament: It is attached above to the ischium, and below some fibers are attached to the base of greater trochanter, but majority of fibers spiral and blend with capsule around femoral neck to form *zona orbicularis*.

N.B.

The ligamentous stability to the hip joint is provided by following three ligaments:

- *Iliofemoral ligament* restricts hyperextension of hip to prevent the backward fall while standing.
- *Pubofemoral ligament* supports the joint inferomedially.
- *Ischiofemoral ligament* supports the joint posteriorly.

Ligament of head of femur (round ligament/ligamentum teres): It is a flat and triangular ligament with apex attached to the fovea capitis of femoral head and its base to transverse acetabular ligament.

Relations

The relations of hip joint are given in the box below and shown in Figure 23.3.

Anterior	Posterior	Superior	Inferior
Iliopsoas Psoas bursa Pectineus Rectus femoris (straight head) Femoral nerve and vessels	Sciatic nerve Piriformis obturator internus with gamelli Quadratus femoris Gluteus maximus	Gluteus minimus Gluteus medius Rectus femoris (reflected head)	Pectineus Obturator externus

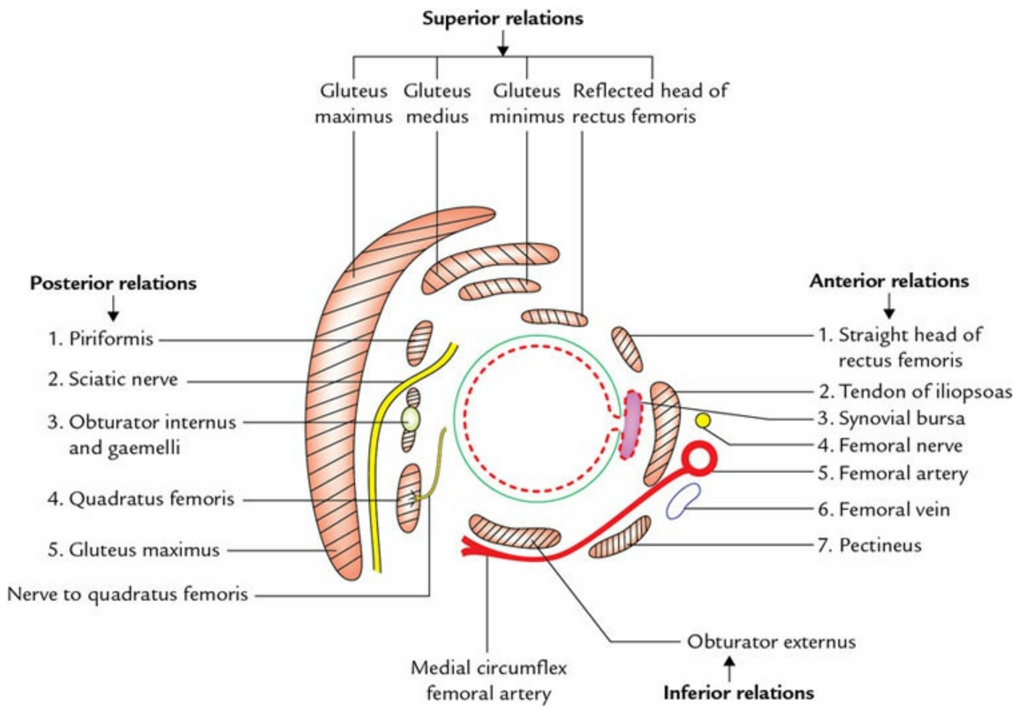


FIG. 23.3 Relations of the hip joint.

Movements and muscles

These are given in the box below:

Movements	Muscles
Flexion (110° to 120°)	Psoas major and Iliacus
Extension (15°)	Gluteus maximus Hamstring muscles
Adduction (limited by opposite limb)	Adductor longus Adductor brevis Adductor magnus
Abduction	Gluteus medius Gluteus minimus
Medial rotation (25°)	Tensor fasciae latae Anterior fibers of gluteus minimus and medius
Lateral rotation (60°)	Short muscles, viz. piriformis, obturator internus, obturator externus and quadratus femoris

Applied anatomy

Dislocation

Acquired dislocation mostly occurs posteriorly and often injures sciatic nerve. (Note that *congenital dislocation* is most common in hip joint.)

Fracture of neck of femur

It commonly occurs between 40 and 60 years of age, especially in females.

Referred pain

In diseases of hip, pain is referred to the knee.

❖ Describe knee joint under the following headings: (a) classification, (b) ligaments and menisci, (c) relations, (d) movements and muscles producing them, and (e) applied anatomy.

Classification

It is a compound synovial joint with following components:

- *Condylar joint (modified hinge joint)*, between medial and lateral condyles of femur and tibia.
- *Saddle joint*, between femur and patella (Fig. 23.4).

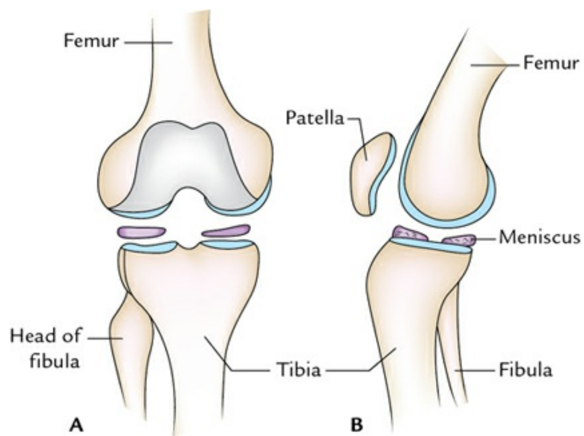


FIG. 23.4 Knee joint: A, condylar joint between condyles of femur and tibia; B, saddle joint between femur and patella.

Ligaments

Capsular ligament (fig. 23.5)

It is attached to the margins of articular surfaces except anteriorly where it is deficient and supplemented by extensor apparatus of the knee joint consisting of tendon of quadriceps, patella, and ligamentum patellae. Posterolaterally, it prevents an opening for the passage of the tendon of popliteus.

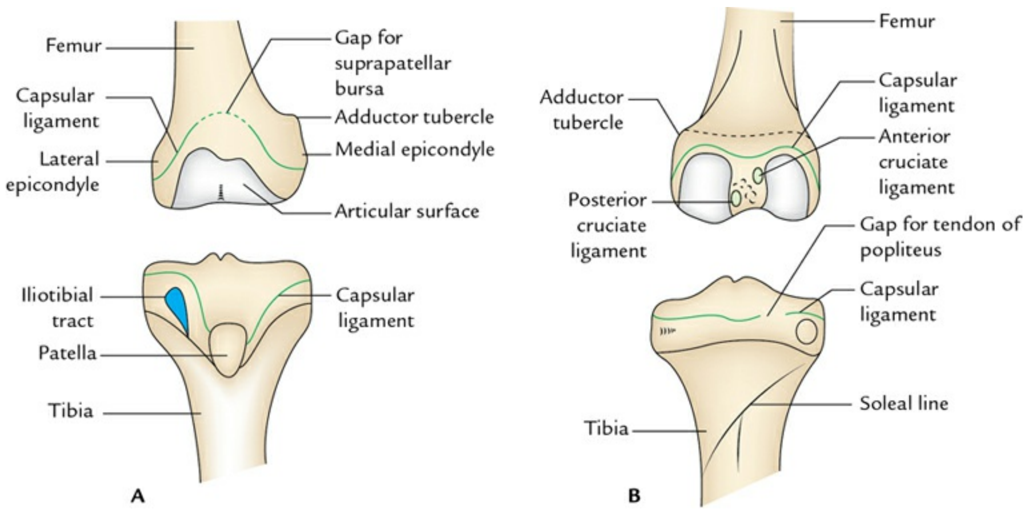


FIG. 23.5 Attachment of the capsular ligament.

Medial (tibial) collateral ligament (fig. 23.6)

It consists of superficial and deep parts. The superficial part is attached above to the epicondyle of femur and below to the upper part of the medial border of the tibia. The deep part is firmly attached to the medial meniscus.

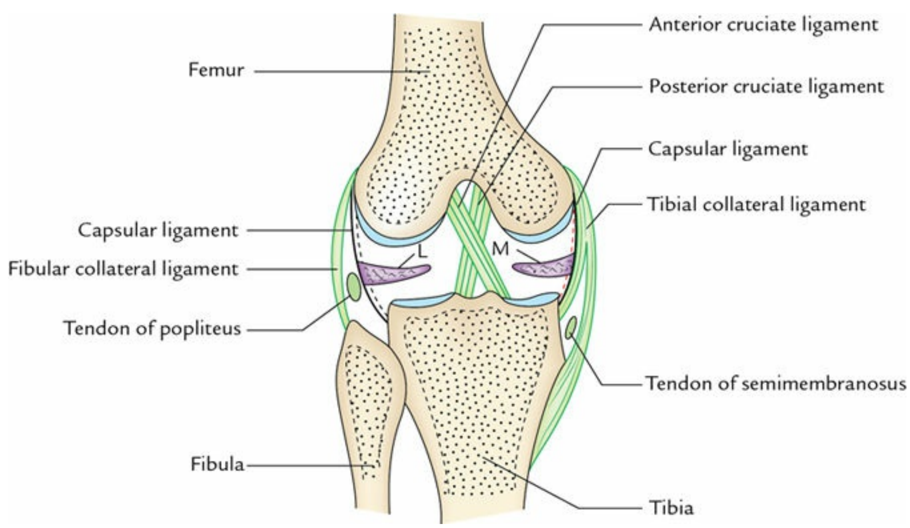


FIG. 23.6 Collateral and cruciate ligaments of the knee joint as seen in coronal section.

Lateral (fibular) collateral ligament

It is attached above to the epicondyle of femur and below to the head of the fibula. It lies away from meniscus.

Cruciate ligaments (anterior and posterior) (fig. 23.7)

They are intracapsular. The *anterior cruciate ligament* extends from anterior part of the intercondylar area of the tibia to the medial side of lateral femoral condyle. It prevents hyperextension and resists forward movement of tibia on the femur.

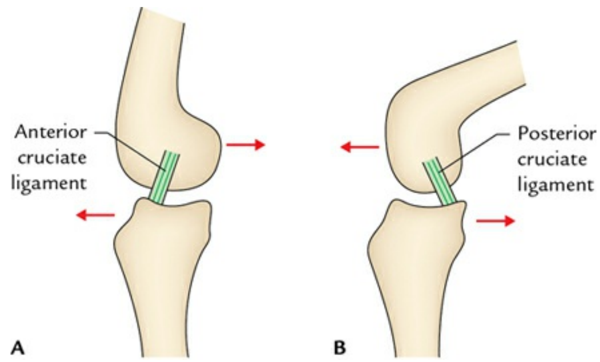


FIG. 23.7 Attachments of the cruciate ligaments.

The *posterior cruciate ligament* extends from posterior part of the intercondylar area of tibia to lateral side of the medial femoral condyle. It becomes taut in hyperflexion and resists posterior displacement of tibia on the femur.

Menisci (semilunar cartilages) (fig. 23.8)

These are semilunar fibrocartilaginous plates that lie on the articular surfaces of the superior surface of tibia. The medial meniscus is larger and 'C'–shaped, while lateral meniscus is relatively smaller and 'O'–shaped. They are attached to the tibial intercondylar area by their horns (anterior and posterior) and peripherally by **coronary ligaments.**

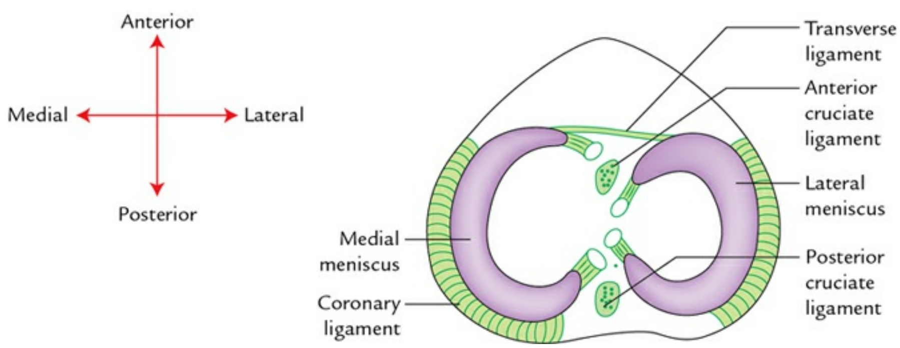


FIG. 23.8 Attachments of menisci.

Relations

These are given in the box below:

Anterior	Posterior	Medial	Lateral
Quadriceps femoris Patella Ligamentum patellae	Popliteal vessels Tibial nerve Lateral and medial heads of gastrocnemius	Medial patellar retinaculum Sartorius Gracilis Semimembranosus Semitendinosus	Lateral patellar retinaculum Common peroneal nerve Tendon of biceps femoris

Movements

These are given in the box below:

Movements	Muscles producing them

Extension	Quadriceps femoris Tensor fascia latae
Flexion	Popliteus Biceps femoris Semitendinosus Semimembranosus Sartorius
Medial rotation	Semimembranosus Sartorius
Lateral rotation	Biceps femoris Gracilis

Applied anatomy

Osteoarthritis

Being a weight-bearing joint, osteoarthritis (degenerative changes in articular cartilages and surfaces) is most common in the knee joint.

Unhappy triad of the knee joint

A combination of injury involving (a) tibial collateral ligament, (b) medial meniscus, and (c) anterior cruciate ligament is termed as *unhappy triad of the knee joint*.

❖ Write a short note on locking and unlocking of the knee joint.

The full extension of knee is called *locking* of the knee joint. It occurs due to medial rotation of femur on fixed tibia or lateral rotation of tibia on fixed femur in terminal phase of extension.

The initial flexion of locked knee is called *unlocking* of the knee joint. It occurs due to lateral rotation of femur on tibia.

The purpose of locking and unlocking of the knee is to provide stable movements at the knee joint.

Anatomical basis of locking and unlocking

- Articular surfaces of tibia and femur are not proportionate and incongruent.
- During the terminal phase of the knee extension, the small articular surface of tibia is used by the femur. Now to accommodate this unused articular surface of femur on tibia, the femur or tibia rotates to have a stable movement at knee.

Differences between locking and unlocking of the knee joint

These are given in the box below:

	Locking	**Unlocking**
Rotation of bones:		
When tibia is fixed	Medial rotation of femur on tibia	Lateral rotation of femur on tibia
When femur is fixed	Lateral rotation of tibia on femur	Medial rotation of tibia on femur
Muscle involved	Quadriceps femoris	Popliteus
Status of joint	Absolutely rigid (no further extension)	Slightly flexed (further flexion possible)
Status of ligaments	All ligaments are taut	All ligaments are relaxed

❖ Enumerate bursae around the knee joint.

There are approximately 12 bursae around the knee joint (Fig. 23.9):

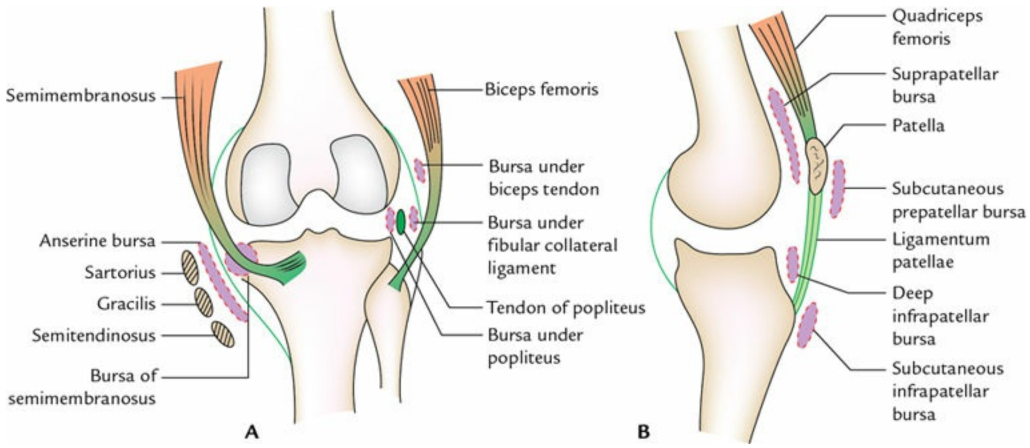


FIG. 23.9 Bursae around the knee joint.

Anterior bursae

- Prepatellar subcutaneous
- Suprapatellar
- Infrapatellar: (a) subcutaneous and (b) deep

Lateral bursae

- Between fibular collateral ligament and tendon of biceps femoris
- Between fibular collateral ligament and tendon of popliteus
- Between tendon of popliteus and lateral femoral condyle
- Between tendons of semimembranosus and semitendinosus

Medial bursae

- Anserine bursa, between the tendons of sartorius, gracilis, and semitendinosus
- Between semimembranosus and medial tibia condyle

Posterior bursae

- Deep to lateral head of gastrocnemius
- Deep to medial head of gastrocnemius (**Brodie's bursa**)

N.B.

Inflammation of prepatellar subcutaneous bursa leads to *Housemaid's knee*, inflammation of subcutaneous infrapatellar bursa leads to *Clergyman's knee*, and inflammation of bursa deep to tendon of semimembranosus leads to *Baker's cyst*.

❖ Describe ankle joint under the following headings: (a) classification, (b) ligaments, (c) relations, (d) movements, and (e) applied anatomy.

Classification

- It is synovial joint of modified hinge variety.
- It is formed between lower ends of tibia and fibula, and talus (Fig. 23.10).

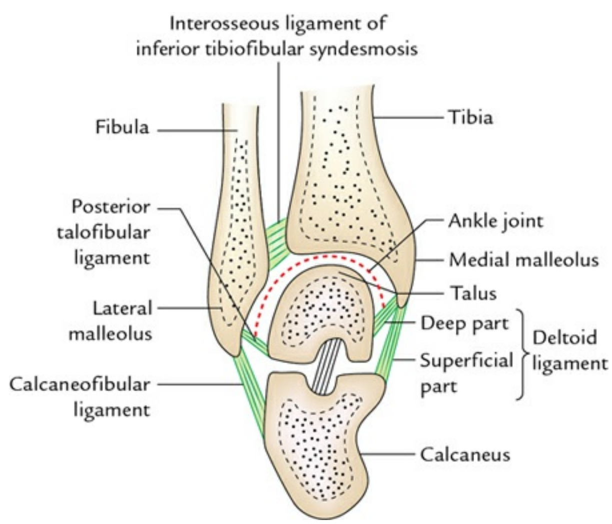


FIG. 23.10 Articular surfaces of the ankle joint.

Ligaments (fig. 23.11)

Capsular ligament

It encloses the articular surfaces. It is lax anteriorly to permit uninhibited hinged movements.

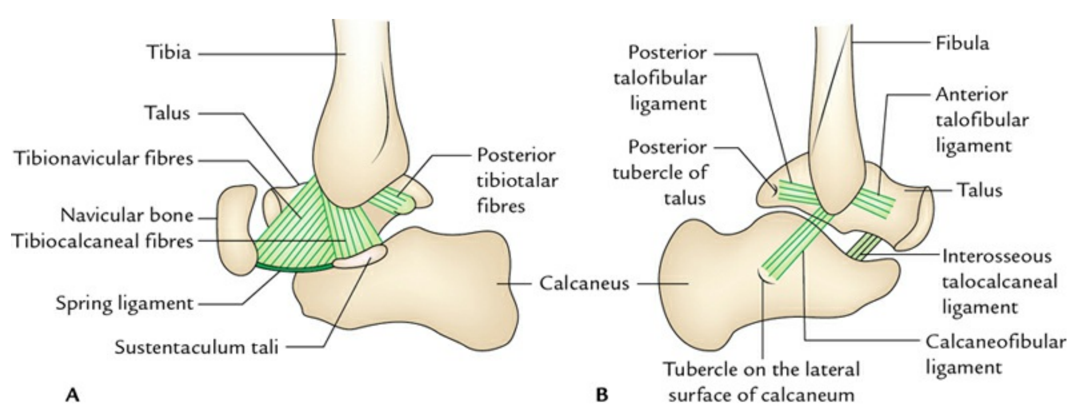


FIG. 23.11 Collateral ligaments of ankle joint: A, medial collateral; B, lateral collateral.

Medial collateral (deltoid) ligament

It is a strong triangular ligament and consists of superficial and deep parts. The deep part is vertical band extending between medial malleolus and talus. The superficial component is fan–shaped. It is attached above to medial malleolus and below to (from front to back) tuberosity of navicular, spring ligament, sustentaculum tali, and posterior tubercle of the talus.

Lateral collateral ligament

It consists of 3 bands/components: anterior talofibular, posterior talofibular, and calcaneofibular ligament. The anterior talofibular ligament is attached to the neck of talus, posterior talofibular ligament to the lateral tubercle of the talus, and calcaneofibular ligament to the lateral surface of the calcaneus.

Relations

Anterior:

From medial to lateral:

- Tendon of **t**ibialis anterior
- Extensor **h**allucis longus
- **A**nterior tibial vessels
- Deep peroneal **n**erve
- Extensor **d**igitorum longus
- **P**eroneus tertius

Mnemonic: The **H**imalayas **a**re **n**ever **d**ry **p**laces.

Posterior

(Behind tibial malleolus) From anterior to posterior:

- Tendon of **t**ibialis posterior
- Flexor **d**igitorum longus
- Posterior tibial **a**rtery
- Tibial **n**erve
- Tendon of flexor **h**allucis longus.

Mnemonic: The **D**octors **a**re **n**ot **h**ere.

Movements and muscles producing them

These are given in the box below:

Movements	Muscles
Dorsiflexion (10° to 20°)	Tibialis anterior Extensor hallucis longus Extensor digitorum longus
Plantar flexion (20° to 40°)	Triceps surae

	Tibialis posterior Flexor digitorum longus Flexor halluces longus

Applied anatomy

Ankle sprains

It occurs due to tear in anterior talofibular (most common) and calcaneofibular ligaments following excessive eversion of plantar flexed foot. Clinically, it presents as pain, swelling, and loss of movements.

Pott's fracture

It includes avulsion of deltoid ligament (*first degree*); avulsion of deltoid ligament and fracture of medial malleolus (*second degree*); and avulsion of deltoid ligament, fracture of medial malleolus, and fracture of lateral malleolus (*third degree*).

In severe cases of *third degree Pott's fracture*, there is a fracture of posterior lip of tibial facet (also called *third malleolus*). The Pott's fracture occurs when foot is caught in the rabbit hole and everted forcibly.

❖ Give a brief account of talocalcaneonavicular, subtalar and midtarsal joints.

Talocalcaneonavicular joints (fig. 23.12)

It is compound synovial joint of ball and socket variety (roughly). It is formed between head of talus above (ball) and calcaneum, navicular and spring ligament below (socket). It may be divided into two components: posterior and anterior subtalar joints.

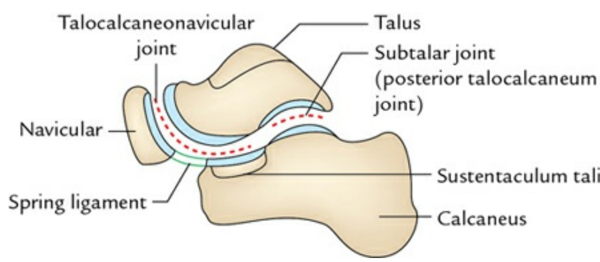


FIG. 23.12 Talocalcaneonavicular and subtalar joints.

Subtalar joint

It is *posterior subtalar joint* between the body of talus and middle third of the superior surface of the calcaneum.

Midtarsal joint

It consists of calcaneocuboid and talonavicular joints. Both of them are plane type of synovial joints.

❖ Describe inversion and eversion in brief.

When the foot is off the ground.

- *Inversion* is the movement in which medial border of foot is raised so that sole faces medially.
- *Eversion* is the movement in which lateral border of foot is raised so that sole faces laterally.
- These movements take place at talocalcaneonavicular (mainly) and midtarsal joints.
- These movements take place around an *oblique axis*, which passes forward, upward, and medially from back of calcaneum through sinus tarsi to the superomedial aspect of the neck of talus (Fig. 23.13).
- The inversion is akin to supination and eversion to pronation of forearm.
- The range of motion is more in inversion than that in eversion.
- Inversion is produced by tibialis anterior and tibialis posterior, while eversion is produced by peroneus longus and peroneus brevis.

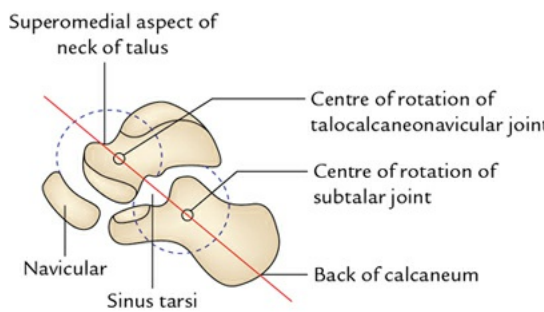


FIG. 23.13 Axis of inversion and eversion.

SECTION IV
General embryology

OUTLINE

CHAPTER 24

General embryology

❖ Define embryology.

The embryology is the study of the developmental events beginning with the fertilization of an ovum and culminating with the birth of a baby.

Generally, this phase of development is divided into two periods:

- *Embryonic period*: From fertilization to the end of 8th week.
- *Fetal period*: From beginning of 9th week till the birth of a baby.

❖ What is fertilization? Give steps and results of the fertilization.

The fertilization is a process of union of male and female gametes (pronuclei).

Steps of fertilization

These are:

• Penetration of corona radiata

• Penetration of zona pellucida

• Fusion of cell membranes of sperm and oocyte

• Completion of second meiotic divisions of the secondary oocyte

• Formation of male and female pronuclei

• Fusion of male and female pronuclei

Results of fertilization (i.e., events occurring just after fertilization):

These are:

• Formation of zygote (transient)

• Restoration of diploid number of chromosomes

• Determination of genetic sex

• Initiation of cleavage

• Variation of species

❖ Write a short note on spermatogenesis (fig. 24.1).

The spermatogenesis is a process of events by which spermatogonia are transformed into spermatozoa.

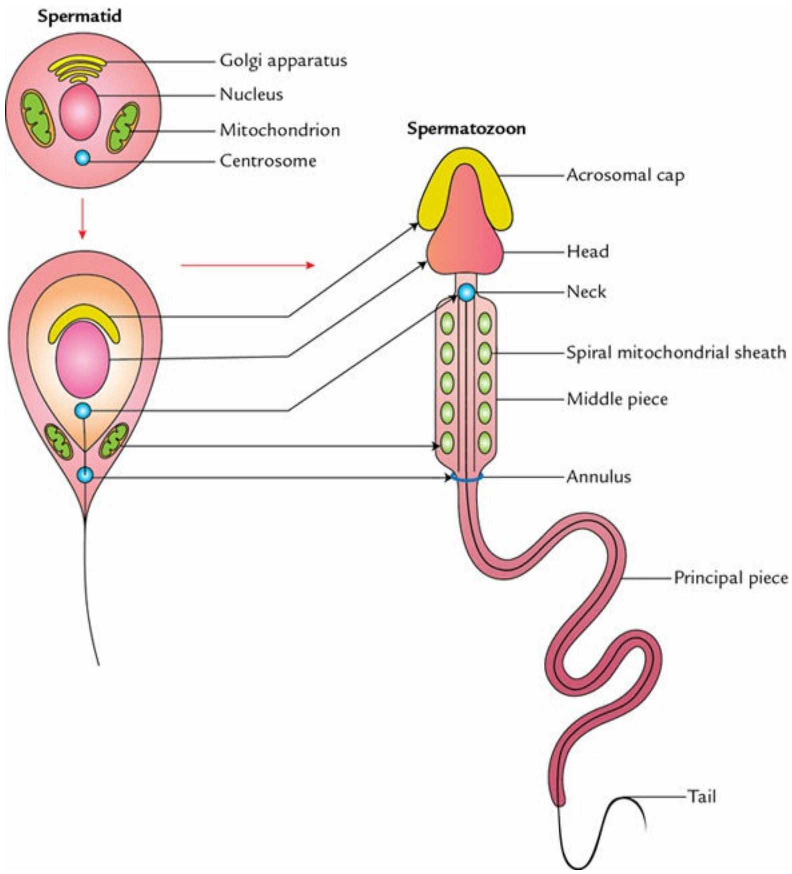


FIG. 24.1 Spermatogenesis.

Stages of spermatogenesis

- Spermatogonia (diploid) divides mitotically into two primary spermatocytes.
- Each primary spermatocyte (diploid) undergoes first meiotic division to form two secondary spermatocytes.
- Each secondary spermatocyte (haploid) undergoes second meiotic division to form two spermatids (haploid).
- Each spermatid (haploid) is transformed into a spermatozoon by a process called spermiogenesis.

❖ Write a short note on spermiogenesis (fig. 24.2).

- It is a process by which spermatids are transformed into spermatozoa.
- The spermatid is a small circular cell with a spherical nucleus, golgi complex, mitochondria, and a centriole.

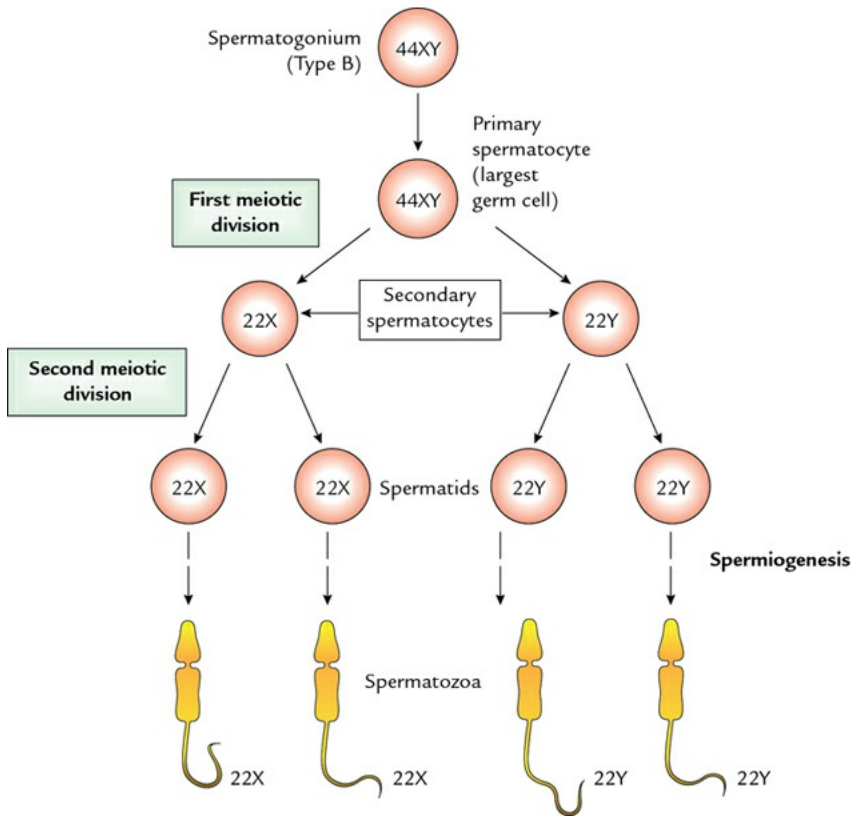


FIG. 24.2 Spermiogenesis.

The following changes take place in the spermatid:

- Nucleus becomes denser and more ovoid to form head.
- Golgi complex is converted into an acrosomal cap (a dense staining body) that caps the head.
- Centriole divides into two centrioles.

❒ One moves to neck and gives rise to *axial filament*.

❒ Other moves distally, becoming ring shaped to form an annulus (i.e., ring around the distal end of the middle piece).

- Axial filament between head and annulus becomes surrounded by mitochondria to form the *middle piece of the spermatozoa*.

- Axial filament elongates to form tail (principal piece).
- Cytoplasm is extruded/shed off, and only cell membrane remains as the *covering of spermatozoa*.

❖ Write a short note on oogenesis (fig. 24.3).

It is process by which oogonia are transformed into oocytes (female gametes).

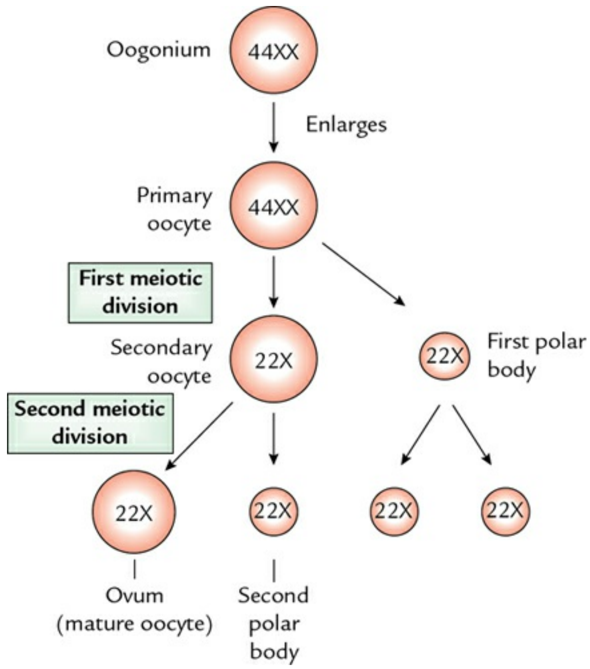


FIG. 24.3 Oogenesis.

Stages of oogenesis

- Oogonium enlarges to form primary oocyte (diploid).
- Primary oocytes undergo first meiotic division to form secondary oocyte (haploid) and the 1st polar body (haploid).
- Secondary oocyte (haploid) undergoes second meiotic division to form an ovum (mature secondary oocyte) and the second polar body (haploid).

N.B.

The first meiotic division of ovum completes at its formation, while its second meiotic division completes only if the ovum is fertilized.

❖ Write a short note corpus luteum (fig. 24.4).

After ovulation, the empty Graafian follicle, under the influence of LH, shrinks and is transformed into a yellowish glandular structure called *corpus luteum* (Fig. 24.4).

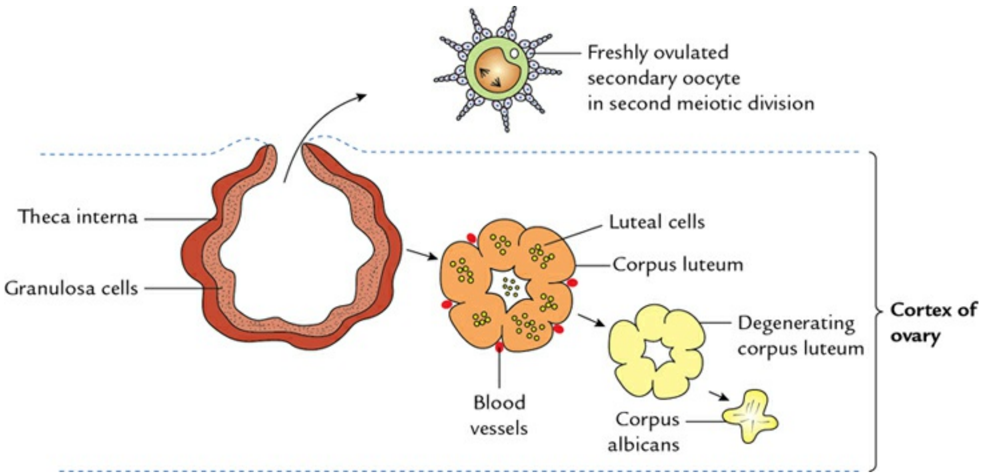


FIG. 24.4 Corpus luteum.

Steps of formation

- First, the granula cells and theca internal cells get vascularized by the surrounding vessels and become polyhedral.
- Later, a yellow pigment develops in these cells, and they are called as *luteal cells*.

Fate of corpus luteum

- If *fertilization occurs*, the corpus luteum persists for 3–4 months (under the influence of HCG) and is called as *corpus luteum of pregnancy.* It secretes progesterone that maintains pregnancy for the initial 3–4 months.
- If *fertilization does not occur*, the corpus luteum lasts only for 10–14 days. Thereafter, it degenerates and transformed into a mass of fibrous tissue called *corpus albicans*. It is also known as *corpus luteum of menstruation*.

❖ Write a short note on implantation.

It is the embedding of the blastocyst in the endometrium. It occurs during 6–10 days after fertilization.

Stages of implantation (fig. 24.5)

- Zona pellucida disappears.
- Trophoblast adheres to the endometrium.
- Trophoblast differentiates into cytotrophoblast and syncytiotrophoblast.
- Syncytiotrophoblast penetrates the endometrium.
- Migration of blastocyst into the endometrium.

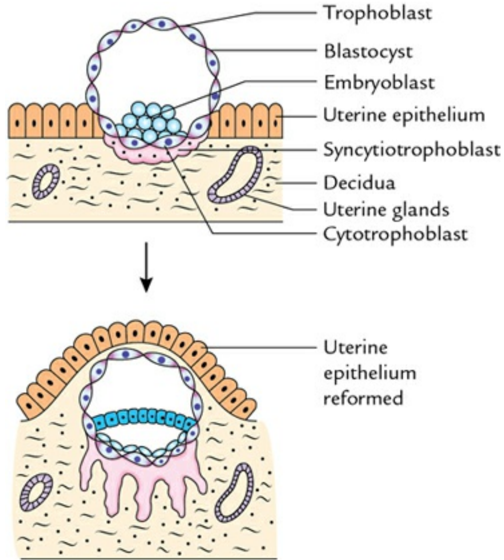


FIG. 24.5 Stages of implantation.

Site of implantation

Endometrium of the posterior wall of uterine cavity near the fundus.

Applied anatomy

If the implantation is deep, it may lead to postpartum bleeding.

❖ Enumerate abnormal sites of the implantation.

The abnormal sites of implantation are (Fig. 24.6):

- Within the uterus

❒ Near internal OS

- Outside the uterus

❒ In the uterine tube (tubal implantation): The order of frequency is (i) ampulla, (ii) infundibulum, and (iii) interstitial part.

❒ In the abdomen (abdominal implantation): The order of frequency is (i) pouch of Douglas (rectouterine pouch) and (ii) mesentery.

❒ In the ovary (ovarian implantation).

❖ Write a short note on ectopic pregnancy.

The implantation of blastocyst outside the uterus is called ectopic pregnancy (Fig. 24.6). The common ectopic pregnancies in order of frequency are: (i) uterine tube, (ii) abdominal cavity, and (iii) ovary. The tubal pregnancy is the commonest (95%), and if it is allowed to progress, the uterine tube generally ruptures in 2nd month of the pregnancy, leading to severe internal bleeding.

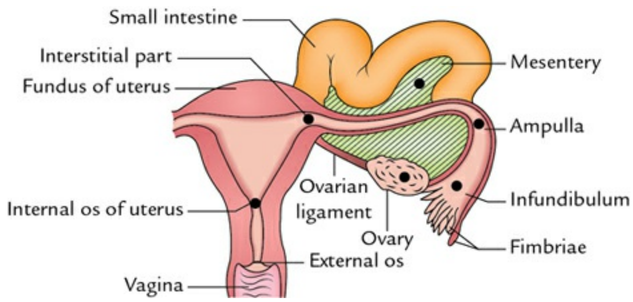


FIG. 24.6 Abnormal sites of implantation.

❖ Write a short note on decidua.

The endometrium of the uterus that undergoes decidual reaction after implantation is termed as decidua (decidua = shedding off).

Decidual reaction

It occurs under the influence of the HCG. The following changes occur in the endometrium.

Cells of endometrial glands swell due to the accumulation of glycogen and lipid in their cytoplasm (now called *decidual cells*).

- Nuclei become rounded.
- Number of cytoplasmic organelles increases.

Functions

- To provide suitable site for implantation.
- To provide nutrition for early embryo.
- To provide immunologically privileged site for conceptus.

Parts (fig. 24.7)

- *Decidua basalis*, part towards the embryonic pole, i.e., deep to the embryo.
- *Decidua capsularis*, part toward the embryonic pole, i.e., uterine cavity. It surrounds the embryo.
- *Decidua parietalis*, the remaining part of the decidua.

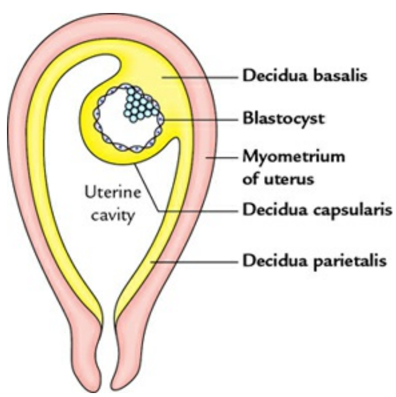


FIG. 24.7 Parts of decidua (as seen in coronal section of uterus).

Fate

- Decidua basalis undergoes development to form *decidual plate,* which gives rise to the maternal component of the placenta.
- Decidua capsularis disintegrates and fuses with the decidua parietalis, and obliterates the uterine

cavity.

- At the time of delivery, placenta separates with decidua and expelled out.

❖ Write a short note on blastocyst (fig. 24.8).

The morula (consisting of 16 blastomeres) is transformed into blastocyst shortly after it enters into uterine cavity (4th day after fertilization). The fluid-filled space appears inside morula called blastocyst cavity. As the fluid level increases in this cavity, the blastomeres are separated into two parts:

- An outer cell layer called *trophoblast* (G. trophic = nutrition).
- An inner cell mass of remaining blastomeres at one side called *embryoblast*.

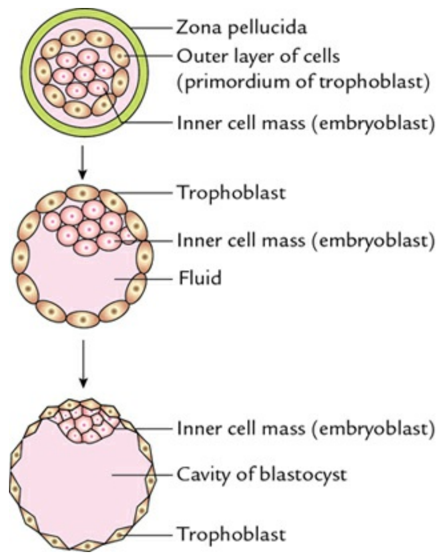


FIG. 24.8 Formation of blastocyst.

The zona pellucida is shed off to permit the blastocyst to increase in size.

Fate of blastocyst

- Embryoblast give rise to the embryo proper.
- Trophoblast gives rise to the embryonic part of the placenta.
- Fluid in the blastocyst provides nutrition to the blastomeres.

❖ Write a short note on extraembryonic/fetal membranes.

All structures derived from the zygote and yet not forming any part of the embryo are called extraembryonic/fetal membranes. These are:

- Amnion
- Chorion
- Yolk sac
- Allantois
- Placenta
- Umbilical cord

The roles played by these membranes are given as follows:

- *Amnion* forms amniotic sac filled with fluid. It protects the fetus from injury.
- *Chorion* forms fetal part of placenta.
- *Yolk sac* forms primitive gut tube and allantois.
- *Allantois* forms apex of urinary bladder and median umbilical ligament.
- *Placenta* provides exchange, respiratory gases (O_2 and CO_2) nutrition, and waste products between mother and fetus.
- *Umbilical cord* provides passages for blood to pass to and pro between mother and fetus to subserve the functions of placenta hence, it is also called lifeline between mother and fetus.

❖ Write a short note on yolk sac.

The yolk sac develops from blastocyst cavity and thus lies ventral to the embryonic disc. The functions of the yolk sac are:

• Providing nutrition to the developing of embryo (early stage)

• Hemopoieses until the liver is formed

• Formation of primordial germ cells

Stages of development (fig. 24.9):

The yolk sac undergoes 3 stages of development as follows:

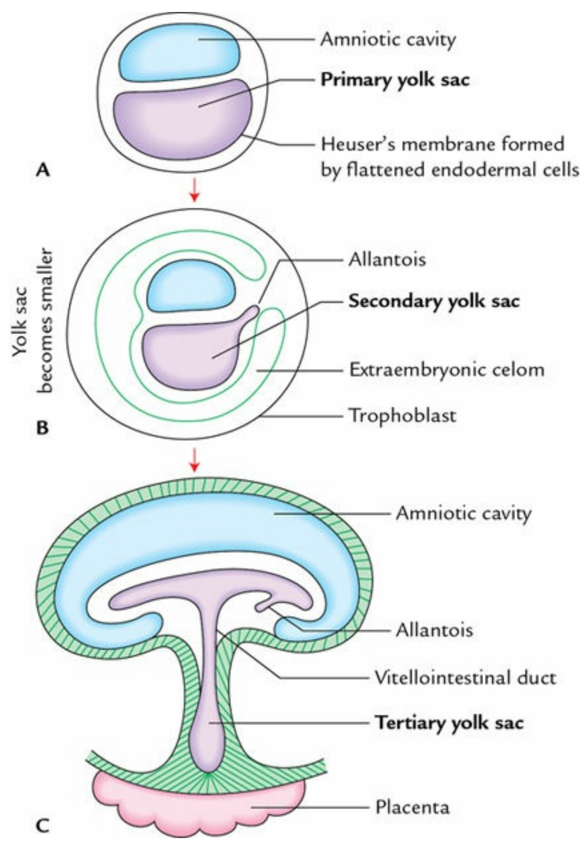


FIG. 24.9 Stages of development of yolk sac: A, primary; B, secondary; C, tertiary.

Primary yolk sac

At the end of 2nd week, the cavity of blastocyst becomes lined by Heuser's membrane and becomes primary yolk sac. The Heuser's membrane is made up of flattened cells derived from the endoderm of the embryonic disc.

Secondary yolk sac

With the appearance of extraembryonic coelom, the primary yolk sac becomes much smaller, and flattened cells lining it become cuboidal. The primary yolk sac is now called secondary yolk sac.

Tertiary yolk sac (remnant of secondary yolk sac)

The dorsal part of the secondary yolk sac becomes incorporated in the embryo while the ventral part which is not incorporated in the embryo, communicate with the midgut by vitellointestinal duct.

Thus, the secondary yolk sac is divided into 3 parts:

- Intraembryonic part
- Intermediate connecting part, called vitellointestinal duct
- Extraembryonic part, called tertiary yolk sac

Fate

- *Intraembryonic part* gives rise to gut tube (foregut, midgut, and hindgut) and allantoic diverticulum.
- *Intermediate part or vitello intestinal duct* atrophies and get detached from midgut loop.
- Extraembryonic part atrophies and disappears.
- Vitelline vessels supplying yolk sac give rise to celiac superior mesenteric and inferior mesenteric vessels.

Applied anatomy

If vitello-intestinal duct fails to atrophy it persists as Meckel's diverticulum, sinus, or fistula.

❖ Write a short note on allantois.

Allantois is a diverticulum, which arises from the caudal end of the yolk sac. It grows into connecting stalk. After the folding of the embryo, it becomes connected to dilated terminal part of the hindgut, the **cloaca**, and passes from ventral side of cloaca into the connecting stalk (Fig. 24.9). The allantois is vascularized by allantoic vessels.

Fate

The developing urinary bladder is continuous with the allantois.

- Allantois atrophies and is seen in postnatal life as a fibrous band – *the urachus*, which extends from the apex of urinary bladder to the umbilicus. It is also called as *median umbilical ligament*. It may contribute to the formation of the apex of the urinary bladder.
- Allantoic vessel becomes umbilical vessels and gets connected to the placenta.

Congenital anomalies

If allantois fails to fibrose; it persist as: urachal fistula, sinus, or cyst.

❖ Write a short note on amnion and discuss its applied anatomy.

The amnion is a thin, tough extraembryonic membrane that forms amniotic sac filled with fluid called *amniotic fluid*. Initially, the sac lies dorsal to the embryonic disc but as it enlarges, it envelops the embryo future umbilical cord and fetal part of the placenta. It develops during 10–12 weeks of IUL.

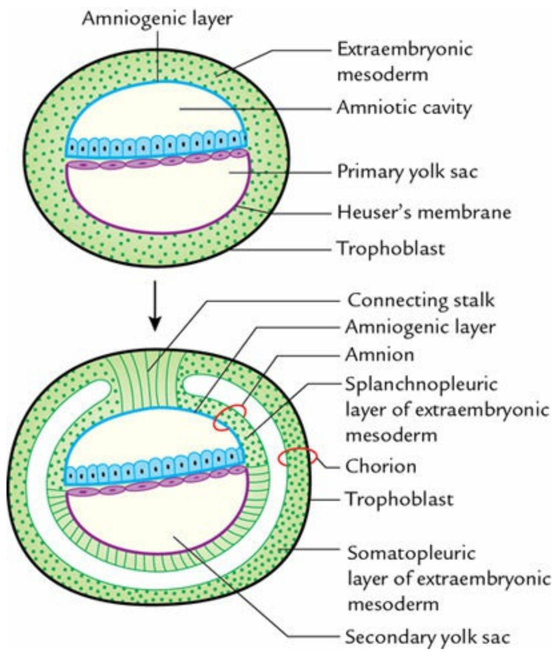


FIG. 24.10 Amnion.

Formation

The amnion consists of two layers: an inner layer of amniogenic/amniotic cells and an outer layer of somatopleuric mesoderm. The amniogenic layer is derived from the edges of the epiblast of the embryonic disc, while somatopleuric layer is derived from extraembryonic mesoderm.

Applied anatomy

- Amniotic cells lack major histocompatibility complex antigens, which enable these cells to be exposed to the maternal immune system without any adverse reaction.
- Nowadays, the amnion is being used:

❒ In the repair of corneas.

❒ As a graft material for restructuring vagina in women with cloacal abnormalities.

❖ Describe in brief the amniotic fluid and its applied importance.

It is a fluid present in the amniotic sac of the developing embryo.

Formation

It is formed by:

- Filtration of fluid from maternal and fetal vessels
- Urine secreted by the fetus

Volume of amniotic fluid

- At week 10 of gestation = 30 ml
- At week 20 of gestation = 350 ml
- At week 37 of gestation = 800–1000 ml

Composition

- Metabolites
- Hormones (HCG and HPL)
- Desquamated cells of fetal epithelium
- Fetal urine

Circulation

Part of it:

- Goes into maternal blood
- Swallowed by the fetus

Functions

- Protects embryo from injury by acting as a water cushion (shock absorber)
- Permits symmetrical external growth of the embryo
- Regulates body temperature of the embryo
- Forms hydrostatic bag (bag of waters), which helps in dilatation of cervix during birth
- Allows free movements of the fetus for proper development of musculoskeletal system

Congenital anomalies

Oligohydramnios

A condition in which the amount of amniotic fluid is less than 400 ml. It is associated with renal agenesis. This condition may cause pulmonary hypoplasia, facial defects, limb defects, and compression of umbilical cord.

Polyhydramnios

A condition in which the amount of amniotic fluid is more than 2000 ml. It is usually associated with severe anomalies of central nervous system and esophageal atresia.

Applied anatomy

Amniocentesis

It is the aspiration of amniotic fluid to estimate the level of alpha-fetoprotein to detect fetal defects and to do chromosomal analysis for antenatal sex determination. It is done at 14th or 15th week of gestation when the amount of fluid is about 200 ml.

❖ Write a short note on chorion.

The chorion is an extraembryonic membrane that envelops the developing embryo and plays a key role in the development of placenta (Fig. 24.11).

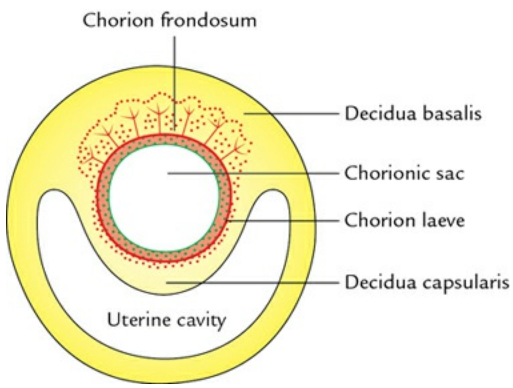


FIG. 24.11 Chorion.

Formation

It is formed by an outer layer of trophoblast and an inner layer of somatopleuric extra-embryonic mesoderm.

Fate

It gives rise to numerous fingers like projections called **chorionic villi**, which grow into the surrounding decidua and later the chorion differentiation into two parts chorion laeve and chorionic frondosum.

Chorion laeve

On the side of decidua capsularis, the chorionic villi degenerate, leaving behind a smooth surface called chorionic leave.

Chorionic frondosum

On the side of decidua basalis, these villi grow further, giving rise a leafy appearance called chorionic frondosum. This forms fetal part of the placenta.

Applied anatomy

Chorionic villi biopsy

It is done to detect genetic disorders at week 8, i.e., much earlier than the amniocentesis which is performed after week 14 of gestation.

❖ Write a short note on the umbilical cord.

It is a long cord with a length of 2 ft (50 cm) and a diameter of 1–2 cm, which extends from umbilicus of fetus to the placenta. It is considered as a lifeline connecting fetus to the mother.

Formation

After folding of embryo, the connecting stalk elongates to form the umbilical cord. It is covered by a glistening membrane, the amnion.

Contents (fig. 24.12)

- Two umbilical arteries
- One umbilical vein (left)
- Wharton's jelly (formed due to mucoid degeneration of intraembryonic mesoderm of the connecting stalk)
- Remnants of vitellointestinal duct
- Remnants of allantoic diverticulum

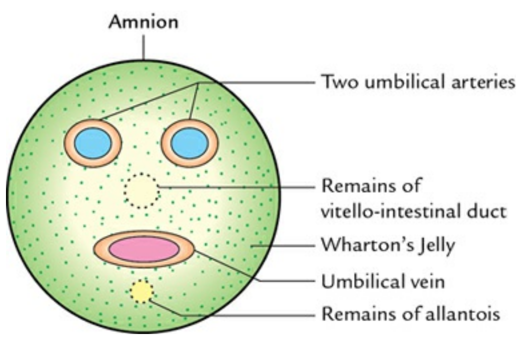


FIG. 24.12 Contents of umbilical cord.

Functions

- It provides passage to transfer deoxygenated blood of fetus to placenta.
- It provides passage to transfer oxygenated blood from placenta to fetus.
- It suspends fetus into the amniotic cavity.

Applied anatomy

- *Cord prolapse*: The umbilical cord may prolapse through uterus during childbirth and may be compressed between fetal head and pelvic wall of the mother. This may cause *fetal hypoxia.*
- During delivery, it may encircle the neck of fetus and cause *fetal strangulation.*

- Nowadays, umbilical cord is being cryopreserved for stem cells for future clinical use.

❖ Describe placenta in brief and discuss its applied anatomy.

The placenta is a highly vascular disc-like structure, by which fetus is intimately connected to the mother (uterus).

Functions

- Exchanges of respiratory gases, i.e., O_2 and CO_2 between fetus and mother
- Transport of nutrients from mother to fetus
- Transport of waste products from fetus to the mother
- Synthesis of hormones, such as HCG, progesterone, estrogenous somatotropic hormone, and relaxin.
- Prevention of harmful microorganisms, drugs, and hormones (ACTH and TSH) to enter into the fetal blood from mother (barrier function).
- Storage of glycogen, calcium, and iron in early month of pregnancy
- Transmission of antibodies from mother to fetus, viz. IgG, α-globulins, and immunoglobulins

Development/formation

The placenta develops from two sources: fetal and maternal. The fetal source is *chorion frondosum*, and maternal source is *decidua basalis* (Fig. 24.13). (The chorion consists of trophoblast and extraembryonic mesoderm. The trophoblast differentiates into cytotrophoblast and syncytiotrophoblast. The chorion with villi is called chorion frondosum.)

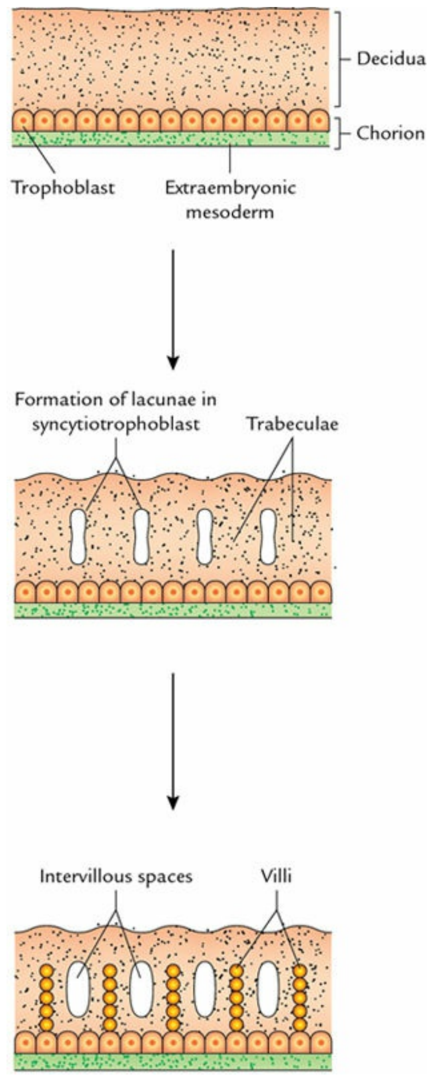


FIG. 24.13 Chorion and decidua.

Chorion frondosum

It forms villi (primary, secondary, and tertiary villi), cytotrophoblastic shell, and intervillous spaces.

- *Primary villi*: These are finger-like projections derived from cytotrophoblast covered by syncytiotrophoblast (Fig. 24.14).
- *Secondary villi*: The mesodermal core penetrates the primary villi to form the secondary villi (Fig. 24.14).
- *Tertiary villi*: The fetal blood vessels develop in the mesoderm of the secondary villi to form the tertiary villi (Fig. 24.14).
- *Cytotrophoblastic shell*: The cytotrophoblast from apical region of villi penetrates the syncytiotrophoblast to reach the decidua basalis where it spreads out to form a layer called *cytotrophoblastic shell.* Now, all the tertiary villi are anchored to the decidua basalis, and they are called as *anchoring villi.*
- *Intervillous spaces*: These are lacunae in syncytiotrophoblast, which communicate with each other and filled with maternal blood. The blood enters into these spaces due to erosion of blood vessels of

endometrium by the syncytiotrophoblast.

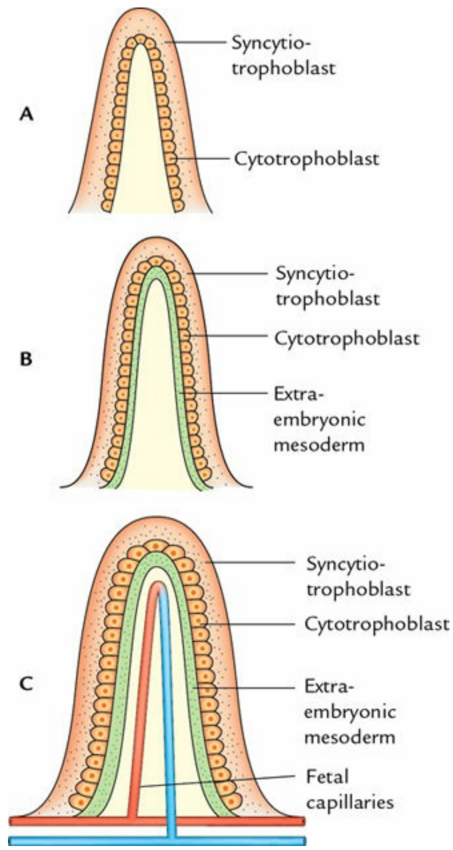


FIG. 24.14 Types of villi: A, primary; B, secondary; C, tertiary.

Decidua basalis

The decidua basalis provides the site where chronic frondosum grows to form villi and intervillous spaces to allow maternal blood vessels to enter into the intervillous spaces. The decidua basalis also forms septa, which grow into intervillous spaces of the developing placenta and divides it into various lobules called *cotyledons.*

Full-term placenta

It presents the following features:

• *Shape*: Disc-shaped.

• *Dimensions*

❒ Weight: 500–600 gm

❒ Diameter: 15–20 cm

❒ Thickness: 3 cm

• *Surfaces*: These are two (Fig. 24.15):

❒ *Maternal surface*: Presents 15–20 lobes/cotyledons.

❒ *Fetal surfaces*: Smooth, shining and covered with amnion. Umbilical vessels ramify under amnion.

❒ Umbilical cord is attached to this surface.

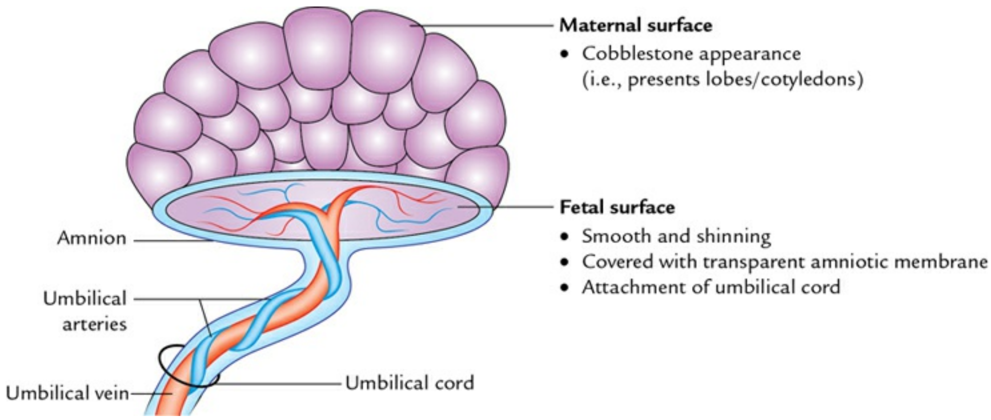


FIG. 24.15 Full-term placenta.

N.B.

The full-term placenta consists of:

❒ Amnion

❒ Chorion

❒ Choriodecidual spaces

❒ Cotyledons

❒ Decidua

Applied anatomy

Hydatidiform mole or vesicular mole

It occurs due to excessive proliferation of the trophoblast to form a vesicular or polycystic mass called *hydatidiform mole*. It resembles a bunch of grapes. It often leads to the death of the embryo. It is usually a noninvasive growth. But in about 3–5% of cases, the hydatidiform mole may undergo malignant change and form *choriocarcinoma.*

❖ Write a short note on placental membrane or placental barrier.

The placental membrane/barrier separates fetal blood from maternal blood within the placenta. It is across this membrane that the exchange of gases, nutrients, and waste products takes place. It measures about 14 m^2.

Layers of placental membrane (fig. 24.16)

From maternal to fetal side, these are:

- Syncytiotrophoblast
- Cytotrophoblast
- Basement membrane of cytotrophoblast
- Mesoderm of villus
- Basement membrane of fetal capillaries
- Endothelium of fetal capillaries

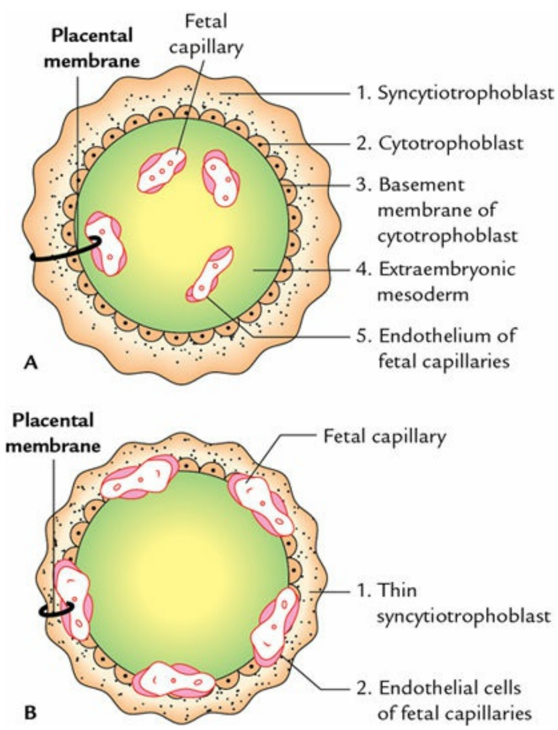


FIG. 24.16 Layers of placental membrane/barrier: A, in early pregnancy; B, in late pregnancy.

In the *later part of pregnancy*, the thickness of placental membrane decreases from 0.25 mm to 0.002 mm to increase the efficiency for the transport of nutrients as a result of the following changes:

- Syncytiotrophoblast becomes thin.

- Cytotrophoblast disappears.
- Two basement membranes disappear.
- Endothelial cells of the capillaries become thin.

❖ Give brief account of anomalies of placenta according to its shape.

These are (Fig. 24.17):

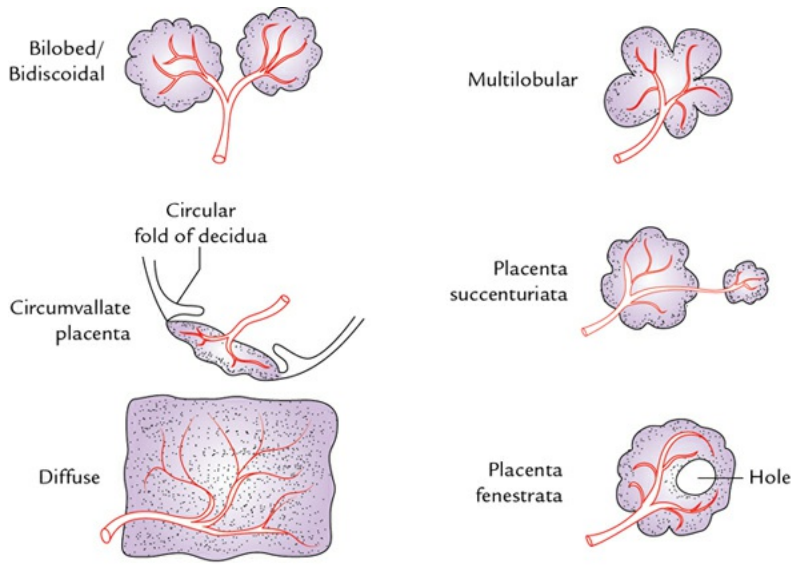


FIG. 24.17 Anomalies of placenta due to shapes.

Bilobed/bidiscoidal

Placenta consists of two lobes.

Multilobular

Placenta is divided into more than two lobes.

Circumvallate

Peripheral margin of placenta is surrounded by a sulcus and overlapped by a circular fold of decidua.

Placenta succenturiata

In this, a small placenta is connected to the main placenta by blood vessels and membrane.

Diffuse placenta

Placenta is thin and not disc-shaped.

Placenta fenestrata

In this, a hole is present in the placental disc.

❖ Give brief account of anomalies of placenta according to the sites of attachment of the umbilical cord.

These are (Fig. 24.18):

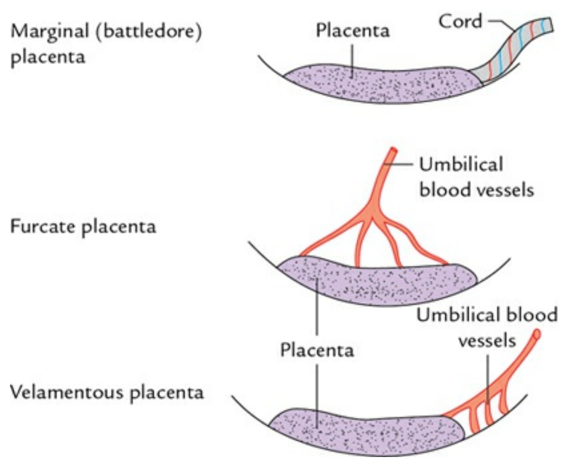


FIG. 24.18 Anomalies of placenta according to the sites of attachment of the umbilical cord.

Marginal (battledore) placenta

Cord is attached close to the margin of the placenta.

Furcate placenta

Umbilical vessels get divided before reaching the placenta.

Velamentous placenta

Cord fails to reach the placenta and gets attached to the amnion at the periphery. The umbilical vessels ramify in the amnion.

❖ Write a short note on placenta previa.

The implantation of placenta in the lower uterine segment (i.e., lower 1/3rd of the body of uterus) is called placenta previa.

Incidence

1:200.

Degrees of placenta previa

These are of 4 types (Fig. 24.19):

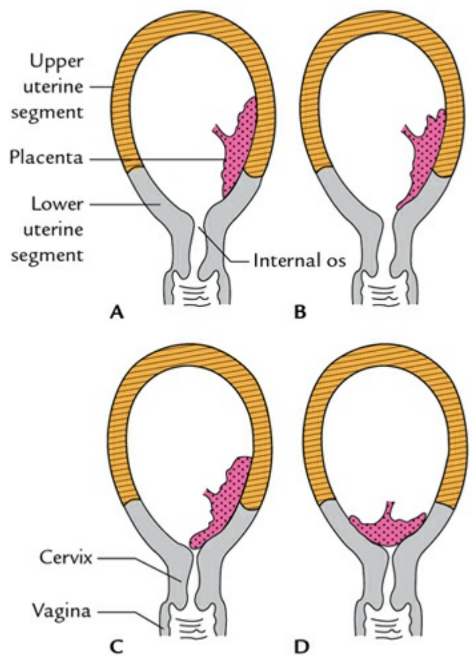


FIG. 24.19 Types of placenta previa.

First-degree (fig. 24.19a)

Attachment of placenta does not reach up to the internal OS.

Second-degree (fig. 24.19b)

Margin of placenta reaches the internal OS but does not cover it.

Third-degree (fig. 24.19c)

Edge of placenta covers the internal OS, but when the OS is dilated at birth, the placenta does not occlude it.

Fourth-degree (fig. 24.19d)

Placenta completely covers the internal OS and keeps it occluded even after the OS is dilated at birth. It is also called *central placenta previa*.

Applied anatomy

The painless bleeding in the third trimester of pregnancy (usually in the 8th month) is a diagnostic feature of placenta previa. It commonly occurs in the 4th degree of placenta previa.

❖ What is gastrulation?

- It is the process of formation of the three germ layers. They are precursors of all the embryonic tissues.
- It is the beginning of the morphogenesis to develop body form.
- It is the most important event during the third week of the pregnancy.
- During this period, the embryo is referred to gastrula.
- During gastrulation, bilaminar embryonic disc is converted into trilaminar embryonic disc.
- The first sign of gastrulation begins with the formation of the primitive streak.

❖ Write a short note on primitive streak.

The important features of primitive streak are (Fig. 24.20):

- It is a thickened linear band of epiblast that appears caudally in the median plane on the dorsal aspect of the embryonic disc at the beginning of the 3rd week.
- It is formed as a result of proliferation and movements of the epiblast cells to the median plane of the embryonic disc.
- It elongates by the addition of cells to its caudal end, whereas its cranial end proliferates to form a rounded elevation called *primitive node*.
- A narrow groove called *primitive groove* is continuous with a small depression in the primitive node called *primitive pit*.
- The primitive groove and primitive pit are formed by invagination (inward movement) of epiblastic cells.

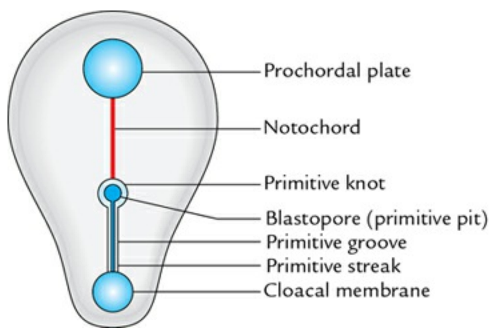


FIG. 24.20 Primitive streak.

Significance

- To determine craniocaudal axis of embryo
- To determine dorsal and ventral surfaces of the embryo
- To determine right and left halves of the embryo

Fate of primitive streak

Forms extraembryonic mesoderm by ingression of its cells into embryonic disc until the end of 3rd week of IUL.

Applied anatomy

Sacrococcygeal teratoma

Normally, the primitive streak undergoes degenerative changes and disappears by the end of the 4th week of IUL. But, the remnants of primitive streak may persist and give rise to *sacrococcygeal teratoma*, the most common tumor of newborn.

❖ Write a short note on the development of trilaminar germ disc.

The cells of embryonic disc differentiate into 3 layers placed one above the other. From superficial to deep, these are: ectoderm, mesoderm, and endoderm. This is called trilaminar (three-layered) germ disc.

The process of formation of these layers is as follows (Fig. 24.21):

- The cells of embryoblast first differentiate into two layers: (a) a superficial layer of columnar cells called ***epiblast*** and a deep layer of flattened cells called ***hypoblast.***
- The cells of epiblast migrate toward the future primitive streak. As they reach this region, they become flask-shaped. These flask-shaped cells detach themselves from epiblast and slip underneath it.
- Some of these cells replace the hypoblast cells to form the ***endoderm*** and others lie above the newly formed endoderm to form the ***mesoderm.*** The remaining cells of epiblast form the ***ectoderm.***

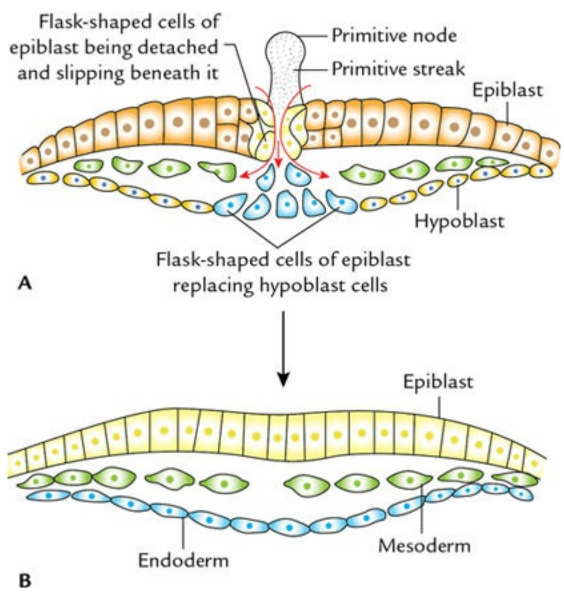


FIG. 24.21 Formation of three germ layers.

N.B.

All the tissues and organs of body develop from these three primary germ layers.

❖ Enumerate the derivatives of three germ layers.

Derivatives of ectoderm

- Epidermis of skin, hair, nails, sweat and sebaceous glands, and mammary gland
- Epithelium of lips, cheek, gums, floor of mouth, palate, nasal cavities, and paranasal air sinuses
- Epithelium of lower part of anal canal, lower part of vagina, and external urethral meatus
- Enamel of teeth, Rathke's pouch that gives rise to adenohypophysis (anterior part of pituitary)
- Lens of the eye, anterior epithelium of cornea, and outer layer of tympanic membrane
- Central nervous system including the retina, the optic nerve, epithelium over the ciliary body and iris, and musculature of the iris
- Peripheral nervous system and adrenal medulla (derivatives of neural crest)

Derivatives of mesoderm

- Connective tissue, cartilage, bone, and dentine of teeth
- Muscles, smooth cardiac, and skeletal
- Heart, blood vessels, and blood cells
- Lymph glands, lymph vessels, and spleen
- Connective tissue sheaths of muscles, tendons and nerve endings, synovial membranes of joints, and bursae
- Dermis of skin
- Pachymeninx or dura mater
- Urinary system, i.e., kidney, ureter, and urinary bladder (except the part of the urinary bladder)
- Cortex of suprarenal (adrenal) gland
- Pericardium pleura and peritoneum
- Testes and ovaries

Derivatives of endoderm

- Epithelium of gastrointestinal tract except lower end of anal canal
- Epithelium of tongue, pharynx, and respiratory tract (i.e., larynx, trachea, bronchi, and alveoli of the lungs)
- Epithelium of pharyngotympanic tube, middle ear cavity, inner layer of tympanic membrane, and mastoid air cells

- Parenchyma of liver, pancreas, thyroid, parathyroid, and thymus
- Epithelium of urinary bladder (except trigone), most of female urethra, part of male urethra, prostate, and vagina
- Epithelium of uterus and upper part of the vagina

❖ Write a short note on the notochord.

The notochord is solid rod of cells situated in the midline of the embryonic disc. It extends from primitive knot to the prochordal plate. The cells of notochord are derived from the primitive knot of the primitive streak.

Formation

- The cells of primitive knot proliferate and move inward to form a depression called *blastopore.*
- The cells from the bottom of blastopore migrate forward in the midline toward the prochordal plate called *notochordal process.*

❒ Notochordal process gets canalized to form notochordal canal, which is continuous within the blastopore.

❒ Cells at the floor of notochordal canal break and form a communication between the amniotic cavity and yolk sac. This is called *neurocentric canal.*

❒ Wall of the neurocentric canal is flattened to form a *notochord plate.*

❒ Notochordal plate becomes curved to form a canal again.

❒ Cells of tube proliferate to fill its lumen. Thus, a solid rod of cells is formed again. This is called *definitive notochord*, which extends from primitive knot to the prochordal plate (refer to Fig. 24.20).

Significance/functions

- Forms the central axis of the embryo
- Supports the embryo
- Acts as a vertebral column of the embryo
- Induces the surface ectoderm to form the neural tube

Fate of notochord

- It is embryonic structure and disappears in later life.
- In the adult life, its remains are as follows:

❒ Nucleus pulposus of intervertebral discs

❒ Apical ligament of dens

Applied anatomy

Chordoma

It is a tumor that may arise from remains of notochordal cells. It commonly arises either in cranial region or in the sacral region.

❖ Give a brief account of intraembryonic mesoderm.

It is the intermediate layer of the three laminar embryonic discs, i.e., it is present between ectoderm and endoderm.

Formation

It is formed in the 3rd week of gestation from cells of primitive streak that migrate laterally between ectoderm and endoderm. These cells spread all over the embryonic disc except at two areas – prochordal plate (buccopharyngeal membrane) and cloacal membrane (Fig. 24.20). With the development of neural tube, it lies on either side of this tube.

Subdivisions

On either side of neural tube, intraembryonic mesoderm is divided into 3 parts (Fig. 24.22). From medial to lateral, these are:

- Paraxial mesoderm
- Intermediate cell mass (intermediate mesoderm)
- Lateral plate mesoderm

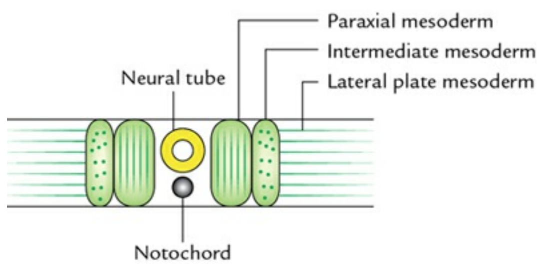


FIG. 24.22 Subdivisions of intraembryonic mesoderm.

❖ Enumerate derivatives of the 3 subdivisions of intraembryonic mesoderm (paraxial mesoderm, intermediate cell column, and lateral plate mesoderm).

- *Paraxial mesoderm* gives rise to somitomeres and somites.
- *Intermediate cell mass* gives rise to:

❐ Connective tissue of the gonads

❐ Metanephric blastema

❐ Smooth muscle and connective tissue of the reproductive system

- *Lateral plate mesoderm* gives rise to:

❐ Septum transversum

❐ Intraembryonic coelom that later differentiates into pericardial and peritoneal cavities

❐ *Splanchnopleuric* layer that forms smooth muscle and connective tissue of intestinal and respiratory tracts and their associated glands

❐ *Somatopleuric layer* that forms appendicular skeleton

❐ *Angiogenic mesoderm* that forms endocardium of the heart and epithelium of vessels

❖ Describe somites in brief.

The thick longitudinal column of paraxial mesoderm extends from cranial to the caudal end of the notochord bilaterally. It undergoes segmentation to form cubical block of mesoderm called *somites*.

Formation of somites

A total of 42–44 somites are formed during 20th to 30th day of gestation (somite period of human development) in a craniocandal direction. These are (Fig. 24.23):

- 4 occipital
- 8 cervical
- 12 thoracic
- 5 lumbar
- 5 sacral
- 8–10 coccygeal

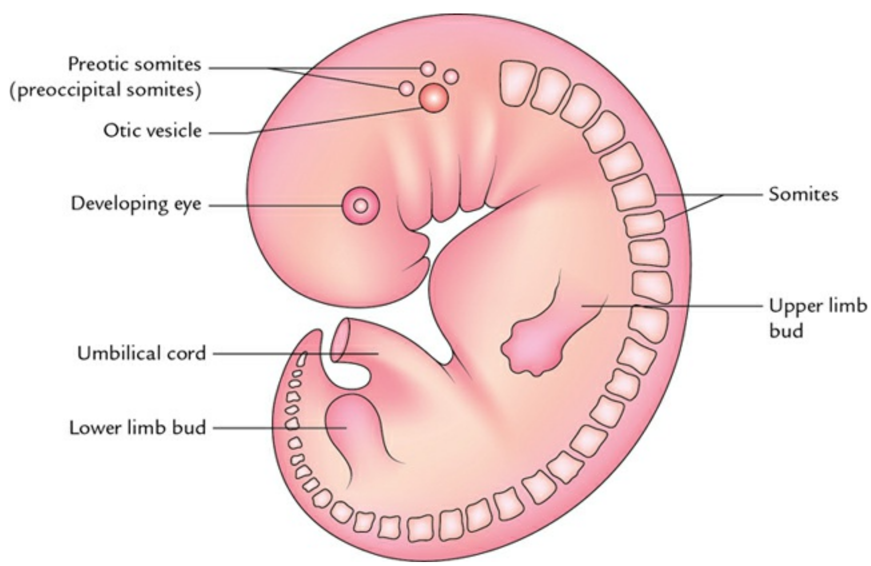


FIG. 24.23 Somites (as seen in lateral view of 30 day old embryo).

N.B.

First pair of somites is formed in the occipital region on day 20. Then, approximately 3 pairs of somites are added each day until day 30.

Fate of somites

Each somite is triangular in section with a small slit-like cavity in the center. It is subdivided into 3 parts. From medial to lateral, these are (Fig. 24.24):

- Sclerotome

• Myotome

• Dermatome

❒ *Sclerotome* forms axial skeleton, vertebrae, ribs, and sternum.

❒ *Myotome* forms muscles of back and front of trunk and limb muscles.

❒ *Dermatome* forms dermis of the skin on the back and front of trunk and limbs.

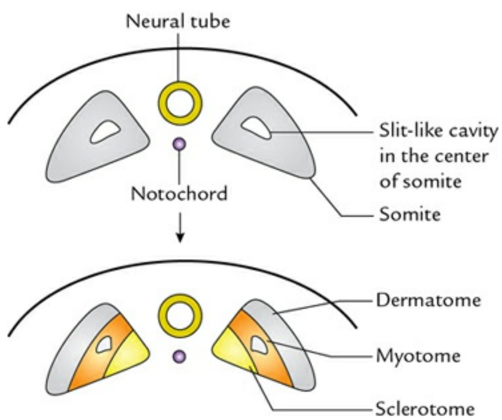


FIG. 24.24 Subdivisions of the somites.

Applied anatomy

Age determination

The age of fetus can be determined by counting the number of somites.

❖ Write a short note on septum transversum.

The septum transversum is an unsplitted part of the lateral plate mesoderm cranial to the prochordal plate (Fig. 24.25).

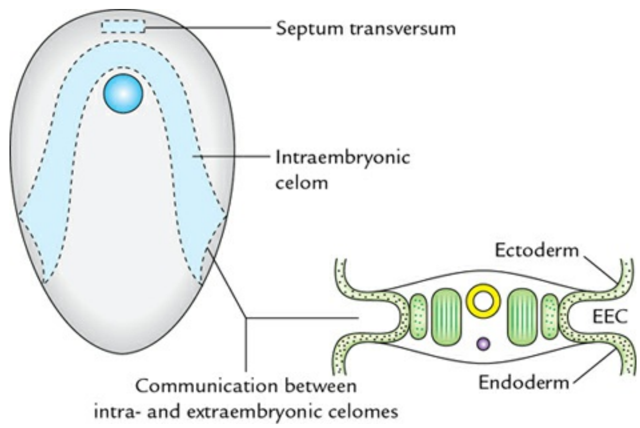


FIG. 24.25 Septum transversum (EEC = extraembryonic coelom).

Derivatives

The derivatives of septum transversum are:

- Epicardium and fibrous pericardium
- Fibrous stroma of the liver
- Part of diaphragm
- Dorsal mesentery of esophagus

❖ Write a short note on intraembryonic coelom.

It is cavity present in the embryonic disc.

Formation

A large number of small cavities appear on each side in the lateral plate mesoderm and mesoderm anterior to the prochordal plate. These cavities coalesce to form a single large horseshoe-shaped cavity called *intraembryonic coelom* (Fig. 24.25).

Subdivisions

The intraembryonic coelom is divided into 3 parts as follows (Fig. 24.26):

(a) *Pericardial cavity* anterior to prochordal plate.

(b) and (c) *Right and left primitive peritoneal cavities.*

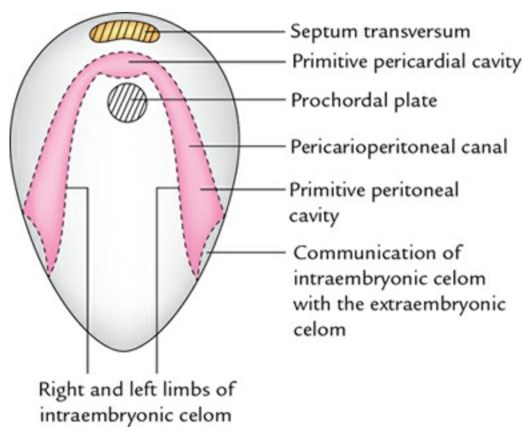


FIG. 24.26 Subdivisions of intraembryonic coelom.

The pericardial cavity communicates with the peritoneal cavities through *pericardioperitoneal canals.*

Fate of intraembryonic coelom

As a result of development of 4 partitions – the right and left pleuropericardial and pleuroperitoneal *membranes,* the intraembryonic coelom gives rises to *pericardial, pleural and peritoneal cavities.*

❖ Enumerate derivatives of the wall of the coelomic epithelium.

These are:

- Myocardium and parietal pericardium
- Visceral and parietal layers of the pleura
- Visceral and parietal layers of peritoneum
- Epithelial lining of ductus deferens, epididymis, seminal vesicles, ejaculatory ducts ureters, and trigone of urinary bladder
- Mullerian ducts epithelial lining of uterine tubes, body and cervix of uterus, and vagina.
- Germinal epithelium of gonads
- Germinal epithelium forming adrenal cortex

SECTION V
Genetics

OUTLINE

CHAPTER 25

Genetics

❖ What is genetics?

The genetics is a branch of biology that deals with the inheritance. The inheritance is a process by which children inherit certain traits (characteristics) from their parents.

❖ Write a short note on genes.

- The gene is a hereditary unit formed by a segment of deoxyribonucleic acid (DNA) and contains the information needed to synthesize a particular protein molecule.
- There are about 50,000 to 100,000 genes in a human cell.

Composition

Each gene consists of 3 components:

- Deoxyribose sugar
- Nitrogenous base
- Phosphate group

Parts

Each gene is divided into two parts:

- Exon, a functional part
- Intron, a silent part

Types

These are as follows:

- *Regulator genes*: They inhibit the protein synthesis.
- *Structural genes*: They code for specific amino acid sequence in a protein.
- *Operator genes*: They allow transcription.
- *Dominant genes*: They are able to express their traits, whether the allelic genes are homozygous or heterozygous.
- *Codominant genes*: In this, both allelic genes are dominant but are of two different types and may express concurrently.
- *Recessive genes*: They express their traits only in homozygous state.
- *Sex-linked genes*: They are abnormal genes located on X or Y chromosome.
- *Sex-limited genes*: They express only in one of the sex.
- *Carrier genes*: The heterozygous recessive genes act as carrier genes and express only in a subsequent generation.

❖ Write a short note on alleles.

- Each diploid cell has a pair of genes for each characteristic or trait called alleles.
- If the two alleles are identical, the person is said to be *homozygous* for a particular trait.
- If the alleles are different, the person is said to be *heterozygous* for a particular trait.
- Usually one of the alleles expresses itself that is called *dominant allele*, while the other does not that is called *recessive allele.*

Type of genotypes

Three genotypes are possible when gene pairing involves dominant and recessive alleles.

- Homozygous dominant (EE)
- Homozygous recessive (ee)
- Heterozygous (Ee)

Result

Only two types of phenotypes are possible because dominant allele is expressed in both homozygous dominant and heterozygous individuals, while the recessive allele is expressed only in homozygous recessive individual.

❖ Write a short note on the barr body (sex chromatin).

It is an inactivated chromosome attached to the nuclear membrane of somatic cells of normal (XX) females. During the second week of gestation (blastocyst stage of embryo), one of the X chromosomes is inactivated on a random basis. It was first noticed by Barr and Bertram (in 1949).

The cells with Barr body are called *chromatin-positive* and those without Barr body are called *chromatin-negative.*

Morphological features (fig. 25.1)

- Plano convex darkly stained body (heterochromatin) attached to nuclear membrane.
- It is about 1 μm in dimension.

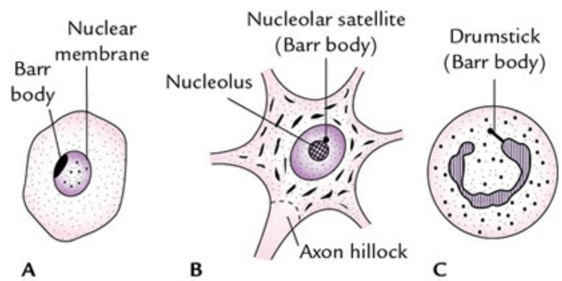


FIG. 25.1 Barr body: **A,** buccal smear; **B,** neuron; **C,** neutrophils.

N.B.

In neurons, it appears as a small dark body opposite to nucleolus, and in neutrophils, it appears as a knob of about 1.5 μm diameter as a drumstick.

❖ Write a short note on Lyon's hypothesis.

The Lyon's hypothesis enunciates that the number of Barr bodies is one less than the total number of X chromosomes in a cell. It is also termed as *n-1 rule* in which *n* represents the number of X chromosomes. The details are given in Table 25.1.

Table 25.1

Number of barr bodies in normal and abnormal conditions

Number of chromosomes	Number of Barr bodies	Condition
XY	0	Normal male
XX	1	Normal female
XXY	1	Klinefelter's syndrome
XXX	2	Triple XXX syndrome
XO	0	Turner's syndrome

❖ Write a short note on chromosomes.

The chromosomes are darkly stained rod-like structures present in the nucleus of a cell. They are formed by the condensation of chromatin containing DNA.

Structure

Each chromosome consists of two parallel identical filaments called **chromatin**, joined together at a narrow constriction termed **primary constriction/centromere/kinetochore.** The free ends of chromatin are called *telomeres* (Fig. 25.2).

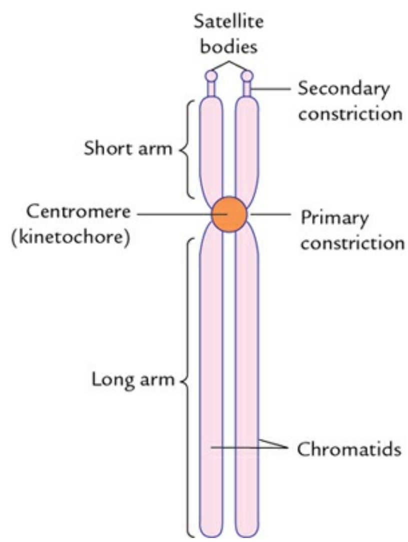


FIG. 25.2 Structure of a chromosome.

N.B.

In some chromosomes, there is another constriction near one end of the chromatins. The segment of chromatin distal to secondary constriction is called *satellite body.*

Types of chromosomes (fig. 25.3)

- According to the position of the centromere (Denver's classification):

Type	Location of centromere
Metacentric	In the middle
Submetacentric	Close to the middle
Acrocentric	Close to the one end
Telocentric (not found in human being)	At one end

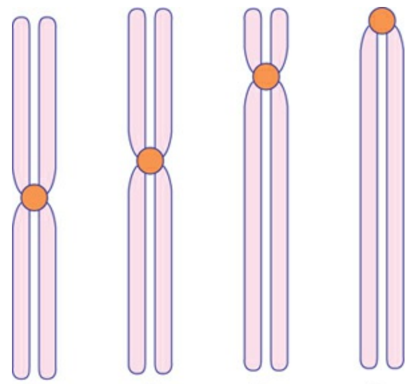


FIG. 25.3 Types of chromosomes: **A,** Metacentric; **B,** submetacentric; **C,** acrocentric; **D,** telocentric.

N.B.

In submetacentric and acrocentric chromosomes, the short arm of a chromosome is called 'p' arm and long arm is called 'q' arm.

- According to functions:

❒ Autosomes: 22 pairs

❒ Sex chromosomes: one pair (XX in female and XY in male)

❖ Write a short note on karyotyping.

The karyotyping is a process of arranging the chromosomes of a cell in groups, in the descending order of their lengths, viz. pair no. 1 is the longest and pair no. 22 is the shortest. In this way, the chromosomes are arranged into 7 groups, which are denoted as A to G (Table 25.2 and Fig. 25.4).

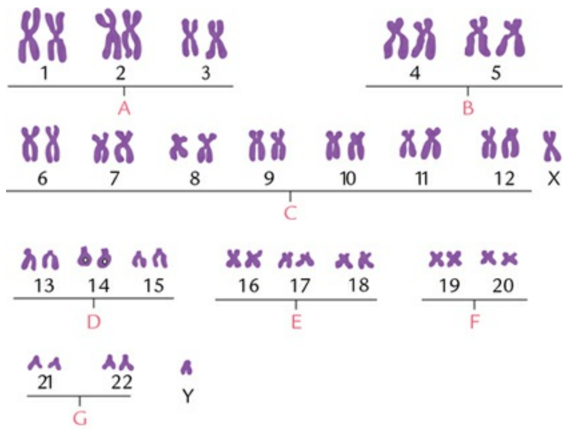


FIG. 25.4 Karyotype of a normal male.

Table 25.2

Groups of chromosomes and their features in a karyotype

Group	Pairs of chromosomes	Features
A	1, 2, and 3	Long and metacentric
B	4 and 5	Fairly long and submetacentric
C	6 to 12+ X chromosome	Medium-sized and submetacentric
D	13 to 15	Medium-sized and acrocentric A *satellite body* is attached to the free end of short arm of each chromosome
E	16 to 18	Fairly short and submetacentric
F	19 to 20	Short and metacentric
G	21 to 22+ Y chromosome	Very short and acrocentric with *satellite bodies* on their short arms

Applied anatomy

The karyotype is helpful:

- In determination of sex in cases of genital ambiguity.
- To detect the structural and numeral aberrations in the chromosomes.

❖ Write a short note on chromosomal aberrations.

The chromosomal aberrations include changes either in structural component or in the number of chromosomes. For example, the deletion of a segment of a chromosome or addition of a segment from other chromosome results in **structural aberration**, while the change in number of chromosomes leads to **numerical aberrations.**

Factors causing chromosomal aberrations

Some of the common ones are:

- Late age of parents at conception
- Nondisjunction during meiosis
- Exposure to radiation
- Viral infection during pregnancy

The types of some structural and numerical aberrations of chromosomes-associated clinical conditions are given in Table 25.3.

Table 25.3

Common types of structural and numerical aberrations of chromosomes

	Types	Associated clinical conditions
Structural aberrations	Deletions Microdeletions Translocation	Cat's cry syndrome (Cri-du-chat syndrome) Prader–willi syndrome, etc. Leukemias
Numerical aberrations	*Aneuploidy* Trisomy (2*n*+1) Monosomy (2*n*-1)	 Down's syndrome (trisomy-21) Turner's syndrome
	Polyploidy Triploidy Tetraploidy	 Abortion Abortion

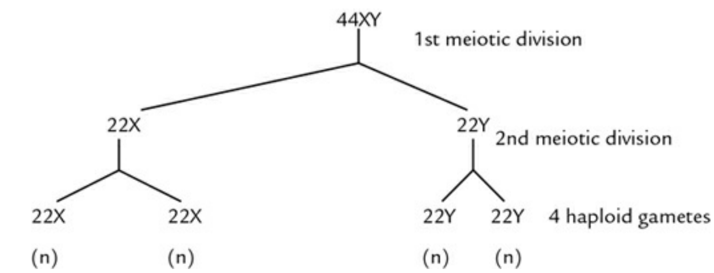
❖ Write a short note on nondisjunction of chromosomes during meiosis.

It may occur either during meiosis I or during meiosis II, due to a faulty spindle formation. It results in the formation of abnormal gametes.

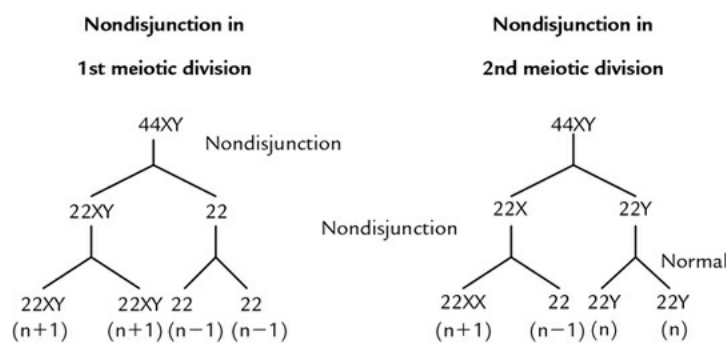
- In *Meiosis I*: It is due to failure of normal migration of chromosome during anaphase.
- In *Meiosis II*: It is due to failure of migration of the chromatids during anaphase.

The following flowcharts show normal and abnormal meiotic divisions during spermatogenesis.

Note: Nondisjunction in meiosis I or meiosis II produces gametes with 24 and 22 chromosomes, respectively (Flowcharts 25.1 and 25.2).



FLOWCHART 25.1 Normal meiotic division.



FLOWCHART 25.2 Abnormal meiotic division.

❖ Write a short note on Cat's cry syndrome/Cri-du-chat syndrome.

This condition occurs due to a structural chromosomal aberration, in which there is a deletion in the terminal portion of short arm of chromosome 5 (5p-).

Clinical features

- Characteristic cat-like cry (meowing cry) of an infant
- Microcephaly
- Round face
- Oblique palpebral fissure/hypertelorism
- Saddle nose
- Mental retardation and muscular hypotonia
- Premature graying of hair

❖ Write a short note on Down's syndrome (trisomy 21).

Down's syndrome is the most common numerical chromosomal abnormality. It was first described by Langdon Down in 1886. It occurs in every 650 to 700 births (i.e., 1/650 to 1/700).

Genotype

Trisomy 21
47XX (+21)
Or
47XY (+21)

Risk factor

Increase in age of mother at conception: Majority of the babies with Down's syndrome are born to mothers above 35 years of age due to aging of the ova.

Clinical features (fig. 25.5)

- Round face with oblique palpebral fissure and upward slanting of its lateral end and inner epicanthic fold (**mongoloid facies**)
- Flat nasal bridge
- Low set square ear
- Open mouth with protruding tongue
- Short, broad hands with single transverse palmar crease (**Simian's crease**)
- Short stature with hyper flexibility of joints

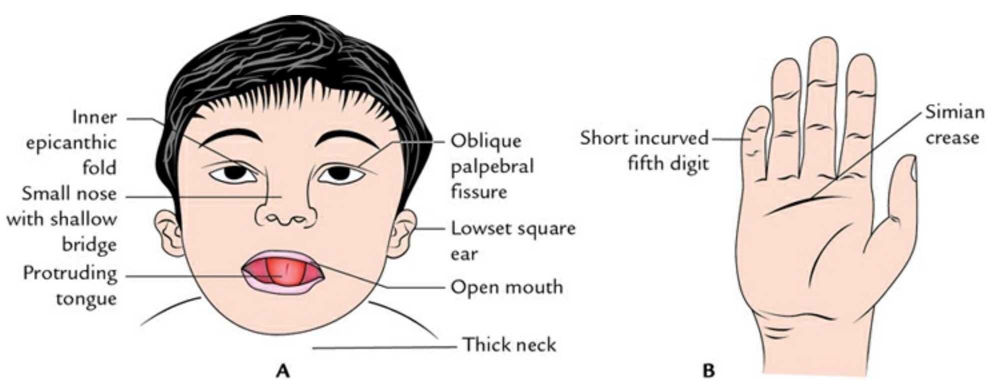


FIG. 25.5 Down's syndrome.

❖ Write a short note on Klinefelter's syndrome.

Introduction

It occurs due to numerical abnormality of chromosomes in which there is one extra chromosome due to non-disjunction of XX chromosomes during oogenesis.

It was described by Klinefelter in 1942.

It occurs in 1:500 male births.

Genotype

47, XXY with Barr body present.

Phenotype

Male.

Characteristic clinical features (fig. 25.6)

1. Tall, individual with long arms and legs.
2. Scanty chest hair, absence of axillary and pubic hair.
3. Gynaecomastia.
4. Small testis, infertile, azoospermia.
5. Hypospadias.

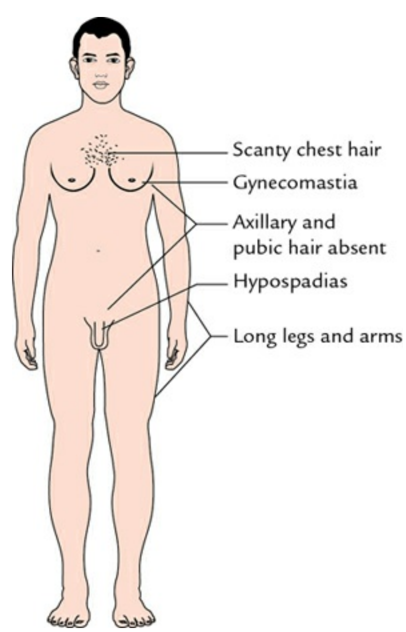


FIG. 25.6 Klinefelter's syndrome.

❖ Write a short note on Turner's syndrome.

Turner's syndrome is a numerical chromosomal abnormality in which there is a loss of one **X chromosome.** It was first described by Turner in 1938. It occurs in 2:3000 female births.

Genotype

45XO.

Phenotype

Female with the absence of a Barr body.

Clinical features (fig. 25.7)

- Short stature with webbed neck
- Shield chest with pinpoint nipples placed widely
- Infantile genitalia, infertility
- Bilateral cubital valgus
- Gonadal dysgenesis with amenorrhoea

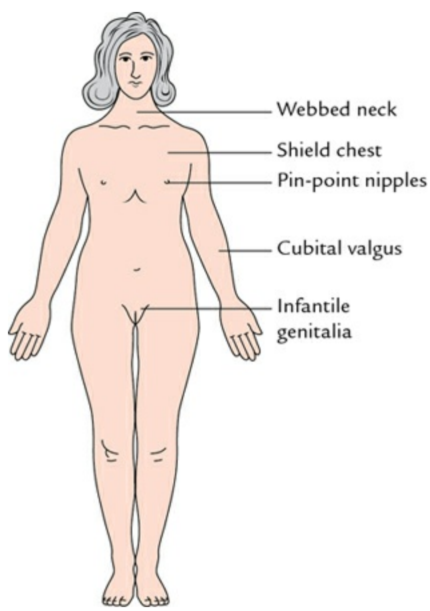


FIG. 25.7 Turner's syndrome.

❖ Write a note on sex-linked genes.

The Y chromosome is shorter in length than X chromosome. Therefore, traits coded on nonhomologous part of X chromosome have no corresponding traits on Y chromosome. These genes on sex chromosomes are called *sex-linked genes*. Those on X chromosome are *X-linked* and those on Y chromosome are *Y-linked.*

❖ Write a short note on x-linked recessive inheritance.

In X-linked recessive inheritance, the disease is usually observed only in males because they have only one X-chromosome.

X-linked recessive traits

These are:

- Hemophilia
- Color blindness
- Duchenne muscular dystrophy (DMD)

Features of x-linked recessive inheritance (fig. 25.8)

- Females are carriers and the males are sufferers.
- No direct transmission of traits from father to son.
- Zigzag transmission, i.e., one generation escapes and trait appears in the next generation.

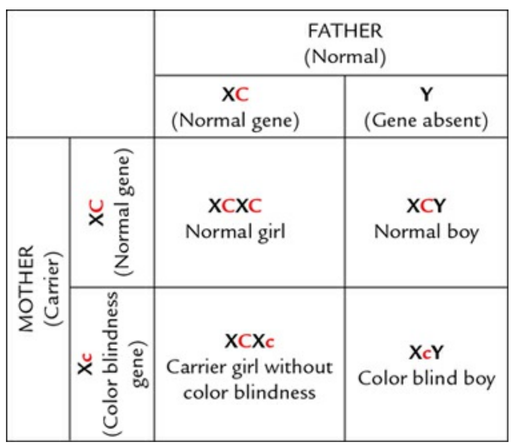


FIG. 25.8 Punnett square showing X-linked inheritance for color blindness.

N.B.

Females may be affected rarely if X chromosome with normal gene is deactivated. The affected female is produced usually by consanguineous marriage between carrier female and affected male.

❖ Write a short note on Marfan's syndrome.

This syndrome is caused by an autosomal dominant inheritance, i.e., only one defective gene from either parent can cause it.

Clinical features (fig. 25.9)

- Arm span greater than height
- Long spidery fingers (arachnodactyly)
- High arched palate
- Ectopic lens
- Funnel-shaped chest (pectus excavatum)
- Aortic dilatation or dissection

FIG. 25.9 Marfan's syndrome.

❖ **Enumerate the important clinical features of the following syndromes in a tabular form: (a) Down's syndrome, (b) Klinefelter's syndrome, (c) Turner's syndrome, and (d) Marfan's syndrome.**

Syndrome	Genotype	Phenotype	Clinical features
Down's syndrome	Trisomy-21 47 XY (+21) or 47 XX (+21)	Male Female	Mongoloid face Simian's crease Epicanthic fold
Klinefelter's syndrome	Trisomy 47 XXY	Male (Barr body is present)	Tallness Long legs and arms Reduced hair Gynecomastia
Tuner's syndrome	Monosomy 45 XO	Female (Barr body is absent)	Short stature Webbed neck Shield like chest infantile genitalia
Marfan's syndrome	Autosomal dominant inheritance	Male/female	Long spidery fingers Arm span greater than length High arched palate

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