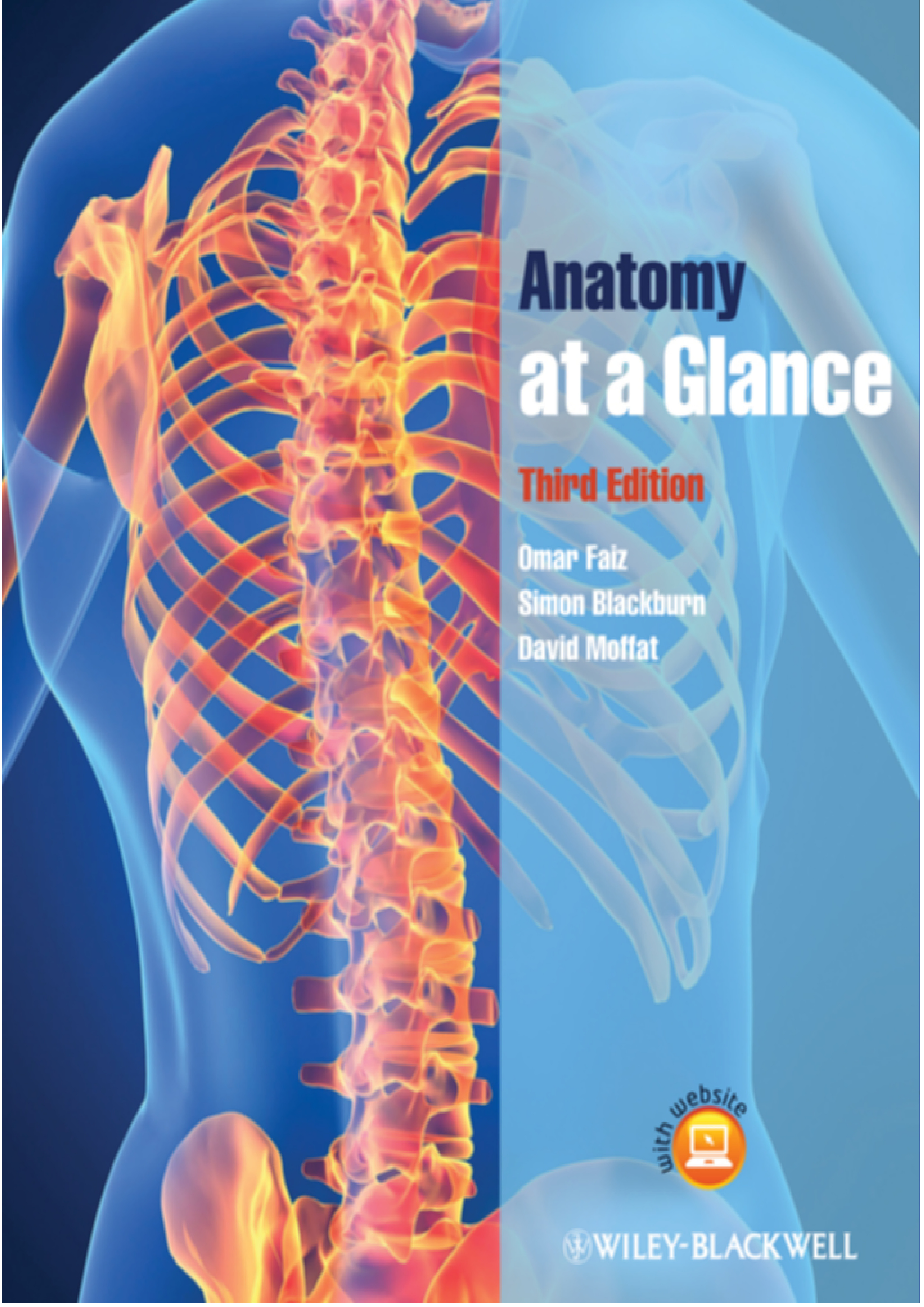

Anatomy at a Glance

Third Edition

Omar Faiz
Simon Blackburn
David Moffat

with website

WILEY-BLACKWELL

Anatomy at a Glance

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Anatomy at a Glance

Third edition

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Contents

Preface to the first edition

The study of anatomy has changed enormously in the last few decades. No longer do medical students have to spend long hours in the dissecting room searching fruitlessly for the otic ganglion or tracing the small arteries that form the anastomosis round the elbow joint. They now need to know only the basic essentials of anatomy with particular emphasis on their clinical relevance and this is a change that is long overdue. However, students still have examinations to pass and in this book the authors, a surgeon and an anatomist, have tried to provide a means of rapid revision without any frills. To this end, the book follows the standard format of the *at a Glance* series and is arranged in short, easily digested chapters, written largely in note form, with the appropriate illustrations on the facing page. Where necessary, clinical applications are included in italics and there are a number of clinical illustrations. We thus hope that this book will be helpful in revising and consolidating the knowledge that has been gained from the dissecting room and from more detailed and explanatory textbooks.

The anatomical drawings are the work of Jane Fallows, with help from Roger Hulley, who has transformed our rough sketches into the finished pages of illustrations that form such an important part of the book, and we should like to thank her for her patience and skill in carrying out this onerous task. Some of the drawings have been borrowed or adapted from Professor Harold Ellis's superb book *Clinical Anatomy* (9th edition), and we are most grateful to him for his permission to do this. We should also like to thank Dr Mike Benjamin of Cardiff University for the surface anatomy photographs. Finally, it is a pleasure to thank all the staff at Blackwell Science who have had a hand in the preparation of this book, particularly Fiona Goodgame and Jonathan Rowley.

Omar Faiz
David Moffat

Preface to the second edition

The preparation of the second edition has involved a thorough review of the whole text with revision where necessary. A great deal more clinical material has been added and this has been removed from the body of the text and placed at the end of each chapter as 'Clinical Notes'. In addition, four new chapters have been added containing some basic embryology, with particular reference to the clinical significance of errors of development. It is hoped that this short book will continue to offer a means of rapid revision of fundamental anatomy for both undergraduates and graduates working for the MRCS examination.

Once again, it is a pleasure to thank Jane Fallows, who prepared the illustrations for the new chapters, and all the staff at Blackwell Publishing, especially Fiona Pattison, Helen Harvey and Martin Sugden, for their help and cooperation in producing this second edition.

Omar Faiz
David Moffat

Preface to the third edition

For this third edition, the whole text and the illustrations have been reviewed and modified where necessary and two new chapters have been added on, respectively, anatomical terminology and the early development of the human embryo. In addition, a number of new illustrations have been added featuring modern imaging techniques. We hope that this book will continue to serve its purpose as a guide to 'no frills' clinical anatomy for both undergraduates and for those studying for higher degrees and diplomas.

Once again, it is a pleasure to thank the staff of Blackwell Publishing for their expert help in preparing this edition for publication, especially Martin Davies, Jennifer Seward and Cathryn Gates. Finally, we would like to thank Jane Fallows, our artist who has been responsible for all the illustrations, old and new, that form such an important part of this book.

Omar Faiz
Simon Blackburn
David Moffat

1 Anatomical terms

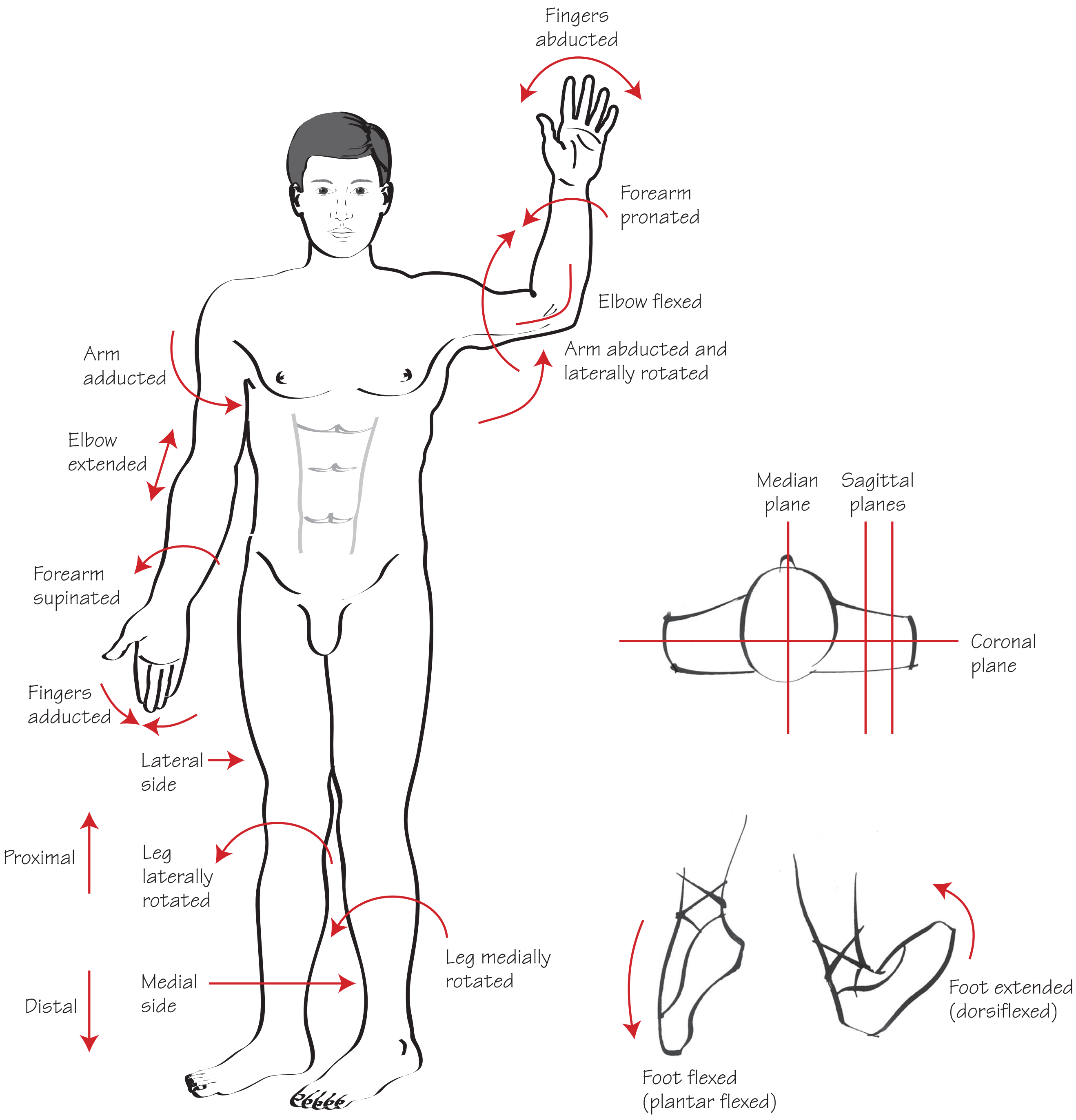

Fig.1.1 Some anatomical terminology

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Correct use of anatomical terms is essential to accurate description. These terms are also essential in clinical practice to allow effective communication.

Anatomical position

It is important to appreciate that the surfaces of the body, and relative positions of structures, are described, assuming that the body is in the 'anatomical position'. In this position, the subject is standing upright with the arms by the side with the palms of the hands facing forwards. In the male the tip of the penis is pointing towards the head.

Surfaces and relative positions

• *Anterior/posterior:* the anterior surface of the body is the front, with the body in the anatomical position. The shin, for example, is referred to as the anterior aspect of the leg, regardless of its position in space. The term 'posterior' refers to the back of the body. These terms can also be used to describe relative positions. The bladder, for example, may be described as being anterior to the rectum, or the rectum posterior to the bladder.

• *Superior/inferior:* these terms refer to vertical relationships in the long axis of the body, between the head and the feet. Superior refers to the head end of the body, inferior to the foot end. These terms are most commonly used to describe relative position. The head, for example, may be described as superior to the neck. It is important to remember that the anatomical position refers to a standing subject. When a patient is lying down, their head remains superior to their neck.

• *Medial/lateral:* these terms refer to relationships relative to the midline of the body. A structure which is medial is nearer the midline, and a lateral structure is further away. So, for example, the inner thigh may be referred to as the medial part of the thigh, and the outer thigh as the lateral part. These terms are also used to describe relationships; the lung may be described as lateral to the heart, or the heart may be described as medial to the lung. In some parts of the body, these terms may cause confusion. The mobility of the forearm in space means that it is easy to get confused about which side is medial or lateral. The terms 'radial' and 'ulnar', referring to the relationship of the forearm bones, are often used instead.

• *Proximal and distal:* these terms are used to refer to relationships of structures relative to the middle of the body, the point of origin of a limb or the attachment of a muscle. These terms are commonly used to describe relationships along the length of a limb. A proximal structure is nearer the origin and a distal one further away. The hand is distal to the elbow, for example, and the elbow proximal to the hand.

• *Ventral/dorsal:* these terms are slightly different from anterior/posterior as they refer to the front and back of the body in terms of embryological development rather than the anatomical position. For the majority of the body, the anterior surface corresponds to the ventral surface and the posterior surface to the dorsal surface. The lower limb is one exception as it rotates during development such that the ventral parts come to lie posteriorly. The ventral surface of the foot, therefore, is the sole.

The ventral surface of the hand is often referred to as the palmar surface and that of the foot as the plantar surface.

• *Cranial/caudal:* These terms also refer to embryonic development. Cranial refers to the head end of the embryo, and caudal to the tail end.

Planes

Anatomical planes are used to describe sections through the body as if cut all the way through. These planes are essential to understanding cross-sectional imaging:

• *Sagittal:* this plane lies front to back, such that a sagittal section in the midline would divide the body in half through the nose and the back of the head, continuing downwards.

• *Coronal:* this plane lies at right angles to the sagittal plane and is parallel to the anterior and posterior surfaces of the body.

• *Transverse:* this plane lies across the body and is sometimes also referred to as the axial or horizontal plane. A transverse section divides the body across the middle, much like the magician sawing his assistant in half.

Movements

The following anatomical terms are used to describe movement:

• *Flexion*: is usually taken to mean the bending of a joint, such as bending the elbow or knee. Strictly, it refers to the apposition of two ventral surfaces, which is generally taken to mean the same thing.

• *Extension*: is the straightening of a joint or the movement of two ventral surfaces such that they come to lie further apart.

• *Abduction:* is movement of a part of a body away from the midline in the coronal plane. For example, abduction of the arm is lifting the arm out sideways.

In the hand, the midline is considered to be along the middle finger. Thus, abduction of the fingers refers to the motion of spreading them out. In the foot, the axis of abduction is the second toe.

The thumb is a special case. Abduction of the thumb refers to anterior movement away from the palm (see Fig. 1.1). Adduction is the opposite of this movement.

• *Adduction:* is movement towards the middle of the body in the coronal plane.

• *Plantar/dorsiflexion:* are used to describe movement of the foot at the ankle as the use of the terms 'flexion' and 'extension' is confusing. True flexion of the foot is straightening at the ankle, because this leads to two ventral surfaces coming closer together. This is, however, somewhat confusing. For this reason, the term 'plantar/flexion' is used to refer to the action of pointing the toes and dorsiflexion to refer to bending at the ankle such that the toes move towards the face.

• *Rotation*: rotation is movement around the long axis of a bone. For example rotation of the femur at the hip joint will cause the foot to point laterally or medially.

• *Supination/pronation:* are special terms used to refer to rotational movements of the forearm, best thought of when the elbow is flexed to 90 degrees. Supination refers to rotation of the forearm at the elbow laterally, such that the palm faces superiorly. Pronation refers to an inward rotation, such that the dorsal surface of the hand is uppermost.

2 Embryology

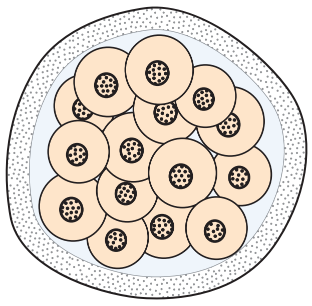

Fig.2.1
A morula, enclosed with the zona pellucida which prevents the entry of more than one spermatozoon

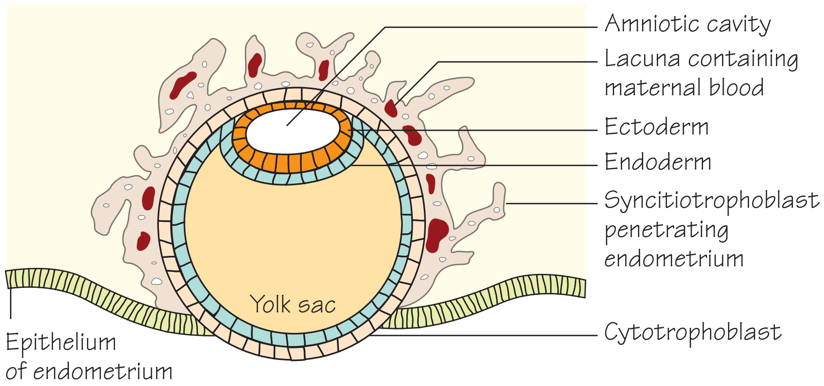

Fig.2.3
An almost completely implanted conceptus. The trophoblast has differentiated into the cytotrophoblast and the syncitiotrophoblast. The latter is invasive and breaks down the maternal tissue

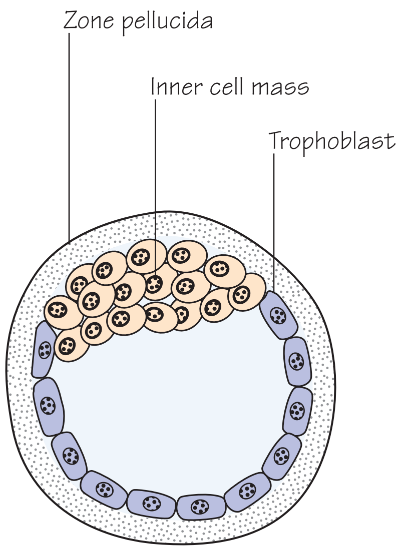

Fig.2.2
A blastocyst, still within the zona pellucida

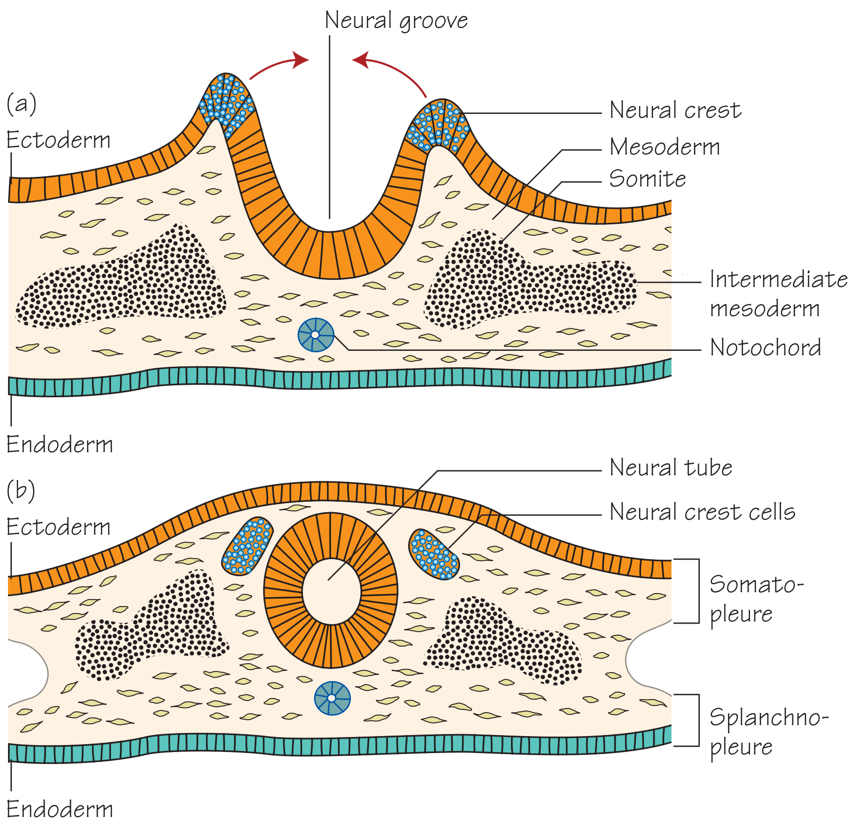

Fig.2.4a, b
Two stages in the development of the neural tube. In (b) the lateral mesoderm is splitting into two layers. One layer, together with the ectoderm, forms the somatopleure and the other, together with the endoderm, forms the splanchnopleure

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Normal pregnancy lasts 40 weeks. The first 8 weeks are termed the *embryonic period*, during which the body structures and organs are formed and differentiated. The *fetal period* runs from eight weeks to birth and involves growth and maturation of these structures.

The combination of ovum and sperm at fertilisation produces a *zygote*. This structure further divides to produce a ball of cells called the *morula* (Fig. 2.1), which develops into the *blastocyst* during the 4th and 5th days of pregnancy.

The blastocyst (Fig. 2.2): consists of an outer layer of cells called the *trophoblast* which encircles a fluid filled cavity. The trophoblast eventually forms the placenta. A ball of cells called the *inner cell mass* is attached to the inner surface of the trophoblast and will eventually form the embryo itself. At about six days of gestation, the blastocyst begins the process of implanting into the uterine wall. This process is complete by day 10.

Further division of the inner cell mass during the second week of development causes a further cavity to appear, the *amniotic cavity*. The blastocyst now consists of two cavities, the amniotic cavity and the *yolk sac* (derived from the original blastocyst cavity) (Fig. 2.3). These cavities are separated by the *embryonic plate.* The embryonic plate consists of two layers of cells, the *ectoderm* lying in the floor of the amniotic cavity and the *endoderm* lying in the roof of the yolk sac.

Gastrulation: is the process during the third week of gestation during which the two layers of embryonic plate divide into three, giving rise to a *trilaminar disc*. This is achieved by the development of the *primitive streak* as a thickening of the ectoderm. Cells derived from the primitive streak invaginate and migrate between the ectoderm and endoderm to form the *mesoderm*. The embryonic plate now consists of three layers:

Ectoderm: eventually gives rise to the epidermis, nervous system, anterior pituitary gland, the inner ear and the enamel of the teeth.

Endoderm: gives rise the epithelial lining of the respiratory and gastrointestinal tracts.

Mesoderm: lies between the ectoderm and endoderm and gives rise to the smooth and striated muscle of the body, connective tissue, blood vessels, bone marrow and blood cells, the skeleton, reproductive organs and the urinary tract.

The notochord and neural plate

The notochord develops from a group of ectodermal cells in the midline and eventually forms a tubular structure within the mesodermal layer of the embryo. The notochord induces development of the *neural plate* in the overlying ectoderm and eventually disappears, persisting only in the intervertebral discs as the *nucleus pulposus*.

The neural plate invaginates centrally to form a groove and then folds to form a tube by the end of week three, a process known as *neurulation* (Fig. 2.4). The neural tube then becomes incorporated into the embryo, such that it comes to lie deep to the overlying ectoderm. The resultant neural tube develops into the brain and spinal cord.

Some cells from the edge of the neural plate become separated and come to lie above and lateral to the neural tube, when they become known as *neural crest cells*. These important cells give rise to several structures including the dorsal root ganglia of spine nerves, the ganglia of the autonomic nervous system, Schwann cells, meninges, the chromaffin cells of the adrenal medulla, parafollicular cells of the thyroid and the bones of the skull and face.

Mesoderm

The mesodermal layer of the embryo comes to lie alongside the notochord and neural tube and is subdivided into three parts:

Paraxial mesoderm: lies nearest the midline and becomes segmented into paired clumps of cells called *somites*. The somites are further divided into the *sclerotome,* which eventually surrounds the neural tube and notochord to produce the vertebral column and ribs, and the *dermatomyotome* which forms the muscles of the body wall and the dermis of the skin. The segmental arrangement of the somites explains the eventual arrangement of dermatomes in the body wall and limbs (Fig. 78.1).

Intermediate mesoderm: lies lateral to the paraxial mesoderm. It eventually gives rise to the precursors of the urinary tract (see Chapter 31).

Lateral mesoderm: is involved with the formation of body cavities and the folding of the embryo (Fig. 2.4b).

A separate group of cells from the primitive streak migrate around the neural plate to form the *cardiogenic mesoderm*, which eventually gives rise to the heart.

Folding of the embryo

The folding of the embryo commences at the beginning of the fourth week (Fig. 2.5). The flat embryonic disc folds as a result of faster growth of the ectoderm cranio-caudally, such that it is concave towards the yolk sac and convex towards the amnion. Lateral folding occurs around the yolk sac in the same manner.

During this process, the lateral plate mesoderm splits to create the *embryonic coelom* or body cavity (Fig. 2.4). The inner layer is called the *splanchnopleure* and surrounds the yolk sac in such a way that it becomes incorporated into the embryo, forming the cells lining the lumen of the gastrointestinal tract. The cranial part of the yolk sac migrates further cranially, forming the foregut, and the caudal part migrates further caudally, forming the hindgut (Fig. 2.6). As the folding of the embryo continues the yolk sac forms a small vesicle lying outside the embryo and connected to the gut by a narrow *vitello-intestinal duct* (see Chapter 31). The two ends of the primitive gut are separated from the amniotic cavity at the cranial end by the *buccopharyngeal membrane,* and the caudal end by the *cloacal membrane*, which are formed of ectoderm and endoderm with no intervening mesoderm. They eventually disappear to form cranial and caudal openings into the pharynx and the anal canal, respectively.

The outer layer of the lateral mesoderm is called the *somatopleure.* This layer is invaded by paraxial mesoderm, forming the body wall muscles. Outgrowths from the somatopleure form the limbs, which appear as buds during the 4th week of gestation.

At the end of the process of folding, the embryo contains a single internal cavity, the intra-embryonic coelom, which is eventually separated by the formation of the diaphragm into pleural and peritoneal cavities.

During this period of folding, the branchial arches develop and form a number of structures described in Chapter 76.

Between the 4th and 8th week of gestation, the limb buds, facial structures, palate, digits, gonads and genitalia, all start to differentiate, such that by the end of week eight all the external and internal structures required are present.

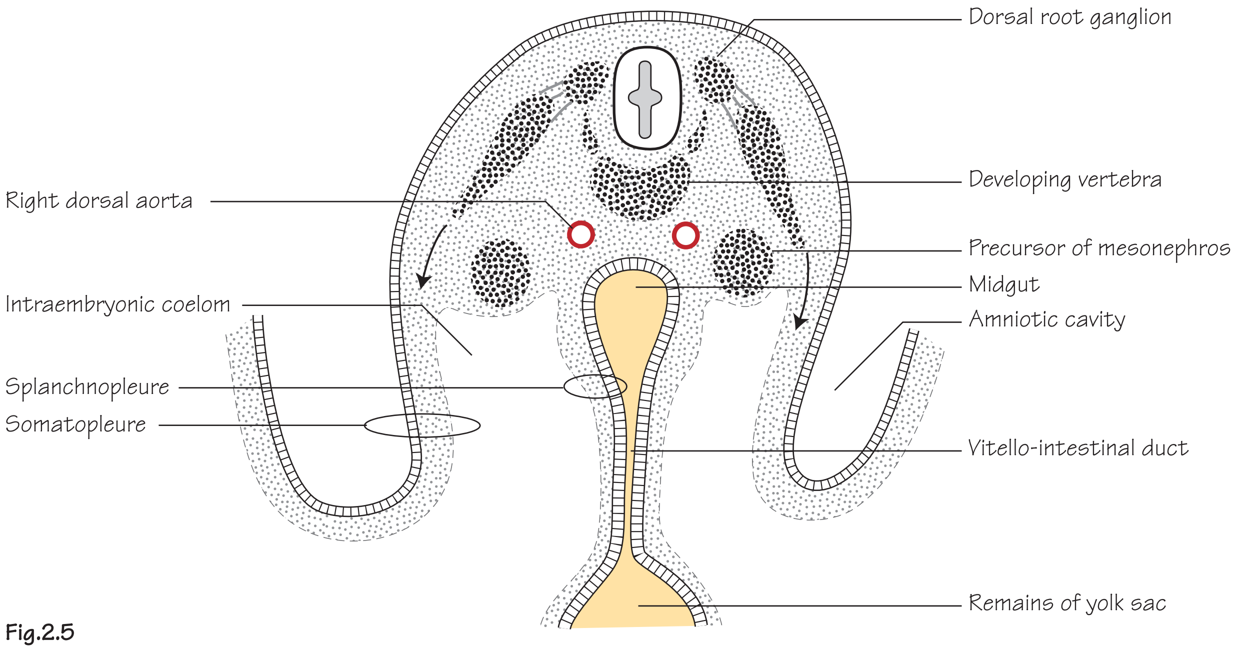


Fig.2.5
Lateral folding of the embryo so that it projects into the amniotic cavity. Striated muscle, from the somites, is growing down into the somatopleure (body wall) taking its nerve supply with it. Smooth muscle of the gut will develop in the mesoderm of the splanchnopleure

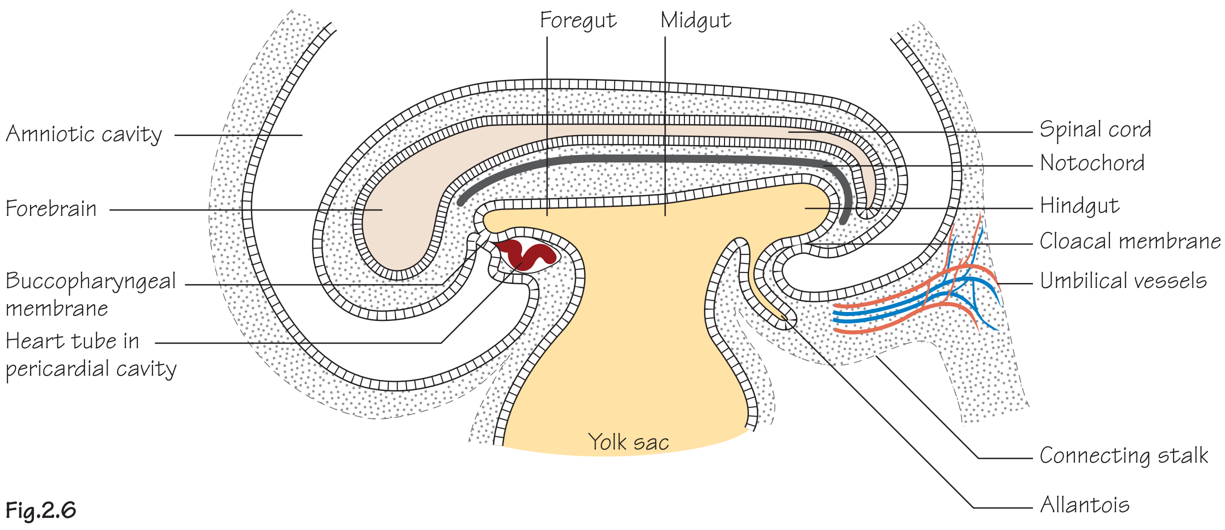


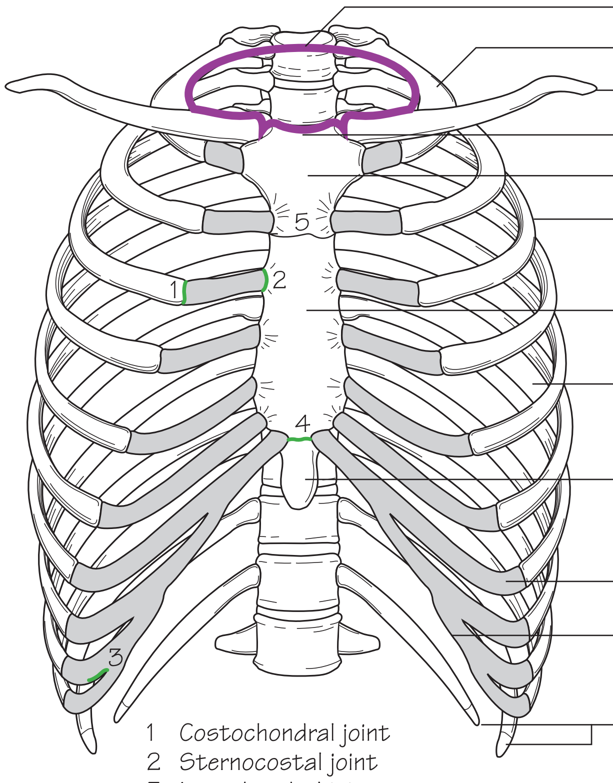
Fig.2.6
Lateral view to show the head and tail folds. The neck of the yolk sac will later close off, leaving the midgut intact. The allantois is functionless and will later degenerate to form the median umbilical ligament. The connecting stalk contains the umbilical vessels (intraembryonic course not shown)

Clinical notes

Sacrococcygeal teratomas: these rare tumours arise as a result of failure of the normal obliteration of the primitive streak. As the primitive streak contains cells which are capable of producing cells from all three germ cell layers (ectoderm, mesoderm and endoderm), these tumours contain elements of tissues derived from all of them.

Neural tube defects: failure of the neural plate to completely fold to form the neural tube can cause abnormalities in the formation of the central nervous system. At the most extreme, the brain fails to develop completely (*anencephaly*). Failure of closure of the neural tube can also cause abnormalities of the overlying structures. *Spina bifida*, for example, results from failure of normal fusion of the posterior part of the vertebral column (see Chapter 77).

3 The thoracic wall I



1 Costochondral joint
2 Sternocostal joint
3 Interchondral joint
4 Xiphisternal joint
5 Manubriosternal joint (angle of Louis)

Fig.3.1
The thoracic cage. The outlet (inlet) of the thorax is outlined

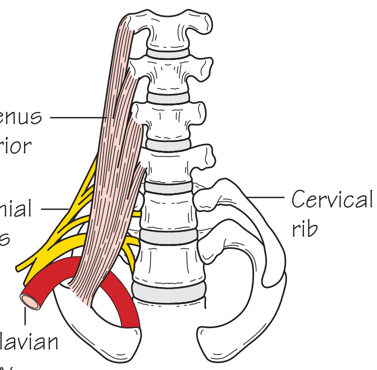


Fig.3.3
Bilateral cervical ribs.
On the right side the brachial plexus is shown arching over the rib and stretching its lowest trunk

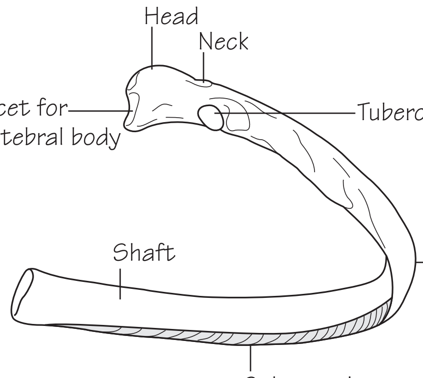


Fig.3.2
A typical rib

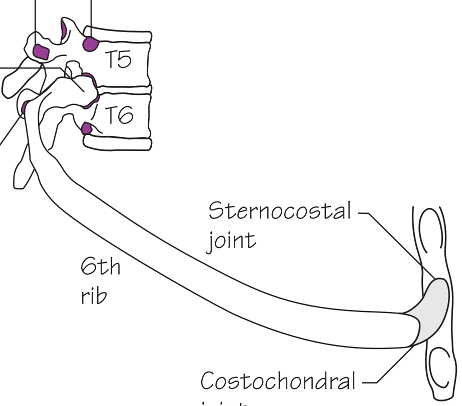


Fig.3.4
Joints of the thoracic cage

The thoracic cage

The thoracic cage is formed by the sternum and costal cartilages in front, the vertebral column behind and the ribs and intercostal spaces laterally.

It is separated from the abdominal cavity by the diaphragm and communicates superiorly with the root of the neck through the *thoracic inlet* (Fig. 3.1).

The ribs (Fig. 3.1)

• Of the 12 pairs of ribs, the first seven articulate with the vertebrae posteriorly and with the sternum anteriorly by way of the costal cartilages (*true ribs*).
• The cartilages of the 8th, 9th and 10th ribs articulate with the cartilages of the ribs above (*false ribs*).
• The 11th and 12th ribs are termed 'floating' because they do not articulate anteriorly (*false ribs*).

Typical ribs (3rd–9th)

These comprise the following features (Fig. 3.2):
• A *head* which bears two demifacets for articulation with the bodies of the numerically corresponding vertebra and the vertebra above (Fig. 3.4).
• A *tubercle* which comprises a rough non-articulating lateral facet as well as a smooth medial facet, which articulates with the transverse process of the corresponding vertebra (Fig. 3.4).
• A *subcostal groove* which is the hollow on the inferior inner aspect of the shaft accommodating the intercostal neurovascular structures.

Atypical ribs (1st, 2nd, 10th, 11th, 12th)

• The **1st rib** (see Fig. 68.2) is short, flat and sharply curved. The head bears a single facet for articulation. A prominent tubercle (*scalene tubercle*) on the inner border of the upper surface represents the insertion site for scalenus anterior. The subclavian vein passes over the 1st rib anterior to this tubercle, whereas the subclavian artery and lowest trunk of the brachial plexus pass posteriorly.
• The **2nd rib** is less curved and longer than the 1st rib.
• The **10th rib** has only one articular facet on the head.
• The **11th** and **12th ribs** are short and do not articulate anteriorly. They articulate posteriorly with the vertebrae by way of a single facet on the head. They are devoid of both a tubercle and a subcostal groove.

The sternum (Fig. 3.1)

The sternum comprises a manubrium, body and xiphoid process.
• The *manubrium* has facets for articulation with the clavicles, 1st costal cartilage and upper part of the 2nd costal cartilage. It articulates inferiorly with the body of the sternum at the *manubriosternal joint*.
• The *body* is composed of four parts or *sternebrae* which fuse between 15 and 25 years of age. It has facets for articulation with the lower part of the 2nd and the 3rd to 7th costal cartilages.
• The *xiphoid* articulates above with the body at the *xiphisternal joint*. The xiphoid usually remains cartilaginous well into adult life.

Costal cartilages

These are bars of hyaline cartilage which connect the upper seven ribs directly to the sternum and the 8th, 9th and 10th ribs to the cartilage immediately above.

Joints of the thoracic cage (Figs. 3.1 and 3.4)

• The *manubriosternal joint* is a symphysis (a joint in which the bone ends are covered with two layers of hyaline cartilage which are themselves joined by fibrocartilage). It usually ossifies after the age of 30 years.
• The *xiphisternal joint* is also a symphysis.
• The *1st sternocostal joint* is a primary cartilaginous joint (a joint in which the two bones are directly joined by a single layer of hyaline cartilage). The rest (2nd to 7th) are synovial joints (joints which include a cavity containing synovial fluid and lined by synovial membrane). All have a single synovial joint except for the 2nd which is double.
• The *costochondral joints* (between the ribs and costal cartilages) are primary cartilaginous joints.
• The *interchondral joints* (between the costal cartilages of the 8th, 9th and 10th ribs) are synovial joints.
• The *costovertebral joints* comprise two synovial joints formed by the articulations of the demifacets on the head of each rib with the bodies of its corresponding vertebra, together with that of the vertebra above. The 1st and 10th–12th ribs have a single synovial joint with their corresponding vertebral bodies.
• The *costotransverse joints* are synovial joints formed by the articulations between the facets on the rib tubercle and the transverse process of its corresponding vertebra.

Clinical notes

- **Cervical rib**: a cervical rib is a rare 'extra' rib which articulates with C7 posteriorly and the 1st rib anteriorly. A neurological deficit and vascular insufficiency arise as a result of pressure from the rib on the lowest trunk of the brachial plexus (T1) and subclavian artery, respectively (Fig. 3.3).
- **Rib fracture**: although significant injury is generally required to damage the bony thoracic wall, pathological rib fractures (i.e. fractures occurring in diseased bone – usually metastatic carcinoma) can result from minimal trauma. Many rib fractures are not visible on X-rays unless complications, such as a pneumothorax or a haemothorax, are present. Treatment of simple rib fractures aims to relieve pain, as inadequate analgaesia can lead to poor chest expansion and consequent pneumonia. In severe trauma, multiple rib fractures can give rise to a 'flail' segment, in which two or more ribs are fractured in two or more places. When this occurs, ventilatory compromise can supervene. This usually results from associated traumatic lung injury but is also exacerbated by paradoxical movement of the 'floating' flail segment with respiration.
- **Pectus excavatum and carinatum**: deformities of the chest wall are uncommon. Pectus excavatum represents a visible furrow in the anterior chest wall that results from a depressed sternum. In contrast, pectus carinatum (pigeon chest) is a clinical manifestation that results from a sternal protrusion. Rarely do either of these conditions require surgical correction.

4 The thoracic wall II

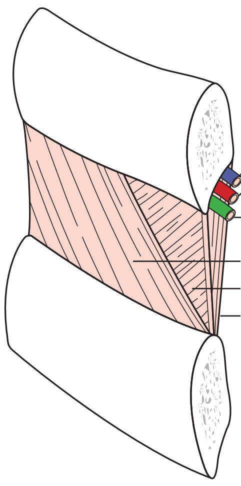


Fig.4.1
An intercostal space

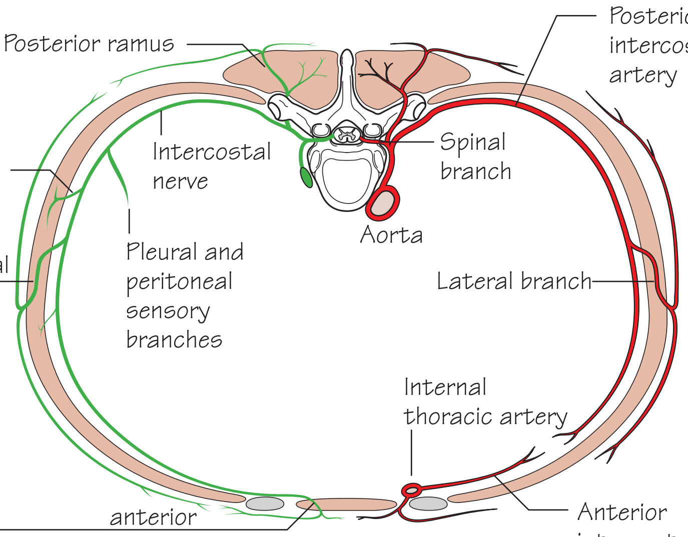


Fig.4.2
The vessels and nerves of an intercostal space

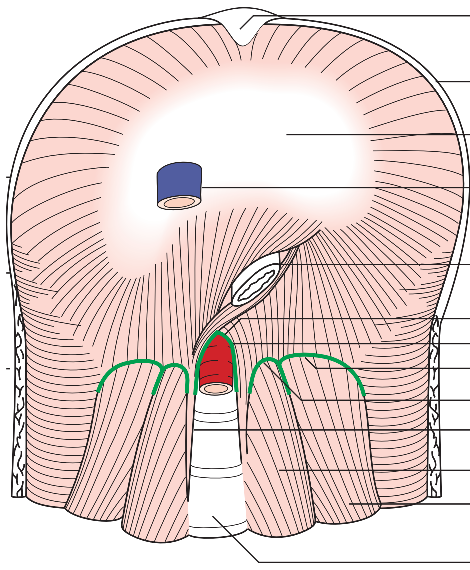


Fig.4.3
The diaphragm

 Anatomy at a Glance, Third Edition. Omar Faiz, Simon Blackburn and David Moffat.

The intercostal space (Fig. 4.1)

Typically, each space contains three muscles comparable to those of the abdominal wall. These include the:

• **External intercostal**: this muscle fills the intercostal space from the vertebra posteriorly to the costochondral junction anteriorly where it becomes the thin anterior intercostal membrane. The fibres run downwards and forwards from rib above to rib below.

• **Internal intercostal**: this muscle fills the intercostal space from the sternum anteriorly to the angles of the ribs posteriorly where it becomes the posterior intercostal membrane which reaches as far back as the vertebral bodies. The fibres run downwards and backwards.

• **Innermost intercostals**: this group comprises the *subcostal* muscles posteriorly, the *intercostales intimi* laterally and the *transversus thoracis* anteriorly. The fibres of these muscles span more than one intercostal space.

The neurovascular space is the plane in which the neurovascular bundle (intercostal vein, artery and nerve) courses. It lies between the internal intercostal and innermost intercostal muscle layers.

The intercostal structures course under cover of the subcostal groove.

Vascular supply and venous drainage of the chest wall

The intercostal spaces receive their *arterial supply* from the anterior and posterior intercostal arteries.

• The *anterior intercostal arteries* are branches of the internal thoracic artery and its terminal branch, the musculophrenic artery. The lowest two spaces have no anterior intercostal supply (Fig. 4.2).

• The first 2–3 *posterior intercostal arteries* arise from the superior intercostal branch of the costocervical trunk, a branch of the 2nd part of the subclavian artery (see Fig. 65.1). The lower nine posterior intercostal arteries are branches of the thoracic aorta. The posterior intercostal arteries are much longer than the anterior intercostal arteries (Fig. 4.2).

The anterior intercostal *veins* drain anteriorly into the internal thoracic and musculophrenic veins. The posterior intercostal veins drain into the azygos and hemiazygos systems (see Fig. 6.2).

Lymphatic drainage of the chest wall

Lymph drainage from the:

• **Anterior chest wall** is to the anterior axillary nodes.
• **Posterior chest wall** is to the posterior axillary nodes.
• **Anterior intercostal spaces** is to the internal thoracic nodes.
• **Posterior intercostal spaces** is to the para-aortic nodes.

Nerve supply of the chest wall (Fig. 4.2)

The intercostal nerves are the anterior primary rami of the thoracic segmental nerves. Only the upper six intercostal nerves reach the sternum, the remainder run initially in their intercostal spaces, then within the muscles of the abdominal wall, eventually gaining access to its anterior aspect.

Branches of the intercostal nerves include:

• *Cutaneous* anterior and lateral branches.

• A *collateral* branch which supplies the muscles of the intercostal space (also supplied by the main intercostal nerve).

• *Sensory* branches from the pleura (upper nerves) and peritoneum (lower nerves).

Exceptions include:

• The 1st intercostal nerve is joined to the brachial plexus and has no anterior cutaneous branch.

• The 2nd intercostal nerve is joined to the medial cutaneous nerve of the arm by the intercostobrachial nerve branch. The 2nd intercostal nerve consequently supplies the skin of the armpit and medial side of the arm.

The diaphragm (Fig. 4.3)

The diaphragm separates the thoracic and abdominal cavities. It is composed of a peripheral muscular portion which inserts into a central aponeurosis—the *central tendon*.

The muscular part has three component origins:

• A *vertebral part* which comprises the crura and arcuate ligaments. The right crus arises from the front of the L1–3 vertebral bodies and intervening discs. Some fibres from the right crus pass around the lower oesophagus.

The left crus originates from L1 and L2 only.

The medial arcuate ligament is made up of thickened fascia which overlies psoas major and is attached medially to the body of L1 and laterally to the transverse process of L1. The lateral arcuate ligament is made up of fascia which overlies quadratus lumborum from the transverse process of L1 medially to the 12th rib laterally.

The median arcuate ligament is a fibrous arch which connects left and right crura.

• A *costal part* attached to the inner aspects of the lower six ribs.

• A *sternal part* which consists of two small slips arising from the deep surface of the xiphoid process.

Openings in the diaphragm

Structures traverse the diaphragm at different levels to pass from thoracic to abdominal cavities and vice versa. These levels are as follows:

• T8, the *opening for the inferior vena cava*: transmits the inferior vena cava and right phrenic nerve.

• T10, the *oesophageal opening*: transmits the oesophagus, vagi and branches of the left gastric artery and vein.

• T12, the *aortic opening*: transmits the aorta, thoracic duct and azygos vein.

The left phrenic nerve passes into the diaphragm as a solitary structure, having passed down the left side of the pericardium (Fig. 9.1).

Nerve supply of the diaphragm

• **Motor supply**: the entire motor supply arises from the phrenic nerves (C3,4,5). Diaphragmatic contraction is the mainstay of inspiration.

• **Sensory supply**: the periphery of the diaphragm receives sensory fibres from the lower intercostal nerves. The sensory supply from the central part is carried by the phrenic nerves.

Clinical notes

• **Diaphragmatic herniae**: the diaphragm is formed by the embryological fusion of the septum transversum, dorsal mesentery and pleuro-peritoneal membranes. Failed fusion results in congenital diaphragmatic herniae. Most commonly, congenital herniation occurs through the Bochdalek foramen posteriorly (through the pleuroperitoneal canal), it may also occur through the Morgagni foramen anteriorly (between the xiphoid, costal cartilages and the attached diaphragm). Acquired diaphragmatic hernia occurs frequently. The most common type of this kind is the hiatus hernia. It represents a weakening of the oesophageal hiatus. This condition occurs mostly in adulthood and often gives rise to symptomatic acid reflux. The majority of patients require medical treatment only, but some require surgical correction.

5 The mediastinum I – the contents of the mediastinum

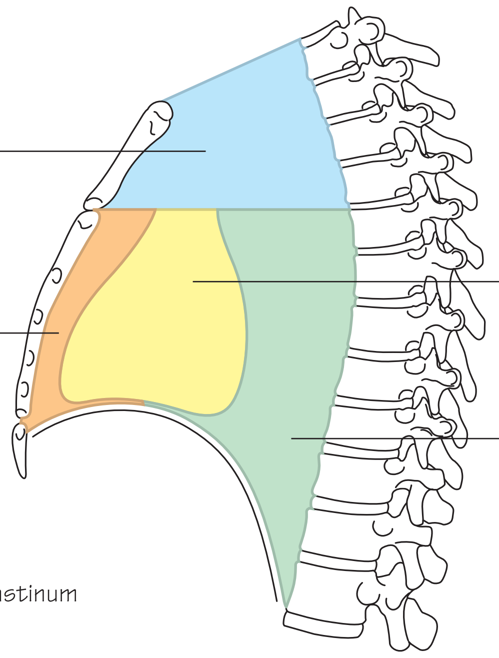


Fig.5.1
The subdivisions of the mediastinum and their principal contents

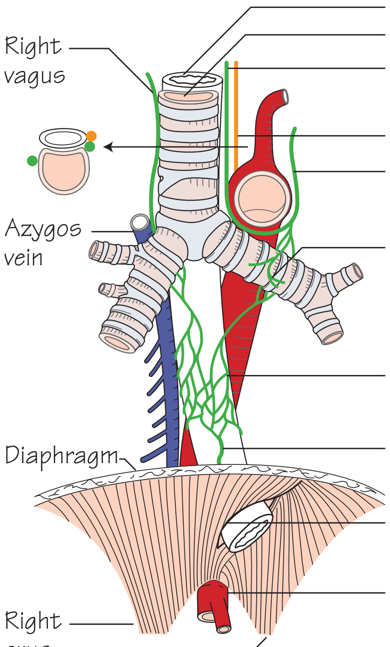


Fig.5.2
The course and principal relations of the oesophagus. Note that it passes through the *right* crus of the diaphragm

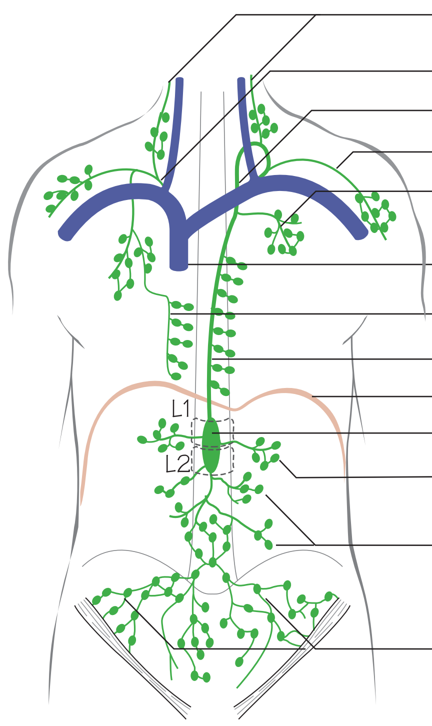


Fig.5.3
The thoracic duct and its areas of drainage. The right lymph duct is also shown

