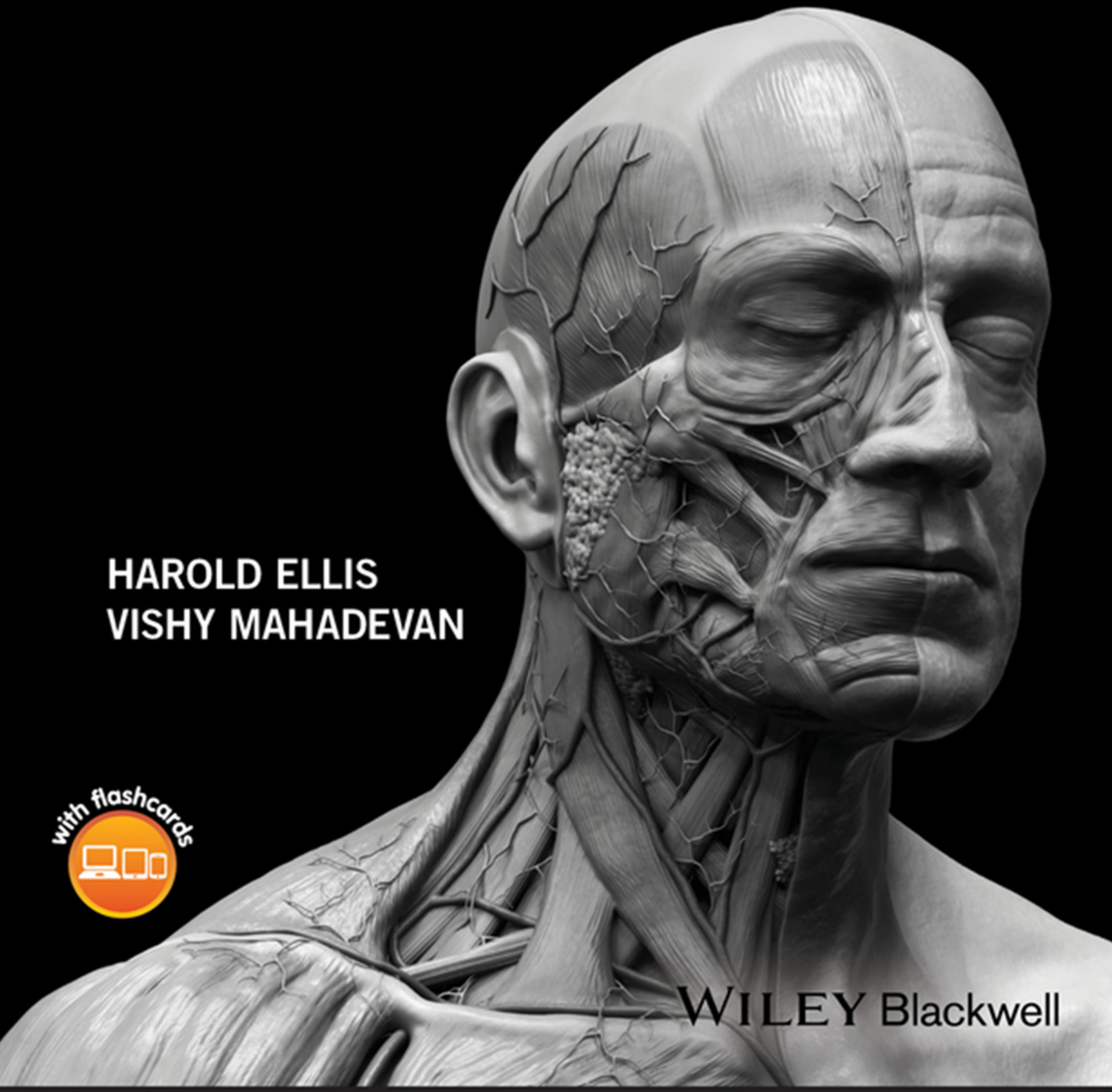
CLINICAL ANATOMY

APPLIED ANATOMY FOR STUDENTS AND JUNIOR DOCTORS

FOURTEENTH EDITION



HAROLD ELLIS
VISHY MAHADEVAN

with flashcards

WILEY Blackwell

Clinical Anatomy

To my wife, Wendy, and my late parents

H. E.

To my wife, Neila, and my late parents

V. M.

Clinical Anatomy

Applied Anatomy for Students and Junior Doctors

HAROLD ELLIS

CBE, MA, DM, MCh, FRCS, FRCP, FRCOG, FACS (Hon)
Clinical Anatomist, Guy's, King's and St Thomas' School of Biomedical Sciences;
Emeritus Professor of Surgery, Charing Cross
and Westminster Medical School, London;
Formerly Examiner in Anatomy, Primary FRCS (Eng)

VISHY MAHADEVAN

MBBS, PhD, FRCSEd, FDSRCSEng (Hon), FRCS
Barbers' Company Professor of Anatomy & Professor of Surgical Anatomy
The Royal College of Surgeons of England
Lincoln's Inn Fields

This edition first published 2019 © 2019 by John Wiley & Sons Ltd

Edition History
Harold Ellis (1960, 1962, 1966, 1969, 1971, 1977, 1977, 1983, 1992, 1992, 2002, 2006); Harold Ellis and Vishy Mahadevan (2010); John Wiley & Sons Ltd (2013).

Registered Offices
John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office
9600 Garsington Road, Oxford, OX4 2DQ, UK

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Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

A catalogue record for this book is available from the Library of Congress and the British Library.

ISBN 9781119325536

Cover image: © graphiks-walid/Shutterstock
Cover design by Wiley

Set in 9/12pt Palatino LTStd by SPi Global, Pondicherry, India

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Preface to the Fourteenth Edition

As a teacher of medical students and surgical trainees, I know that much of clinical examination and diagnosis depends on an adequate knowledge of anatomy. No matter how good the doctors are at communication skills and patient empathy, unless they know what lies beneath their examining fingers or under the bell of their stethoscopes, they will have great difficulty in the interpretation of clinical signs. Understanding and interpreting the exquisite details of modern radiological imaging also requires a good knowledge of the structure of the human body.

This was true over 55 years ago when I wrote the first edition of this book, and is perhaps even more so today, when the content of anatomical knowledge in the medical student's curriculum has been greatly reduced.

Over these many years, during which time I have taught students and postgraduates in five medical schools, and examined them in eight countries and sixteen universities, my belief in the importance of an adequate knowledge of anatomy as an adjunct to clinical training has been strongly reinforced.

In the preparation of the 12th edition (Golden Jubilee edition) and the subsequent two editions (including this one), I have been fortunate indeed in having been able to recruit Professor Vishy Mahadevan, the Barbers' Company Professor of Anatomy at the Royal College of Surgeons of England, as co-author. He is a renowned and revered teacher of surgical trainees as well as being a current examiner in the MRCS and in overseas medical schools. Together, in this new edition, we have carried out a careful revision and updating of the text and diagrams.

We hope that this book will continue to help our students and postgraduate trainees throughout the English-speaking world.

Harold Ellis
July 2018

Preface to the First Edition

Experience of teaching clinical students at three medical schools has convinced me that there is still an unfortunate hiatus between the anatomy which the student learns in his pre-clinical years and that which he later encounters in the wards and operating theatres.

This book attempts to bridge this gap. It does so by high-lighting those features of anatomy which are of clinical importance, in medicine and midwifery as well as in surgery. It presents the facts which a student might reasonably be expected to carry with him during his years on the wards, through final examinations and into his post-graduate years; it is designed for the clinical student.

Anatomy is a vast subject and therefore, in order to achieve this goal, I have deliberately carried out a rigorous selection of material so as to cover only those of its thousands of facts which I consider form the necessary anatomical scaffolding for the clinician. Wherever possible practical applications are indicated throughout the text – they cannot, within the limitations of a book of this size, be exhaustive, but I hope that they will act as signposts to the student and indicate how many clinical phenomena can be understood and remembered on simple anatomical grounds.

Harold Ellis
Oxford, 1960

Acknowledgements to the Fourteenth Edition

We wish to thank the many students, undergraduates and postgraduates who have taken the trouble to send us constructive suggestions, many of which have been incorporated into this new edition.

Our thanks to Jane Fallows whose skilfully produced illustrations we continue to use in this edition.

CT and MRI scans were provided by Dr Sheila Rankin and Dr Jeremy Rabouhans of the Department of Radiology at Guy's Hospital, and Professor Adrian Dixon of Cambridge. Our thanks to all three.

Our gratitude to Ruth Swan for her diligent scrutiny and editing of the text in the latter stages of the production of this volume, and for her invaluable editorial advice and help.

We are grateful to the following authors for permission to reproduce illustrations:

The late Lord Brock for Figs 20 and 21 (from *Lung Abscess*); and

Professor R. G. Harrison for Figs 12, 32 and 67 (from *A Textbook of Human Embryology*).

Finally, we wish to express our profound debt and profuse gratitude to Nick Morgan, James Watson, Jennifer Seward, Loan Nguyen and the staff of Wiley Blackwell for their generous and unfailing help, guidance and support.

Harold Ellis
Vishy Mahadevan
July 2018

Acknowledgements to the First Edition

I wish to thank Dr Max Cowan of the Department of Anatomy, Oxford, who has given freely of advice and criticism in the production of this book.

My colleagues – the registrars and house surgeons at the Radcliffe Infirmary – have kindly perused and commented on the text and have given valuable help in proof-reading.

The majority of the illustrations are by Miss Margaret McLarty and Miss Audrey Arnott; I must thank them sincerely for all their care.

I am grateful to the following authors for permission to reproduce illustrations:

Sir Russell Brock for Fig. 15 (from *Lung Abscess*); Professor R. G. Harrison for Figs 10, 23, 53, 67 and 155 (from *A Textbook of Human Embryology*); Professor David Sinclair for Figs 69, 92, 95, 97, 100–1, 105, 107, 114, 126, 132, 137, 139, 177 and 181 (from *An Introduction to Functional Anatomy*); and Professor Sheila Sherlock for Fig. 55 (from *Diseases of the Liver and Biliary System*).

The illustrations for an anatomical textbook are inevitably a costly item, yet I was anxious that this book should be within the budget of the students for whom it is primarily intended. It is therefore a pleasure to acknowledge here the generosity of Upjohn of England Ltd in contributing towards the cost of the blocks: their gesture will be widely appreciated.

To my sister, Mrs L. Witte, go my grateful thanks for invaluable secretarial assistance. Finally, I wish to express my debt to Mr Per Saugman and staff at Blackwell Scientific Publications for guiding the hesitant steps of the beginner.

Harold Ellis

About the Companion Website

Clinical Anatomy has its own resources website:

www.ellisclinicalanatomy.co.uk/14edition

with digital flashcards of the images from the book for easy revision.

Part 1

The Thorax

Clinical Anatomy: Applied Anatomy for Students and Junior Doctors, Fourteenth Edition. Harold Ellis and Vishy Mahadevan.

Companion website: www.ellisclinicalanatomy.co.uk/14edition

Introduction

The clinical anatomy of the thorax, together with the anatomy of radiological and other imaging techniques of the thorax are in daily use in clinical practice. The routine clinical examination of the patient's chest is little more than an exercise in relating the deep structures of the thorax to the chest wall. Moreover, several commonly undertaken procedures – chest aspiration, insertion of a chest drain or of a subclavian line, placement of a cardiac pacemaker, for example – have their basis, and their safe performance, in sound anatomical knowledge.

Surface anatomy and surface markings

Much of the working life of an experienced clinician is spent in relating the patient's surface anatomy to underlying deep structures (Fig. 1; see also Figs 11, 22).

The following bony prominences can usually be palpated in the living subject (corresponding vertebral levels are given in brackets):

- superior angle of the scapula (T2);
- upper border of the manubrium sterni, the suprasternal notch (T2/3);
- spine of the scapula (T3);
- sternal angle (of Louis) – the transverse ridge at the manubriosternal junction (T4/5);
- inferior angle of the scapula (T8); it also overlies the 7th rib;
- xiphisternal joint (T9);
- lowest part of the costal margin – 10th rib (the subcostal line passes through L3).

Note from Fig. 1 that the manubrium sterni corresponds to the 3rd and 4th thoracic vertebrae and overlies the aortic arch, and that the body of the sternum corresponds to the 5th–8th vertebrae and neatly overlies the heart.

Since the 1st and 12th ribs are difficult to feel, the ribs should be enumerated from the 2nd costal cartilage, which articulates with the sternum at the angle of Louis.

The spinous processes of all the thoracic vertebrae can be palpated in the midline posteriorly, but it should be remembered that the first spinous process that can be felt is that of C7 (the vertebra prominens).

The position of the *nipple* varies considerably in the female, but in the male it usually overlies the 4th intercostal space approximately 10 cm (4 in) from the midline. The *apex beat*, which marks the lowest and outermost point at which the cardiac impulse can be palpated, is normally in the 5th intercostal space 9 cm (3.5 in) from the midline and within the midclavicular line. (This corresponds to just below and medial to the nipple in the male, but it is always preferable to use bony rather than soft-tissue points of reference.)

The *trachea* is palpable in the suprasternal notch midway between the heads of the two clavicles.

The trachea (Figs 1, 2)

The trachea commences in the neck at the level of the lower border of the cricoid cartilage (C6) and runs vertically downwards to end below the level of the sternal angle of Louis (T4/5), just to the right of the midline, by dividing to form the right and left main bronchi. In the erect position and in full inspiration the level of bifurcation is at T6.

The pleura (Figs 2, 3)

The *cervical pleura* can be marked out on the surface by a curved line drawn from the sternoclavicular joint to the junction of the medial and middle thirds of the clavicle; the apex of the pleura is approximately 2.5 cm (1 in) above the clavicle. This fact is easily explained by the oblique slope of the first rib. It is important because the pleura can be wounded (with consequent pneumothorax) by a stab wound – and this includes the surgeon's knife and the anaesthetist's needle – above the clavicle, or, in an attempted subclavian vein catheterization, below the clavicle. The lines of pleural reflexion pass from behind the sternoclavicular joint on each side to meet in the midline at the 2nd costal cartilage (the angle of Louis). The right

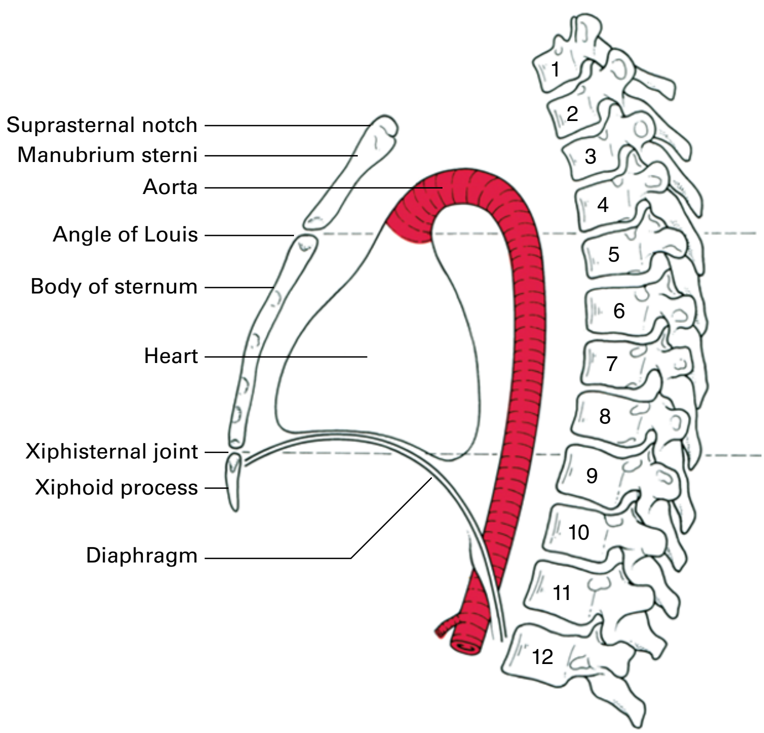

Fig. 1 Lateral view of the thorax – its surface markings and vertebral levels. (Note that the angle of Louis (T4/5) demarcates the lower boundary of the superior mediastinum, the upper margin of the heart and the beginning and end of the aortic arch.)

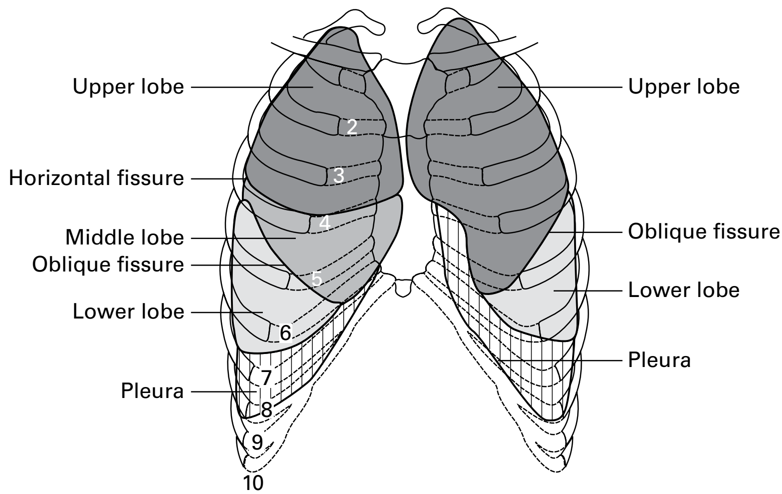

Fig. 2 The surface markings of the lungs and pleura – anterior view.

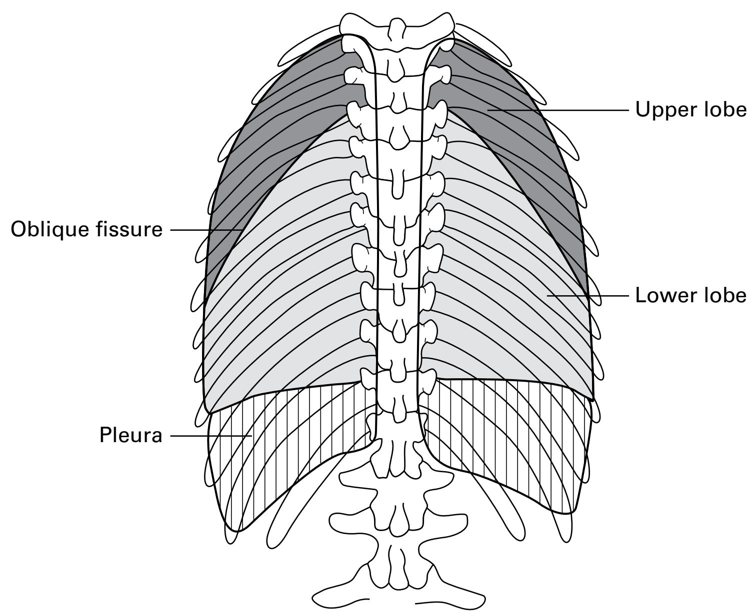

Fig. 3 The surface markings of the lungs and pleura – posterior view.

pleural edge then passes vertically downwards to the 6th costal cartilage and then crosses:

- the 8th rib in the midclavicular line;
- the 10th rib in the midaxillary line;
- the 12th rib at the lateral border of the erector spinae.

On the left side the pleural edge arches laterally at the 4th costal cartilage and descends lateral to the border of the sternum, owing, of course, to its lateral displacement by the heart; apart from this, its relationships are those of the right side.

The pleura actually descends just below the 12th rib margin at its medial extremity – or even below the edge of the 11th rib if the 12th is unusually short; obviously, in this situation, the pleura may be opened accidentally in making a loin incision to expose the kidney, perform an adrenalectomy or drain a subphrenic abscess.

The lungs (Figs 2, 3)

The surface projection of the lung is somewhat less extensive than that of the parietal pleura as outlined previously, and in addition it varies quite considerably with the phase of respiration. The *apex* of the lung closely follows the line of the cervical pleura and the surface marking of the *anterior border of the right lung* corresponds to that of the right mediastinal pleura. On the left side, however, the *anterior border* has a distinct notch (the *cardiac notch*) that passes behind the 5th and 6th costal cartilages. The *lower border* of the lung has an excursion of as much as 5–8 cm (2–3 in) in the extremes of respiration, but in the neutral position (midway between inspiration and expiration) it lies along a line which crosses the 6th rib in the midclavicular line, the 8th rib in the midaxillary line and reaches the 10th rib adjacent to the vertebral column posteriorly.

The *oblique fissure*, which divides the lung into upper and lower lobes, is indicated on the surface by a line drawn obliquely downwards and outwards from 2.5 cm (1 in) lateral to the spine of the 3rd thoracic vertebra along the 5th intercostal space to the 6th costal cartilage approximately 4 cm (1.5 in) from the midline. This can be represented approximately by abducting the shoulder to its full extent; the line of the oblique fissure then corresponds to the position of the medial border of the scapula.

The surface markings of the *transverse fissure* (separating the middle and upper lobes of the right lung) is a line drawn horizontally along the 4th costal cartilage and meeting the oblique fissure where the latter crosses the 5th rib.

The heart (Fig. 4)

The outline of the heart can be represented on the surface by an irregular quadrangle bounded by the following four points (Fig. 4):

1 the 2nd *left* costal cartilage 1.25 cm (0.5 in) from the edge of the sternum;
2 the 3rd *right* costal cartilage 1.25 cm (0.5 in) from the sternal edge;
3 the 6th *right* costal cartilage 1.25 cm (0.5 in) from the sternum;
4 the 5th *left* intercostal space 9 cm (3.5 in) from the midline (corresponding to the apex beat).

The *left border* of the heart (indicated by the curved line joining points 1 and 4) is formed almost entirely by the left ventricle (the auricular appendage of the left atrium peeping around this border superiorly); the *lower border* (the horizontal line joining points 3 and 4) corresponds to the right ventricle and the apical part of the left ventricle; the *right border* (marked by the line joining points 2 and 3) is formed by the right atrium (see Fig. 24a).

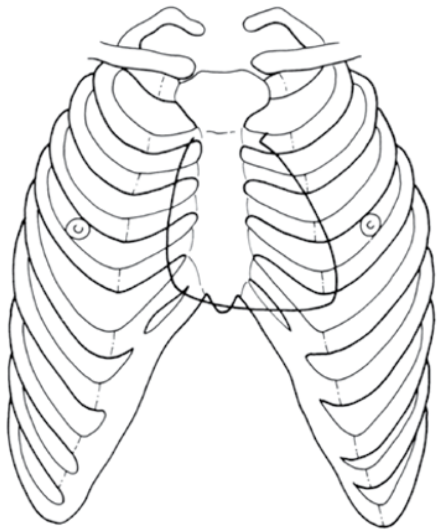

Fig. 4 The surface markings of the heart (see text).

A good guide to the size and position of your own heart is given by placing your clenched right fist palmar surface inwards immediately inferior to the manubriosternal junction. Note that the heart is approximately the size of the subject's fist, lies behind the body of the sternum (therefore anterior to thoracic vertebrae 5–8) and bulges over to the left side.

The surface markings of the vessels of the thoracic wall are of importance if these structures are to be avoided when performing aspiration of the chest. The *internal thoracic* (*internal mammary*) *vessels* run vertically downwards behind the costal cartilages 1.25 cm (0.5 in) from the lateral border of the sternum. The intercostal vessels lie immediately below their corresponding ribs (the vein above the artery) so that it is safe to pass a needle immediately *above* a rib, but hazardous to pass it immediately *below* (see Fig. 8).

The thoracic cage

The thoracic cage is formed by the vertebral column behind, the ribs and intercostal spaces on either side and the sternum and costal cartilages in front. Above, it communicates through the superior aperture of the thoracic cage with the root of the neck; below, it is separated from the abdominal cavity by the diaphragm (Fig. 1). Amusingly, the superior aperture of the thoracic cage is termed the 'thoracic inlet' by anatomists, while clinicians (especially vascular surgeons, neurosurgeons and radiologists) refer to the same aperture as the 'thoracic outlet'.

The thoracic vertebrae

See 'The vertebral column', page 347. See also page 350 and Fig. 228.

The ribs

The greater part of the thoracic cage is formed by the twelve pairs of ribs. Of these, the first seven are connected anteriorly by way of their costal cartilages to the sternum, the cartilages of the 8th, 9th and 10th articulate each with the cartilage of the rib above and the last two ribs are free anteriorly ('floating ribs').

Each typical rib (Fig. 5) has a *head* bearing two articular facets, for articulation with the upper demifacet on the side of the body of the numerically corresponding thoracic vertebra and the lower demifacet of the vertebra above (see Fig. 228). Thus, the head of the third rib articulates with its own third vertebral body and the one above. The head continues as a stout *neck*, which gives attachment to the costotransverse ligaments, a *tubercle* with a rough non-articular portion and a smooth facet, for articulation with the transverse process of the corresponding vertebra, and a long shaft flattened from side to side and divided into two parts by the 'angle' of the rib. The angle demarcates the lateral limit of attachment of the erector spinae muscle.

The following are the significant features of the 'atypical' ribs.

The *1st rib* (Fig. 6) is flattened from above downwards. It is not only the flattest but also the shortest and most highly curved of all the ribs. It has a prominent *tubercle* on the inner border of its upper surface for the insertion of scalenus anterior. In front of this tubercle, the subclavian vein crosses the rib; behind the tubercle is the *subclavian groove*, where the subclavian artery and lowest trunk of the brachial plexus lie in relation to the bone. This is one of the sites where the anaesthetist can infiltrate the plexus with local anaesthetic.

Crossing the front of the neck of the first rib vertically and lying from medial to lateral are the sympathetic trunk, the superior intercostal artery (from the costocervical trunk) and the large branch of the first thoracic nerve to the brachial plexus.

The *2nd rib* is much less curved than the 1st and approximately twice as long.

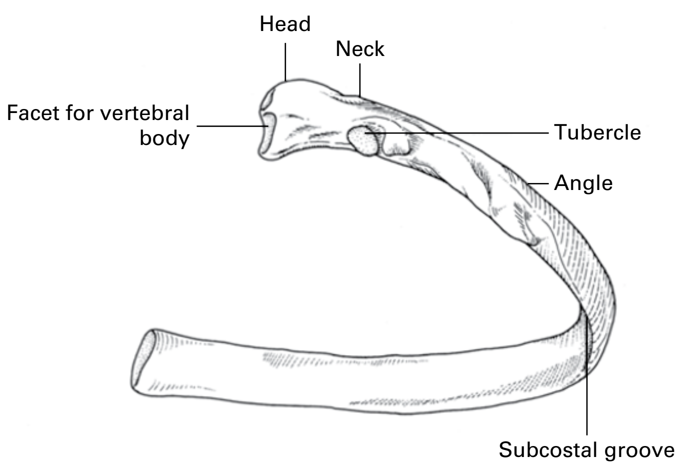

Fig. 5 A typical rib.

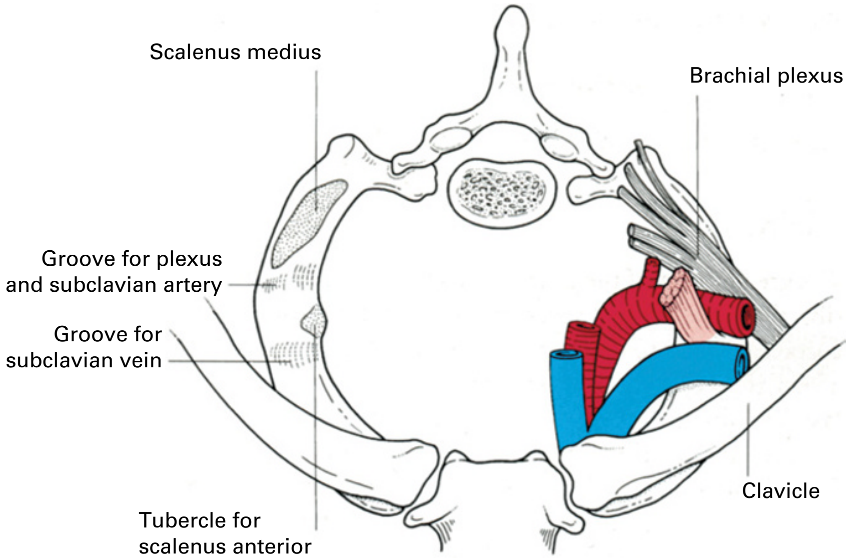

Fig. 6 Structures crossing the first rib.

The *10th rib* has only one articular facet on the head.

The *11th* and *12th ribs* (*the 'floating ribs'*) are short, have no tubercles and only a single facet on the head. The 11th rib has a slight angle and a shallow subcostal groove; the 12th has neither of these features.

CLINICAL FEATURES

Rib fractures

The chest wall of the child is highly elastic and therefore fractures of the rib in children are rare. In adults, the ribs may be fractured by direct violence or indirectly by crushing injuries; in the latter, the rib tends to give way at its weakest part in the region of its angle. Not unnaturally, the upper two ribs, which are protected by the clavicle, and the lower two ribs, which are unattached anteriorly, and therefore swing free, are the least commonly injured.

In a severe crush injury to the chest several ribs may fracture in front and behind so that a whole segment of the thoracic cage becomes torn free ('stove-in chest'). With each inspiration, this loose flap sucks in; with each expiration, it blows out; thus undergoing paradoxical respiratory movement. The associated swinging movements of the mediastinum produce severe shock, and this injury calls for urgent treatment by insertion of a chest drain with underwater seal, followed by endotracheal intubation, or tracheostomy, combined with positive pressure respiration.

Coarctation of the aorta (see Fig. 34b and page 44)

In coarctation of the aorta, the intercostal arteries derived from the aorta receive blood from the superior intercostals (from the costocervical trunk of the subclavian artery), from the anterior intercostal branches of the internal thoracic artery (arising from the subclavian artery) and from the arteries anastomosing around the scapula. Together with the communication between the internal thoracic and inferior epigastric arteries, they provide the principal collaterals between the aorta above and below the block. In consequence, the intercostal arteries undergo dilatation and tortuosity and erode the lower borders of the corresponding ribs to give the characteristic irregular *notching of the ribs*, which is very useful in the radiographic confirmation of this lesion.

Cervical rib

A cervical rib (Fig. 7) occurs in 0.5% of subjects and is bilateral in half of these. It is attached to the transverse process of the 7th cervical vertebra and articulates with the 1st (thoracic) rib or, if short, has a free distal extremity which usually attaches by a fibrous strand to the (normal) first rib. Pressure of such a rib on the lowest trunk of the brachial plexus arching over it may produce paraesthesiae along the ulnar border of the forearm and wasting of the small muscles of the hand (T1). Less commonly vascular changes, even gangrene, may be caused by pressure of the rib on the overlying subclavian artery. This results in poststenotic dilatation of the vessel distal to the rib in which a thrombus forms, from which emboli are thrown off.

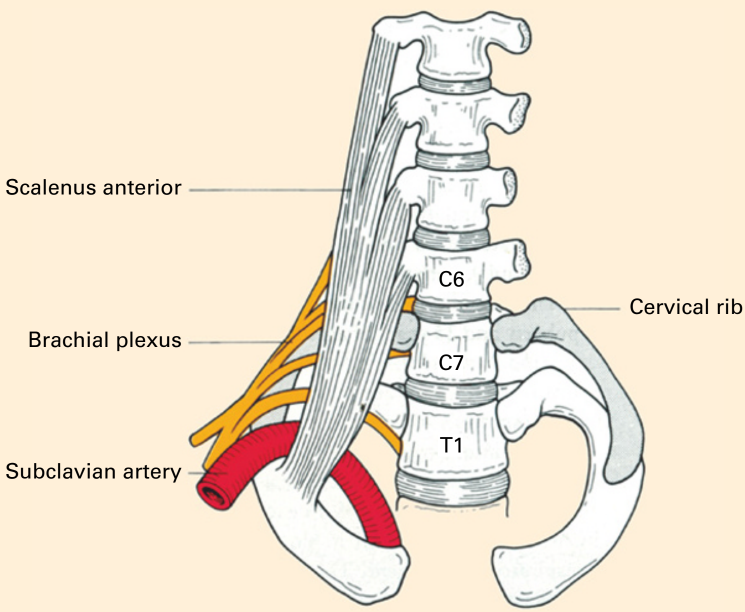

Fig. 7 Bilateral cervical ribs. On the right side the brachial plexus is seen arching over the rib and stretching its lowest trunk. The subclavian artery may also be pressed upon by the underlying cervical rib.

The costal cartilages

These bars of hyaline cartilage serve to connect the upper seven ribs directly to the side of the sternum and the 8th, 9th and 10th ribs to the cartilage immediately above. The cartilages of the 11th and 12th ribs merely join the tapered extremities of these ribs and end in the abdominal musculature.

CLINICAL FEATURES

1 The cartilage adds considerable resilience to the thoracic cage and protects the sternum and ribs from more frequent fracture.
2 In old age (and sometimes also in young adults) the costal cartilages undergo progressive ossification; they then become radio-opaque and may give rise to some confusion when examining a chest radiograph of an elderly patient.

The sternum

This dagger-shaped bone, which forms the anterior part of the thoracic cage, consists of three parts. The *manubrium* is roughly triangular in outline and provides articulation for the clavicles and for the first and upper part of the 2nd costal cartilages on either side. It is situated opposite the 3rd and 4th thoracic vertebrae. Opposite the disc between T4 and T5 it articulates at an oblique angle at the manubriosternal joint (the angle of Louis) with the *body of the sternum* (placed opposite T5–T8). This is composed of four parts or 'sternebrae', which fuse between puberty and 25 years of age. Its lateral border is notched to receive part of the 2nd and the 3rd to the 7th costal cartilages. The *xiphoid process* is the smallest part of the sternum and usually remains cartilaginous well into adult life. The cartilaginous manubriosternal joint and that between the xiphoid and the body of the sternum may also become ossified after the age of 30.

CLINICAL FEATURES

1 The attachment of the elastic costal cartilages largely protects the sternum from injury, but indirect violence accompanying fracture dislocation of the thoracic spine may be associated with a sternal fracture. Direct violence to the sternum may lead to displacement of the relatively mobile body of the sternum backwards from the relatively fixed manubrium.
2 In a sternal puncture a wide-bore needle is pushed through the thin layer of cortical bone covering the sternum into the highly vascular spongy bone beneath, and a specimen of bone marrow aspirated with a syringe.
3 In operations on the thymus gland, and occasionally for a retrosternal goitre, it is necessary to split the manubrium in the midline in order to gain access to the superior mediastinum. A complete vertical split of the whole sternum is one of the standard approaches to the heart and great vessels used in modern cardiac surgery.

The intercostal spaces

There are slight variations between the different intercostal spaces, but typically each space contains three muscles, comparable to those of the abdominal wall, and an associated neurovascular bundle (Fig. 8). The muscles are:

1 the *external intercostal*, the fibres of which pass downwards and forwards from the rib above to the rib below and reach from the vertebrae behind to the costochondral junction in front, where muscle is replaced by the *anterior intercostal membrane*;

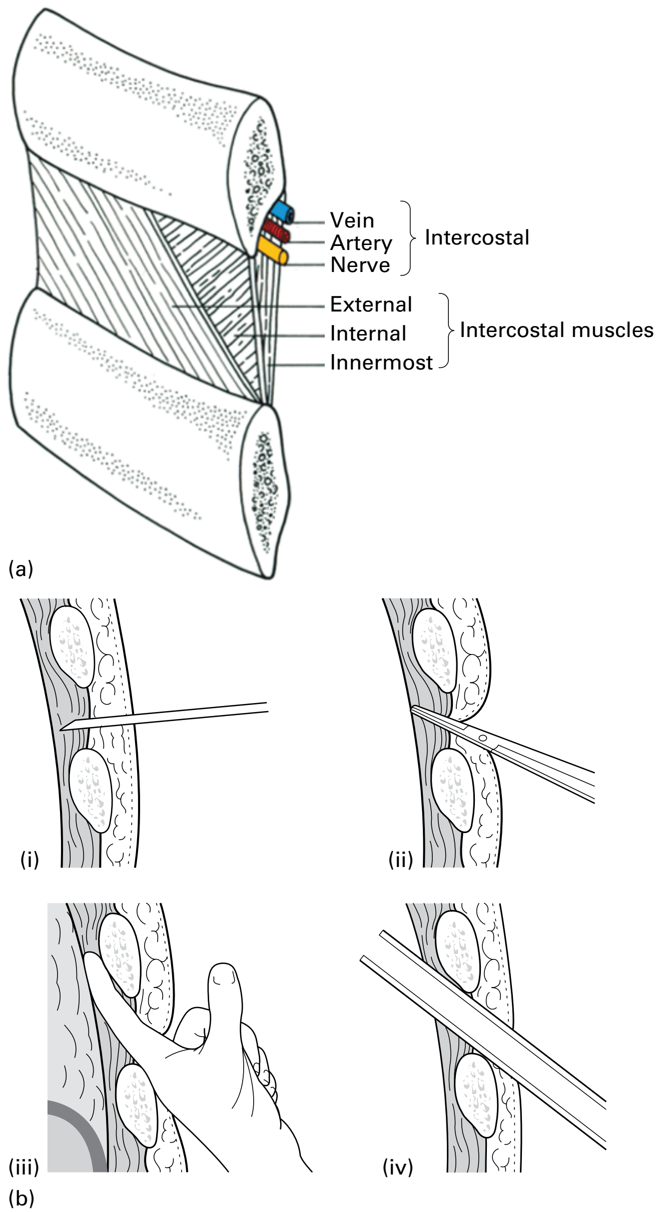

Fig. 8 (a) The relationship of an intercostal space. (Note that a needle passed into the chest immediately *above* a rib will avoid the neurovascular bundle.) (b) Steps in the insertion of a chest drain. (i) Local anaesthetic is infiltrated into an intercostal space. (ii) Incision followed by blunt dissection allows access to the pleura. (iii) A finger is passed through the incision to clear the lung away. (iv) A chest tube is passed into the pleural cavity.

2 the *internal intercostal*, which runs downwards and backwards from the sternum to the angles of the ribs where it becomes the *posterior intercostal membrane*;
3 the *innermost intercostal*, which is only incompletely separated from the internal intercostal muscle by the neurovascular bundle. The fibres of this sheet cross more than one intercostal space and it may be incomplete. Anteriorly it has a more distinct portion that is fan-like in shape, termed the *transversus thoracis* (or sternocostalis), which spreads upwards from the posterior aspect of the lower sternum to insert onto the inner surfaces of the 2nd to the 6th costal cartilages.

Just as in the abdomen, the nerves and vessels of the thoracic wall lie between the middle and innermost layers of muscles. This neurovascular bundle consists, from above downwards, of vein, artery and nerve, the vein lying in a groove on the undersurface of the corresponding rib (remember: v,a,n).

The vessels comprise the posterior and anterior intercostal arteries and veins.

The *posterior intercostal arteries* of the lower nine spaces are direct branches of the descending thoracic aorta, while the first two are derived from the superior intercostal branch of the costocervical trunk, the only branch of the second part of the subclavian artery. Each runs forward in the subcostal groove to anastomose with the anterior intercostal artery. Each has a number of branches to adjacent muscles, to the skin and to the spinal cord. The corresponding veins are mostly tributaries of the azygos and hemiazygos veins. The first posterior intercostal vein drains into the brachiocephalic or vertebral vein. On the left, the 2nd and 3rd veins often join to form a superior intercostal vein, which crosses the aortic arch to drain into the left brachiocephalic vein.

The *anterior intercostal arteries* are branches of the internal thoracic artery (1st–6th space) or of its musculophrenic branch (7th–9th spaces). The lowest two spaces have only posterior arteries. Perforating branches pierce the upper five or six intercostal spaces; those of the 2nd–4th spaces are large in the female and supply the breast.

The *intercostal nerves* are the anterior primary rami of the thoracic nerves, each of which gives off a collateral muscular branch and lateral and anterior cutaneous branches for the innervation of the thoracic and abdominal walls (Fig. 9).

CLINICAL FEATURES

1 Local irritation of the intercostal nerves by such conditions as Pott's disease of the thoracic vertebrae (tuberculosis) may give rise to pain that is referred to the front of the chest or abdomen in the region of the peripheral termination of the nerves.
2 Local anaesthesia of an intercostal space is easily produced by infiltration around the intercostal nerve trunk and its collateral branch – a procedure known as intercostal nerve block.