

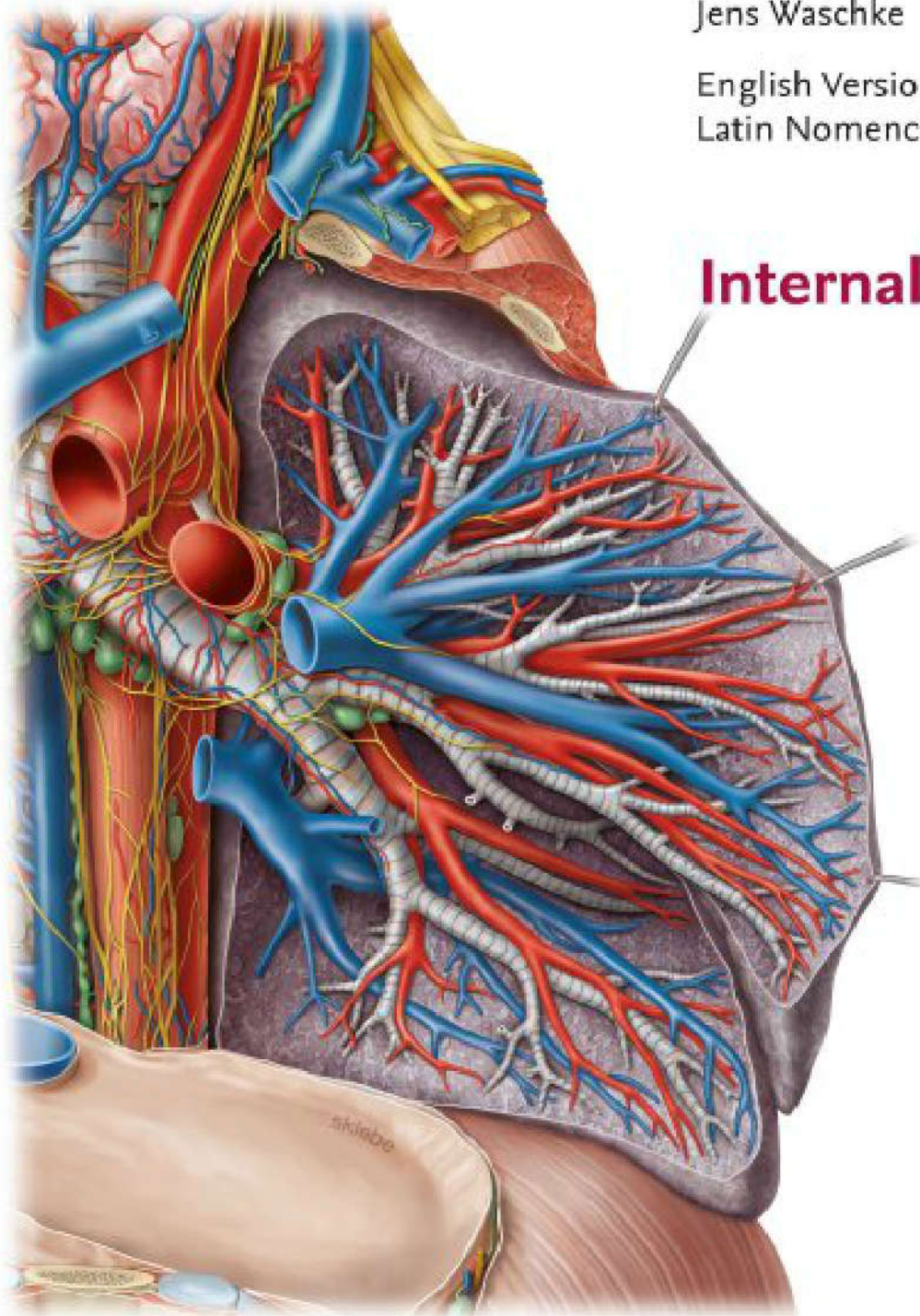
ATLAS OF ANATOMY

Sobotta

16th Edition

Edited by
Friedrich Paulsen and
Jens Waschke

English Version with
Latin Nomenclature



Internal Organs

ELSEVIER

F. Paulsen, J. Waschke

Sobotta

Atlas of Anatomy

Friedrich Paulsen, Jens Waschke (Eds.)

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English Version with Latin Nomenclature

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This atlas was founded by Johannes Sobotta †, former Professor of Anatomy and Director of the Anatomical Institute of the University in Bonn, Germany.

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1st Edition: 1904–1907 J. F. Lehmanns Verlag, Munich, Germany
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Urban & Schwarzenberg, Munich, Germany
13th Edition: 1953, ed. H. Becher
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18th Edition: 1982, eds. H. Ferner and J. Staubesand
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Spanish
Turkish
Ukrainian



Prof. Friedrich Paulsen

Dissection course for students

In his teaching, Friedrich Paulsen puts great emphasis on ensuring that the students in his dissection classes can actually work on body donation cadavers. *'Carrying out dissection yourself is not only extremely important for gaining a three-dimensional understanding of anatomy, forming the fundamental basis of virtually any field of medical science. In dissection classes you will also experience for the first time the touch and feeling of the human body, the organs and individual tissues, but in most cases it will also be your first intensive encounter with issues around death and dying, and the clinical causes of death. You will not only study anatomy, but also learn how to deal with a quite unique and challenging situation as part of a team. Never again will you be in such close contact with your fellow students and teaching staff.'*

Friedrich Paulsen was born in Kiel in 1965 and, after completing his 'Abitur' in Brunswick, he initially trained as a nurse. He then studied medicine at the Christian Albrecht University (CAU) in Kiel. After his house officer training at the Oromaxillofacial Surgery Clinic and a period as resident physician at the ENT Clinic of CAU, in 1998 he moved to the Anatomical Institute of CAU where he graduated as medical doctor in 1997 and further qualified by performing his State doctorate in anatomy in 2001. In 2003 he was offered full professorship at the Anatomy Departments of the Ludwig Maximilians University (LMU) in Munich and the Martin Luther University (MLU) in Halle/Wittenberg. In Halle, he founded a clinical anatomy training centre. After declining yet another professorship, this time at the University of Saarland, he accepted a post at the Friedrich Alexander University (FAU) in Nürnberg as Professor of Anatomy and Head of its Anatomical Institute, a post he has held since 2010. He has continued to decline professorships offered by a number of other renowned universities.

Friedrich Paulsen is an honorary member of the Anatomical Society of Great Britain and Ireland as well as Romania and has been granted numerous scientific awards including the Dr Gerhard Mann Sicca research prize, the Sicca research prize of the German Federation of Ophthalmologists, and the Commemorative Medal of the Comenius University in Bratislava. Additionally, he received several teaching awards.

The key focus of his research is on the innate immune response of the eye surface, and on investigating the causes of dry eyes. Visiting research fellowships have taken him to Spain and the United Kingdom. He is the editor of the journal *Annals of Anatomy* and, as vice-president of Learning and Teaching (until 3/2018), and now People (since 4/2018) also a member of the FAU university administration since 2016.

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Prof. Jens Waschke

Making courses more clinically relevant

For Jens Waschke, one of the most important challenges in the teaching of modern anatomy is how to optimally adapt the courses to meet the requirements of clinical training and subsequent professional practice.

'The clinical aspects of the Atlas give students in the first semesters of medical school a grounding in anatomy and at the same time show them the importance of having a thorough understanding of human anatomy for their subsequent clinical practice, instead of just learning anatomical structures by rote. On the other hand, we prefer to avoid covering highly specialised details that are only needed by a few specialists for occasional diagnostic procedures or surgery, as is the case in other contemporary anatomy books. Since students at the beginning of their training are unable to distinguish between the necessary basics and specialised details, this can cause a mental overload and prevent them from focusing on the essentials.'

Jens Waschke (born in 1974 in Bayreuth) studied medicine at the University of Würzburg, achieving a doctorate in anatomy under Prof. Detlev Drenckhahn in the year 2000. After his internship training in the Anatomy and Internal Medicine Departments, he qualified as a professor of anatomy and cell biology in 2007. Jens Waschke spent nine months as a visiting scholar at the Davis campus of the University of California under Prof. Fitz-Roy Curry in 2003–2004. From 2008 onward he chaired the newly established Department III of the University of Würzburg before being appointed professor at the Ludwig Maximilians University in Munich, where he has been the head of Department I (Vegetative Anatomy) of the Anatomical Institute since 2011. Jens Waschke is heavily involved in the German Anatomical Society as an examiner in specialist anatomy and a member of its Study Commission, and he heads their working group on reducing formaldehyde exposure. He is a representative of the IFAA (International Federation of Associations of Anatomists) and an honorary member of the Anatomical Society of Ethiopia (ASE). In his research he primarily investigates the biological mechanisms regulating cell adhesion and the external and internal barrier functions of the human body. His research predominantly focuses on the regulation of the endothelial barrier during inflammation, and also the mechanisms behind the impaired cell adhesion seen in diseases such as the blistering skin disorder pemphigus, Crohn's disease and arrhythmogenic cardiomyopathy. The aim is to better understand cell adhesion and to discover new treatment approaches.

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Preface of the 24th German Edition

In the preface of the first edition of his atlas in May 1904, Johannes Sobotta writes: 'Long-standing experience in cadaver dissection classes has prompted the author to ensure that the illustrations of the peripheral nervous system and the blood vessels depict the relevant structures in the same way that the student is accustomed to seeing them on the cadaver, i.e. that they depict the vessels and nerves from the same region together. Furthermore, the atlas alternates between pages of text and full-page diagrams. The latter contain the key illustrations in the atlas, while the former – in addition to sketches and schematic drawings and legends – contain a brief, concise text to help the student find information quickly when using the book in the dissection hall.'

Just as fashions change on a regular basis, so do students' reading and studying habits. The ubiquitousness of multi-media and the ready availability of information and stimuli are surely the main reasons why these habits are changing at a much faster rate than ever before. Publishers and publishing houses must stay abreast of these developments and of students' changing expectations regarding atlases and textbooks they wish to use, as well as ensuring the digital availability of the contents. In addition to interviews with students and systematic surveys, a publisher can sometimes gauge students' expectations from the textbook market itself. Detailed textbooks claiming to be completely comprehensive are increasingly being abandoned in favour of textbooks that didactically meet students' educational needs and cover the contents of their courses and exams – whether they are studying medicine, dentistry or biomedical science. Likewise, although the images in atlases such as Sobotta have fascinated many generations of doctors and medical professionals around the world with their precise naturalistic representations of real dissections, they are sometimes perceived by students as being too complicated and too detailed. This realisation requires us to consider how we can build upon the obvious strengths of an atlas – which in the course of over 100 years of tradition and 23 German editions, has become a benchmark of accuracy and quality – to meet modern didactic concepts without the overall work losing its unique, exclusive characteristic and its originality.

For educational reasons, we have maintained the Sobotta's original concept and chosen to publish the atlas, as it has been since the first edition, in three volumes: General Anatomy and Musculoskeletal System (1); Internal Organs (2); and Head, Neck and Neuroanatomy (3). And while the concept mentioned in the preface of the first edition, i.e. linking the pictures in the Atlas with an explanatory text, may be old-fashioned, it

has now come back into fashion – we have simply modernised the concept. Each picture is thus completed with a short explanatory text to introduce the students to the structure depicted and to explain why those particular dissection and depiction methods have been chosen for that particular region. The individual chapters have been systematically structured to follow today's methods of studying, while various illustrations have been updated or replaced. The majority of these new illustrations have been designed from the point of view of the learner, to make it easier to study the key pathways of blood supply and innervation. We have furthermore revised numerous existing illustrations and reduced the number of labels, using bold type to facilitate access to the anatomical content. The numerous clinical practice examples ('Clinical Remarks') show the somewhat 'dry' subject of anatomy at its most vibrant best, demonstrating to beginners how relevant anatomy is for their subsequent professional life and giving them a tantalising taste of their clinical training to come. Another revised feature is the introductory preface to the individual chapters, which sum up the content and the key issues, and include a real-life clinical case. In addition, each chapter ends with a summary of questions which would typically be asked in oral anatomy exams and exam tests. As in the 23rd edition, each chapter contains a brief introduction to the embryology of each body region.

Readers should please note two things:

1. The 24th edition of the Sobotta Atlas cannot replace an explanatory textbook.
2. No matter how good an educational concept is, students still have to put in many hours of intensive studying themselves – a good concept can but make that knowledge more accessible. Learning anatomy is not difficult, but it does take a lot of time; time that is well spent, since everybody – doctor and patient – will benefit from it in the long run. The aim of the 24th edition of the Sobotta Atlas is not only to facilitate your study, but also to make the time you spend studying engaging and interesting, so that the atlas is something you will repeatedly want to pick up and consult, both during your medical training and your subsequent professional career.

Erlangen and Munich, summer of 2017,
exactly 113 years after the first edition was published

Friedrich Paulsen and Jens Waschke

Acknowledgements of the 24th German Edition

The work on the 24th edition of the Sobotta Atlas has once again been a lot of fun, and this intensive involvement has continued to strengthen our sense of pride in the Sobotta.

Today, more than ever, an extensive anatomy atlas of the calibre of the Sobotta requires a lot of teamwork with the coordination of the publishing house. The cornerstone of the 24th edition has been laid by Dr Katja Weimann, who extensively coordinated the project. We are very grateful for her hard work. Also, without the long-standing experience of Dr Andrea Beilmann, who has worked on several previous editions of the Sobotta and has been a true pillar of strength for the Sobotta team, many things would not have been possible. We would like to thank her again most profusely for all her help and support. Benjamin Rempe, another member of the four-person team behind the 24th edition of the Sobotta, has contributed to Sobotta for the first time, approaching the task with real passion and enthusiasm. His unique way of motivating the team served as a continual source of encouragement and motivation for the editors. Benjamin: thank you very much. We fondly recall the monthly conference calls in which Benjamin Rempe and Dr Andrea Beilmann helped us carefully craft the Sobotta Atlas and, despite their different approaches, showing a remarkable gift for intuitively adopting a uniform working style. Sibylle Hartl coordinated the project in collaboration with Dr Andrea Beilmann and was responsible for the entire print production. We are truly grateful to her. Without the tenacity and the protective hand of Dr Dorothea Hennessen and Rainer Simader, who were both in charge of the overall management of the 'Sobotta 24th edition' project and who never lost faith in their Sobotta team or the tight schedule, this edition in its present form would not have been possible. Others whom we are similarly grateful to for their involvement in the project and their share of its success are: Dr Antje Kronenberg (editing), the abavo GmbH team (technical image processing and typesetting) and Nicola Kerber (layout design). We would very much like to thank Dr Ursula Osterkamp-Baust for exhaustively compiling the index.

Special thanks to our team of illustrators Dr Katja Dalkowski, Marie Davidis, Johannes Habla, Anne-Kathrin Hermanns, Martin Hoffmann, Sonja Klebe, Jörg Mair and Stephan Winkler, who in addition to updating the existing images also helped us develop a large number of new illustrations.

For their help in producing the clinical images, we would also like to thank Dr Frank Berger, Institute of Clinical Radiology of Ludwig Maximilians University, Munich; Prof. Christopher Bohr, Phoniatrics and Paediatric Audiology, ENT Clinic at Friedrich Alexander University, Erlangen/Nürnberg; Dr Eva Louise Bramann, Ophthalmology Clinic at Heinrich Heine University, Düsseldorf; Prof. Andreas Dietz, Director of the ENT Clinic and Outpatients' Clinic at the University of Leipzig; Prof. Gerd Geerling, Ophthalmology Clinic at Heinrich Heine University, Düsseldorf; Dr Berit Jordan, University Clinic and Outpatients' Clinic for Neurology, Martin Luther University, Halle/Wittenberg; Dr Axel Kleespies, Surgical Clinic, Ludwig Maximilians University, Munich; Prof. Norbert Kleinsasser, University Clinic for Illnesses of the Ear, Nose and Throat, Julius Maximilians University, Würzburg; Dr Hannes Kutta, ENT practice, Hamburg-Altona/Ottensen; Dr Christian Markus, Anaesthesiology Clinic, Julius Maximilians University, Würzburg; Jörg Pekarsky, Institute for Anatomy II, Friedrich Alexander University, Erlangen/Nürnberg; Dr Dietrich Stövesandt, Clinic for Diagnostic Radiology, Martin Luther University, Halle/Wittenberg; Prof. Jens Werner, Surgical Clinic, Ludwig Maximilians University, Munich; Dr Tobias Wicklein, Erlangen, and Prof. Stephan Zierz, Director of the University Clinic and Outpatients' Clinic for Neurology, Martin Luther University Halle/Wittenberg.

Last but not least, we would like to thank our families, who not only were very gracious and understanding of all the time we devoted to the 24th edition of the Sobotta, but who also gave us very helpful suggestions whenever we needed feedback. You have been a true support.

Erlangen and Munich, summer of 2017
Friedrich Paulsen and Jens Waschke

1. List of Abbreviations

Singular:

- A. = Arteria
- Lig. = Ligamentum
- M. = Musculus
- N. = Nervus
- Proc. = Processus
- R. = Ramus
- V. = Vena
- Var. = Variation

Plural:

- Aa. = Arteriae
- Ligg. = Ligamenta
- Mm. = Musculi
- Nn. = Nervi
- Procc. = Processus
- Rr. = Rami
- Vv. = Venae

- ♀ = female
- ♂ = male

Percentages:
In the light of the large variation in individual body measurements, the percentages indicating size should only be taken as approximate values.

2. General Terms of Direction and Position

The following terms indicate the position of organs and parts of the body in relation to each other, irrespective of the position of the body (e.g. supine or upright) or direction and position of the limbs. These terms are relevant not only for human anatomy but also for clinical medicine and comparative anatomy.

General terms

- anterior – posterior* = in front – behind (e.g. Arteriae tibiales anterior et posterior)
- ventralis – dorsalis* = towards the belly – towards the back
- superior – inferior* = above – below (e.g. Conchae nasales superior et inferior)
- cranialis – caudalis* = towards the head – towards the tail
- dexter – sinister* = right – left (e.g. Arteriae iliaca communes dextra et sinistra)
- internus – externus* = internal – external
- superficialis – profundus* = superficial – deep (e.g. Musculi flexores digitorum superficialis et profundus)
- medius, intermedius* = located between two other structures (e.g. the Concha nasalis media is located between the Conchae nasales superior and inferior)
- medianus* = located in the midline (Fissura mediana anterior of the spinal cord). The median plane is a sagittal plane which divides the body into right and left halves.
- medialis – lateralis* = located near to the midline – located away from the midline of the body (e.g. Fossae inguinales medialis et lateralis)
- frontalis* = located in a frontal plane, but also towards the front (e.g. Processus frontalis of the maxilla)

- longitudinalis* = parallel to the longitudinal axis (e.g. Musculus longitudinalis superior of the tongue)
- sagittalis* = located in a sagittal plane
- transversalis* = located in a transverse plane
- transversus* = transverse direction (e.g. Processus transversus of a thoracic vertebra)

Terms of direction and position for the limbs

- proximalis – distalis* = located towards or away from the attached end of a limb or the origin of a structure (e.g. Articulationes radioulnares proximalis et distalis)
- for the upper limb:
radialis – ulnaris = on the radial side – on the ulnar side (e.g. Arteriae radialis et ulnaris)
- for the hand:
palmaris – dorsalis = towards the palm of the hand – towards the back of the hand (e.g. Aponeurosis palmaris, Musculus interosseus dorsalis)
- for the lower limb:
tibialis – fibularis = on the tibial side – on the fibular side (e.g. Arteria tibialis anterior)
- for the foot:
plantaris – dorsalis = towards the sole of the foot – towards the back of the foot (e.g. Arteriae plantares lateralis et medialis, Arteria dorsalis pedis)

3. Use of Brackets

[]: Latin terms in square brackets refer to alternative terms as given in the Terminologia Anatomica (1998), e.g. Ren [Nephros]. To keep the legends short, only those alternative terms have been added that differ in the root of the word and are necessary to understand clinical terms, e.g. nephrology. They are primarily used in figures in which the particular organ or structure plays a central role.

(): Round brackets are used in different ways:
– for terms also listed in round brackets in the Terminologia Anatomica, e.g. (M. psoas minor)
– for terms not included in the official nomenclature but which the editors consider important and clinically relevant, e.g. (Crista zygomaticoalveolaris)
– to indicate the origin of a given structure, e.g. R. spinalis (A. vertebralis).

Colour Chart

<ul style="list-style-type: none"> Concha nasalis inferior Mandibula Maxilla Os ethmoidale Os frontale Os lacrimale Os nasale 	<ul style="list-style-type: none"> Os occipitale Os palatinum Os parietale Os sphenoidale Os temporale Os zygomaticum Vomer
---	---

In the newborn the following cranial bones are indicated by only one colour:

<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> Os nasale, Os temporale, Mandibula Maxilla, Os incisivum Os occipitale, Os palatinum
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Organs of the Abdominal Cavity

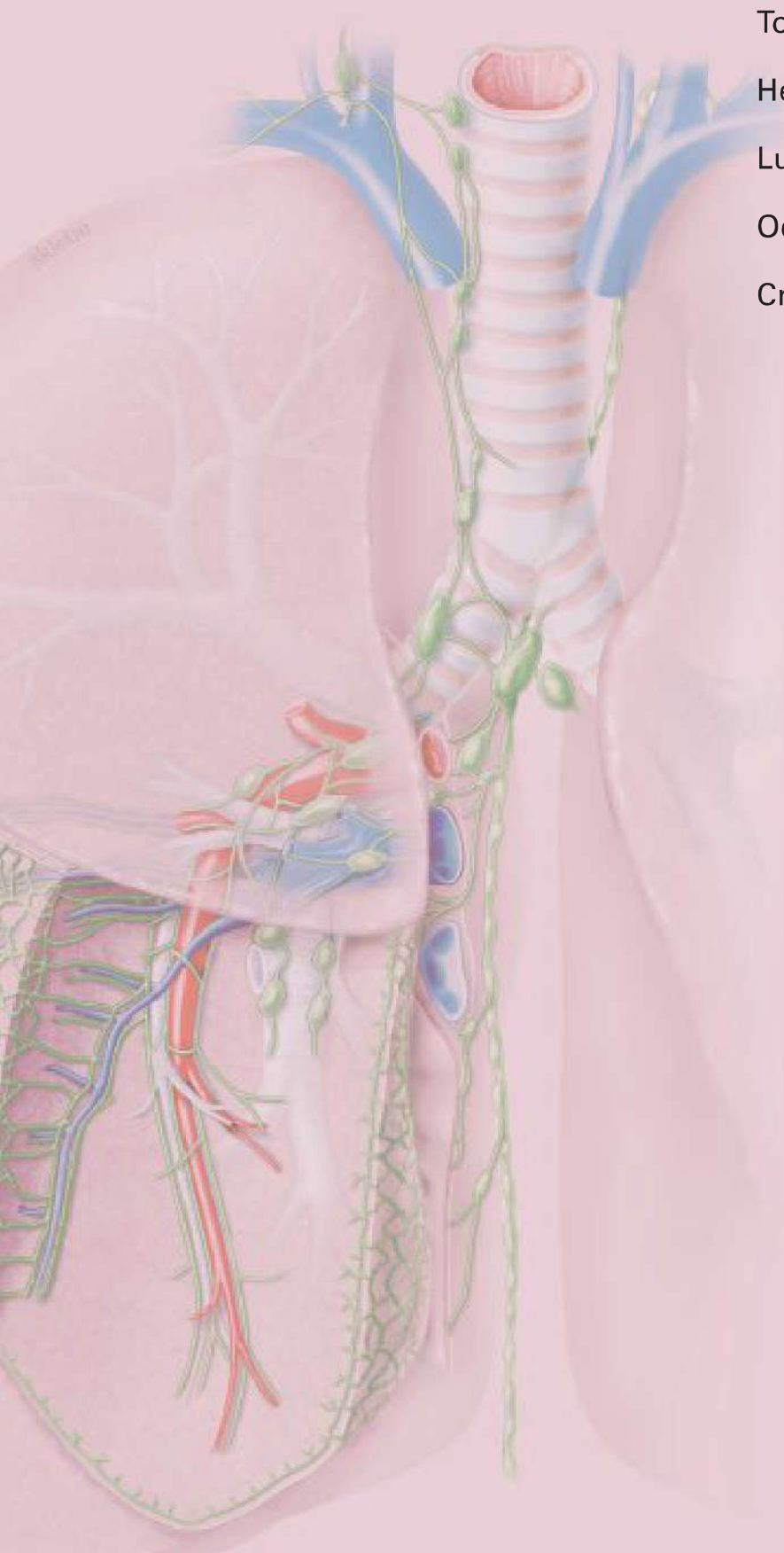
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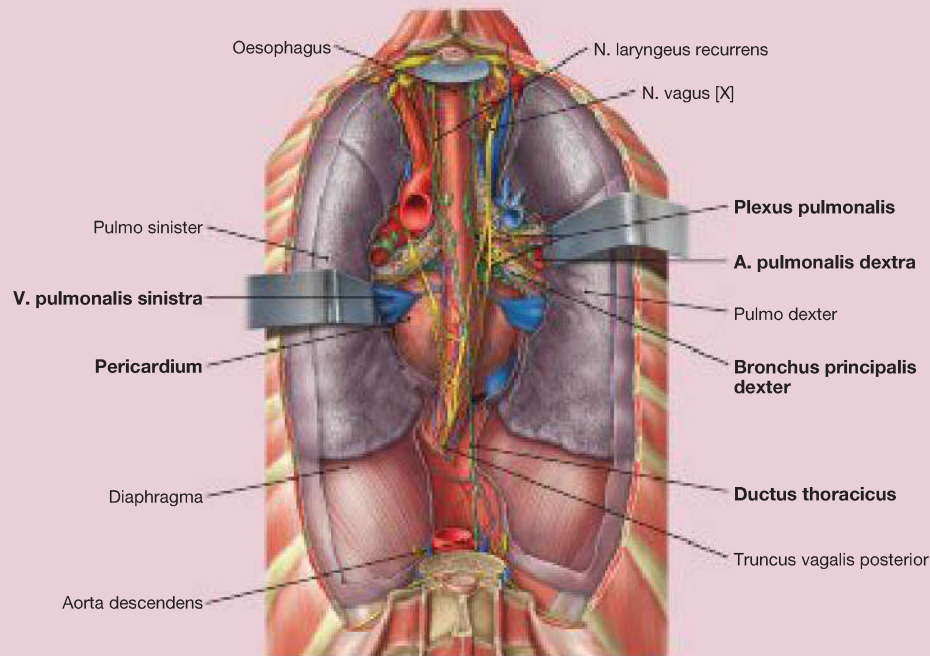
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Organs of the Chest Cavity

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5



Overview

In a dissection course, the opening of the **chest cavity** is one of the key operations which is met by teachers and students with a mixture of awe, suspense and interest. Exposing the heart and lungs as well as being allowed to grasp (literally and metaphorically) these vital organs of the body with one's own hands is considered a great privilege in these lessons.

The chest cavity (Cavitas thoracis) is enclosed by the thoracic cage (Cavea thoracis), consisting of ribs, thoracic spine and sternum. It is separated **below** by the **diaphragm**; **above** there is **no clear** boundary separating the neck. If the anterior thoracic wall, which is made up of important **muscles to aid breathing**, is removed, we can see the division of the Cavitas thoracis into **two pleural cavi-**

ties (Cavitates pleurales) containing the lungs with the connective tissue space of the **mediastinum** lying between becomes visible.

Directly behind the sternum, the **thymus** is embedded in the mediastinum. The **superior vena cava (V. cava superior)** is shifted to the right. The curved **main artery (aorta)** dominates the upper mediastinum. Among the major vessels are the **trachea**, which divides into the right and left main bronchi (Bronchi principales), and, dorsally of the trachea, the **oesophagus**. Within the inferior mediastinum facing the diaphragm the **heart (Cor)** in its pericardial sac (pericardium), resting broadly on the diaphragm, dominates. The **lungs (Pulmones)** are located in both pleural cavi-

Main Topics

After studying this chapter, you should be able to:

Chest cavity

- describe the composition of the chest cavity with the mediastinum and pleural cavities, including their neurovascular pathways on a dissection;
- describe the location and function of the thymus;

Heart

- explain the development of the heart, including foetal circulation with any possible fundamental malformations;
- illustrate the location, orientation and projection of the heart, clearly showing the margins, on a dissection and an X-ray;
- describe the inner and outer structures of the heart chambers, as well as the wall layers, the pericardial sac and the cardiac skeleton on a dissection;
- explain the structure, function and projection as well as the auscultation type of the various heart valves with their malfunctions on a dissection;
- show the conduction system with accurate localisation of the sinuatrial and AV nodes on a dissection and understand the autonomic innervation of the heart;
- indicate the Aa. coronariae with all the important branches on a dissection and describe their importance in the development,

diagnosis and treatment of coronary heart disease; the main features will be sufficient with the veins;

Trachea and lung

- describe the structure of the lower respiratory tract and its development and describe the sections of the trachea;
- indicate the projection of the lungs and their division into lobes and segments on a dissection, and also indicate the systematics of the bronchial tree;
- describe vasa publica and privata of the lungs including origin, course and function, as well as the lymphatic vessel systems and the autonomic innervation;

Oesophagus

- indicate the sections and constrictions of the oesophagus with their positional relationships on a dissection;
- describe the closing mechanisms of the proximal and distal oesophagus and their clinical significance
- explain the neurovascular pathways of the different sections of the oesophagus including the relationship of the veins to the portal venous system.

Clinical Relevance

In order not to lose reference to future everyday clinical life with so many anatomical details, the following describes a typical case that shows why the content of this chapter is so important.

Pulmonary Embolism

Case Study

A 22-year-old student is brought into the emergency department. She reports having woken up in the morning with shortness of breath and coughing the day after she had returned from a flight to the USA. When getting up she noticed that her left lower leg was significantly thicker.

Result of Examination

Cardiac (120/min) and respiratory rates (35/min) are significantly raised. The patient is conscious, awake and fully oriented. She has severe pain in the region of her left leg and is complaining of shortness of breath and chest pain. The left leg is reddened at the shank and shows expanded veins; the area has extended to the ankle and thigh.

Diagnostic Procedure

The blood gas analysis shows a lowering of oxygen content in the blood. Due to a suspected pulmonary embolism, it is primarily coagulation values and D-dimers, formed by cleaved products of blood clots (thrombi), which are determined in blood sampling. The CT angiography of the Cavitas thoracis shows that several branches of the pulmonary arteries are displaced. The ultrasound examination of the heart (echocardiography) indicates stress on the right ventricle. A colour coded duplex ultrasound confirms that the deep leg veins in the area of the femoral vein on the left-hand side are displaced by a blood clot (thrombus).

Diagnosis

Pulmonary embolism from deep vein thrombosis (Fig. a). The clot from the V. femoralis seems to have detached in part and blocked the pulmonary arteries as an embolism. The transatlantic flight, taking oral contraceptives ('the pill') and smoking are already present as risk factors before the exclusion of a coagulation disorder.

Treatment

Via venous access, a breakdown (thrombolysis) of the blood clots is initiated with a plasminogen activator. In addition, the patient is supplied with oxygen via a nasogastric tube. The thrombolysis is successful and the patient is largely symptom-free after a week.

Dissection Lab

To understand this clinical case, we need to look at two body regions: the veins of the leg and the organs of the Cavitas thoracis. Veins are generally a little neglected in anatomy lessons and are usually just reduced to supporting structures of the arteries, which correspond to them in the course that they follow and, therefore, often also in description. In some regions there are, however, deviations from this rule or certain clinical references that require an explanation. At the extremities there is a **superficial (epifascial)** venous system, that flows independently of the arteries, and a **deep venous system (subfascial)** in which two veins usually accompany the corresponding artery distally (in the forearm/lower leg) and proximally merge further on. However, since the superficial veins are connected to the deep venous system via **perforating veins**, which have in the inner semilunar valves and thus allow blood flow only in the direction of the deep veins, the majority (approximately 75%) of venous blood flows through this deep vein system back to the heart.

Blood clots in the veins are potentially life-threatening, as they can be broken off by the blood stream. As embolisms they then move through the **inferior vena cava (V. cava inferior)** into the right atrium of the heart (Atrium dextrum) and through the **right ventricle (Ventriculus dexter)** into the **pulmonary arteries (Aa. pulmonales)** which channel deoxygenated blood into the lungs.



On the right-hand side the main bronchus is located above the artery; the veins right at the front underneath. The black nodes on the surface of a removed lung are the hilum lymph nodes of the lung.



The first time you hold a heart in your hands is a special feeling! In order to orientate yourself, you must always hold the heart in the same way that it lies in the mediastinum. Then the right ventricle is in front!

to the wall strength of the right ventricle, which is normally 3–5 mm thick, approximately one third of the thickness of the left wall. A larger wall diameter can be a sign of chronic damage to the right side of the heart.

Back in the Clinic

The treatment was changed to a six-month oral administration of Marcumar® for anticoagulation. Molecular biological investigation reveals a mutation of clotting factor V and thus an inherited genetic predisposition. Therefore, 'the pill' and smoking were advised against. For long trips and in the case of a planned pregnancy, a subcutaneous injection of low molecular weight heparin and the wearing of compression hosiery were recommended to the patient.

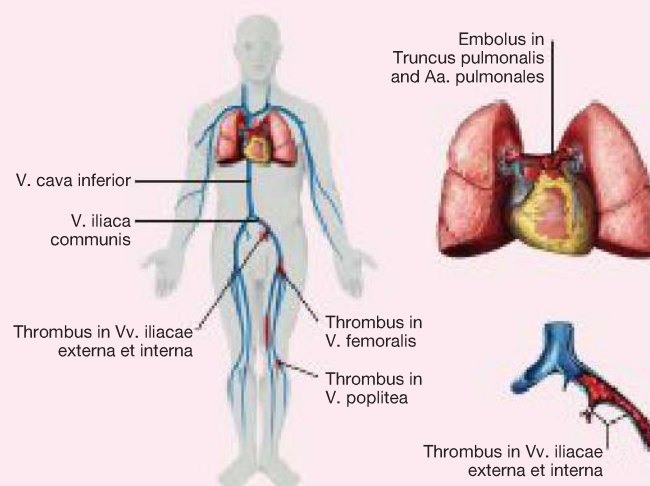


Fig. a Deep vein thrombosis with complication of a pulmonary embolism. [L266]