J. G. Koritké and H. Sick

Atlas of Sectional Human Anatomy

Frontal, Sagittal, and Horizontal Planes

Vol. 2: Abdomen, Pelvis

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Drawings in collaboration with B. Lafleuriel
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138 Photographs and Drawings

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Preface

Illustrations of anatomical sections have existed for a very long time. Some of these sections which are considered characteristic have been presented in papers for essentially didactic purposes. Various parts of the body, in particular the head and the thorax, have been studied using series of sections which have usually been made in one plane in space. Only in exceptional cases have these been made in the three major planes.

New methods of radiologic and tomographic exploration have given a new thrust to the topographical anatomy of sections. It is no longer only the anatomists who deal with pictures of sections of the human body on a daily basis. Today, clinicians in ever-increasing numbers must do the same.

Topographical anatomy has been a part of the Institute of Anatomy at the Department of Medicine in Strasbourg for a long time. It was here that G. Joessel left the most remarkable reproductions of serial sections ever published in their entirety. It was also here that Ph. Bellocq was a lecturer. Here he published his doctoral thesis "Medical-Surgical Anatomy" which actually contained several sections identical to those prepared for this publication.

This atlas could not have been completed without the great help received from the staff at the Institute of Anatomy. We are also grateful to Mr. Robert Becker, the photographer at the Institute of Pathological Anatomy (Director: Prof. Y. Legal). Mr. Bernard Lafleuriel, the illustrator at the Department of Medicine in Strasbourg helped to prepare the diagrams. The control radiographs were made possible through the help of Prof. Francois Kempf.

The publishing house, Urban & Schwarzenberg, has done everything in its power to make the presentation clear and the quality of the print excellent. We are extremely grateful to them, and to Prof. Dr. H. J. Clemens especially, for the insight making it possible to publish an atlas of such high quality.

Strasbourg, April 1982

J. G. Koritké
H. Sick

Introduction

(H. J. Clemens)

An atlas of anatomy normally presents illustrations of a specific anatomical region or organs that are superimposed within that region. Only rarely does it present horizontal sections of the trunk or the extremities, and other sections are even more rare. With the advent of transverse computerized tomography and ultrasonography (echography) and their increasingly common use in clinical examinations, it has become necessary to show serial sections of the various planes of the body. These two diagnostic imaging methods provide the clinician with representations of sections of the human body; interpreting them, however, raises a number of problems, due in part to the lack of literature on normal cross-sectional human anatomy.

Tomographic sections have been prepared in radiology since 1921 (Bocage). These present layers of the body shown by blurring the adjacent zones. The principle involved concerns moving either the X-ray tube and the sensitive plate with respect to the stationary patient or moving the patient and the sensitive plate with respect to the stationary source of radiation. Pictures of sections can be obtained from orientation in all three dimensions. Without minimizing the contribution of this diagnostic method, it should be mentioned that tomography cannot be used to present an exact reproduction of the anatomical substratum.

There has been considerable improvement in the imaging of sections of the human body resulting from computerized tomography (CT). Unlike the methods that were used before this development, the X-rays pass through only the layer to be studied, and yield an exact anatomical reproduction without any displacement. In conventional radiology, the absorption of the X-rays by the body is shown by the various degrees of blackening of the film or by the differences in the luminous intensity of a fluorescent screen. In CT, this absorption is recorded by highly sensitive detectors (scintillation crystals). The source of radiation as well as the system for detecting and measuring the absorption is located behind the patient, and moves horizontally around the body (360° in 2–5 seconds). The impulses detected by the system are amplified electronically and transformed into potential differences. These are sent to a computer where the difference in density is determined for each point of the picture. This information is then sent to a monitor showing the differences in light intensity. The resolving power for two adjacent structures is approximately 2 mm. The tomographic picture displayed on the monitor can be photographed and thus preserved. CT can show differences in absorption of approximately 0.5%, whereas X-ray film only shows differences of 4%. New computer programs will make it possible to produce frontal, sagittal, and oblique sections. In addition they will reduce exposure time and thus artefacts resulting from movement of the heart, the lungs, or other organs.

Two different devices are being used at present: the cranial computer tomograph and the whole body tomograph. The sections of the encephalon are generally made in the axial direction, but depending on the problems presented, the head is sometimes retroflexed (to examine the eye socket) or anteflexed (to examine the posterior fossa). The orbito-meatal line is used as the reference plane in standard examinations. Ten to twelve sections with a thickness of 1 cm are needed to examine the contents of the braincase.

Whole body CT presents transverse sections of the trunk viewed from the inferior side. The section is generally 1 cm thick and can be made at any height of the trunk with the patient supine.

Cranial CT has been of great benefit in medicine. CT of the trunk, however, is only used diagnostically in certain cases since its application overlaps with both ultrasonography and nuclear medicine. In addition to its great importance diagnostically, CT is also used to plan and monitor the progress of therapeutic measures.

An ultrasonic examination, like CT, also makes it possible to present slices of the body. This is based on a completely different physical principle: the reflection of an ultrasonic wave.

Ultrasonic waves emitted by a sender reach the surface of tissues that have varying degrees of permeability. The waves are thus reflected at different intensities. The reflected waves return to the sender, which serves as a receiver between emissions, and there are transformed electronically to luminous points of varying brightness displayed on a screen. Unlike radiology or scintigraphy, this method makes it possible to obtain pictures of sections from any plane of the body. In general, the acoustic borders of the organs are identical to the anatomical borders. The quality of the ultrasonic picture as well as its usefulness depend on the experience and skill of the operator.

The penetration of an ultrasonic wave into organs depends on the degree to which these organs absorb certain frequencies. Generally, the higher the frequency emitted, the lower the penetration. Because bone almost completely reflects ultrasonic waves and air almost completely absorbs them, organs and tissues located behind bone or air cannot be examined using this method. Bone itself cannot be examined, air becomes an obstacle in the lungs, and intestinal gases block that region. Unlike CT, differences in organ density cannot readily be determined by ultrasonography. Liquids can be distinguished from solids with a high degree of certainty, but resolving power is far less that that of computed tomography.

The advantages of this method should be stressed in addition to the drawbacks:

It is a noninvasive method; neither the patient nor the operator is exposed to any dangerous radiation. The procedure is not expensive and can be repeated an unlimited number of times to follow the course of any process. In the same examination, several organs can be observed from various angles depending on the clinical problems involved and the anatomical factors in the region being examined. Less patient compliance is required than with CT (immobility, length of examination). Like classical radiology and CT, ultrasonic methods also make it possible to observe the dynamic phenomena in the human organism and to present views of topographical anatomy.

The "real time scan" is an orienting examination method that can produce series of sonograms at a rate of 16 to 30 per second. The examination can be performed ventrally, dorsally, or from the flanks, and the probe is moved continuously so that any dynamic changes appearing on the screen can be observed and interpreted without interruption. The equipment required is relatively small, easy to handle, and thus portable. This procedure can be compared with radioscopy.

The "storage scan" stores the information obtained by ultrasonography on transverse or longitudinal sections in a computer. This procedure has an advantage over the real time scan in that transverse, longitudinal, and oblique sections can be obtained from the entire epigastric region. These sections are similar to those obtained with CT and are easier to decipher than those obtained with the real time scan. The power of resolution is greater since the borders of the organs are analyzed from several sides.

The A scan presents a graphic reproduction and makes it possible, among other things, to recognize various parenchymatous organs and to make a distinction between tumors and cysts. Its main application is in echoencephalography – a one-dimensional ultrasonic method in which the amplitudes displayed on the screen do not depend on the intensity of the echos. New devices have been developed recently that make it possible to store a picture displayed during a real time scan without interrupting the examination. This picture can be photographed or entered into a computer memory and recalled whenever required. When the picture is being taken, the contrast, brightness, and positive or negative representation are adjusted automatically according to a preset program. Distances of 1 mm can be measured between two sliding marks on this picture. The result appears immediately when the desired function is called.

It is important that the dynamic phenomena can be recorded on video tape and that the static images from the real time scan can be reproduced on standard photographic equipment. Computerized tomography and ultrasonography can supply us with pictures of sections from nearly every part of the body. The sections can vary in thickness, but are generally 1 cm thick with CT, and a few millimeters thick with the ultrasonic method. There are great differences in the power of resolution for both methods, and improvement is a constant goal. Physical limitations are such that sonograms are more difficult to interpret anatomically than are CT scans.

Before the use of ultrasonics and CT became common, physicians had no noninvasive means of obtaining pictures of sections of the human body. For this reason, they did not have to study such sections in the dissecting room or the hospital. Problems involved in presenting these sections are becoming greater now that it is possible to show them in three dimensions.

It is important to note that the clinician should be wary of many CT atlases in which tomograms are placed next to sections of normal or pathological anatomy. The CT pictures are often not of high quality since they may have been taken with first or second generation equipment. They often give nothing more than a relatively rough orientation since details are lacking and the sections are spaced too far apart. As far as a comparison of sections of pathological anatomy and CT pictures is concerned, knowledge concerning sections of normal anatomy is required before the pathological pictures encountered daily in clinical practice can be detected and then interpreted. As is the case in pathology, it is impossible to present one volume with all the forms, varieties, anomalies, and characteristics depending on age and physiological state. There are also varying degrees of modification due to the preparation methods.

This atlas, like other publications including anatomical illustrations, is a collection of "normal" pictures. Artefacts and pathological lesions have been omitted to the greatest possible extent.

Materials and Methods

We were able to progressively improve our techniques over the long period of time involved in the preparation of this atlas. If new series of sections had to be prepared, the report on the experimentation, which has also been adopted for one part of the sections shown in this atlas, could be defined as follows:

Selection and Preservation of the Material

The material must be normal, *i.e.,* free of any lesions, malformations, or deviations as compared to macroscopic standards. Our subjects were preferably mediolineal young adults whose history and cause of death allowed us to assume that the anatomical structures of the regions to be studied were complete. Approximately 30 subjects meeting these requirements were used in this study. The series of sections presented here were supplied by only 11 of them.

As soon as the cadaver is brought to the Institute of Anatomy it is embalmed by injecting a preserving fluid (consisting mainly of alcohol, formaldehyde solution, and glycerine) into one of the femoral arteries. The nerve centers are not sufficiently fixed by this method, so they are injected with 100 cc of a 20% formaldehyde solution into the leptomeningeal spaces. The cadaver is then immersed in a 30% solution of ordinary alcohol where it lies perfectly horizontally for three months. This length of fixation appears to be the most appropriate. If it is shorter, fixation is incomplete, resulting in soft tissues which are difficult to work with and preserve. If it is longer, the colors and contrasts between neighboring tissues are altered. The sections are also preserved in a 30% solution of alcohol.

Production and Preparation of Sections

After removing the cadaver from the fixing fluid, it is placed in the horizontal position in the freezing room. The body is placed and maintained in the anatomical position for the complete freezing period (one week at $-20°$ C). After this period, the different hardened tissues present a uniform resistance to the progression of a saw blade. The low temperature of preparation and the great length of the saw blade reduce the heat generated, and thus prevent any alteration of the slices.

The body, frozen *in toto,* is cut into blocks along the transverse or horizontal planes perpendicular to the median sagittal plane or the frontal plane upon which the subject is lying. These cuts are made at a certain distance from the areas to be studied. Thus, the head and neck block includes the upper part of the thorax; the thorax block extends from the middle of the cervical column to the middle of the lumbar column and the abdomen block from the region above the diaphragm to the middle third of the thigh.

Each block is cut into sections along one of the following planes of reference.

The plane of reference for frontal sections is the plane upon which the subject is lying. The eye-ear plane (Frankfurt, horizontal, orbito-meatal line) is thus perpendicular to this frontal plane of reference.

The plane of reference for sagittal sections is the median plane. It is difficult to locate and follow since the spinal column presents lateral curves, pronounced to varying degrees, in nearly all cases.

The plane of reference for horizontal sections depends on the region to be studied. It is represented by the eye-ear plane (Frankfurt horizontal, orbito-meatal line) for the head and neck and by the plane passing through the two antero-superior iliac spines for the thorax, abdomen, and pelvis.

The sections made from the plane of reference are normally of uniform thickness for a given block. The thickness varies, however, for the different blocks. It ranges from 1.5 cm for horizontal sections from the cephalo-cervical region to 2.5 cm for frontal sections. The very large size of the frontal sections made it necessary to increase their thickness. The block is placed on an adjustable guiding plane parallel to the saw blade in order to ensure that the section is of uniform thickness.

Immediately after sectioning, each specimen is placed on a plate and covered with plastic material permitting easy handling. The accessible surface is placed on a similar plate by simply turning it over. The surfaces of the sections are washed with running water and a sponge. The contents of the

natural cavities are thus removed while the specimen is still in the frozen state. While these simple operations are being performed, the remarkable appearance of the shape and colors of the organs can be observed.
The washed sections are covered with plastic sheet material to prevent dehydration. They are then stored in the refrigerating room. Before photographing, they are studied separately to determine degree of normality, to touch up an organ of primary importance located at a very slight distance from the cutting plane, and to regularize certain contours.

Photography

The photographic equipment consists of a 9×12 Technika Linhof camera with a 4.5/150 mm Xenar F objective. Normal exposure is ½ sec with the aperture set at 16. Two 500 W lamps are placed 1.5 m away from the specimen.
Pictures are taken of both sides of each specimen next to a graduated rule. Enlargements are made in order to present horizontal sections of the trunk in their natural size, to present horizontal sections of the head and neck as 1.5 times their natural size, and to present all sagittal and frontal sections as 0.75 times their natural size. A ruler with the conversion data is contained in the back of this volume.
The photographs have been chosen to a large extent on the basis of their clinical importance. Thus, horizontal sections are viewed from the bottom side; when elements of primary importance only appear on the top side, however, this side has been added to complete the information. All frontal sections are viewed from the front. Some posterior views considered absolutely necessary complete each series. All sagittal sections are viewed from the exterior.
The frontal sections are numbered starting from the posterior plane of reference upon which the subject is lying. The letter "a" indicates that the specimen is viewed from the front and "p" that it is viewed from the back. The sagittal sections are numbered starting from the median plane and moving to the left and the right. The median plane divides the specimen into a right segment viewed from the left (MD) and a left segment viewed from the right (MSi). The horizontal sections are numbered from top to bottom within the same block and are marked with respect to a plane of reference.
Thus, each section is defined as follows: by a first letter indicating the general orientation (F=frontal; S=sagittal; H=horizontal), by a second letter qualifying the overall region to which it belongs (C=cephalo-cervical; T=thoracic; A=abdominal; P=pelvic), by a symbol, if required, indicating the sex (♀ or ♂), by a number marking it within the block, and perhaps by an indication as to the position of the observer with respect to the plane of the section (superior, inferior, right, left, anterior, posterior).

Analysis of Sections

During specimen preparation, the major objective is to keep the organs in their original position.
During the process of identification, however, the organs can be treated individually. A sufficient order must be retained, although, to allow for later verification.
First the sections are radiographed. Each radiologic negative is photographed. The photographic enlarger used to project the radiologic image of the skeleton makes it possible to set up a grid displaying the height of the center of the vertebral bodies. This grid is applied to each side of the photographs of frontal and sagittal sections.
The organ parts separated by the saw cut are sutured to each other and then to the specimen box wall. After all the elements of the section have been joined, it can be immersed in the fixing fluid and handled without being damaged.
Tracing paper is placed on each photograph, which is then compared with the original specimen. The radiologic negative makes it easier to recognize the skeletal elements, but quite frequently the entire anatomical region must be reconstructed. The muscle or aponeurotic layers are separated from each other. Each vascular lumen in all sections is injected systematically to determine the origin and area of the vessels. The full path of the nerves is followed from one section to the next. In some instances we had to revert to histological techniques to support, with certainty, some of our findings.

Drawings

Each drawing, traced from a photograph, is a true reflection of the actual anatomy. Only those elements that are considered absolutely necessary to interpret the photograph are added to the drawing using a conventional code. The photograph thus serves as the primary reference. The drawing directs the observer and stimulates his research, but should in no way limit his field of investigation. Because each photograph contains a vast amount of interesting elements, we were often faced with difficult decisions regarding the representation and references to the labels. Regrettably the multitude of direction lines made it impossible to place the nomenclature in a good readable way at the lines. To achieve a better clearness a code system has been employed whose abbreviations should be understandable internationally.

The references to labels are based on a letter and a number permitting rapid access to the terminology by referring to a system (A = angiology; M = myology; N = nervous system; O = osteology; OS = sense organs; S = splanchnology; Sy = syndesmology). Each reference is explained in the "Index of Labels" section.

The choice of nomenclature is always a difficult problem. To make the terms as accessible as possible, all labels have been reviewed for their appropriateness to the English-speaking clinician and strict adherence to Nomina Anatomica has been abandoned in favor of practical terminology.

Directions for Use

The most important document is the photograph, a true reflection of the actual anatomy. From the very beginning, the observer is able to record a large amount of information, with the progression of the analysis indicated by the diagram and then the labels.

Photographs

The photographs reproduced on the right-hand pages convey different types of information: general appearance of the section, shape of its surfaces, positions, proportions, impressions of the density of the organs. The entire section or each of its elements can be situated within the body by referring to the following: the letters characterizing each section with respect to the planes of reference; the height of the vertebra shown on the osseous section as soon as it appears; the height of the center of the vertebral body indicated on both sides of all photographs of frontal and sagittal sections; the level of the ribs; and the scale shown at the bottom of each photograph.

Drawings

Each diagram, an interpretation of the actual anatomy, brings out the essential characteristic elements of the section. The thickness of the features and the character of the grid representing the organs indicate to which system the organs shown belong. References are also made using keys. Symmetric organs are not necessarily presented in a bilateral manner. This makes the drawing clearer. It was not always possible to superimpose extremely thin planes. A single feature can give an outline of several structures. Cuts of vertebrae and ribs are designated in any case.

Labels

The labels supply further information and help to check the identification of the photograph and the interpretation of the drawing.

Abbreviations have been used for the identification and orientation of the section, the classification of organs referred to by large systems, and finally in the labels. The first examination of the photograph, the interpretation of the drawing, and then reading the labels should logically lead the observer to re-examine the photograph in order to record the numerous elements that could not be referred to in the space allowed. It should then be possible to imagine and compare the image that will be supplied by CT, ultrasound, or any other new technique technology brings to us.

Abbreviations

1. Identification and Orientation of the Sections

<u>a:</u> anterior – anterior
<u>p:</u> posterior – posterior
<u>D:</u> right – dexter
<u>Si:</u> left – sinister
<u>F:</u> frontal – frontalis
<u>H:</u> horizontal – horizontalis
<u>S:</u> sagittal – sagittalis
<u>C:</u> head, neck – caput, collum
<u>T:</u> thorax – thorax
<u>A:</u> abdomen – abdomen
<u>P:</u> pelvis – pelvis
♀: female – femininum
♂: male – masculinum

The vertebrae are indicated by the letters <u>C</u> (cervical – cervicalis), <u>T</u> (thoracic – thoracicus), <u>L</u> (lumbar – lumbalis), <u>S</u> (sacral – sacralis) and <u>Co</u> (coccygeal – coccygea). The number that corresponds to their level is added to the letter. The ribs are marked by a number indicating their level ("3" refers to the third rib).

2. Association of the Organ to a Large System

<u>A:</u> Angiology – Angiologia
<u>M:</u> Myology – Myologia
<u>N:</u> Nervous System – Systema Nervosum
<u>O:</u> Osteology – Osteologia
<u>OS:</u> Sense Organs – Organa Sensuum
<u>S:</u> Splanchnology – Splanchnologia
<u>Sy:</u> Syndesmology, Arthrology – Syndesmologia

3. Abbreviations used in the Labels

<u>a.:</u> artery – arteria
<u>art.:</u> articulation – articulatio
<u>b.:</u> bursar – bursa
<u>C.:</u> cervical (vertebra) – cervicalis (vertebra)
<u>Co.:</u> coccyx – os coccygis
<u>gl.:</u> gland – glandula
<u>L.:</u> lumbar (vertebra) – lumbalis (vertebra)
<u>lig.:</u> ligament – ligamentum
<u>m.:</u> muscle – musculus
<u>n.:</u> nerve – nervus
<u>no.:</u> node (lymphatic) – nodus (lyymphaticus)
<u>r.:</u> ramus – ramus
<u>S.:</u> sacral (vertebra) – sacralis (vertebra)
<u>v.:</u> vein – vena
( ): specifies the preceding term

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Table of Contents

Text

Illustrations

Abdomen (Abdomen and pelvis)

Pelvis

Table of Contents Vol. 1

(Condensation)

Head and neck (cephalic and cervical regions)

Thorax