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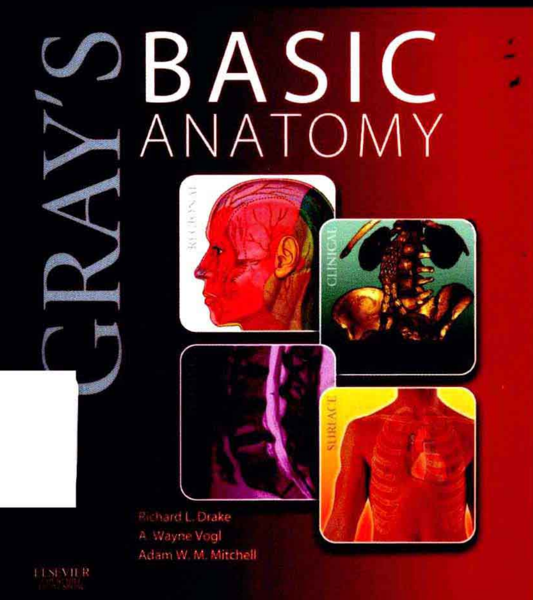
Gray's Basic Anatomy

格氏解剖学基础教程

《格氏解剖学基础教程》英文影印版



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Adam W. M. Mitchell

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1

The Body

ADDITIONAL LEARNING RESOURCES FOR CHAPTER 1, *THE BODY*, ON STUDENT CONSULT (www.studentconsult.com):

- Image Library—illustrations from Chapter 1

What is anatomy?

Anatomy includes those structures that can be seen grossly (without the aid of magnification) and microscopically (with the aid of magnification). Typically, when used by itself, the term *anatomy* tends to mean gross or macroscopic anatomy—that is, the study of structures that can be seen without using a microscopic. Microscopic anatomy, also called histology, is the study of cells and tissues using a microscope.

Observation and visualization are the primary techniques a student should use to learn anatomy. Anatomy is much more than just memorization of lists of names. Although the language of anatomy is important, the network of information needed to visualize the position of physical structures in a patient goes far beyond simple memorization. Knowing the names of the various branches of the external carotid artery is not the same as being able to visualize the course of the lingual artery from its origin in the neck to its termination in the tongue. An understanding of anatomy requires an understanding of the context in which the terminology can be remembered.

HOW CAN GROSS ANATOMY BE STUDIED?

The term *anatomy* is derived from the Greek word *temnein*, meaning "to cut." Clearly, at its root, the study of anatomy is linked to dissection. Dissection of cadavers by students is now augmented, or even in some cases replaced, by viewing prosected (previously dissected) material and plastic models, or using computer teaching modules and other learning aids.

Anatomy can be studied following either a regional or a systemic approach.

- With a **regional approach**, each *region* of the body is studied separately and all aspects of that region are studied at the same time. For example, if the thorax is to be studied, all of its structures are examined. This includes the vasculature, nerves, bones, muscles, and all other structures and organs located in the region of the body defined as the thorax. After studying this region, the other regions of the body (i.e., the abdomen, pelvis, lower limb, upper limb, back, head, and neck) are studied in a similar fashion.
- In contrast, in a **systemic approach**, each *system* of the body is studied and followed throughout the entire body. For example, a study of the cardiovascular system looks at the heart and all of the blood vessels in the body. This approach continues for the whole body until every system, including the nervous, skeletal, muscular, gastrointestinal, respiratory, lymphatic, and reproductive systems, has been studied.

IMPORTANT ANATOMICAL TERMS

The anatomical position

The anatomical position is the standard reference position of the body used to describe the location of structures (Fig. 1.1). The body is in the anatomical position when standing upright with feet together, hands by the side, and face looking forward. The mouth is closed and the facial expression is neutral. The rim of bone under the eyes is in the same horizontal plane as the top of the opening to the ear, and the eyes are open and focused on something in the distance. The palms of the hands face forward with the fingers straight and together and with the pad of the thumb turned 90° to the pads of the fingers. The toes point forward.

Anatomical planes

Three major groups of planes pass through the body in the anatomical position (Fig. 1.1).

- **Coronal planes** are oriented vertically and divide the body into anterior and posterior parts.
- **Sagittal planes** also are oriented vertically, but are at right angles to the coronal planes and divide the body into right and left parts. The plane that passes through the center of the body dividing it into equal right and left halves is termed the **median sagittal plane**.
- **Transverse, horizontal**, or **axial planes** divide the body into superior and inferior parts.

Terms to describe location

Anterior (ventral) and posterior (dorsal), medial and lateral, superior and inferior

Three major pairs of terms are used to describe the location of structures relative to the body as a whole or to other structures (Fig. 1.1).

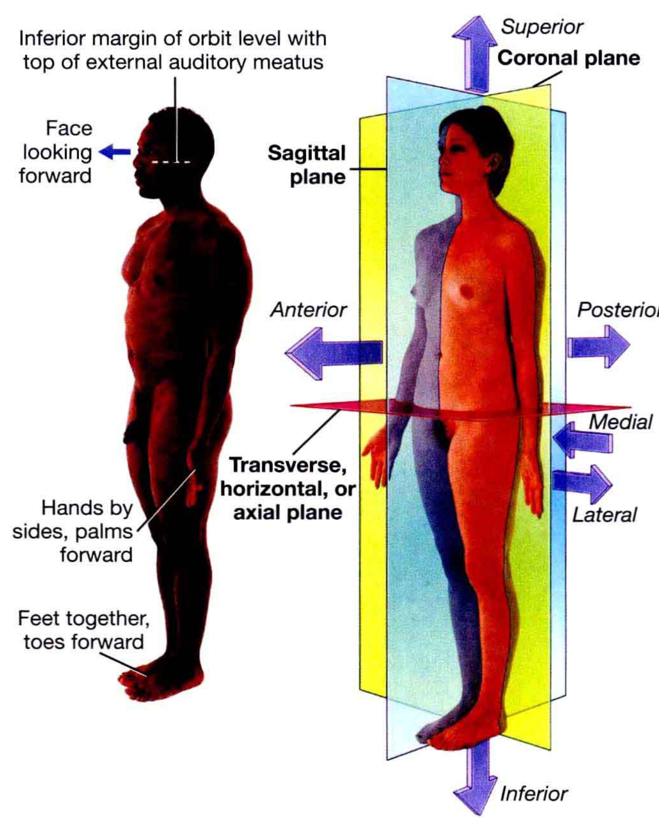

Fig. 1.1 The anatomical position, planes, and terms of location and orientation.

- **Anterior** (or **ventral**) and **posterior** (or **dorsal**) describe the position of structures relative to the "front" and "back" of the body. For example, the nose is an anterior (ventral) structure, whereas the vertebral column is a posterior (dorsal) structure.
- **Medial** and **lateral** describe the position of structures relative to the median sagittal plane and the sides of the body. For example, the thumb is lateral to the little finger.
- **Superior** and **inferior** describe structures in reference to the vertical axis of the body. For example, the head is superior to the shoulders.

Proximal and distal, cranial and caudal, and rostral

Other terms used to describe positions include proximal and distal, cranial and caudal, and rostral.

- **Proximal** and **distal** are used with reference to being closer to or farther from a structure's origin, particularly in the limbs. For example, the hand is distal to the elbow joint. These terms are also used to describe the relative positions of branches along the course of linear structures, such as airways, vessels, and nerves. For example, distal branches occur farther away toward the ends, whereas proximal branches occur closer to and toward the origin.
- **Cranial** (toward the head) and **caudal** (toward the tail) are sometimes used instead of superior and inferior, respectively.
- **Rostral** is used, particularly in the head, to describe the position of a structure with reference to the nose. For example, the forebrain is rostral to the hindbrain.

Superficial and deep

Two other terms used to describe the position of structures in the body are **superficial** and **deep**. These terms are used to describe the relative positions of two structures with respect to the surface of the body. For example, the sternum is superficial to the heart.

Imaging

DIAGNOSTIC IMAGING TECHNIQUES

In 1895 Wilhelm Röntgen used the X-rays from a cathode ray tube to expose a photographic plate and produce the first radiographic exposure of his wife's hand. Over the past 30 years there has been a revolution in medical imaging, which has been paralleled by developments in computer technology.

Plain radiography

The basic physics of X-ray generation has not changed.

X-rays are photons (a type of electromagnetic radiation) and are generated from a complex X-ray tube, which is a type of cathode ray tube (Fig. 1.2). The X-rays are then collimated (i.e., directed through lead-lined shutters to stop them from fanning out) to the appropriate area, as determined by the radiographic technician. As the X-rays pass through the body they are attenuated (reduced in energy) by the tissues. Those X-rays that pass through the tissues interact with the photographic film.

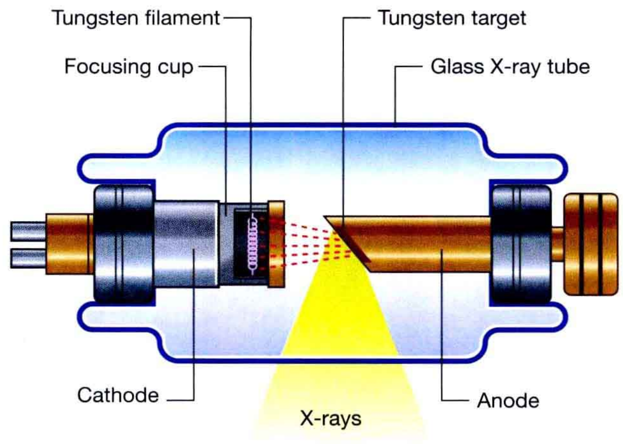

Fig. 1.2 Cathode ray tube for the production of X-rays.

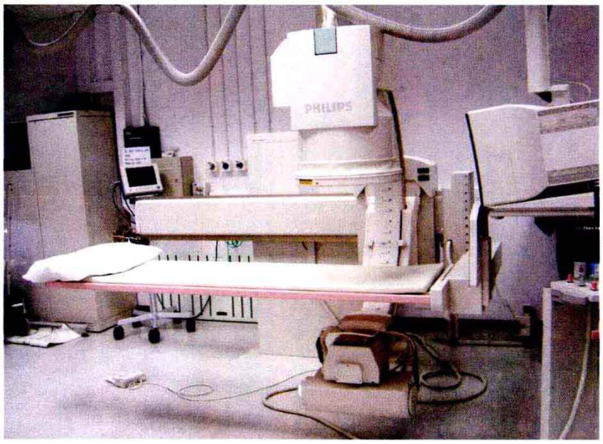

Fig. 1.3 Fluoroscopy unit.

In the body:

- Air attenuates X-rays a little.
- Fat attenuates X-rays more than air but less than water.
- Bone attenuates X-rays the most.

These differences in attenuation result in differences in the level of exposure of the film. When the photographic film is developed, bone appears white on the film because this region of the film has been exposed to the least amount of X-rays. Air appears dark on the film because these regions were exposed to the greatest number of X-rays. Modifications to this X-ray technique allow a continuous stream of X-rays to be produced from the X-ray tube and collected on an input screen to allow real-time visualization of moving anatomical structures, barium studies, angiography, and fluoroscopy (Fig. 1.3).

Contrast agents

To demonstrate specific structures, such as bowel loops or arteries, it may be necessary to fill these structures with a substance that attenuates X-rays more than bowel loops or

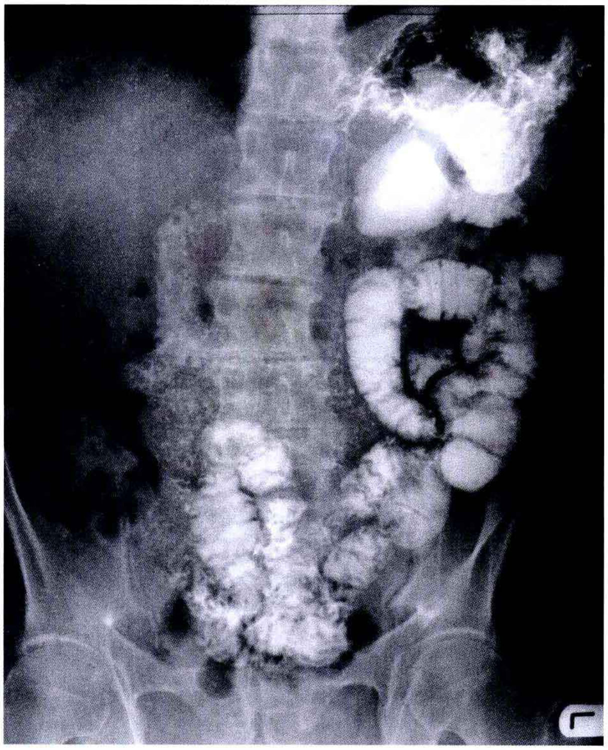

Fig. 1.4 Barium sulfate follow-through.

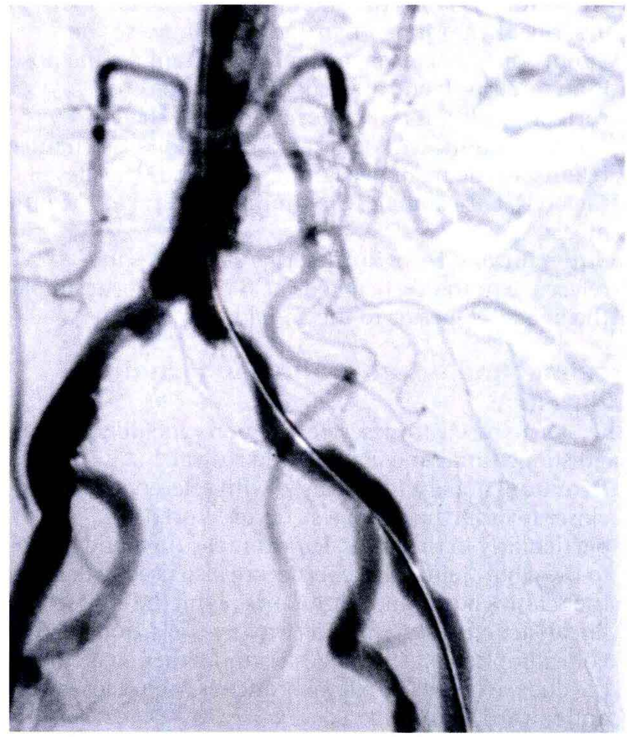

Fig. 1.5 Digital subtraction angiogram.

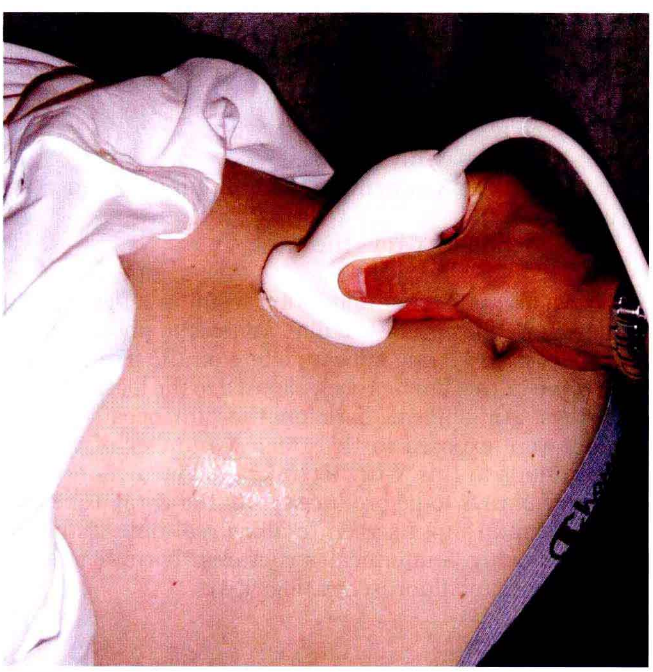

Fig. 1.6 Ultrasound examination of the abdomen.

Fig. 1.7 Computed tomography scanner.

arteries do normally. It is, however, extremely important that these substances are nontoxic. Barium sulfate, an insoluble salt, is a nontoxic, relatively high-density agent that is extremely useful in the examination of the gastrointestinal tract. When **barium sulfate suspension** is ingested it attenuates X-rays and can therefore be used to demonstrate the bowel lumen (Fig. 1.4).

For some patients it is necessary to inject contrast agents directly into arteries or veins. In this case, iodine-based molecules are suitable contrast agents. **Iodine** is chosen because it has a relatively high atomic mass and so markedly attenuates X-rays, but also, importantly, it is naturally excreted via the urinary system. Intra-arterial and intravenous contrast agents are extremely safe and are well tolerated by most patients. These agents not only help in visualizing the arteries and veins, but because they are excreted by the urinary system, can also be used to visualize the kidneys, ureter, and bladder in a process known as **intravenous urography.**

Subtraction angiography

During angiography it is often difficult to appreciate the contrast agent in the vessels through the overlying bony structures. To circumvent this, the technique of subtraction angiography has been developed. Simply, one or two images are obtained before the injection of contrast media. These images are inverted (such that a negative is created from the positive image). After injection of the contrast media into the vessels, a further series of images are obtained, demonstrating the passage of the contrast through the arteries and into the veins. By adding the "negative precontrast image" to the positive postcontrast images, the bones and soft tissues are subtracted to produce a solitary image of contrast only (Fig. 1.5).

Ultrasound

Ultrasonography of the body is widely used for all aspects of medicine (Fig. 1.6).

Ultrasound is a very high frequency sound wave (not electromagnetic radiation) generated by piezoelectric materials, such that a series of sound waves is produced. Importantly, the piezoelectric material can also receive the sound waves that bounce back from the internal organs. The sound waves are then interpreted by a powerful computer, and a real-time image is produced on the display panel.

Doppler ultrasound

Developments in ultrasound technology, including the size of the probes and the frequency range, mean that a broad range of areas can now be scanned.

Traditionally ultrasound is used for assessing the abdomen (Fig. 1.6) and the fetus in pregnant women. Ultrasound is also widely used to assess the eyes, neck, soft tissues, and peripheral musculoskeletal system. Probes have been placed on endoscopes, and endoluminal ultrasound of the esophagus, stomach, and duodenum is now routine. Endocavity ultrasound is carried out most commonly to assess the genital tract in women using a transvaginal or transrectal route. In men, transrectal ultrasound is the imaging method of choice to assess the prostate in those with suspected prostate hypertrophy or malignancy.

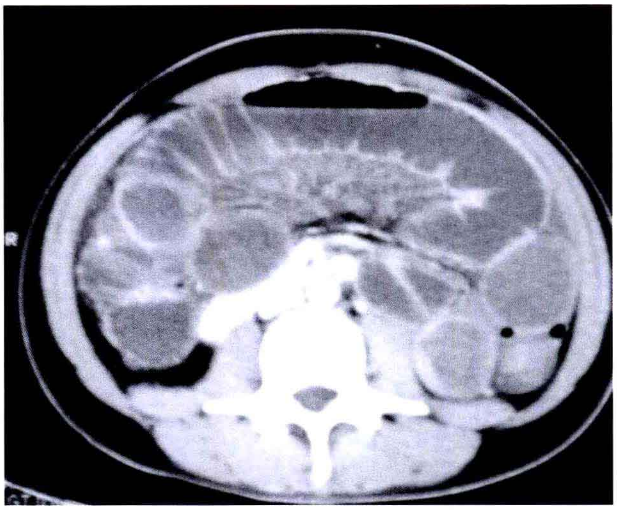

Fig. 1.8 Computed tomography scan of the abdomen at vertebral level L2.

Doppler ultrasound enables determination of flow, its direction, and its velocity within a vessel using simple ultrasound techniques. Sound waves bounce off moving structures and are returned. The degree of frequency shift determines whether the object is moving away from or toward the probe and the speed at which it is traveling.

Computed tomography

Computed tomography (CT) was invented in the 1970s by Sir Godfrey Hounsfield, who was awarded the Nobel Prize in Medicine in 1979. Since this inspired invention, there have been many generations of CT scanners.

A CT scanner obtains a series of images of the body (slices) in the axial plane. The patient lies on a bed, an X-ray tube passes around the body (Fig. 1.7), and a series of images are obtained. A computer carries out a complex mathematical transformation on the multitude of images to produce the final image (Fig. 1.8).

Magnetic resonance imaging

The process of magnetic resonance imaging (MRI) is dependent on the free protons in the hydrogen nuclei in molecules of water (H_2O). Because water is present in almost all biological tissues, the hydrogen proton is ideal. The protons within a patient's hydrogen nuclei should be regarded as small bar magnets, which are randomly oriented in space. The patient is placed in a strong magnetic field, which aligns the bar magnets. When a pulse of radio waves is passed through the patient the magnets are deflected, and as they return to their aligned position they emit small radio pulses. The strength and frequency of the emitted pulses and the time it takes for the protons to return to their pre-excited state produces a signal. These signals are analyzed by a powerful computer, and an image is created (Fig. 1.9).

Fig. 1.9 A T2-weighted image in the sagittal plane of the pelvic viscera in a woman.

By altering the sequence of pulses to which the protons are subjected, different properties of the protons can be assessed. These properties are referred to as the "weighting" of the scan. By altering the pulse sequence and the scanning parameters, T1-weighted images (Fig. 1.10A) and T2-weighted images (Fig. 1.10B) can be obtained. These two types of imaging sequences provide differences in image contrast, which accentuate and optimize different tissue characteristics.

From the clinical point of view:

- Most T1-weighted images show dark fluid and bright fat—for example, within the brain the cerebrospinal fluid (CSF) is dark.
- T2-weighted images demonstrate a bright signal from fluid and an intermediate signal from fat—for example, in the brain the CSF appears white.

MRI can also be used to assess flow within vessels and to produce complex angiograms of the peripheral and cerebral circulation.

Nuclear medicine imaging

Nuclear medicine involves imaging using gamma rays, which are another type of electromagnetic radiation. The important difference between gamma rays and X-rays is that gamma rays are produced from within the nucleus of an atom when an unstable nucleus decays, whereas X-rays are produced by bombarding an atom with electrons.

For an area to be visualized, the patient must receive a gamma-ray emitter, which must have a number of properties to be useful, including a reasonable half-life (e.g., 6 to 24 hours); an easily measurable gamma ray; and an energy deposition in as low a dose as possible in the patient's tissues.

The most commonly used radionuclide (radioisotope) is technetium-99m. This may be injected as a technetium salt or combined with other complex molecules. For example, by combining technetium-99m with methylene diphosphonate (MDP), a radiopharmaceutical is produced. When injected into the body this radiopharmaceutical specifically binds to bone, allowing assessment of the skeleton. Similarly, combining technetium-99m with other compounds permits assessment of other parts of the body; for example, the urinary tract and cerebral blood flow.

Images obtained using a gamma camera are dependent on how the radiopharmaceutical is absorbed, distributed, metabolized, and excreted by the body after injection.

Positron emission tomography

Positron emission tomography (PET) is an imaging modality for detecting positron-emitting radionuclides. A positron is an antielectron, which is a positively charged particle of antimatter. Positrons are emitted from the decay of proton-rich radionuclides. Most of these radionuclides are made in a cyclotron and have extremely short half-lives.

The most commonly used PET radionuclide is fluorodeoxyglucose (FDG) labeled with fluorine-18 (a positron emitter). Tissues that are actively metabolizing glucose take up this compound, and the resulting localized high concentration of this molecule compared to background emission is detected as a "hot spot."

PET has become an important imaging modality in the detection of cancer and the assessment of its treatment and recurrence.

IMAGE INTERPRETATION

Plain radiography

Plain radiographs are undoubtedly the most common form of image obtained in a hospital or local practice. Before interpretation, it is important to know about the imaging technique and the standard views obtained.

In most instances (apart from chest radiography), the X-ray tube is 1 m away from the X-ray film. The object in question, for example a hand or a foot, is placed upon the film. When describing subject placement for radiography, the part closest to the X-ray tube is referred to as "anterior" and that closest to the film is referred to as "posterior."

When X-rays are viewed on a viewing box, the right side of the patient is placed to the observer's left; therefore, the observer views the radiograph as though looking at a patient in the anatomical position.

Chest radiograph

The chest radiograph is one of the most commonly requested plain radiographs. An image is taken with the patient erect and placed posteroanteriorly (PA chest radiograph).

Occasionally, when patients are too unwell to stand erect, films are obtained on the bed in an anteroposterior (AP) position. These films are less standardized than PA films, and caution should always be taken when interpreting AP radiographs.

A good quality chest radiograph will demonstrate the lungs, cardiomediastinal contour, diaphragm, ribs, and peripheral soft tissues.

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