Lucio Olivetti
Editor

Atlas of Imaging Anatomy

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“It’s never too late to be who you might have been”

George Eliot

To Carlotta and Elena

Preface

The first exam of my degree course in Medicine and Surgery was Normal Human Anatomy; it was many years ago, and medical students used to say that after passing such an exam, along with the Clinical Pathology one, you could be considered as a medical doctor (there are actually more than 28 exams). I passed both of them brilliantly, but I remember I liked the first one much more: it was my first 30/30 cum laude so far. Years later, at the beginning of my career as a radiologist, through images, I really started to see the real anatomy, that I had previously studied only in books, or, less frequently, in the Pathological Anatomy Department and that I had stored in my mind as a long list of hundreds of names. Another memory of the beginning of my career as a radiologist is that of a convention organized by Professor Gian Franco Pistolesi, an Italian Master in Radiology, titled *Anatomy: The Queen of the Image*. The main subjects were conventional X-ray and cross-sectional imaging (ultrasound scan, CT and MRI), able to "translate" human anatomy into images. I understood that only through the perfect knowledge of the normal anatomy we can understand the pathological patterns, and the radiologist is able to control the imaging instruments only when he is aware of their importance in the description of anatomical findings. The image acquisition (radiographer) and interpretation (radiologist) of the correct images is not possible without a proper knowledge of any single detail of the morphology of the human body: it is essential to highlight, through imaging techniques, the patients' normal elements, variables and pathological alterations.

This editorial project is a consequence of the above story and follows the publication of my two previous books *Imaging of Urogenital Disease* and *Professione TSRM* (published in Italian only). In the following pages, you will find both anatomical pictures and the corresponding images obtained with the different techniques.

The labor for this book was, unexpectedly fast, and accelerated. I wish I had more time to work on this project, but nowadays hospital doctors have heavy workloads and it is often difficult to find the time for other pleasures such as writing that, for some of us, gives meaning to life. Nevertheless, I hope this is an eutocic delivery, and this book is issued wishing success, or simply a good and profitable reading.

Cremona, Italy — Lucio Olivetti

Contents

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Brain

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Mario Crispino and Emanuela Crispino

The nervous system is a combination of specialised structures that receive and identify the stimuli coming from outside and inside the organism, and develop coordinated effector responses, either voluntary or involuntary (reflected actions); it consists of neuroglia cells, with support and trophic function, and neurons, specialised in the production and conduction of nerve impulses.

From an anatomical and functional point of view, neurons are single cells; the cell body (soma) and the dendrites, the short branch projections of neurons, represent the receptive part of the nerve cell, receiving nervous impulses from other neurons; the axon is instead a single projection of different measurements that transmits nervous impulses through the synapses; the synapses are, therefore, the point at which two neurons come into contact and enable, through the release of a chemical mediator (neurotransmitter), the passage of the nerve impulse from a pre-synaptic neuron to a post-synaptic one.

The presynaptic side consists of the axon terminals, while the post-synaptic side, where the receptors of the neurotransmitters are located, may be any part of the neuron; we can therefore distinguish among axosomatic, axodendrosomatic and, less commonly, axoaxonic synapses.

From a functional perspective, synapses transmit the nerve impulses unidirectionally, can be divided into excitatory and inhibitory synapses, and are therefore capable of activating, or reducing, the activity of the post-synaptic neuron, according to the nature of the neurotransmitter and to the characteristics of the post-synaptic receivers.

1.1 Normal Anatomy

The human nervous system consists of a central organ (central nervous system, CNS), which includes the *brain* and the *spinal cord* – capable of taking in afferent and sensitive information and providing efferent somatic or visceral responses – along with the nerves – long cords that form the peripheral nervous system (PNS) – that establish the connection between the CNS and the rest of the body.

The differences between the central and peripheral nervous system are merely topographical and have educational purposes only; in reality, the CNS and the PNS constantly interact and they are a unique and inseparable system.

From a macroscopic examination, we can observe that the CNS consists of two parts that can be distinguished for their grey–pink or

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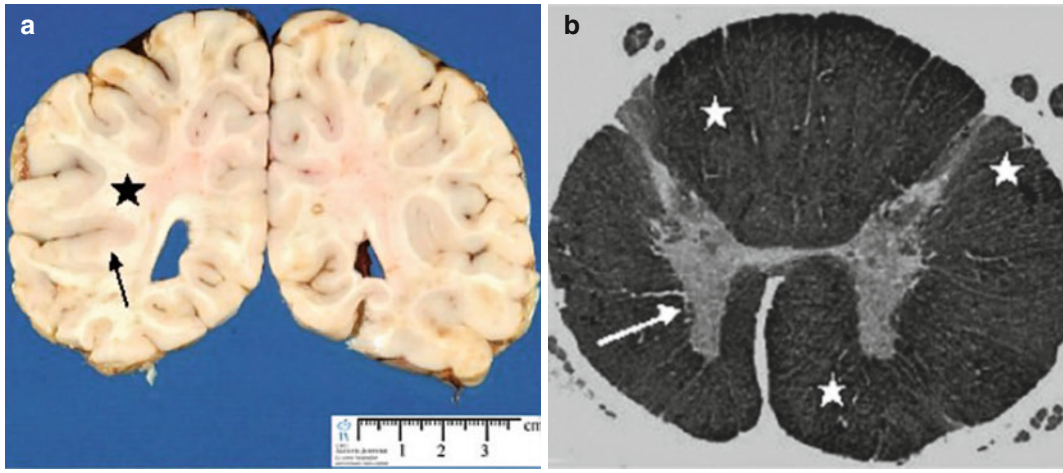

Fig. 1.1 (**a**) Anatomical coronal section of the brain showing the frontal lobes: peripheral cerebral cortex (*arrow*), white matter (*star*). (**b**) Axial section of the cervical spinal cord, coloured with the techniques for myelin. The grey matter (*arrow*) and the white matter (*star*) are highlighted

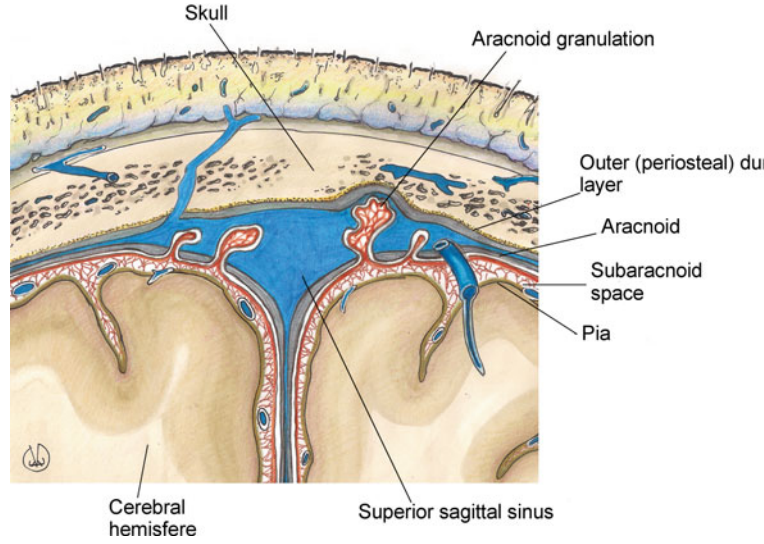

Fig. 1.2 Anatomy of the meningeal structures of the cerebral regions, coronal section

white colours named grey and white matter respectively (Fig. 1.1); the first receives the nerve cells, and may have different shades according to the level of vascularisation; the second as a stronger consistency and includes the short and long connections of the CNS and the peripheral nerves.

The CNS consists of two parts, anatomically connected through the foramen magnum, that are distinguished for their structures and positions: the brain, in the cranial cavity, and the spinal cord, in the spinal channel (see Chap. 2).

1.1.1 Meninges and Cephalorachidian Liquid

The CNS structures are enveloped in three layers of connectival membranes called meninges (the dura mater, the arachnoid mater, and the pia mater), located inside the osseous case (the skull and spinal canal of the spinal column; Fig. 1.2).

The dura mater is the most external part, it has a fibrous and resistant nature and perfectly adheres to the periosteum on the inner surface of the skull, from which it is separated by an ana-

tomical space containing meningeal arteries and vessels (the epidural space). In the spine, the dura mater does not adhere to the spinal canal; rather, it is separated from it by the epidural space that contains adipose tissue and venous plexuses. The internal surface of the dura mater, in the endocranial part, is divided into three parts: the falx cerebri, which separates the two cerebral hemispheres; the tentorium cerebelli that exists between, and separates, the supratentorial region of the brain (telencephalon and diencephalon) from the subtentorial region (mesencephalon, pons, medulla oblongata, cerebellum), located in the posterior part; and the diaphragma sellae, a small stratum crossed by the hypophyseal peduncle.

The two layers of the dura mater contain vascular structures covered by endothelium tissue, named venous sinus, and they constitute the brain's venous drainage system.

The arachnoid mater is the middle element of the meninges: it does not have vessels and it is similar to a spider web, containing the cephalorachidian liquid in the subarachnoid space (between the arachnoid and the pia mater). The arachnoid mater adheres to the dura mater's internal surface, from which it is separated by the subdural cavity, which, in the skull area, is crossed by the "bridge" veins, while it is merely a virtual area in the spinal region. Since 10 years of age, the arachnoid mater is characterised by villi called arachnoid or Pacchioni's granulations, located towards the venous sinus of the dura mater, that are involved in the reabsorption of the cephalorachidian liquid, helping the flow of the venous circulation (Fig. 1.2). The pia mater is the internal membrane, strictly adherent to the CNS surface; it contains a large amount of vessels continuing into the CNS. The pia mater of the brain, in correspondence with the brain's ventricles, forms the tela chorioidea and the choroid plexus.

The dura mater and the spinal and brain's arachnoid membrane follow one another in the foramen magnum region. The limit between the brain's pia mater and the spinal pia mater coincides with the limit between the medulla oblongata and the spinal one. When exiting the brain cavities, at the level of the spinal canal, the three meninges envelop the brain and the spinal nerves, and continue to cover them.

The arachnoid mater and the pia mater are separated by the subarachnoid space in which the cephalorachidian liquid is contained; however, they are intensively connected to one another from the fibrous bridges of the subarachnoid space and therefore they are also considered to be a unique entity called leptomeninges. As the pia mater, contrary to the arachnoid mater, follows any prominence or depression of the neuraxis, the amplitude of the subarachnoid space is not regular, and presents wider regions at the brain level, called cisterns (base cisterns, chiasmatic cistern, Sylvian cistern, pericallosal cistern; Fig. 1.3).

The cephalorachidian liquid (whose function is to reduce the weight of the brain contained in it, to cushion it, and to enable the perfusion at a regular pressure) is produced at the level of the choroid plexuses (in the brain ventricles) and it is subject to its own dynamic movements, whose rhythm is provided by the cardiac rhythm. During the systole, the liquid from the lateral ventricles goes toward the third and fourth ventricles and, from there, into the subarachnoid spaces and the spinal canal. The opposite happens during diastole. Normally, the nervous system contains 150 ml of liquid, which is produced on a regular basis and needs to be regularly re-absorbed.

1.1.2 Brain

The brain, enveloped by the meninges, occupies the skull cavity. It is egg-shaped, with a sagittal major axis, weighing approximately 1,300 g in an adult person; the superior side is convex and the inferior side is flattened, the three posterior parts are rounded and they are called the frontal, temporal, and occipital lobes, the first are smaller, and located in the front part, the third one, at the back, is more voluminous (Fig. 1.4).

From the macroscopic point of view, the brain is composed of an axial caudal part, the brainstem, and by the rostral super-axial centres that correspond to the voluminous masses of the telencephalon, above, and the cerebellum, behind.

The phylogenetical analysis shows that the brain is divided in three parts, derived from the primitive embryonic vesicle, the hindbrain, the midbrain,