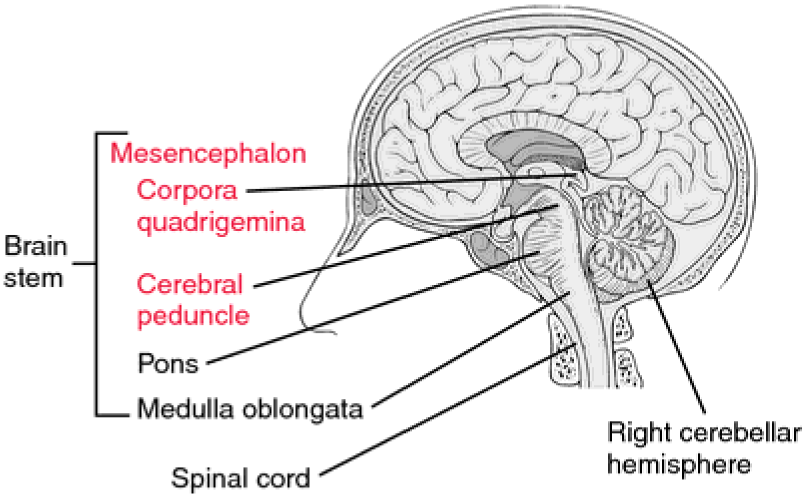
Brainstem



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It is usually described as including the medulla oblongata (myelencephalon), pons (part of metencephalon), and midbrain (mesencephalon).

Brainstem (or brain stem) is the posterior part of the brain, adjoining and structurally continuous with the spinal cord.

The brainstem is one of the most complex structures of the human body and has the most complex intracranial anatomy, which makes surgery at this level the most difficult. Due to its hidden position, the brainstem became known later by anatomists, and moreover, brainstem surgery cannot be understood without knowing the evolution of ideas in neuroanatomy, neuropathology, and neuroscience. Starting from the first attempts at identifying brainstem anatomy in prehistory and antiquity, the history of brainstem discoveries and approach may be divided into four periods: macroscopic anatomy, microscopic anatomy and neurophysiology, posterior fossa surgery, and brainstem surgery [1)]

Less frequently, parts of the diencephalon are included.

Function

The brainstem provides the main motor and sensory innervation to the face and neck via the cranial nerves.

Of the twelve pairs of cranial nerves, ten pairs come from the brainstem. Though small, this is an extremely important part of the brain as the nerve connections of the motor and sensory systems from the main part of the brain to the rest of the body pass through the brainstem. This includes the corticospinal tract (motor), the posterior column-medial lemniscus pathway (fine touch, vibration sensation, and proprioception), and the spinothalamic tract (pain, temperature, itch, and crude touch). The brainstem also plays an important role in the regulation of cardiac and respiratory function. It also regulates the central nervous system, and is pivotal in maintaining consciousness and regulating the sleep cycle. The brainstem has many basic functions including heart rate, breathing, sleeping, and eating.

Brainstem surgery remains a challenge for the neurosurgeon despite recent improvements in neuroimaging, microsurgical techniques, and electrophysiological monitoring. A detailed knowledge of the microsurgical anatomy of the brainstem surface and its internal architecture is mandatory to plan appropriate approaches to the brainstem, to choose the safest point of entry, and to avoid potential surgical complications.

An extensive review of the literature was performed regarding the brainstem surgical approaches, and their correlations with the pertinent anatomy were studied and illustrated through dissection of human brainstems properly fixed with 10% formalin. The specimens were dissected using the fiber dissection technique, under ×6 to ×40 magnification. 3D stereoscopic photographs were obtained (anaglyphic 3D) for better illustration of this study. RESULTS The main surgical landmarks and their relationship with the cerebellum and vascular structures were identified on the surface of the brainstem. The arrangements of the white matter (ascending and descending pathways as well as the cerebellar peduncles) were demonstrated on each part of the brainstem (midbrain, pons, and medulla oblongata), with emphasis on their relationships with the surface. The gray matter, constituted mainly by nuclei of the cranial nerves, was also studied and illustrated.

The objective of this article is to review the microsurgical anatomy and the surgical approaches pertinent to the brainstem, providing a framework of its external and internal architecture to guide the neurosurgeon during its related surgical procedures [2)].

Dysfunction

(pupillary dilation, coma, and fatal systemic decompensation).

Baroreflex

The baroreflex or baroreceptor reflex is one of the body's homeostatic mechanisms that helps to maintain blood pressure at nearly constant levels. The baroreflex provides a rapid negative feedback loop in which an elevated blood pressure reflexively causes the heart rate to decrease and also causes blood pressure to decrease. Decreased blood pressure decreases baroreflex activation and causes heart rate to increase and to restore blood pressure levels. The baroreflex can begin to act in less than the duration of a cardiac cycle (fractions of a second) and thus baroreflex adjustments are key factors in dealing with postural hypotension, the tendency for blood pressure to decrease on standing due to gravity.

The system relies on specialized neurons, known as baroreceptors, in the aortic arch, carotid sinuses, and elsewhere to monitor changes in blood pressure and relay them to the brainstem. Baroreceptors are stretch receptors and respond to the pressure induced stretching of the blood vessel in which they are found. Baroreflex induced changes in blood pressure are mediated by both branches of the autonomic nervous system - that is the parasympathetic and sympathetic nerves. Baroreceptors are active even at normal blood pressures so that their activity informs the brain about both increases and decreases in blood pressure.

The body contains two other, slower acting systems to regulate blood pressure: the heart releases atrial natriuretic peptide when blood pressure is too high, and the kidneys sense and correct low blood pressure with the renin angiotensin system.

Autonomic impairment, as measured by heart rate variability and baroreflex sensitivity, is significantly associated with increased mortality after traumatic brain injury. These effects, though partially interlinked, seem to be independent of age, trauma severity, intracranial pressure, or autoregulatory status, and thus represent a discrete phenomenon in the pathophysiology of traumatic brain injury. Continuous measurements of heart rate variability and baroreflex sensitivity in the neuromonitoring setting of severe traumatic brain injury may carry novel pathophysiological and predictive information [3)].

Pathology

Brainstem cavernous malformation

Brainstem compression

Brainstem hemorrhage

Brainstem lesion

Brainstem abscess

Brainstem injury

Brainstem tumor

Penetration of the clivus is required for surgical access of the brainstem

Surgery of the Brainstem

see Brainstem surgery

Brainstem safe entry zones

see Brainstem safe entry zones.

[1]
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[2]
Párraga RG, Possatti LL, Alves RV, Ribas GC, Türe U, de Oliveira E. Microsurgical anatomy and internal architecture of the brainstem in 3D images: surgical considerations. J Neurosurg. 2015 Oct 30:1-19. [Epub ahead of print] PubMed PMID: 26517774.

[3]
Sykora M, Czosnyka M, Liu X, Donnelly J, Nasr N, Diedler J, Okoroafor F, Hutchinson P, Menon D, Smielewski P. Autonomic Impairment in Severe Traumatic Brain Injury: A Multimodal Neuromonitoring Study. Crit Care Med. 2016 Mar 10. [Epub ahead of print] PubMed PMID: 26968025.