ANESTHETIC MODALITIES FOR INTERVENTIONAL NEURO-RADIOLOGY

Essay
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Summary

The general principle of endovascular neurosurgical procedures involves the placing of special catheters into the arterial circulation of the head, neck or spinal cord through a transfemoral artery approach. By using this approach and through the utilization of special techniques (superselective anesthesia functional examination **(SAFE)** it is now possible to safely and accurately access distal target vessels to allow placement of embolic materials and drugs.

The brain is supplied by the two internal carotid and two vertebral arteries. These four arteries anastomose on the inferior surface of the brain and form the circulus or the Circle of Willis. The spinal cord is supplied by three distinct longitudinal vessels; an anterior spinal artery that runs down along the anterior median sulcus and supplies the anterior 80 % of the spinal cord, and two posterior spinal arteries that supply the posterior 20 % of the spinal cord.

The venous drainage of the brain is by veins that lie in the subarachnoid space. The veins pierce the arachnoid matter and the meningeal layer of the dura to drain into the cranial venous sinuses.

The General Goals of Endovascular Neurosurgical Procedures In Cerebrovascular Disorders Are:

- **Defenitive** treatment for certain disorders.
- **Adjunctive** therapy to surgery or radiotherapy.
- **Palliative** treatment e.g. for malignant and inoperable tumors.

The great improvement in basic applications of interventional methods including development of

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Al-Amin Abd El-Monem Essam

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Introduction

The medical world has seen rapid advances in diagnostic and interventional radiology, including interventional neuroradiology. Many intracranial vascular pathologies can now be successfully managed by interventional neuroradilogy techniques by the endovascular approach, thus either avoiding surgical intervention or making it safer for the patient. These techniques include embolization of vascular tumors and arterio-venous malformations (AVM), coiling of cerebral aneurysms, and balloon occlusion of some vascular lesions (**Muller et al., 2007)**.

The last decades have seen the development of the basic applications of the interventional neuroradiological methods regarding the development of improved fluoroscopic equipments, angiographic techniques, magnetic resonance angiography as well as a better understanding of the neurovascular anatomy (**Young, 2007).**

Interventional neuroradiolgy is a hybrid of traditional neurosurgery and neuroradiology, with certain overlaps with aspects of head-and-neck surgery. It can be broadly defined as treatment of central nervous system disease by endovascular access for the purpose of delivering therapeutic agents, including both drugs and devices. Because of recent advancement in this field, more anesthesiologists are involved in care of patients undergoing procedures. Anesthesiologists have several important concerns when providing care to patients who undergo procedures, including: Maintenance of patient immobility and physiologic stability; manipulating systemic or regional blood flow; managing anticoagulation; treating and managing sudden unexpected complications during the procedures; guiding the medical management of critical care patients during transport to and from the radiology suites; and, rapid recovery from anesthesia and sedation during or immediately after the procedure to facilitate neurologic examination and monitoring. To achieve these goals, anesthesiologists should be familiar with specific radiological procedures and their potential complications. **(Hashimoto et al., 2002)**.

The procedures performed in interventional radiology practice are usually inherently life-threatening, even in experienced hands. A primary goal of anesthesia coverage is immediate intervention in the event of catastrophe, such as intracranial hemorrhage (**Yong and Pile–Spellman, 1994).**

As the frontiers of endovascular neurosurgery expand, care of these patients will demand more of anesthetist's participation. Historically, the pioneers of endovascular neurosurgery provided light intravenous sedation with rudimentary monitoring for their adult patients, although many prefer to have an anesthetist in attendance. Some centers have employed anesthetists on an on-call fashion. As the complexity of the procedures and breadth of patient populations expand, the distinction between the endovascular therapists' angiography suite and the operating room will blur and need for sophisticated sedation techniques and monitoring will increase (**Varma et al., 2007).**

Anatomical and Physiological Considerations of Cerebral Circulation

Blood Supply of The Brain :

Arteries of The Brain :

The brain is supplied by the two internal carotid and two vertebral arteries. These four arteries anastomose on the inferior surface of the brain and form the circulus arteriosus or the Circle of Willis **(Snell, 2000).**

1. **Internal Carotid Artery :**

The internal carotid artery arises from the bifurcation of the common carotid artery, ascends in the neck and enters the carotid canal of the temporal bone. Its subsequent course is said to have petrous, cavernous and cerebral parts **(Standring, 2004)**.

The cerebral portion emerges from the cavernous sinus on the medial side of the anterior clinoid process by perforating the dura matter. Branches of the cerebral portion of the internal carotid arteries are:

a) **The ophthalmic artery** which enters the orbit through the optic canal below and lateral to the optic nerve.

b) **The posterior communicating artery** which runs backwards to join the posterior cerebral artery.

c) **The choroidal artery** which ends in the choroid plexus.

d) **The anterior cerebral artery** which is the smaller and one of the two terminal branches of the internal carotid. It is joined to the artery of the opposite side by the anterior communicating artery. It supplies the tip of the cortex on the lateral surface and the entire medial surface of the cortex. It also supplies the "leg area" of the precentral gyrus and a number of its central branches pierce the brain substance and supply the deep mass of the gray matter within the cerebral hemispheres **(Fig. 1) (Snell, 2000)**.

e) **The middle cerebral artery** which is the largest branch of the internal carotid artery. Its cortical branches supply the entire lateral surface of the hemisphere. It supplies all the motor area except the "Leg area". The central branches also supply the deep mass of the gray matter within the cerebral hemispheres **(Snell, 2000)**.

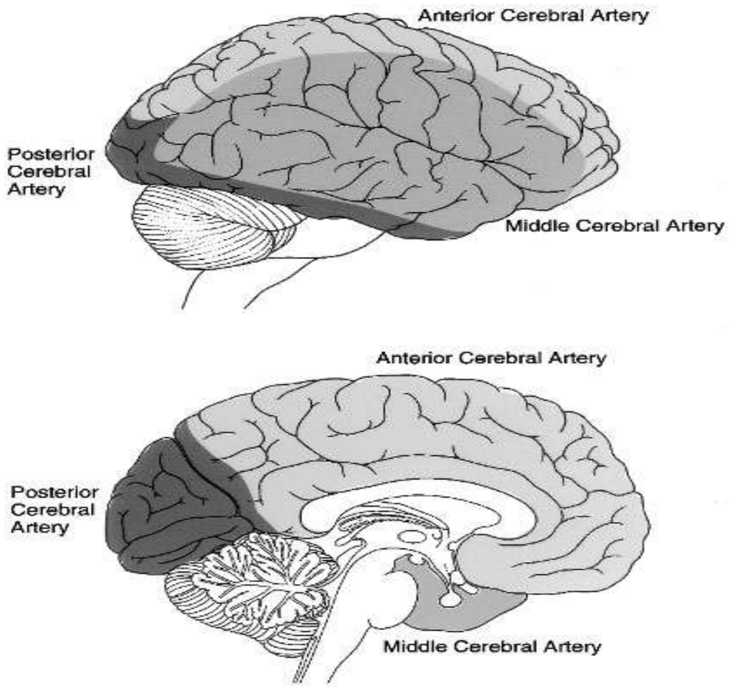

Figure 1: Areas supplied by the cerebral arteries **(Snell, 2000).**

2. Vertebral Artery :

The vertebral artery, a branch of the first part of the subclavian artery, enters the skull through the foramen magnum **(Snell, 2000).**

At the lower border of pons, it joins the vessel of the opposite side to form the basilar artery. It gives meningeal arteries, the anterior and the posterior spinal arteries, the posterior inferior cerebellar artery and medullary arteries **(Snell, 2000)**.

3. Basilar artery :

At the upper border of pons, it divides into two posterior cerebral arteries. It gives branches to pons, the cerebellum and to the internal ear. ***The posterior cerebral arteries*** supply the visual cortex, the midbrain and the deep masses of the gray matter within the cerebral hemispheres **(Snell, 2000).**

Circulus Arteriosus :

It lies at the interpeduncular fossa at the base of the brain. It allows blood that enters by either the internal carotid or vertebral arteries to be distributed to any part of both cerebral hemispheres. Cortical and central branches arise from the circle and supply the brain substance **(Fig. 2)** (**Snell, 2000).**

Veins of The Brain:

They emerge from the brain and lie in the subarachnoid space. The veins pierce the arachnoid matter and the meningeal layer of the dura to drain into the cranial venous sinuses. There are cerebral and cerebellar veins of the brain stem. The great cerebral vein is formed of the union of the two internal cerebral veins and drains into the straight sinus **(Snell, 2000)**.

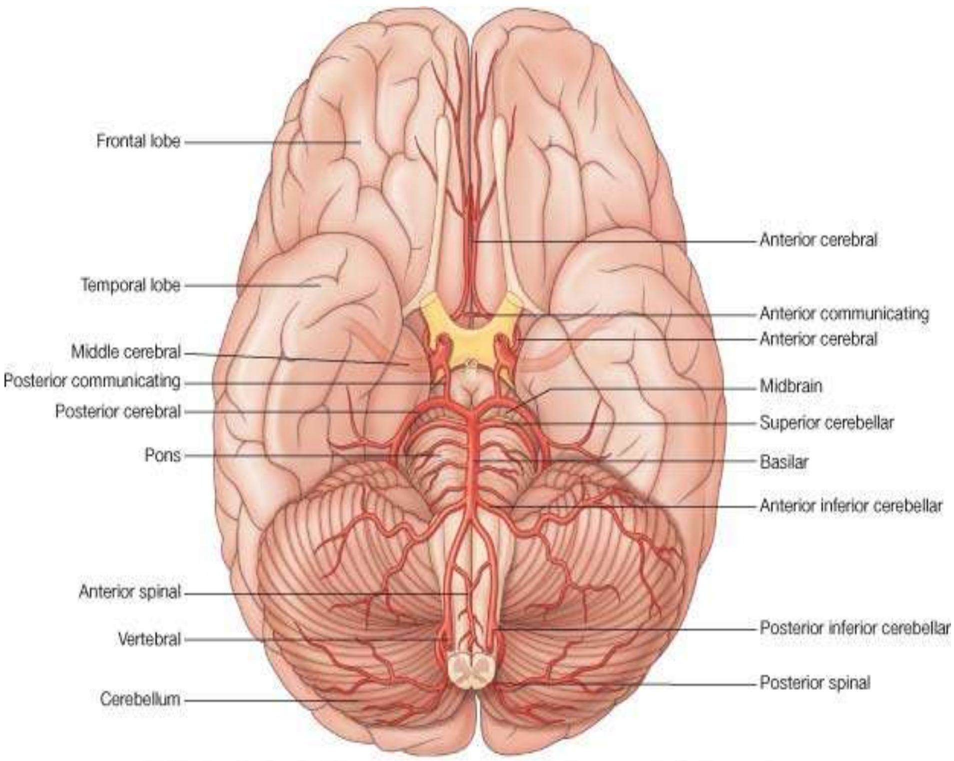

Figure 2: Relationship of Circle of Willis and branches to the base of the brain **(Snell, 2000).**

Blood Supply of the Spinal Cord :

The spinal cord is supplied by three distinct longitudinal channels, one anterior spinal artery and two posterior spinal arteries **(Duvernoy et al., 1998)**.

The anterior spinal arteries arise as paired structures near the termination of the vertebral arteries. In the upper cervical region, these two vessels unite to form one continuous artery that extends along the anterior median sulcus of the spinal cord. Several arteries contribute to the anterior spinal artery along its course, including the vertebral, ascending cervical, deep cervical, posterior intercostal and lumbar arteries. The artery of Adamkiewicz is one notable large branch that arises in the thoracolumbar region on the left side. There is frequently another large branch in the region of the 5th or 6th cervical vertebra and another near the 5th thoracic vertebra arising from the right bronchial artery. The anterior spinal artery supplies the anterior 80% of the spinal cord **(Duvernoy et al., 1998)**.

A posterior spinal artery usually arises from the posterior inferior cerebellar artery but it may come directly from the vertebral artery near the medulla oblongata. It passes posteriorly and descends as two branches which lie anterior and posterior to the dorsal roots of the spinal nerves. These are reinforced by spinal twigs from the vertebral, ascending cervical, posterior intercostal and first lumbar arteries, all of which reach the vertebral canal through the intervertebral foramina, thereby sustaining the posterior spinal arteries to the lower spinal levels. The posterior spinal arteries supplie the posterior 20% of the spinal cord **(Standring, 2004)**.

Physiology of Cerebral Blood Flow :

Cerebral blood flow (CBF), is the amount of blood that passes through the brain at a given moment **(Tolias and Sgouros, 2007).**

Although it represents only 2 % of body weight, the brain accounts for 20% of resting oxygen consumption at a rate of 3-3.5ml/100g brain/min which is even more in infants and young children (5ml/100g brain/min). Due to its lack of substrate storage and its high metabolic rate, the brain is very sensitive to oxygen deprivation. For its optimal oxygen supply, the brain receives almost 15 % of total cardiac output (i.e. nearly 700-750 ml/min or 55 ml/min/100 gm brain tissue) **(Newfield et al., 1999).**

Adequate cerebral blood flow to each part of the brain is essential for its normal functioning as cerebral tissues are very intolerant of hypoxia. The cessation of cerebral blood flow/ circulation for a few minutes can produce permanent damage to the brain. In addition, the CBF determines the cerebral blood volume (CBV) which itself is the net result of cerebral arterial supply and venous drainage. The CBV being a major and variable component of intracranial contents plays an important role in determining its total volume. The cranium being a closed hard case (except in young children with open fontanelles or suture lines) with limited compliance, the abnormal changes in CBV and intracranial contents manifest in the form of a proportionate change in intracranial pressure (ICP) **(Bissonnette, 1997).**

Intracranial Pressure :

The cranial vault is a rigid structure with a fixed total volume, consisting of brain (80%), blood (12%), and CSF (8%). Any increase in one component must be offset by an equivalent decrease in another to prevent a rise in ICP. ICP by convention means supratentorial CSF pressure measured in the lateral ventricles or over the cerebral cortex and is normally 10 mmHg or less. Minor variations may occur depending on the site measured, but, in the lateral recumbent position, lumbar CSF pressure normally approximates supratentorial pressure **(Morgan et al., 2002).**

Intracranial compliance is determined by measuring the change in ICP in response to a change in intracranial volume. Normally, increases in volume are initially well compensated **(Fig. 3)**. A point is eventually reached, however, at which further increases produce precipitous rises in ICP. Major compensatory mechanisms include:

1. An initial displacement of CSF from the cranial to the spinal compartment.
2. An increase in CSF absorption.
3. A decrease in CSF production.