Updates in anesthesia for Carotid Endarterectomy

An Essay

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John Hossni Megalla

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List of Abbreviations

ABP : Arterial Blood Pressure.

ACA : Anterior Cerebral Artery.

ACAS : Asymptomatic Carotid Atherosclerosis Study.

ACC : American College of Cardiology.

ACCP : American College of Chest Physicians.

ACOM : A nterior Communicating Artery.

ACS : Acute Coronary Syndrome.

ACST : Asymptomatic Carotid Surgery Trial.

AHA : American Heart Association.

AAN : American Academy of Neurology.

BMS : Bare Metal Stent.

C : Cervical.

°C : Celsius.

CABG : Coronary Artery Bypass Grafting.

CAD : Coronary Artery Disease.

CAS : Carotid Artery Surgery.

CBF : Cerebral Blood Flow.

CEA : Carotid Endarterectomy.

CHD : Congestive Heart Disease.

CMRO٢ : Cerebral Metabolic Rate of Oxygen.

CPP : Cerebral Perfusion Pressure.

CO_2 : Carbon Dioxide.

COPD : Chronic Obstruction Pulmonary Disease.

CT : Computed Tomography.

CVR : Cerebral Vascular Resistance.

List of Abbreviations (Cont.)

DAP : Diastolic Arterial Pressure.

DECREASE : Dutch Echocardiographic Cardiac Risk Evaluation Applying Stress Echo.

ECG : Electrocardiogram.

ECST : European Carotid Surgery Trial.

EEG : Electroencephalogram.

GA : General Anesthesia.

HR : Heart Rate.

ICA : Internal Carotid Artery.

ICP : Intracranial Pressure.

ICU : Intensive Care Unit.

IV : Intravenous.

KPa : Kilo Pascal.

LA : Local Anesthesia.

MAC : Minimum Alveolar Concentration.

MAP : Mean Arterial Blood Pressure.

MCA : Middle Cerebral Artery.

MCAv : Middle Cerebral Artery Velocity.

McSPI : Multicenter Study of Perioperative Ischemia Research.

MI : Myocardial Infarction.

MRI : Magnetic Resonant Imaging.

NASCET : North American Symptomatic Carotid Endarterectomy Trial.

NO : Nitric Oxide.

PAD : Peripheral Arterial Disease.

$PaCO_2$: Arterial Carbon Dioxide Tension.

List of Abbreviations (Cont.)

PaO_2	:	Arterial Oxygen Tension.
PCA	:	Posterior Cerebral Artery.
PCI	:	Percutaneous Coronary Intervention.
PCOM	:	Posterior Communicating Artery.
PCWP	:	Pulmonary Capillary Wedge Pressure.
rCBF	:	Regional Cerebral Blood Flow.
SAP	:	Systolic Arterial Pressure.
SSEP	:	Somato Sensory Evoked Potential.
TCD	:	Transcranial Doppler.
TEE	:	Transoesophageal Echocardiogram.
TIA	:	Transient Ischemic Attack.
TIVA	:	Total Intravenous Anesthesia.

Introduction

Carotid endarterectomy (CEA) is an effective method, with acceptable mortality and morbidity ratios, which can reduce the incidence of stroke. Although the result of carotid artery stenting has improved especially with the use of cerebral protection devices **(Taylor *et al.*, ٢٠٠٣)**, carotid endarterectomy is still the gold standard to prevent ischemic stroke. The goal of carotid endarterectomy is the successful removal of the atherosclerotic plaque and reconstruction of the carotid artery without perioperative complications **(Rerkasem and Rothwell, ٢٠٠٨) (Findlay *et al.*, ٢٠٠٤).**

Ischemia and emboli are the main causes of mortality and morbidity in these patients. Several techniques and devices including electroencephalography (EEG), somatosensory evoked potentials (SEP), transcranial doppler ultrasound monitoring, selective or routine intracarotid shunting, use of barbiturate neuronal protection, patch grafting, and carotid artery stump pressure monitoring have been developed in order to avoid these complications in general anaesthesia **(Howell, ٢٠٠٧) (Harbaugh, ٢٠٠٠).**

Performing CEA under regional anesthesia (RA) in an awake patient is another recommended method. Regional anesthesia allows communication with the patient and gives the surgeon the opportunity to closely monitor the neurological status during the operation providing immediate intervention if necessary.This approach also offers the advantage of avoiding the possible cardiovascular and pulmonary complications due to general anesthesia (GA) and reduce the duration of hospitalization **(Hakel *et al.*, ٢٠٠٧) (McCarthy *et al.*, ٢٠٠١).**

Anatomy

Common Carotid Arteries:

The common carotid arteries differ on the right and left sides with respect to their origins. On the right, the common carotid arises from the brachiocephalic artery as it passes behind the sternoclavicular joint. On the left , the common carotid artery comes directly from the arch of the aorta in the superior mediastinum. The right common carotid has, therefore, only a cervical part whereas the left common carotid has cervical and thoracic parts. Following a similar course on both sides ***(Ashrafian, ٢٠٠٧).***

The common carotid artery ascends, diverging laterally from behind the sternoclavicular joint to the level of the upper border of the thyroid cartilage of the larynx (Cervical ٣–٤ junction), where it divides into external and internal carotid arteries. This bifurcation can sometimes be at a higher level. The artery may be compressed against the prominent transverse process of the sixth cervical vertebra and above this level it is superficial and its pulsation can be easily felt ***(Lo et al., ٢٠٠٦).***

In the lower part of the neck the common carotid arteries are separated by a narrow gap which contains the trachea. Above this, the arteries are separated by the thyroid gland, larynx and pharynx. Each artery is contained within the carotid sheath of deep cervical fascia, which encloses the internal jugular vein and vagus nerve with it. The vein lies lateral to the artery, and the nerve lies between them and posterior to both The sympathetic trunk is behind the carotid sheath ***(Lo et al., ٢٠٠٦).***

In ١٢٪ of cases the right common carotid artery arises above the level of the sternoclavicular joint, or it may be a separate branch from the aorta. The left common carotid artery varies in origin more than the right and may arise with the brachiocephalic artery. Division of the common carotid may occur higher, near the level of the hyoid bone, or more rarely at a lower level alongside the larynx ***(Standring ,).***

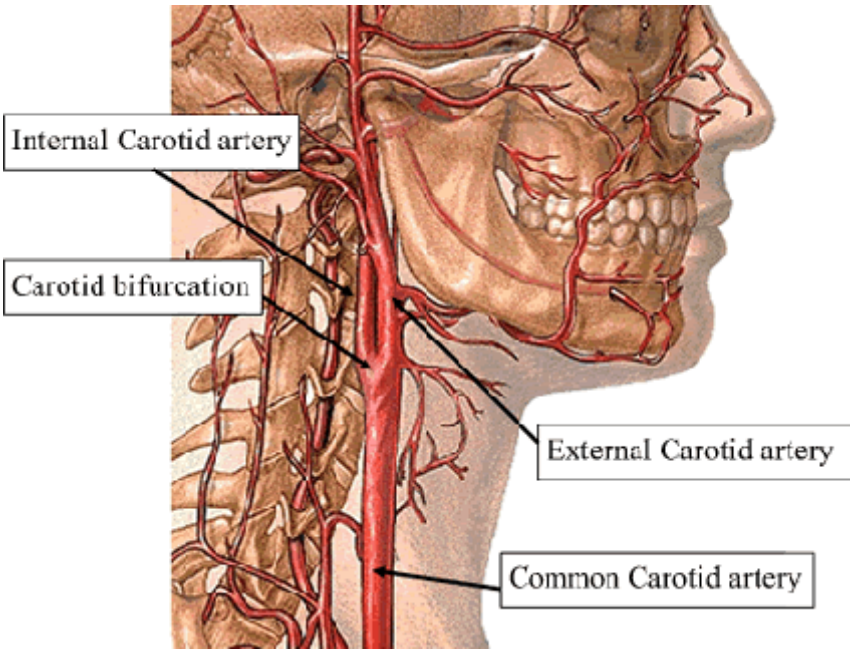

Fig (١): Common carotid artery *(Williams et al.,)*.

Very rarely it ascends without division, so that either the external or internal carotid is absent, or it may be replaced by separate external and internal carotid arteries which arise directly from the aorta, on one side or bilaterally. Atherosclerosis most commonly involves the bifurcation of the common carotid artery with frequent extension into both the internal and external carotid arteries ***(Williams et al.,)*.**

External Carotid Arteries:

The external carotid artery begins lateral to the upper border of the thyroid cartilage at the level of intervertebral disc between the third and fourth cervical vertebrae. A little curved and with a gentle spiral, it first ascends slightly forwards and then inclines backwards and laterally to pass midway between the tip of the mastoid process and the angle of the mandible. Here, in the substance of the parotid gland behind the neck of the mandible it divides into its terminal branches, the superficial temporal and maxillary arteries. As it ascends, it gives off several large branches, and diminishes rapidly in calibre ***(Standring ,).***

In children the external carotid is smaller than the internal carotid,but in adults the two are of almost equal size. At its origin, it is in the carotid triangle and lies anteromedial to the internal carotid artery. It later becomes anterior, then lateral, to the internal carotid as it ascends. At the mandibular level, the styloid process and its attached structures intervene between the vessels: the internal carotid is deep, and the external carotid is superficial, to the styloid process. A fingertip placed in the carotid triangle perceives a powerful arterial pulsation, which represent the termination of the common carotid ***(Berkovitz ,).***

The external carotid artery has eight named branches distributed to the head and neck as showen in figure(٢) ***(Williams et al.,).***

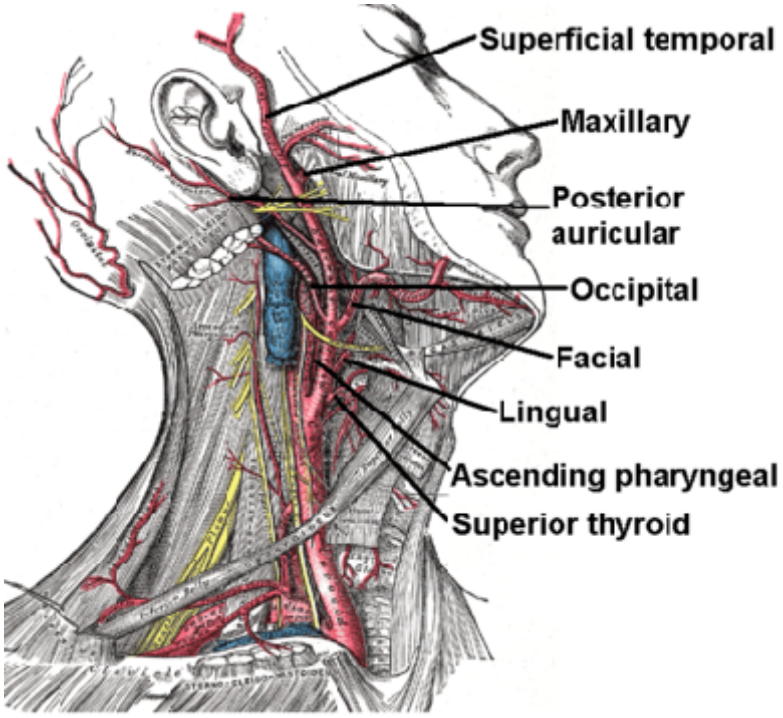

Fig (٢): External carotid artery *(Williams et al.,*).

Internal Carotid Arteries:

The internal carotid artery supplies most of the ipsilateral cerebral hemisphere, eye and accessory organs, forehead and, in part, the nose. From its origin at the carotid bifurcation (where it usually has a carotid sinus), it ascends in front of the transverse processes of the upper three cervical vertebrae to the inferior aperture of the carotid canal in the petrous part of the temporal bone. Here it enters the cranial cavity and turns anteriorly through the cavernous sinus in the carotid groove on the side of the body of the sphenoid bone. It terminates below the anterior perforated substance by division into the anterior and middle cerebral arteries. It may be divided conveniently into cervical, petrous, cavernous and cerebral parts ***(Standring ,***).

The first major branch of the internal carotid artery is the ophthalmic artery. It arises from the cavernous segment. Other small branches originate from the petrous and the cavernous segment of the artery. The cerebral segment of the artery terminates in the anterior cerebral artery that supplies the fontal lobe, the middle cerebral artery that supplies the lateral surface of the cerebral hemisphere, caudate, lentiform nuclei, and the internal capsule and choroidal artery that supplies the optic tract and the crus cerebri ***(Ashrafian, ٢٠٠٧).***

Occlusive atherosclerotic disease within either the internal carotid or common carotid artery may cause strokes or transient ischaemic attacks (TIAs) characterized by weakness of the contralateral side ***(Standring ,*** ***).***

Circle of Willis:

The brain receives its blood supply from four major arteries. Eighty-to-ninety percent of the cerebral blood supply is delivered via the two internal carotid arteries with the majority of the remainder coming from the vertebrobasilar system. The carotid arteries and basilar artery unite to form the Circle of Willis at the base of the brain. This ring of arteries offers the brain considerable protection against the occlusion of one or another vessel, but its presence should not lead to clinical complacency. The Circle of Willis is incomplete in ١٥٪ of normal people and in patients with cerebrovascular disease one or more of the vessels within the circle may be occluded by atheromatous plaque ***(Cavestro et al.,*** ***).***

The circle of Willis (circulus arteriosus cerebri) is an anastomotic system of arteries that sits at the base of the brain and supply blood to the brain. The "circle" was named after Thomas Willis by his student Richard Lower. The circle of Willis encircles the stalk of the pituitary gland and provides important communications between the blood supply of the forebrain and hindbrain (ie, between the internal carotid and vertebrobasilar systems following obliteration of primitive embryonic connections). A complete circle of Willis is present in most individuals, although a well-developed communication between each of its parts is identified in less than half of the population ***(Donaldson,).***

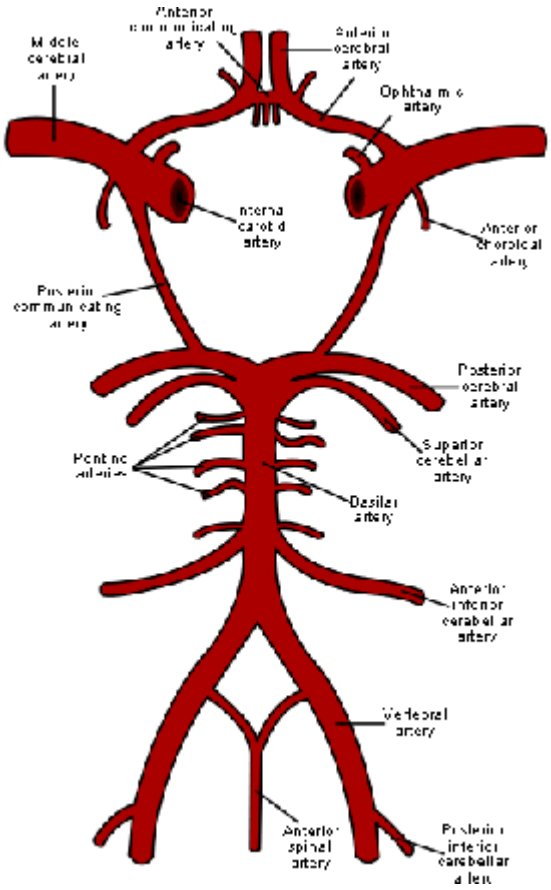

Fig ( ): Circle of Willis (*Choudhari, Sharma, Leyon, . *).