Carotid Artery Stenting (CAS) In Egyptian patients Feasibility, Safety, and Technical Difficulties

Thesis
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Introduction

Percutaneous transluminal angioplasty (PTA) of the carotid artery has in the meanwhile more than a twenty years history. It began in 1977 with animal experiments and was continued in 1979 when a 32 years old female with fibromuscular dysplasia causing symptomatic carotid stenosis was treated for the first time by a balloon angioplasty (Mathias 1977).

In 1981, Mathias reported the first percutaneous transluminal angioplasty for atherosclerotic carotid disease in Germany (Mathias 1981).

In 1989 the first stent PTA of atherosclerotic stenosis of the internal carotid artery was applied. Carotid artery stenting (CAS) is currently being investigated as an alternative treatment to carotid endarterectomy (CEA). The goal of both procedures is identical that is prevention of stroke from extracranial carotid disease. Carotid artery stenting offers a less invasive and a less traumatic means of achieving this goal. It is increasingly evident that results of CAS compares favourably with carotid endarterectomy (Roubin et al 2001)(Theron et al 1996).

The efficacy of carotid artery stenting in preventing stroke is evidently dependant on preventing intraoperative complications. This can be achieved by careful attention to the patient selection and technical details. Additionally, the application of “distal protection devices” designed to capture embolic matter released during the stenting procedure has added an important new dimension to the performance of a safe carotid stenting procedure. (Ohki et al 2001).

Preliminary clinical reports have been encouraging and indicate that these strategies are associated with a low incidence of embolic neurological events, particularly remarkable for the very low incidence of major stroke (Reimers et al 2001).

Aim of the work

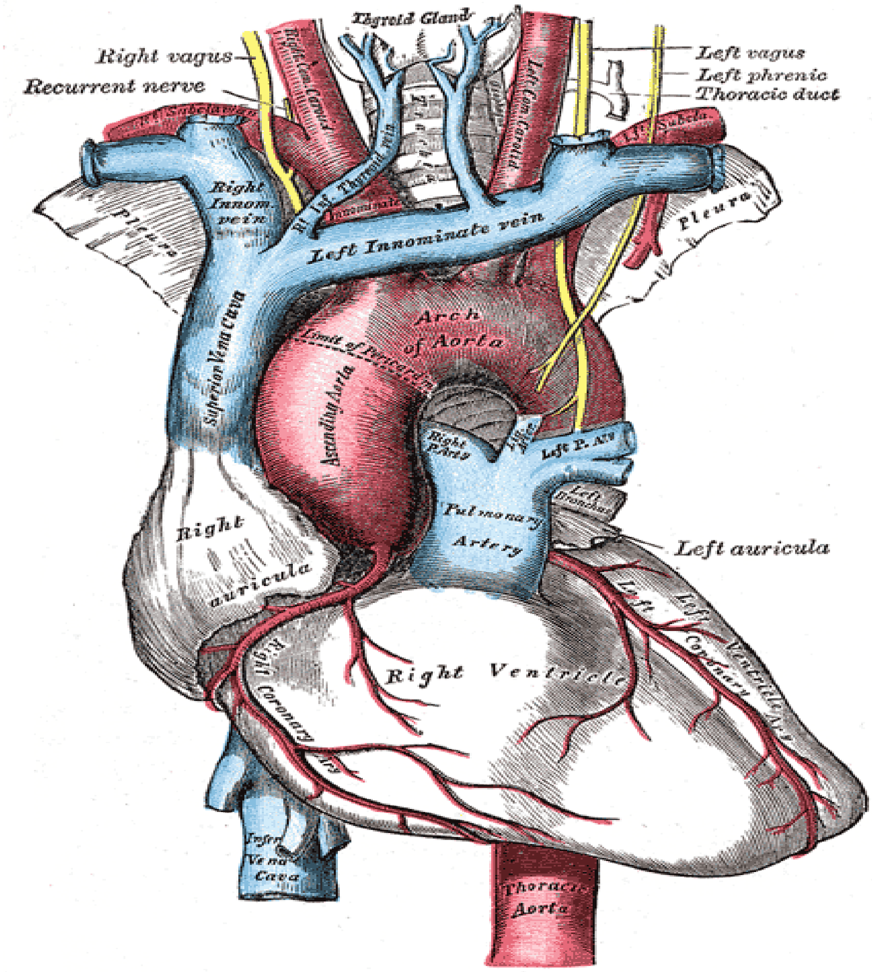
To evaluate carotid artery stenting as a relatively new technique in Egypt that may be suitable for selected group of patients suffering from carotid artery stenosis, with respect to its feasibility and safety to our Egyptian patients, as well as its different potential complications and technical difficulties in hand of vascular surgeons.

Chapter1

Normal Extra and Intracranial Vasculature

The surgical approach of the treatment of cerebrovascular disease requires an understanding of the vascular anatomy that begins with the aortic arch and ends with the principal intracranial arteries.

Aortic arch and its branches



(Coated from Gray 1995)

The normal aortic arch curves smoothly upwards into the superior mediastinum, running from right to left and anterior to posterior, with its apex at approximately the mid-manubrium. It passes to the left of the trachea, arching over the pulmonary artery bifurcation and the left main bronchus, descending to the left of the esophagus. The ligamentum arteriosum, the fibrous remnant of the fetal ductus arteriosus, tethers the concave undersurface of the aortic arch to the proximal left main pulmonary artery, attaching at a point just distal to the left subclavian artery. *(Deutsch 2000)*

In approximately 95% of all individuals, the aortic arch gives rise to three major branches: -the right brachiocephalic trunk (formerly designated the innominate artery), the left common carotid artery, and left subclavian artery. One of the most common variants is a common ostial origin of the brachiocephalic and the left common carotid arteries which occurs in approximately 10% of individuals and has been termed “bovine trunk” because of its occurrence in that animal. However, a few millimeters in length that then divides into the right brachiocephalic and the left common carotid arteries is relatively rare. Originating of the left vertebral artery dividing from the aorta proximal to the left subclavian artery is another common anatomic variant, occurring in approximately 5%of individuals.

True anomalies of the aortic arch are actually rare, present in less than 2% of adults. Anomalies, such as double aortic arch; interrupted arch, right sided arch, especially the mirror image branching form, and cervical arch, are often associated with complex congenital heart disease.

The most common aortic arch anomaly compatible with long term survival is aberrant right subclavian artery that originates from the proximal descending thoracic aorta and passes posterior to the esophagus. Unless this anomaly causes dysphagia in the neonatal period, it may escape detection until the patient is examined angiographically later in life. A diverticulum often accompanies the origin of an aberrant right subclavian artery, called Kommerelli's diverticulum; it becomes aneurysmal, with rupture or compressive symptom. Simple right aortic arches with normal branching, uncomplicated right arches with mirror image branching, and mirror image arches associated with thoracic situs inversus are sufficiently uncommon that many surgeons and angiographers will never actually encounter in their practice.

(Deutsch 2000)

Right brachiocephalic trunk (Innominate artery)

The right brachiocephalic trunk (Innominate artery) is the first major branch of the thoracic aorta and the largest of its branches. It originates in the superior mediastinum posterior to the mid-point of the sternal manubrium and passes superiorly and posteriorly for a distance of 4-6 cm, then bifurcates into the right common carotid and right subclavian arteries in the root of the neck posterior to the right sternoclavicular joint. Whereas the proximal segments of the other major branches of the aortic arch are usually relatively straight, the right brachiocephalic trunk and the proximal segments of the right common carotid and subclavian arteries are often rather tortuous I elderly patients. Such tortuousity, especially when it involves the right subclavian artery at the base of the neck, often can mimic aneurysmal dilatation on physical examination and angiography.*(Snell 1996)*

Subclavian Arteries

The right subclavian artery originates from the right brachiocephalic trunk and arches laterally and posteriorly, passing behind the anterior scalene muscle. The left subclavian artery originates directly from the aorta and is usually its third branch. It ascends vertically within the mediastinum, then arches laterally in the root of the neck, also to pass behind the anterior scalene muscle. Both subclavian arteries passes immediately above the dome of the pleura. The principle branches of the subclavian arteries arise from the segment proximal to the medial border of the anterior scalene muscle and consist of the vertebral, internal mammary, thyrocervical, and costocervical arteries. The vertebral and internal mammary arteries have a very constant relationship, originating directly opposite each other, with vertebral artery arising from the cephalad aspect and the internal mammary artery arising from the anteroinferior aspect. The subclavian arteries then exit from the neck by passing over the superior surface of the first rib posterior to the clavicle, in close relationship to the lower portion of the brachial plexus. After they pass the lateral aspect of the first rib, these vessels are designated the axillary arteries. Although the vertebral artery is the primary subclavian branch that contribute to the cerebral circulation, the other branches become important sources of collateral supply of the vertebral artery stenoses.

(Van de Graffe 2002)

Common Carotid Arteries

The right common carotid artery originates from the right brachiocephalic trunk in the base of the neck, whereas the left common carotid artery originates directly from the aortic arch in the mediastinum. However, the anatomy of the cervical segments is virtually identical on both sides. The common carotid arteries ascends in the neck, running anterior to the transverse processes of the cervical vertebra and separated from them by the anterior scalene, longus coli, and capitus muscles and by the sympathetic trunks. The common carotid artery usually bifurcates into the external and the internal carotid arteries near the superior horn of the thyroid cartilage (at approximately vertebrae C2-C3),although there is considerable variation in the level of this bifurcation. The carotid arteries bifurcate at the same level in only 28% of cases; in 50%, the left bifurcation is higher than the right one, whereas the reverse is present in the remaining 22%. Throughout their cervical course, the common and the internal carotid arteries are enclosed in a fibrous sheath – deemed the carotid sheath, which also encompasses the internal jagular vein and the vagus nerve.*(Crossman & Neary 2000)*

External Carotid Arteries

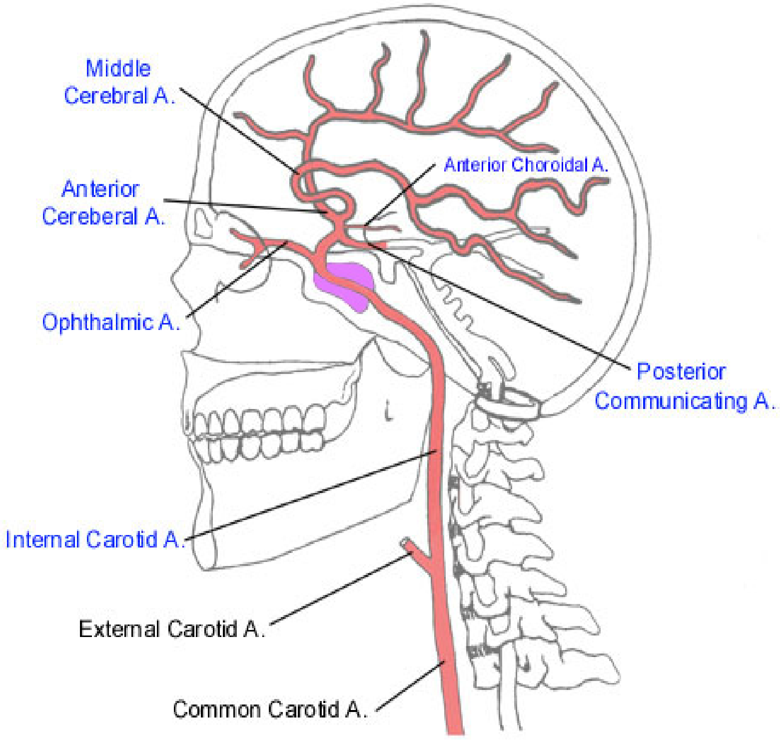
The external carotid artery is usually smaller than the internal carotid artery and originates anterior and medial to it, passing lateral to ascend just posterior to the ramus and neck of the mandible and superficial to the styloid process. It supplies the face, scalp, oronopharynx, skull and meningies through four major branch vessels:

1. anterior branches (superior thyroid, lingual, facial, transverse facial)
2. posterior branches(occipital, and auricular)
3. ascending branches (ascending pharyngeal)
4. Terminal branches (superficial temporal, internal maxillary).

These vessels are of significance to the cerebral circulation in the setting of carotid or vertebral artery occlusive disease, where they can become important sources of collateral blood supply.

One of the most common collateral routes involves distal anastomoses between the pterygopalatine branches of the internal maxillary artery and the ethmoidal branches of the ophthalmic artery system. Other important collateral pathways include anastomoses between orbitonasal branches of the facial artery and orbital branches of the ophthalmic artery, anastomoses between anterior branches of the superficial temporal artery and ethmoidal branches of the ophthalmic artery, and anastomoses between ascending pharyngeal branches of the external carotid artery and muscular branches of the vertebral artery. *(Deutsch 2000)*

Internal Carotid Artery



(Modified from Gratn's atlas of anatomy 1996)

The internal carotid artery is divided into five major segments; carotid bulb, cervical, petrous, cavernous, and cerebral. The *carotid bulb,* literally a focal bulbous dilation, is located at the origin of the internal carotid artery. It is a relatively constant feature, although its shape and size vary considerably among individuals.

The *cervical* segment has no significant branches and ascends in the neck immediately anterior to transverse processes of the cervical vertebrae and their associated muscles. The internal carotid artery than enters skull via the carotid canal, traversing the *petrous* portion of the temporal bone in a slightly medial direction and separated from the middle ear structures by only a thin layer of bone. The petrous also has no major branches although there are minor branches that anastomoses with small ptergopalantine branches of the internal maxillary artery that can become sources of collateral supply in the setting of occlusive disease.

The *cavernous* segment of the internal carotid artery is called the carotid Siphon because of its gentle, S-shaped configuration as it passes through the cavernous sinus along the sella turcica toward the anterior clinoid process. Along its course through the cavernous sinus it often indents the of the sphenoid sinus, sometimes separated from the sinus cavity by only dura and sinus mucosa. Although this segment has several minor branches, the ophthalmic artery is the cavernous segment branch of primary clinical significance since it can become an important collateral route to the intracranial circulation in the setting of extracranial occlusive disease of the internal carotid artery, and because hemodynamic or embolic phenomenon can produce amaurosis fugax. Thus, the ophthalmic artery is the first branch of the internal carotid artery of major clinical importance.

The *cerebral* segment of the internal carotid artery is relatively short. After traversing the dura mater medial to the anterior clinoid process, it passes superolaterally to divide into the anterior and middle cerebral arteries

(Deutsch 2000).

Vertebral Artery

The vertebral artery is the first branch of the subclavian artery. It takes a relatively straight coarse, entering the transverse foramina of C6 – C1. Because the transverse foramen of the atlas is lateral to that of the axis it passes laterally between the axis and the atlas. It then run postromedially along the arch of the atlas laterally to the atlanto-occipital joint. After passing the atlas it turns sharply cephalad to enter the cranium via the foramen magnum. Within the skull, the paired vertebral arteries pass medially along the inferior surface of the brain stem to unite into a single midline vessel, the basilar artery.

Although the carotid arteries are similar size bilaterally, considerable asymmetry is frequent in the vertebral system, even including absence of one vertebral arteries. The left vertebral artery is dominant in approximately 50% of individuals, whereas the right one is dominant in 25%, and they are roughly equal caliber in the remaining 25%. These variations are of little or no clinical significance except in cases of subclavian artery disease proximal to the vertebral origin. A moderate degree of tortuosity and smooth variation in caliber of the intracranial vertebral arteries is common even in young individuals and is also of no clinical significance.

The cervical portion of the vertebral arteries supplies multiple small segmental branches to the spinal cord, cervical vertebra, and adjacent muscles. The anastomotic