Carotid angioplasty and stenting, an alternative to carotid endarterectomy
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Introduction
Carotid angioplasty stenting (CAS) was introduced as an option for treatment of carotid artery disease in early 90's. Purpose of this article to review the evolution of treatment of carotid artery disease and present day application of CAS.

Discussion
CAS is successful in 95-98% of the cases. Peri-procedure (30 days) and short term (4 years) stroke, myocardial complication, death and survival rates are comparable to Carotid Endarterectomy (CEA) in high risk patients. However results of CAS in all patients population and long term outcome yet to be determined. Stroke continues to be third leading cause of death in United States and is amongst top five major cause of death around the world. 50-60% of all strokes are because of extra cranial carotid artery disease and 40-50% of cerebral infract are from carotid bifurcation disease. Since early 70's extensive retrospective analysis as well as rigorous prospective randomized studies been done worldwide regarding carotid endarterectomy and been proven to be not only effective treatment for symptomatic carotid artery disease but also established the fact that carotid endarterectomy results in 50% reduction of stroke in asymptomatic carotid artery disease with >60% stenosis, especially in male. First surgical procedure for extracranial carotid disease was reported by Eastcott, Pickering and Rob in 1954 for hemispheric transient ischemic attack. The initial proposed surgical approach for relief of cerebral dysfunction and prevention of stroke was the excision of the lesion in extra cranial carotid artery. Surgical approach for extracranial carotid artery has evolved and matured to carotid endarterectomy (CEA). CEA is one of the most rewarding and technically satisfying procedure in vascular surgery. CEA has fulfilled the objective of minimizing the operative complications and maximizing the benefit for large group of population with carotid artery disease. CEA has achieved average combined morbidity and mortality of 1-4% for both symptomatic as well as asymptomatic carotid disease. The experience of the institution and operating surgeon, directly influences the rate of morbidity and mortality.

Complications of the procedure can be sub grouped into:

Operative or immediate
1. Acute bleeding
2. Intraoperative embolization resulting stroke
3. Intraoperative nerve injury- vagus, hypoglossal, recurrent and superior laryngeal, sympathetic chain and phrenic nerve
4. Thoracic duct injury

Delayed
1. Hematoma neck causing respiratory compromise
2. Intracranial bleed secondary to reperfusion injury
3. Recurrent stenosis
4. Cardiac and respiratory complication

With tremendous improvement of technology and advancement of techniques of endovascular procedures during last few decades, carotid angioplasty and stenting (CAS) was introduced in early 90's for the management of carotid artery disease. Objective of this approach is to minimize the morbidity and mortality even less than carotid endarterectomy, if not at least match comparatively with CEA. If the procedure is deemed technically successful and clinically
Efficacious, it would even be applicable for the group of patients who otherwise are of significant high risk for CEA. Since CAS is considerably less invasive than CEA, pioneers of the procedure expected and promoted the procedure as good as CEA, perhaps would be superior in terms of morbidity and mortality. In fact initial anecdotal reports suggested CAS has significantly lower rate of stroke and cardiac complications as compared to CEA. During the last decade with wider acceptance of the procedure around the world and across various specialty, CAS has established its clinical applications and as an option for the management of carotid artery disease. There are numerous single and multi centers published reports regarding technical success and clinical outcome of CAS. Over all CAS is successful in 95-98% of the cases. Failure to complete the procedure is primarily because of anatomical configuration of aortic arch and tortuous carotid artery, henceforth, failure to maintain the access for deployment of embolic protection device, advancement of balloon catheter and placement of stent. Multiple published series reported 30 days morbidity and mortality (TIA’s, Stroke, MI and Death) rate ranges from 1.29-4.9% in CAS for symptomatic and asymptomatic carotid disease. Comparatively CEA morbidity and mortality (TIA’s, stroke, MI and death) rate ranges from 1.0-2.6% in symptomatic and asymptomatic carotid artery disease in same reported series. However the difference is statistically non significant. No significant difference was shown in longterm outcome ie stroke, death rate and recurrent stenosis in 4 years between patients who underwent CAS and those who underwent CEA, irrespective of low or increased surgical risk patients, symptomatic or asymptomatic carotid artery disease.

Deployment of embolic protection device (EPD) has become a standard for CAS. The embolic protection devices those are available for use:

A. Distal occlusion device: (PercuSurge GuardWire) has a low profile occlusion balloon at the tip of guide wire. The guide wire is advanced across the lesion then balloon is inflated distally. The occluding balloon diameter ranging from 3-6 mm, provides distal embolic protection. After completion of angioplasty and stenting of carotid artery, an aspiration catheter is advanced over the guide wire up to the occluding balloon. The debris collected against the occluding balloon is aspirated. Subsequently flow is restored by deflating the balloon. The occluding balloon itself can cause distal ischemia, depending on the occlusion time as well as patient condition, particularly the collateral circulation. The device preparation is some what cumbersome and also cause significant limitation of adequate angiographic visualization of carotid artery while balloon is inflated, thus making assessment of the artery and placement of stent more difficult.

B. Filters: (Accunet, AngioGuard, MedNova NeuroShield, FilterWire EX and SipderWire) Filters are made of thin porous polymeric membrane capable of trapping embolic debris as small as 80 micromillimeter, supported by fine Nitonol metal skeleton of various configurations with diameter ranging 4-10mm. After crossing the lesion and reaching the distal internal carotid artery the filter is deployed, preferably in straight segment of distal internal carotid artery. During manipulation of balloon and stent the embolic debris is captured in the filter and at the end of the procedure the filter is collapsed into a retrieving catheter and the entire device is withdrawn with entrapped embolic debris. Filter devices are easy to prepare for deployment, has good visibility during the procedure. Unlike occlusion devices, the angiographic visualization of the lesion and stent is much easier with filter device since antegrade flow in the carotid artery is maintained. All of the filter device has nice crossing profile. However filter potentially can cause intimal damage at the site of deployment due to the vigorous movement of it during the procedure. Some of the filter can be potentially difficult in crossing the deployed stent during filter withdrawal because of fairly stiff retrieval pod and tortuous carotid artery.
C. Proximal suction device: (Parodi Anti-Embolic System, MO. MA) These are guiding catheter with a balloon at the distal end of the catheter. After the guiding catheter tip is advanced in common carotid artery proximal to the carotid targeted lesion, the balloon is inflated. External carotid artery is also occluded with a second balloon to cease reversal flow into internal carotid artery. Complete reversal flow is established in internal carotid artery with a mechanical device attached to guiding catheter. Suctioned blood volume is then infused back through a venous port. This technique allows protection before the lesion is manipulated and the risk of embolization is practically eliminated. The devices are bulky, there is potential for damage at the balloon inflation site and some time becomes difficult to advance the device to the desired site, importantly because of tortuous artery.

Several series has reported significant reduction of TIA'S and stroke rate with the use of EPD, however there is no prospective and randomized studies yet to show the use of EPD has significantly reduced the rate of TIA'S and stroke with CAS procedure. One comparative study indicated use of EPD resulted higher incidence of lesions on magnetic weighted lesions as compared to CAS without EPD. These lesions however were not clinically significant to cause any cerebral ischemic events. Increased MRI lesions were felt to be secondary to extra manipulation necessary to advance EPD across the carotid artery stenosis.

At present in United States CAS is approved for certain clinical scenario with significant carotid artery disease:

A. Patients with high risk for CEA and has symptomatic carotid stenosis >50%

B. Patients with high risk for CEA and has asymptomatic carotid stenosis >80%

Clinical conditions that qualify the patients as high surgical risk are:

1. Age at or above 80 years
2. Clinical significant cardiac diseases (CHF, NYHA class III or IV, Unstable angina & need for CABG, Recent myocardial infarction and ejection fraction <30%)
3. High grade recurrent carotid stenosis
4. High cervical carotid artery lesion
5. Contra lateral carotid artery occlusion
6. End stage renal failure
7. Severe chronic obstructive pulmonary disease
8. History of tracheostomy
9. Contra lateral laryngeal nerve palsy
10. History of previous neck radiation

CAS is increasingly performed because of presumed benefits of reducing peri-procedure complications and decreasing the hospital stay. At present CAS is at best non inferior to CEA in terms of clinical outcome and hospital stay. Procedural cost of CAS is significantly higher than those with CEA, mainly as result of high material (guide wire, catheters, balloon, stent and EPD device) cost.

Conclusion
CAS can be successfully performed in 95-98% of the cases and is accepted as an alternative option of treatment for carotid artery disease, especially in high risk surgical patients. Efficacy and outcome of CAS is comparable to CEA in high risk patients. CAS has not been proven yet as an option in low risk surgical patients with carotid artery disease. Long term results of CAS are yet to be determined especially since procedure is been widely accepted as an alternative to CEA only for few years. However multiple CAS studies are ongoing and are in various stage of study to assess the long term efficacy and the results.

References