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Oh No! Both Arteries in My Neck Are Blocked! Now What?

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Stem Case and Key Questions Content

A 68 year old male who had a transient ischemic attack (TIA) involving his face, 48 hours ago, is scheduled for left carotid endarterectomy (CEA). He is 5'11" and weighs 110 Kgs. He has history of hypertension for the last 22 years and is on lisinopril. He smoked a pack per day since he was a teenager. He is a non-insulin dependent diabetic on metformin. He has 99% stenosis on the left side and 70% stenosis on the right side. He is allergic to penicillin. His vital signs: blood pressure (BP) 188/106 (left arm), pulse 94, oxygen saturation 92% with room air.

1. What are the risk factors for carotid artery disease in this patient? What is the pathophysiology of carotid artery stenosis?

2. What is the carotid sheath? What are the contents of the carotid sheath? What cranial nerves are in close relationship to the carotid sheath? What is the location of the carotid body and the carotid sinus? What is the normal role of the carotid sinus and the carotid body? What is their significance in relation to CEA?

3. How would you evaluate this patient preoperatively? How would you assess the severity of carotid stenosis? What imaging studies should be done prior to surgery?

4. When should this patient be scheduled for surgery? Early or late? What are the risk factors for perioperative stroke? Patient's BP is 188/106. How would you manage the blood pressure? What is your target? What is the role of preoperative aspirin/clopidogrel and anticoagulants? What is the role of statin therapy? Patient's blood sugar is 230 mg/dl. How would you manage his blood sugar? What is your target?

5. What is the role of CEA in carotid artery stenosis in a patient with prior TIA? What is the role of CEA in a patient with more than 70% stenosis without TIA? What is the role of CEA in a symptomatic/asymptomatic patient with 60% stenosis? What is the preferred management in a symptomatic patient with less than 50% stenosis?

6. What is the role of carotid artery stent (CAS) in the management of carotid artery disease? What are the advantages and disadvantages over CEA?

7. This patient says that he cannot walk more than a block without taking rest. What are the possible causes? How would you assess his respiratory status? How would you evaluate his cardiac status? Further cardiac evaluation reveals three vessel coronary artery disease and the

patient is scheduled for coronary artery bypass graft (CABG). When should the CEA be scheduled? Prior to CABG or as a synchronous procedure with CABG?

8. Surgeon requests regional anesthesia. What technique you would like to use? How would you perform regional technique? What are the possible complications of regional anesthesia? What are the advantages of regional anesthesia over general anesthesia?

9. Patient refuses regional anesthesia and requests general anesthesia. What are your anesthetic goals? What monitors would you like to use? What neuromonitors are used for CEA? Which neuromonitor do you prefer? Why? How would you induce? How would you maintain anesthesia? Would you prefer inhalational anesthesia or total intravenous anesthesia? Why?

10. What are the different types of CEA surgical techniques? What is the advantage of CEA with patch angioplasty over primary closure? What is the advantage of vein patch graft over synthetic patch graft? What is eversion CEA? What are its advantages and disadvantages over conventional CEA?

11. Surgeon gives you a five minute warning for cross clamping. What preparation would you make? Surgeon applies a cross clamp and stump pressure is 40 mm/Hg. What would you do? Surgeon plans for insertion of a shunt. What are the advantages of shunting? What are the disadvantages of a shunt? What is the role of selective shunting?

12. During the procedure heart rate drops down to 40/min and BP to 80 mm/Hg. systolic. What is the likely cause? How would you manage? What should be done to prevent such an event? Surgeon releases the cross clamp. How would you manage patient's blood pressure? Surgery completed. Would you extubate this patient?

13. What postoperative complications would you anticipate in PACU? Patient's BP is 160/98, how would you manage patient's blood pressure? What is your target? What is cerebral hyperperfusion syndrome (CHS)? What is its etiology? What is the pathophysiology of CHS? What is its incidence? What nerve injuries are likely to occur following CEA? What are its implications to anesthesiologist in PACU?

14. Two hours later in PACU patient complains of breathing difficulty. What is the likely cause? Neck appears to be swollen. What would you do? Patient requires re-exploration of the neck. How would do you manage the airway?

Model Discussion Content

Stroke is the second most common cause of mortality in the world and it is the fourth most common cause of death in the US. Carotid artery stenosis accounts for 10-20% of strokes.[1] The most common site of stenosis is the bifurcation of common carotid artery and atherosclerosis is the most common etiology. Smoking, diabetes, hypertension, hyperlipidemia are the risk factors for the development of carotid artery disease.[2] Coronary artery disease and peripheral vascular disease are frequently associated with carotid artery stenosis.[2] Carotid endarterectomy (CEA) is a preventive surgical procedure to prevent further strokes. Perioperative myocardial infarction (MI) is the leading cause of morbidity and mortality in patients presenting for CEA.

Anatomy and Physiology: The right common carotid artery is the branch of brachiocephalic artery which is the first branch of arch of the aorta. The left common carotid artery arises from the arch of the aorta. The common carotid artery bifurcates into external carotid and internal carotid artery (ICA). The common carotid artery and the ICA are enclosed in a fibrous sheath called the carotid sheath, which also contains internal jugular vein. The Vagus nerve is also within the sheath and lies posteriorly between the artery and the vein. In upper part of neck the carotid sheath also contains hypoglossal, glossopharyngeal and accessory nerves. The carotid sinus is a dilatation at the origin of the ICA. The carotid sinus contains baroreceptors which are involved in maintaining the normal blood pressure. Hypertension stimulates the baroreceptors. The afferent pathway is through the glossopharyngeal nerve and the efferent pathway is through the vagus nerve resulting in bradycardia and hypotension. Carotid sinus stimulation can occur during CEA. The carotid body is located at the bifurcation of common carotid artery which is a highly vascular structure and contains chemoreceptors which are responsible for the hypoxic drive of respiration.

Clinical presentation and assessment of severity of carotid stenosis: The patient may remain asymptomatic and may be identified by the presence of a bruit which warrants further evaluation. Auscultation of a carotid bruit has high specificity and negative predictive value for the presence of carotid artery stenosis; however it has a lower sensitivity and poor positive predictive value for the presence of carotid artery stenosis.[3] Symptomatic patients may present with hemispheric or retinal TIA or stroke. Carotid stenosis should be initially evaluated with duplex ultrasound; further evaluation should be carried out using magnetic resonance angiography, CT angiography or catheter angiography. The measurement of the degree of stenosis is essential because it directs the treating physician in deciding between medical or surgical management. The choice between surgical intervention and medical management is based on current evidence and recommendations from the American Stroke Association (ASA) of the American Heart Association (AHA) and other societies.

Surgery Vs. Medical Management: High quality randomized trials have identified the role of CEA in the management of symptomatic and asymptomatic carotid artery stenosis.

Asymptomatic carotid stenosis: The data from **A**symptomatic **C**arotid **A**rtery **S**tenosis (ACAS) trial, a multicenter trial involving 1662 patients and 39 centers, conducted between 1987-93 reported the benefit of CEA with aspirin compared to aspirin alone in asymptomatic patients over 60% stenosis at the end of 5 years. The risk of ipsilateral stroke or death was 5.1% in surgical patients compared to 11% in medically managed patients. The combined perioperative risk of stroke or death in this trial was 3.0%.[4] Another multicenter trial, Veterans Affairs (VA trial) with 344 patients confirmed a similar benefit.[5] However another multicenter trial, the CASSANOVA (**C**arotid **A**rtery **S**tenosis with **A**symptomatic Narrowing; **O**peration vs. **A**spirin) study did not find the benefit of CEA over medical management in asymptomatic patients with 50%-90% stenosis.[6] Patients with stenosis greater than 90% were excluded from the trial. Later a large European multicenter trial, **A**symptomatic **C**arotid **S**urgery **T**rial (ACST-1), conducted between 1993-2003; involving 3120 asymptomatic patients with over 60% stenosis from 126 centers in 30 countries reported the benefit of combined medical therapy and CEA to medical therapy alone. The Surgical group had a lower stroke risk compared to the medical management group at the end of 5 years (4.1% vs. 10.0%) and at the end of 10 years this risk was 10.8% and 16.9% respectively. The perioperative risk of stroke or death in this trial was

3.0%.[7]

Symptomatic carotid artery stenosis: The **N**orth **A**merican **S**ymptomatic **C**arotid **E**ndarterectomy **T**rial (NASCET) comprising 1415 patients proved the benefit of CEA over medical management in symptomatic patients who had greater than 70% stenosis.[8] Another multicenter **E**uropean **C**arotid **S**urgery **T**rial (ECST) conducted between 1981-1994 involving 3024 patients, also reported that CEA is beneficial in symptomatic patients with greater than 80% stenosis, these benefits were maintained at the end of 10 years of follow up.[9] The results of NASCET and ECST trials showed only a moderate stroke reduction rate for symptomatic carotid artery disease with moderate stenosis (50-69% stenosis).[8,9] In 2011, based on the above said evidence the ASA of the AHA in collaboration with other societies, recommended CEA for symptomatic patients with stenosis greater than 70% by noninvasive technique or 50% stenosis by catheter angiography provided the periprocedural stroke and death rate is less than 6%. It recommended CEA for symptomatic patients with moderate stenosis (50%-69%) in selected group of patients considering age, life expectancy and other comorbidities. Patients with less than 50% stenosis should be managed with medical therapy alone. CEA should be considered for asymptomatic patients with more than 70% stenosis provided the periprocedural risk of stroke and death rate is less than 3%.

Carotid endarterectomy (CEA) vs. Carotid artery stenting (CAS): The **C**arotid **R**evascularization **E**ndarterectomy vs. **S**tenting **T**rial (CREST) a randomized multicenter trial (n=2502) did not find the difference in primary outcome of combined death rate, stroke and MI at the end of 4 years (7.2% to 6.8%).[10] The periprocedural stroke rate was higher with the stenting group (4.1%) compared to the endarterectomy group (2.3%). However the MI rate was higher in CEA group. Beyond this period the incidence of stroke rate was similar in each group (2.0% and 2.4%). The periprocedural risk was higher for patients above 70 years and in symptomatic patients.[10] The ICSS (**I**nternational **C**arotid **S**tenting **S**tudy), a multicenter trial involving 1713 patients with recent symptomatic carotid stenosis found that the 120 day combined stroke, death and MI rate was higher with CAS group than CEA group (8.5%to 5.2%) and at the end of 5 years this rate was 9.2% to 5.8% respectively.[11] However, other multicenter trials, **S**tent-**P**rotected **A**ngioplasty versus **C**arotid **E**ndarterectomy (SPACE, n=1214) trial, **S**tenting and **A**ngioplasty with **P**rotection in **P**atients at **H**igh **R**isk for **E**ndarterectomy (SAPPHIRE, n=334), **E**ndarterectomy **V**ersus **A**ngioplasty in patients with symptomatic severe carotid stenosis (EVA-3S, n=527) trial, did not find a statistically significant difference in the combined risk of stroke and death between carotid stenting and CEA, at the end of two, three and four years. A systemic review in 2009, comprising 206 studies published between 1990 and 2008, involving 54713 patients who had CAS procedure, reported the overall 30 day risk of stroke and mortality as 4.7%.[12] Such risk was increased by two fold in symptomatic patients compared to asymptomatic patients. This review revealed this risk at 7.6% in symptomatic patients and 3.5 % in asymptomatic patients. However the risk of MI, wound hematoma and cranial nerve injuries were lower in CAS according to an analysis of data from the CREST trial.[13] Another meta-analysis of randomized trials reported a favorable 30 day risk of stroke and death rate for CEA compared to CAS.[14] Such risk is increased in patients over the age of 80 years who had CAS procedure. In 2011, based on the current evidence the ASA of the AHA along with other societies recommended CAS as an alternative technique to CEA provided the operator had a periprocedural morbidity and mortality rate less than 6%. CEA is preferable over CAS in older patients and in patients with unfavorable anatomy for surgery**.**

Early vs. late intervention: In the past surgery was delayed for a month to reduce the risk of periprocedural complications. The data from a systemic review did not find an increased operative risk in patients who had TIA or mini stroke and were neurologically stable.[15] The authors reported that surgery can be done safely in the first week. Stroke in evolution or crescendo TIA increased the risk of stroke in this series.[15] A pooled analysis of data from NASCET and ECST-1 trials showed that surgery can be performed safely within two weeks in a symptomatic patient following the TIA.[16] An analysis of data from a Swedish registry of 2596 patients revealed that the periprocedural complications of mortality and stroke rate were higher when CEA was undertaken within 48 hours. This data showed that CEA can be done safely in the first week beyond this period.[17] The statement from the ASA of the AHA along with othersocieties in the US recommends early intervention within 2 weeks.

Periprocedural risk factors for stroke and mortality: The risk of stroke is increased in patients with neurological symptoms, ulcerated plaque morphology, smoking, hyperglycemia, hypertension and contralateral stenosis.
Symptomatic patients: The combined risk of stroke and death was higher (6-7%) in symptomatic carotid artery stenosis trials for more than 70% stenosis (NASCEST and ECST) compared to asymptomatic carotid artery stenosis trials (ACAS and ECST-1). In the asymptomatic trials this rate was 3% for similar degree of stenosis.[4,7,8,9]
Hyperglycemia: Diabetic patients have other co-morbidities and the risk of stroke is not increased in well controlled diabetic patients.[18] However perioperative hyperglycemia increases the risk.[19]
Contralateral stenosis: A most recent systemic review with 27,265 patients(28,846 CEA's) with 3120 contralateral carotid occlusion found an increased risk of perioperative stroke in patients with contralateral stenosis.[20] Another prospective study from the UK and Ireland with 700 patients,108 with contralateral stenosis reported that the incidence of combined risk of stroke and death in patients with contralateral stenosis was doubled.[21] However a systemic review involving 2420 patients with 338 contralateral occlusion found an increased incidence of periprocedural stroke only in symptomatic patients.[22]
Hypertension: Elevated blood pressure (BP) increases the risk of perioperative stroke in symptomatic patients as per the analysis of data from the NASCET, ECST and the United Kingdom Transient Ischemic Attack (TIA) trial.[23]
Retinal vs. hemispheric TIA: The risk of stroke is increased in patients with high grade stenosis who had first ever retinal TIA (amarousis fugax, mono-ocular blindness) compared to patients who had hemispheric TIA as per the subset analysis of data from the ACST-1 trial.[24] The data also revealed that the patients who had retinal TIA has better outcome than those who had hemispheric TIA.*Plaque ulceration*: An analysis of data of plaque morphology from 241 patients from NASCET and ACAS trial showed that patients with ulcerated plaques had a higher incidence of perioperative stroke.[25]

Preoperative preparation: Patients should be started on aspirin and dipyridamole. Clopidogrel increases the incidence of perioperative bleeding and should be avoided in the preoperative period. However clopidogrel is beneficial in patients with coronary artery disease who are allergic to aspirin as an antiplatelet agent. Elevated BP should be reduced, but there is no data to suggest a target BP, however 140/90 is a commonly accepted target. BP reduction should be gradual in patients with contralateral stenosis. Patient should be advised to cease smoking and hyperglycemia should be controlled. Perioperative statin therapy is shown to reduce the

incidence of perioperative stroke in symptomatic patients.[26]

CEA and Coronary Artery Bypass Graft (CABG), staged vs. synchronous procedure? : In patients who require CABG, CEA can be done as a staged procedure prior to CABG or as synchronous procedure. An analysis of nationwide in patient sample (NIS) database between 1998-2007 did not find any significant difference in mortality or stroke rates between the two groups.[27] However patients who underwent on pump CABG had a higher stroke rate in synchronous group. Out of 22,792 procedures 28.9% underwent CEA as a staged procedure in this analysis.

General(GA) vs. regional anesthesia: A retrospective analysis of data on elective CEA from 2005- 2009, from the American College of Surgeons National Surgical Quality Improvement Program, determined that regional anesthesia was used for 15.4% of the cases.[28] Surgical anesthesia for C2-C4 dermatomal level is needed for CEA. Combined superficial and deep cervical plexus block is the most commonly used technique. Deep cervical plexus block can be done as a single injection at C3 transverse process or alternatively C2, C3 and C4 nerve roots can be blocked separately.[29] Additional local infiltration can be by the surgeon as needed. Supplemental local infiltration at the angle of the jaw will reduce pain and discomfort from the retractors.[29] There is insufficient data to show the benefit of routine infiltration of local anesthetic into the carotid sheath to block carotid sinus reflex.[30] Such infiltration results in increased incidence of perioperative hypertension due to the blockade of carotid sinus nerve, a branch of glossopharyngeal nerve. The possible complications of deep cervical plexus block are hoarseness of voice from recurrent laryngeal nerve block, stellate ganglion block, dysphagia, intravascular injection, Horner's syndrome, phrenic nerve block and neck hematoma.[29] The GALA (**G**eneral **A**nesthesia vs. **L**ocal **A**nesthesia for carotid endarterectomy) trial, a large multicenter trial (95 centers, 34 countries involving 3526 patients) did not find a difference between GA or regional anesthesia for CEA in terms of 30 day stroke/MI/ death rate.[31] However post-operative wound hemorrhage was lower in regional anesthesia group. A subsequent Cochrane database review of 10 randomized trials involving 4335 patients, showed no difference in 30 day stroke or death between GA and regional groups.[32] In this review GALA trial alone had 3526 patients. However regional anesthesia results in an awake patient and enables the surgeon and anesthesiologist to monitor the neurological status of the patient. However the advantage in terms of neurological outcome of such monitoring is not proven. Moreover inadequate anesthesia may result in conversion to general anesthesia.

General anesthesia*: Intravenous versus inhalational anesthesia?* *:* Limited data is available over the superiority of one technique over another. Neurological recovery is found to be similar in intravenous or inhalational technique; the use of remifentanil does not make a difference compared to fentanyl.[33]

Monitoring: Along with standard monitoring, invasive arterial blood pressure monitoring is essential. The critical periods are induction, intubation, cross clamping, unclamping, emergence and extubation. The hypertensive and hypotensive episodes during these periods should be avoided.

Neuromonitoring: The advantage of one technique over another is not proven in terms of stroke reduction and neurological outcome. The commonly employed techniques are an awake patient, carotid stump pressure measurement, SSEP, EEG, cerebral oximetry and transcranial

doppler (TCD) monitoring. The role of vagus nerve monitoring to prevent nerve injuries needs to be studied in a large randomized trial. The TCD has an added advantage of monitoring the embolic load which is the primary cause of stroke during CEA.

Shunting vs. no shunt vs. selective shunting: A systemic review of the studies published between 1990-2010 showed that routine shunting or selective shunting is associated with lower rate of stroke compared to no shunt.[34] The authors reported stroke rate of 1.4% with routine shunting and CEA without shunt had a stroke rate of 2%. The periprocedural stroke rate with selective shunting varied between the neuromonitoring techniques. This rate was 1.6% for EEG, 4.8% for TCD 1.6% for carotid stump pressure, 1.8% for SSEP and 1.1% for awake patients with cervical block anesthesia. A Cochrane database review in 2009 did identify statistically significant benefit from the use of routine shunt or selective shunting during CEA.[35] Large randomized trials are required to address the question of routine shunting or selective shunting.

Perioperative blood pressure (BP) management: The BP is likely to be labile during CEA. During cross clamping BP is likely to increase and hypertension is likely to resolve during unclamping or with the use of selective shunting. The risk factors for labile perioperative hypertension are contralateral carotid stenosis, inadequately controlled hypertension, recent cerebral ischemic event, eversion endarterectomy, carotid sheath infiltration and resection of carotid sinus nerve during surgery. It is a common practice to elevate the BP during carotid cross clamp.[36] BP augmentation may result in adverse cardiac and cerebral events. A retrospective analysis showed that BP augmentation is associated with less incidence of postoperative cognitive deficits.

Surgical technique: Primary closure vs. patch graft: Artery is exposed in the neck through a longitudinal incision, cross clamp is applied above and below the stenotic plaque and atheroma is removed via a longitudinal incision. The methods of closure include either a primary closure or a patch angioplasty using a vein graft or a synthetic graft. The primary closure is associated with higher incidence of carotid thrombosis, ipsilateral stroke and late restenosis rate. There is no significant difference in outcome with regard to carotid thrombosis, ipsilateral stroke or late stenosis between synthetic graft and vein graft patch angioplasty.

Eversion CEA: An oblique transection of the ICA is made at the origin of the ICA, plaque removed through eversion and re-implantation of ICA is made into the carotid bulb. Eversion CEA is associatedwith increased periprocedural stroke rate and 30 day mortality as per the data analysis from SPACE-1 trial.[37]

Postoperative complications: Hypertension*:* Hypertension is more frequently seen than hypotension. Hypotension is due to the over distention of carotid sinus following the removal of atheroma. Postoperative hypertension is likely to increase the incidence of wound hematoma and may increase the incidence of cerebral hyperperfusion syndrome (CHP).

Wound hematoma: The NASCET trial reported the overall incidence as 5.5%. A single center retrospective analysis of 3,225 CEA's over a period of 10 years reported the incidence of neck hematoma requiring exploration of the neck as 1.4%.[39] Neck hematoma and edema may distort the airway and glottic area. Decompression by opening the neck incision may aid better visualization of the glottic area during re-intubation.[38]

Cerebral hyperperfusion syndrome (CHP): CHP can occur immediately following surgery or up to a month after surgery, but the usual time duration is 5 days. The incidence varies from 0.75-3%.[39] The etiology is multifactorial including hypertension, hyperperfusion, impaired cerebral autoregulation, and ischemia reperfusion injury secondary to oxygen free radicals and complement activation. The role of hypertension as an etiology of cerebral CHP is controversial and CHP may occur without hyperperfusion. Contralateral CEA done within three months is identified as a risk factor for CHP. This syndrome is associated with increased capillary permeability, impaired blood brain barrier resulting in cerebral edema and intracerebral hemorrhage. Depending upon the severity CHP may present as headache, focal neurological signs, convulsions, drowsiness and loss of consciousness.[39]

Nerve injuries: The risk of nerve injury following CEA is 5.1% and the incidence of persistent cranial nerve injury beyond the hospital discharge as per the ECST study is 3.7%.[40] In this series out of 1739 patients, 27 hypoglossal, 17 marginal mandibular, 17 recurrent laryngeal nerve, one accessory nerve injury and three Horner syndrome cases were reported.

Conclusion: CEA is a high risk procedure aimed at reducing future embolic strokes. Regional anesthesia is not proven superior to general anesthesia in terms of neurological outcome. CAS has higher risk than CEA in elderly and symptomatic patients and CEA is preferred over CAS in these patients.

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