55 Carotid Endarterectomy

Pathophysiology and Management of Perioperative Complications

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1. A 66-year-old male, with past medical history of transient ischemic attack, coronary artery disease (CAD), hypertension and diabetes, presents for carotid endarterectomy (CEA). Which of the following statements regarding perioperative BP management is TRUE?

A. Preoperative high blood pressure should be aggressively lowered to a "normal" level before induction of anesthesia

B. BP augmentation during carotid cross-clamping will not pose cardiac risk to a patient

C. Regional anesthesia (RA) may help avoid empirical BP augmentation during CEA

D. BP augmentation should be continued in PACU to prevent cerebral ischemia
A. Preoperative high blood pressure should be aggressively lowered to a "normal" level before induction of anesthesia

- This is a FALSE statement.

- In the setting of chronic cerebral ischemia, cerebral blood flow (CBF) is largely dependent on cerebral perfusion pressure (CPP). In a patient who has chronic hypertension, both the upper and the lower limits of autoregulation are shifted to higher level of pressure. It is crucial to avoid a significant drop in BP from a patient’s baseline in order to prevent cerebral hypoperfusion, especially in the absence of signs of cerebral hemorrhage or myocardial ischemia.

B. BP augmentation during carotid cross-clamping will not pose cardiac risk to a patient

- This is a FALSE statement.

- Evidences suggest that this practice may be associated with an increased risk of perioperative myocardial ischemia. Myocardial infarction is reported as the major cause of mortality after CEA. Co-existing CAD is common in patients undergoing CEA, which renders a patient susceptible to myocardial ischemia in the setting of BP augmentation during carotid cross-clamping.

C. Regional anesthesia (RA) may help avoid empirical BP augmentation during CEA

- This is a TRUE statement.

- An awake patient under RA represents the most sensitive and reliable neurologic monitoring during CEA to assess the adequacy of cerebral perfusion. Empirical or prophylactic BP augmentation could be avoided (in the absence of new/worsening neurologic deficits), which may help decrease the risk of myocardial ischemia, cerebral hemorrhage and brain edema.
D. BP augmentation should be continued in PACU to prevent cerebral ischemia

- This is a FALSE statement.
- After a successful CEA, ipsilateral cerebral perfusion is significantly improved. The practice of BP augmentation is usually unnecessary. Postoperative profound hypertension should be avoided for the fear of cerebral hyperperfusion syndrome, myocardial ischemia and wound hematoma.

2. Electroencephalogram (EEG) was used for neuromonitoring during carotid endarterectomy. Ischemic EEG changes were noted during carotid artery test clamping. The surgeon decided to place a shunt. Which of the following statements regarding shunt placement is **TRUE**?

A. Shunt placement will decrease the carotid cross-clamping time

B. Shunt placement reliably decreases the risk of ischemic stroke

C. Regional anesthesia precludes the need for shunt placement

D. After a shunt is appropriately placed, BP augmentation may pose cerebrovascular risk to a patient
A. Shunt placement will decrease the carotid cross-clamping time

- This is a FALSE statement.

- Shunt placement may increase cross-clamping time because of impaired surgical access to the carotid artery. In addition, this procedure is associated with some other risks including (1) an embolism-related stroke from dislodgement and embolization of atheroma from the carotid artery wall, (2) carotid artery injury, (3) shunt malfunction (e.g. kinking of the shunt, shunt occlusion against the side of the vessel wall), and (4) risk of air embolism.

B. Shunt placement reliably decreases the risk of ischemic stroke

- This is a FALSE statement.

- Shunt placement is beneficial only if the cause of cerebral ischemia is inadequate cerebral blood flow (e.g. carotid stenosis). However, studies suggest that new neurologic deficits developed during CEA are more commonly caused by thromboembolic events.

- In addition, the procedure of placing a shunt may lead to an embolism-related stroke. In the presence of shunt malfunction, a patient will be at a significant risk of ischemic stroke.

C. Regional anesthesia precludes the need for shunt placement

- This is a FALSE statement.

- Regional anesthesia (RA) does not preclude the need for shunt placement. The main advantage of RA is that an awake patient represents the most sensitive and reliable neurologic monitoring during CEA to assess the adequacy of cerebral perfusion and the need for shunt placement. If any new or worsening neurologic deficit develops during carotid test clamping in an awake patient, a shunt may be placed to maintain antegrade cerebral blood flow.
D. After a shunt is appropriately placed, BP augmentation may pose cerebrovascular risk to a patient

- This is a TRUE statement.

- During carotid cross-clamping, a patient's BP is commonly maintained at the high normal range or 20% above baseline BP to facilitate collateral perfusion from the circle of Willis.

- Once a shunt is appropriately placed, the antegrade cerebral blood flow to the ipsilateral brain area would be significantly improved. BP augmentation, especially profound hypertension should be avoided to prevent cerebral hemorrhage and brain edema.
3. Which of the following statements regarding the impact of carotid endarterectomy (CEA) on carotid receptor is TRUE?

A. Sudden bradycardia during surgical manipulation of the carotid sinus is a result of direct stimulation of the vagus nerve

B. Local anesthetic infiltration of the carotid sinus may lead to undesired hemodynamic changes

C. Post-CEA carotid body denervation will not cause respiratory depression

D. Post-CEA carotid sinus “hypersensitivity” following removal of atheromatous plaques may contribute to hypertension in PACU
A. Sudden bradycardia during surgical manipulation of the carotid sinus is a result of direct stimulation of the vagus nerve

- This is a FALSE statement.
- The stretch of the carotid sinus during surgical manipulation is sensed by carotid sinus baroreceptors. The nerve signals are then transmitted to brain stem through the glossopharyngeal nerve (afferent limb). The vagus nerve is at the efferent limb of the carotid sinus baroreceptor reflex, transmitting the nerve signals (increased parasympathetic tone) from brain stem to the heart to regulate (decrease) the heart rate.
B. Local anesthetic infiltration of the carotid sinus may lead to undesired hemodynamic changes

- This is a TRUE statement.

- In order to prevent profound bradycardia or heart block during surgical manipulation of the carotid sinus, some surgeons infiltrate the area of carotid sinus with local anesthetics (lidocaine). As a result of a blunted carotid sinus baroreceptor reflex, hypertension and tachycardia may develop during or after CEA, secondary to altered sympathetic and parasympathetic tone.

C. Post-CEA carotid body denervation will not cause respiratory depression

- This is a FALSE statement.

- Carotid body denervation may occur after CEA and impairs the circulatory and ventilatory responses to hypoxemia and increased resting PaCO2. Unilateral loss of carotid body function is rarely of clinical significance. In patients with bilateral denervation of carotid body chemoreceptors, special attention must be directed toward preventing hypoxemia or hypercapnia resulting from pharmacological (e.g. narcotics) or cardiopulmonary (e.g. atelectasis) causes, since serious respiratory depression may occur.

D. Post-CEA carotid sinus “hypersensitivity” following removal of atheromatous plaques may contribute to hypertension in PACU

- This is a FALSE statement.

- If the carotid sinus nerve is spared during CEA, carotid sinus baroreceptors will be able to perceive BP oscillations more clearly following removal of atheromatous plaques, which may lead to carotid sinus hypersensitivity and contributes to postoperative hypotension (as a result of increased vagal tone and decreased sympathetic outflow).

4. The following complications are the result of ischemic cerebrovascular changes secondary to advanced carotid stenosis **EXCEPT:**

A. Cerebral hyperperfusion syndrome in the setting of postoperative hypertension

B. Worsening focal cerebral ischemia in the setting of intraoperative hypercapnia

C. Bradycardia in the setting of surgical manipulation of the carotid sinus

D. Stroke in the setting of hypotension during carotid cross-clamping
A. Cerebral hyperperfusion syndrome in the setting of postoperative hypertension

- This is an INCORRECT answer.

- The regional cerebral vessels have lost their ability to autoregulate due to the maximal vasodilation as a result of chronic ischemia. Cerebral hyperperfusion syndrome is thought to result from an abrupt increase in blood flow, after surgical reperfusion, in the chronically ischemic brain area where autoregulation is lost. A patient may experience seizure, focal neurologic deficits, headache, brain edema, and cerebral hemorrhage. Patients with uncontrolled hypertension are believed to be at increased risk for this syndrome.

B. Worsening focal cerebral ischemia in the setting of intraoperative hypercapnia

- This is an INCORRECT answer.

- In the presence of hypercapnia, cerebral blood flow may be diverted from ischemic brain area (with maximal vasodilation, thus no further vasodilation in response to hypercapnia) to nonischemic brain area (with vasodilation in response to hypercapnia), which leads to “intracerebral steal” and worsening focal cerebral ischemia.

- Whereas extreme hypocapnia may decrease cerebral perfusion by causing cerebral vasoconstriction. Ventilation should be adjusted to maintain normocapnia during CEA.
C. Bradycardia in the setting of surgical manipulation of the carotid sinus

- This is a CORRECT answer.

- Reflex bradycardia during CEA is not a result of ischemic cerebrovascular changes, but a result of activation of the carotid baroreceptor reflex. This phenomenon is also observed in healthy individuals without carotid disease.
D. Stroke in the setting of hypotension during carotid cross-clamping

- This is an INCORRECT answer.

- Cerebral autoregulation is impaired in the ischemic brain area, thus cerebral blood flow is largely dependent on cerebral perfusion pressure. Hypotension during carotid cross-clamping may contribute to intraoperative ischemic stroke.

5. In PACU, the patient is noticed to have stridor after carotid endarterectomy. He is awake and complains of difficulty breathing. BP 186/99, RR 28, SaO2 92% with 6L/min O2 delivered via simple oxygen mask. Which of the following perioperative events would be the LEAST likely cause of his stridor?

A. Neck wound hematoma

B. Cranial nerve palsies resulting from surgical retraction

C. Airway trauma during endotracheal intubation

D. Carotid body denervation
A. Neck wound hematoma

- This is an INCORRECT answer.

- An expanding neck hematoma may lead to airway compression and stridor as a result of the mass effect.

- The contributing factors for neck hematoma after carotid endarterectomy include inadequate hemostasis, hypertension, vigorous coughing and bucking upon emergence from anesthesia.
B. Cranial nerve palsies resulting from surgical retraction

- This is an INCORRECT answer.

- Recurrent laryngeal nerve (RLN) injury may occur as a result of intraoperative surgical trauma (excessive retraction, forceps, electrocautery, or the application of arterial clamps). Unilateral RLN injury leads to ipsilateral true vocal cord paralysis in the paramedian position, bilateral RLN injuries may result in stridor and life-threatening upper airway obstruction.

- Other cranial nerves which may be injured after this operation include vagus N, superior laryngeal N, hypoglossal N, marginal mandibular N and glossopharyngeal N.

C. Airway trauma during endotracheal intubation

- This is an INCORRECT answer.

- During endotracheal intubation, if significant airway trauma (such as vocal cord injury, airway edema/swelling or hematoma) occurs, airway patency would be compromised, which may subsequently lead to airway obstruction and stridor.
D. Carotid body denervation

- This is a CORRECT answer.
- Although post-CEA carotid body denervation may contribute to postoperative respiratory depression, it will not cause stridor.