General Anesthesia Considerations & Strategy for Carotid Endarterectomy

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Carotid Endarterectomy (CEA) is performed to treat symptomatic or asymptomatic carotid stenoses in order to reduce the risk of stroke[1]. This patient population is at high risk of perioperative death, MI, and stroke[2], particularly if there are high-grade bilateral carotid stenoses.[3] At MGH, CEAs are performed by Vascular surgeons or Neurosurgeons with most patients under GETA. Regional block (deep and superficial cervical blocks) is an alternative anesthetic approach in selected cases. Of note, stenting for carotid stenosis is an alternative procedure usually performed under MAC, and is associated with less MI, but more perioperative stroke and death than CEA.[2]

At MGH, elective surgical CEA patients are usually monitored intra-operatively using 24-lead EEG, managed by a technologist who consults with a neurologist if necessary. Unilateral persistent EEG slowing during CEA are predictive of postoperative stroke, particularly if irreversible.[4] In predicting stroke, the specificity of intraoperative EEG changes is high, but sensitivity is only around 50%, perhaps because a significant fraction of strokes occur postoperatively. When unilateral (or bilateral) EEG slowing is observed during CEA it is presumed to indicate cerebral ischemia and maneuvers to improve cerebral perfusion, including induced hypertension and temporary shunting across the carotid cross-clamp, are initiated with the aim of reversing EEG changes. Because general anesthetics can slow EEG frequency (although globally rather than focally), it is critically important for anesthesia clinicians to inform the EEG tech about any drugs administered or changes in the dosing of anesthetics.

Some MGH Vascular surgeons forego EEG monitoring and instead monitor “carotid stump pressure” (CSP) after cross-clamp *via* a small needle and sterile cobe tubing in the surgical field. The CSP presumably reflects the integrity of collateral circulation to the ipsilateral brain distal to the clamp, and the desired SBP or MAP is dictated by the surgeon. The anesthesia team provides a transducer set-up for CSP. Note: there is no evidence that CSP monitoring is an effective approach to predict or prevent stroke.[5]

1) The CEA Surgical Procedure

a. Positioning is beach chair with head turned away from surgical side. A thyroid bag under the shoulders is used to increase neck extension. Make sure the head is supported.

b. Dissection: The surgeon will expose the carotid artery and protect other important nerves and vascular structures in the surgical field. This phase typically **takes 20-30 minutes**.

c. Heparin administration: usually 70 to 100 U/Kg—always flush the line with 10cc or more to assure that the dose is delivered. The surgeon should request anticoagulation before cross-clamping, but if it appears that cross-clamping is proceeding, the anesthesiologist should confirm whether or not heparin has been given. In rare cases of heparin-induced-thrombocytopenia (HIT), argatroban, hirudin, or another anticoagulant may replace heparin.

d. Cross-clamp: A period of at least 3 minutes should pass after heparin administration before x-clamps are placed. After gaining proximal and distal control, clamps are placed on the common, internal, and external carotid arteries.

e. Endarterectomy: The vessel is opened, blood removed, and the endarterectomy is performed. This phase typically lasts **15-20 min**.

f. Carotid closure: In almost all cases, the vessel is modified by addition of a patch across the incision. This increases vessel diameter, reduces shear stress, and slows recurrence of atherosclerosis. This can take **20-30 minutes**

g. Unclamping: The vessel is usually "flushed" with both heparinized saline and a flash of blood (by briefly unclamping the CCA) to clear any debris that may remain in the artery before unclamping and re-establishing flow. In-field Doppler is used to check for bloodflow.

h. Drying up: Bleeding from the patch suture lines or other parts of the surgical field is halted. The surgeon may request that a small dose of protamine (10 -50 mg) be administered. This phase typically takes **10-15 min**.

i. Closure: This is typically very fast—**5 to 10 minutes**.

j. Total time for procedure: 70 to 100 minutes

2) Anesthetic Goals:

a. Maintaining Brain Perfusion
   i. A-line (place opposite operative side unless MAP is 15 mmHg or more lower than operative side).
   ii. Vaso-active drugs: phenylephrine and nitroglycerine (or nicardipine)
   iii. Deliberate hypertension during x-clamp or if EEG slowing seen on operative side

b. Optimize EEG monitoring sensitivity
   i. Light anesthesia increases EEG sensitivity to ischemia
   ii. Deep NMB during carotid x-clamped period—improves EEG sensitivity
   iii. Maintain **constant anesthetic depth between x-clamp and unclamp**

c. Fast Emergence (and formal neuro check after extubation)
   i. NO BENZODIAZEPINES
   ii. Light general anesthesia
   iii. Rocuronium for NMB and suggamadex reversal*****
   iv. No NMB administered after unclamp

d. Generic GA goals
   i. Hypnosis/Amnesia (2 x MAC-awake = 0.7 MAC)
   ii. Pain management: 2-3 ug/kg fentanyl on induction, no other opioids until after wakeup—pain is modest
   iii. Optimize surgical conditions
      1. Deep NMB during dissection to unclamping
      2. No bite block if high lesion (or surgeon is GML)

e. Additionally: Minimize coughing during emergence
   i. Remifentanil 0.05 ug/kg bolus and 0.03 ug/kg/min infusion during closure
   ii. Consider deep extubation but avoid putting pressure on carotid arteries when providing mask ventilation!

3) Anticipated Problems

a. Bradycardia during dissection/retraction around carotid bifurcation (vagal stimulus)
   i. Prevention with 0.2 to 0.4 mg glycopyrrolate after induction (HR permitting)
   ii. Stop traction if this occurs, treat with glycopyrrolate
   iii. Surgeons can block reflex by infiltrating carotid bifurcation with lidocaine

b. EEG slowing after x-clamp
   i. Increase BP (SBP up to 200 mmHg)
   ii. If raising BP doesn't reverse EEG changes, the surgeon will usually place a shunt across the endarterectomy (re-establishing some blood flow on the operative side)

c. Bradycardia/Asystole after NMB reversal with neostigmine/glycopyrrolate

i. Risk increased with beta-blockers
ii. If HR < 60, give glycopyrrolate first and neostigmine *after* HR increases.

d. Tachycardia and Hypertension during Emergence
   i. Avoid neostigmine/glycopyrrolate administration—use rocuronium/suggamadex
   ii. Have labetolol available

e. Persistent post-op hypotension
   i. Phenylephrine usually adequate—need second post-op IV in PACU
   ii. Occasionally requires overnight PACU monitoring

4) Details

a. NO BENZODIAEPINES!!
b. Insert all lines on upper extremity of non-operative side if possible
c. Check BP in both arms **twice** (alternating each time) when checking for MAP differences
d. 18 g IV is adequate. PACU RNs want a second IV if pt on vasoactive drugs
e. Inform the EEG tech about all drugs when administered and any changes in anesthetic dose settings
f. The EEG tech can tell you if early signs of muscle activity are present—just ask
g. 65% N2O + 1/3 MAC of volatile anesthetics ensures hypnosis and rapid wake-up
h. TIVA is an option, but note that with continuous propofol infusion, target site concentration rises over time.

*****Rocuronium reversed with suggamadex may be advantageous to reversal with neostigmine/glycopyrrolate, which is associated with extreme heart-rate changes (both bradycardia and tachycardia [6]). If suggamadex is unavailable, cisatracurium provides for more reliable reversal using neostigmine/glycopyrrolate than rocuronium.

Questions to consider:

During a CEA under GETA, the EEG tech announces “slowing contralateral to the surgical side”. What else do you want to know? What maneuvers might the care team perform to address this situation?

Your patient awaiting CEA in Peri-op is extremely anxious and takes Xanax at home. Is it suitable to treat her with midazolam? What alternative approaches can you list to allay her anxiety?

What is the expected incidence of awareness during general anesthesia if you administer 0.7 x MAC of inhaled anesthetics (nitrous + volatile)?

What patient characteristics would you consider suitable for a CEA under regional block? Would you alter your monitoring from that for a GETA? What would you do if the patient complains of pain during the procedure under block? What would you do if the patient shows signs consistent with intra-operative stroke during the procedure under block?

References

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