Carotid Artery Shunting during Carotid-Subclavian Artery Bypass Surgery

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Carotid-subclavian artery bypass (CSBG) surgery is indicated for the alleviation of upper extremity ischemia, subclavian steal syndrome and vertebrobasilar insufficiency.[1] This procedure requires clamping the ipsilateral carotid artery during deployment of the polytetrafluoroethylene (PTFE) graft. Clamping causes concern for ischemia, necessitating the need for adequate cerebral arterial collateral blood flow. Carotid artery shunting is not routinely used until signs of cerebral artery compromise manifests through the use of electroencephalography (EEG) monitoring. EEG monitoring has become an essential tool to assess the need for carotid artery shunting and to lengthen the arterial ischemic time without causing harm to cerebral vasculature.

Case Report

A 37-year old female, 167 cm tall and 65 kg, presented for a right CSBG. Her medical history was significant for transient ischemic attacks in 2010 and 2011, asthma, hypertension, and lupus. Her current medications consisted of methotrexate, pregabalin, hydroxychloroquine, clopidogrel, losartan potassium, valacyclovir hydrochloride, and albuterol. Her surgical history included an open reduction and internal fixation of a right sternoclavicular dislocation, tubal ligation, cardiac catherization, and tonsillectomy, all of which were associated with postoperative nausea and vomiting.

Computed tomography angiography confirmed significant right subclavian artery stenosis with adequate patent arterial cerebral circulation. A preoperative physical evaluation revealed lightheadedness with right arm extension above 180 degrees and a weak right radial pulse.

In the operating room standard American Society of Anesthesiologists monitors were applied and denitrogenation was initiated with 100% oxygen via facemask using an oxygen flow of 10 L/min for 3 minutes. General anesthesia was induced with intravenous fentanyl 100 mcg, lidocaine 60 mg, and propofol 150 mg. Mask ventilation was successful. Vecuronium 6 mg was administered followed by 3 minutes of bag-mask ventilation. Direct laryngoscopy was performed using a Macintosh 3 blade with a grade I view. A 7.5 mm endotracheal tube was advanced through the glottis with inflation of the endotracheal cuff. Positive bilateral breath sounds and positive end-tidal carbon dioxide ($EtCO_2$) were confirmed. Volume control ventilation was utilized to maintain an $EtCO_2$ between 32-35 mmHg. General anesthesia was maintained with the use of isoflurane

0.5% inspired concentration in a mixture of oxygen 0.5 L/min and air 0.5 L/min, vecuronium 0.01 mg/kg, and fentanyl 25-50 mcg. Half minimum alveolar concentration was utilized. Theta waves with a frequency of 4-8 hertz without burst suppression noted on the EEG monitor, confirming general anesthesia without cerebral ischemia. A left radial arterial line was inserted. A 16 French urinary catheter was inserted. During clamping of the carotid artery, mean arterial pressures (MAP) were maintained between 70-75 mmHg with phenylephrine boluses of 80-160 mcg as needed. A carotid artery shunt not utilized as cerebral ischemia was not noted on EEG monitoring.

At the conclusion of the case, neuromuscular blockade was antagonized with glycopyrolate 0.6 mg and neostigmine 3 mg. Ondansetron 4 mg was administered. Isoflurane was discontinued and 10 L/min of oxygen was initiated. Spontaneous ventilations were noted and the patient was weaned off of mechanical ventilation. Once the patient was awake, able to follow commands, and maintain a sustained head lift she was extubated. Upon extubation a neurologic examination of the patient was completed, which showed the patient to be at her baseline. Further, the patient demonstrated improved strength and a bounding right radial pulse in the operative side. The patient was taken to the post anesthesia recovery unit.

Discussion

Carotid-subclavian bypass surgery is a major vascular surgery typically involving medically debilitated patients. The role of the anesthetist is to choose an anesthetic plan that will keep the patient safe and comfortable providing the surgeon an optimal working environment. Regional and general anesthesia are both acceptable options in caring for these patients. However, the concern surrounds the question of whether to use a shunt during the clamping of the ipsilateral carotid artery for PTFE graft deployment. The anesthetist needs to have a discussion with the surgeon prior to the case to assess whether the threshold to shunt is high or low.

During carotid clamping, hypoperfusion may be attenuated by placing a shunt around the carotid clamp to perfuse the ipsilateral circulation.[2] However, this shunt is not benign and poses multiple risks including: air embolism, blood embolism, and injury to the distal internal carotid artery intima.[3] Apart from surgeon preference, two anesthetic options exist. One option includes utilizing regional anesthesia through a combined superficial-deep cervical plexus block to allow for continuous neurological assessment of the awake patient. The other alternative involves implementing general anesthesia with the use of EEG monitoring to assess for neurologic compromise. The anesthetic implications of each of these modalities play a critical role in determining the optimal safe anesthetic plan for each patient.

Regional anesthesia is initiated with the use of a superficial-deep cervical plexus block.[3] Once the block is performed, the patient is awake throughout the procedure to allow the surgeon to detect any neurologic complications through direct communication. If the patient were to experience any adverse neurologic symptoms, the surgeon would assess the need for a carotid shunt. The benefits of this approach include: allowing direct assessment of the patient's neurologic status, avoiding unnecessary carotid shunting, and a shorter postoperative recovery period.[3] The complications associated with this technique include: diaphragmatic dysfunction from phrenic nerve blockade, epidural or subarachnoid injections, vertebral artery injection, Horner's syndrome, and hoarseness from recurrent laryngeal nerve blockade.[4] In addition, if the block were to fail or the patient required the conversion to general anesthesia, then EEG monitoring would not be available and the surgery could become dangerous.

General anesthesia is another appropriate option for this procedure; however, it must be accompanied by cerebral monitoring modalities to detect cerebral ischemia. EEG monitoring assesses the spontaneous electrical activity of the cerebral cortex assessing for activity changes that would indicate inadequate cerebral perfusion.[5] Even though EEG monitoring is time consuming, it is the most sensitive test for cerebral ischemia and thwarts the unnecessary deployment of a carotid shunt.[6] When utilized as a continuous monitoring device, EEG allows for the comparison of electrical activity in the surgical versus contralateral hemisphere.[5] Volatile anesthetics can be used during EEG monitoring as long as appropriate anesthetic depth is maintained and burst suppression is avoided. Keeping the patient at a consistent anesthetic depth is very important, especially during carotid artery clamping to ensure ischemia is sensitive to poor perfusion and altered cerebral metabolism. It is vital for the anesthesia professionals to maintain MAP values slightly above preoperative levels to maintain adequate cerebral perfusion through the contralateral carotid artery during this critical period.[3] In this particular case, it was determined MAP values should be maintained between 70-75 mmHg during carotid artery clamping from a preoperative assessment of MAP values between 60-65 mmHg. Complementing the maintenance of MAP, hemodilution and hyperglycemia should be avoided and normocarbia should be maintained for cerebral protection.[3]

In this CSBG case, the decision to use EEG monitoring was made by the surgical team, anesthesia professionals, and the patient. It was felt that this was the most sensitive neurologic test and prevented shunting unless ischemia was noted. Regional anesthesia was not an option in this case because the patient did not feel comfortable with this approach. However, it would have been an appropriate option because her medical presentation warranted regional anesthesia. This highlights the importance of presenting all options and not only assessing the patient's medical condition, physical assessment and medication list, but also encompassing a psychological assessment of the patient to determine the most appropriate plan. Even if the surgeon does not fully agree with the decision, it is the responsibility of the anesthesia practitioners to keep the patient safe, providing the best chance of a successful and safe surgery. The patient in this case did not need a shunt, and the surgery went well without compromise to cerebral perfusion. However, it would be beneficial to use regional anesthesia in the future to note any differences. This would be an enlightening experience and help with anesthetic planning for future patients undergoing this procedure or similar procedures.

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