A LITERATURE REVIEW ON ANESTHETIC PRACTICE FOR CAROTID ENDARTERECTOMY SURGERY BASED ON COST, HEMODYNAMIC STABILITY, AND NEUROLOGIC STATUS

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An extensive literature review was undertaken to evaluate the best anesthetic practice for carotid endarterectomy surgery. Two anesthetic techniques were evaluated: general anesthetic with an endotracheal tube and regional anesthetic block. Three variables were reviewed with respect to significant clinical outcomes based on anesthetic technique. Relevant literature was obtained through multiple sources that included professional journals, a professional website, and textbooks. According to the literature, there is an advantage to performing regional anesthesia with respect to cost and neurologic status. Information analyzed was inconclusive with respect to hemodynamic stability and anesthetic technique. We conclude that regional anesthesia may have some slight advantages; however, more investigation is warranted.

Key words: **Anesthesia, carotid endarterectomy, general anesthesia, regional anesthesia.**

Carotid stenosis is caused by atherosclerotic plaques formed at the carotid bifurcation that lead to narrowing of the artery and/or embolization of thrombus or plaque debris causing transient ischemic attacks or stroke. The risk of stroke has been estimated at approximately 5% per year if the patient is asymptomatic and about 10% per year for a patient who has already had a transient ischemic attack.[1]

Carotid endarterectomy (CEA) is a leading way to prevent stroke in patients who have a high degree of occlusive disease of the carotid arteries. According to the National Institute of Neurological Disorders and Stroke,[2] there are about 132,000 CEAs performed in the United States each year. Since Debakey et al performed the first CEA in 1954, there has been much debate about the safest anesthetic method for this procedure.[3] Research studies have demonstrated that surgical treatment of carotid stenosis may be performed under local or general anesthesia. Based on a review of current literature, there is no consensus as to which technique is superior. However, there is evidence from several nonrandomized studies suggesting that the regional anesthetic technique offers considerable benefits. We examined the current literature to determine the best anesthetic practice for CEA based on cost, hemodynamic stability, and neurologic status.

Carotid endarterectomy is a procedure used to treat severe atherosclerotic occlusive disease involving the internal carotid arteries, most often at the common carotid artery bifurcation. The operation is performed by opening the common carotid arteries and the proximal internal carotid arteries in the neck, removing plaques from the inside of the arteries, and resuturing the wall of the arteries. Opening the carotid artery (arteriotomy) requires temporary occlusion of the proximal common carotid artery, distal internal carotid artery, external carotid artery, and, usually, its first branch, the superior thyroid artery. If the collateral blood flow to the territory supplied by the occluded internal carotid is deemed adequate, the entire procedure can be completed under continued occlusion of these vessels. Alternatively, an intraluminal shunt between the proximal common carotid artery and the distal internal carotid artery can be placed after the arteriotomy for use during the procedure if deemed necessary.[4]

The most appropriate type of anesthesia to maintain cerebral blood flow during clamping of the carotid artery continues to be a subject of debate. The 2 main methods used by anesthesia providers are general anesthesia with an endotracheal tube and regional anesthetic block that consists of a deep cervical plexus block and superficial infiltration of local anesthetic.

History

During the advent of the procedure, CEA was mainly performed under local anesthesia. It was hypothesized that this technique was essential for the safety of the patient by preventing cerebral depression, reducing blood pressure, and allowing for close observation of any neurologic deficits during the operation.

The focus then shifted to general anesthetic technique as being easier for the patient to tolerate and producing better surgical conditions for the physician. With this supporting rationale, the general anesthetic technique was believed to offer increased tolerance to cerebral ischemia by decreasing the cerebral metabolic rate.[3] However, most intraoperative neurologic events are now believed to be embolic rather than ischemic, so the benefits of a reduced cerebral metabolic rate may have been overestimated.[5]

In the past decade, there has been a resurgence of interest in local anesthesia for carotid surgery that is prompting many recent reviews in the literature. With the advent of modern regional anesthetic techniques with intravenous sedation, patient compliance with regional anesthesia has been markedly enhanced.[3]

Review of the literature

An extensive literature review was performed using multiple search engines on the Internet, MEDLINE, and CINAHL. Inappropriate references were discarded. After the relevant references were reviewed, the sources were organized, analyzed, and integrated into a literature review that addressed multiple key variables. The articles were selected for inclusion in the literature review if they contained the following: (1) information on CEA and local anesthesia, general anesthesia, or a comparison of the two; and (2) information on at least 1 of 3 variables under investigation—cost, neurologic monitoring, and hemodynamic stability. All articles were from peer-reviewed healthcare journals. These variables were compared and contrasted as they relate to general anesthesia with an endotracheal tube and regional anesthetic block.

First, cost is a significant factor when evaluating regional vs general endotracheal anesthesia for CEA. The safety of the patient should be considered above all other matters; however, the issue of cost is a relatively important consideration for today's healthcare setting as reimbursement issues mount.

Ricotta et al[6] demonstrated a significant cost difference between the 2 common methods of anesthesia for carotid surgery. In the perioperative period, a significant cost savings was noted with regional vs general anesthesia. The authors found a cost savings of approximately $4,534 with the regional technique even when patients with a length of stay greater than 4 days were excluded from the study.[6]

Gabelman et al[7] demonstrated that patients who received cervical block anesthetic required a shorter hospital stay and less intensive monitoring. General endotracheal anesthesia cost $5,115, and the cost of regional anesthetic block was $3,611. The mean savings was determined to be 30% of hospital costs.

Papavasiliou et al[8] found that the mean hospital length of stay after CEA was significantly shorter in the regional anesthetic group (1.25 days) than in the general anesthetic group (3.48 days), further decreasing cost. In a study by Stone et al,[9] total operative time was decreased with the regional anesthetic technique. Patients receiving regional anesthesia had a mean operating room time of 146 minutes vs 163 minutes for patients who received a general anesthetic.[9] Recent literature supports the use of a local anesthetic technique as a means to decrease the amount of intraluminal shunts placed in CEA patients. This measure further decreases the cost associated with carotid surgery.

A second major concern in a patient population undergoing CEA is hemodynamic instability as a result of symptomatic or occult coronary artery disease. Because the incidence of myocardial ischemia is twice that of cerebral morbidity for carotid surgery, hemodynamic instability in the perioperative period should be minimized to preserve adequate myocardial oxygenation to decrease the risk of an adverse cardiac event.[10] Mortality in the perioperative period is 1% to 4% and due primarily to cardiovascular complications (myocardial infarction).[11] It is well known that patients who have carotid artery disease frequently have several other comorbidities such as diabetes, hypertension, peripheral vascular disease, and coronary artery disease. Thus, a major concern when performing CEA is hemodynamic instability. *Hemodynamic instability* can be defined as hypertension or hypotension, conduction abnormalities, or perioperative myocardial insult or injury.

General anesthesia presents several advantages and disadvantages to patients undergoing CEA. Volatile anesthetic agents such as isoflurane offer some degree of cerebral protection by reducing the cerebral metabolic rate. Many anesthesia providers believe that general anesthesia provides the surgeon with better operating conditions, a motionless field, and better visualization. These factors are especially helpful in patients who have a high carotid bifurcation in an area that is difficult to anesthetize with local anesthetic. The element of stress reduction may benefit patients

with unstable cardiovascular comorbidities.[5] Furthermore, general anesthesia is necessary in some cases in which a patient is unable to tolerate the regional technique. Patients who would not be considered candidates for a regional block include patients unable to remain still or follow directions, claustrophobic patients, and patients with neurologic disorders or tremors.

Several disadvantages have been associated with general anesthesia for CEA. Sternbach et al[12] showed a markedly increased incidence of hemodynamic instability in patients who underwent CEA with general anesthesia that persisted into the first 48 hours of the postoperative period. As a result, patients who underwent general anesthesia required more vasoactive medications, more frequently were admitted to the intensive care unit, and had a greater rate of postoperative complications than patients who underwent local anesthetic block. In a study of 198 patients by Eibes and Gross,[13] patients who received general anesthetic required significantly more sodium nitroprusside for control of hypertension than patients receiving regional anesthesia in the first 8 postoperative hours. Length of stay was also longer in the general anesthesia group than in the regional anesthesia group for the intensive care unit and the entire hospital stay. General anesthesia has also been associated with more labile blood pressure and the use of pressors to maintain mean arterial pressure during surgery. The increased use of pressors to support blood pressure during surgery has been shown to increase perioperative morbidity due to an increased myocardial workload.[14]

The supposed advantages of the regional anesthetic technique for carotid surgery with respect to hemodynamic stability are compelling. A meta-analysis of nonrandomized trials has shown that local anesthesia is associated with lower cardiorespiratory complications in the perioperative period.[15] Takolander et al[16] found that local anesthesia was associated with activation of the sympathetic nervous system with increases in heart rate and blood pressure. On the other hand, general anesthesia produced marked hypotensive responses.[16] According to Sbarigia et al,[17] despite more episodes of tachycardia and hypertension in patients who had local anesthesia, the rate of myocardial ischemia was half that of patients who received a general anesthetic. Magnadottir et al[18] made the assertion based on a prospective series of 600 CEAs that regional anesthesia is safer than general anesthesia with respect to cardiopulmonary complications. Patients who undergo general endotracheal anesthesia are 13 times more likely to have a nonneurologic adverse perioperative event such as myocardial infarction than patients who received a regional anesthetic.[18]

The third and final variable that will be discussed in relation to anesthetic technique for CEA is that of neurologic integrity. Perioperative morbidity is linked to neurologic complications (4%-10%) and is highest for patients with preexisting neurologic deficits.[11] The internal carotid arteries provide a majority of the blood supply to the brain. As a result, maintaining cerebral perfusion becomes a chief priority when providing anesthesia to patients undergoing CEA because a large portion of blood flow becomes "clamped off" during the procedure. One concern during carotid surgery is whether to use an intraluminal shunt to facilitate cerebral blood flow by bypassing the carotid cross-clamp on the affected side during the procedure.

For a patient under general anesthesia, there is considerable difficulty detecting inadequate cerebral perfusion. As a result, several techniques have been developed to attempt to detect inadequate cerebral perfusion. Some of these methods include measurement of stump pressures in the internal carotid artery, somatosensory evoked potentials, traditional electroencephalographic monitoring, and transcranial Doppler scan measurements. However, all of these methods have relatively poor sensitivity and specificity for detecting inadequate cerebral perfusion; thus, some surgeons insert a shunt in all patients undergoing general anesthesia. In contrast, an awake patient provides a sensitive and specific monitor of cerebral perfusion, and changes in consciousness, speech, or motor power after clamping can indicate the need for a shunt.[1] "Most surgeons now recognize the benefits of selective shunting during CEA, and yet, no consensus has been reached to define the optimal method of intraoperative cerebral perfusion monitoring."[19] According to Zvara,[20] if one combines the accumulated data from 7,619 CEAs, analysis shows more than a 3-fold difference in the incidence of stroke and transient ischemic attacks between general anesthesia (3.9%) and regional (1.1%) groups.

Neurologic monitoring of a patient who is awake provides an accurate and reliable indication of the need for protection of the brain with a shunt during occlusion of the internal carotid artery during CEA. Rockman et al[21] claim that although excellent results have been generated with the combination of general anesthesia and a variety of monitoring approaches, no single monitoring technique during general anesthesia has correlated well with the neurologic status of an awake patient. Monitoring of an awake patient under regional anesthesia has proven to be more specific

than electroencephalography (EEG) when determining the need for an intraoperative shunt.[22] According to Stoughton et al[19] "EEG monitoring yielded a significant number of false positive (6.7%) and false negative (4.5%) results in the detection of neurologic deficits when compared with mental status evaluation in the awake patients." In addition, according to Stoughton et al,[19] when regional anesthesia was used preferentially, there was less overall shunt use and possibly a lower stroke rate. Rockman et al[21] found a trend toward higher frequencies of perioperative stroke (3.2% vs 2%, respectively) with general anesthesia vs regional anesthesia.

Discussion

The goal of this literature review was to examine the various practices in regard to anesthetic choice for CEA. The question remains: Is there clear and convincing evidence that either method of anesthetic technique is associated with an improvement in patient outcome? To date, large, prospective, randomized studies are lacking answers on this issue, and, thus, the absence of scientific evidence limits our ability to draw concrete conclusions or put forth broad generalizations. Conversely, some advantages to the regional anesthetic technique are beginning to emerge through nonrandomized, retrospective studies in the literature. There is a clear cost advantage to performing CEA under a regional anesthetic block; however, the technique should be chosen based on patient-specific criteria and the technique that is safest for the patient. It is evident from reviewing the existing studies that the best monitoring modality to assess neurologic status is an awake patient. However, this does not disqualify the fact that general anesthetic can be safely performed while maintaining adequate cerebral blood flow in some patients.

In regard to hemodynamic status, the literature suggests that patients who undergo general anesthesia for CEA require more vasoactive medications, a longer hospital stay, and more invasive monitoring in the perioperative period.[12] However, the data suggest that catecholamine levels are increased in awake patients and can lead to cardiac ischemia.[16]

The literature review revealed varying results with regard to the most appropriate choice of anesthetic technique for CEA. In the past, CEA has been performed safely with regional anesthesia and general anesthesia with an endotracheal tube. We suggest that there may be emerging evidence that suggests a slight advantage to the patient when a regional block is used for carotid surgery. Carotid endarterectomy carries with it a relatively high incidence of perioperative adverse events such as neurologic and myocardial events. The choice of anesthetic technique is constantly under debate in an attempt to reduce the morbidity and mortality for a procedure that is preventive.

Summary

The reviewed literature suggests a possibility of distinct advantages to performing CEAs under regional anesthesia. Advantages such as decreased cost and resource utilization, better neurologic outcomes, and the possibility of decreased myocardial events have been documented. However, one must consider the idea that institutional data should also be a factor in the evaluation of which anesthetic choice is considered superior. If the anesthesia providers and vascular surgeons in an institution have a long-standing record of low numbers of adverse events with regard to carotid surgery, a change in anesthetic technique should be carefully considered. A continuation of current research and critical review will be necessary before any persuasive conclusions can be drawn and applied to clinical practice.

REFERENCES

1. Stoneham MD, Knighton JD. Regional anaethesia for carotid endarterectomy. *Br J Anaesth.* 1999;82:910-919.
2. National Institute for Neurological Disorders. Stroke treatment: Carotid endarterectomy. 2002. Available at: http://www.strokecenter.com. Accessed November 3, 2002.
3. Bowyer MW, Zierold D, Loftus JP, Egan JC, Inglis, KJ, Halow, KD. Carotid endarterectomy: a comparison of regional versus general anesthesia in 500 operations. *Ann Vasc Surg.* 1998;14:145-151.
4. Jaffe RA, Samuels SI. *Anesthesiologist's Manual of Surgical Procedures.* 2nd ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 1999.
5. O'Hare DJ, Bodenham AR. Carotid endarterectomy under local anaesthesia. *Hosp Med.* 1999;60:271-276.
6. Ricotta, JJ., Hargadon, T, O'Brien-Irr M. Cost management strategies for carotid endarterectomy. *Am J Surg.* 1998;176:188-192.
7. Gabelman CG, Gann DS, Ashworth CJ, Carney WI. One hundred consecutive carotid reconstructions: local versus general anesthesia. *Am J Surg.* 1983;145:477-482.
8. Papavasiliou AK, Magnadottir HB, Gonda T, Franz D, Harbaugh RE. Clinical outcomes after carotid endarterectomy: comparison of the use of regional and general anesthetics. *J Neurosurg.* 2000;92:291-296.
9. Stone ME, Kunjummen BJ, Moran JC, Wilkerson DK, Zatina MA. Supervised training of general surgery residents in carotid endarterectomy performed on awake patients under regional block is safe and desirable. *Am Surg.* 2000;66:781-786.
10. Godet G, Watremez C, El Kettani C, Soriano C, Coriat P. A comparison of sevoflurane, target-controlled infusion propofol, and propofol/isoflurane anesthesia in patients undergoing carotid surgery: a quality of anesthesia and recovery profile. *Anesth Analg.* 2001;93:560-565.
11. Morgan GE, Mikhail MS. *Clinical Anesthesiology.* 2nd ed. Stamford, Conn: Appleton & Lange; 1996.
12. Sternbach Y, Illig KA, Zhang R, et al. Hemodynamic benefits of regional anesthesia for carotid endarterectomy. *J Vasc Surg.* 2002;35:333-339.

13. Eibes TA, Gross WS. The influence of anesthetic technique on perioperative blood pressure control after carotid endarterectomy. *Am Surg.* 2000;66:641-647.
14. Boysen G, Engell HC, Henriksen H. The effect of induced hypertension on the internal carotid artery pressure and regional cerebral blood flow during temporary carotid clamping for carotid endarterectomy. *Neurology.* 1972;22:113-114.
15. Tangkanakul C, Counsell, CE, Warlow CP. Local versus general anesthesia in carotid endarterectomy: a systematic review of the evidence. *Eur J Endovasc Surg.* 1997;13:491-499.
16. Takolander R, Bergquist D, Hulthen UL, Johansson A, Katzman PL. Carotid artery surgery: local versus general anesthesia as related to sympathetic activity and cardiovascular effects. *Eur J Vasc Surg.* 1990;4:265-270.
17. Sbarigia E, DarioVizza C, Antonini M, et al. Locoregional versus general anesthesia in carotid surgery: is there an impact on perioperative myocardial ischemia? results of a prospective monocentric randomized trial. *J Vasc Surg.* 1999;30:131-138.
18. Magnadottir HB, Lightdale N, Harbaugh RE. Clinical outcomes for patients at high risk who underwent carotid endarterectomy with regional anesthesia. *Neurosurgery.* 1999;45:786-795.
19. Stoughton J, Nath RL, Abbott WM. Comparison of simultaneous electroencephalographic and mental status monitoring during carotid endarterectomy with regional anesthesia. *J Vasc Surg.* 1998;28:1014-1023.
20. Zvara DA. In my opinion: regional anesthesia preferable for carotid surgery. *J Clin Monit Comput.* 2000;16:67-68.
21. Rockman CB, Riles TS, Gold M, et al. A comparison of regional and general anesthesia in patients undergoing carotid endarterectomy. *J Vasc Surg.* 1996;24:946-956.
22. Hafner CD, Evans WE. Carotid endarterectomy with local anesthesia: results and advantages. *J Vasc Surg.* 1988;7:232-239.

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