Low morbidity and mortality of carotid endarterectomy performed with regional anesthesia

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Various anesthetic and surgical techniques have been recommended with or without cerebral function monitoring in attempts to reduce the risk of carotid endarterectomy, but there is no consensus as to the ideal method for performing this procedure. General anesthesia is now the most common anesthetic technique used, but of 337 carotid endarterectomies performed by the authors' service from 1981 through 1985, 305 (91%) were conducted with regional anesthesia. This paper presents the morbidity and mortality rates for those patients. There were two perioperative transient ischemic attacks (0.66%), two perioperative strokes (0.66%), and two perioperative deaths (0.66%). No patient in the series suffered a myocardial infarction within 30 days after endarterectomy. This series demonstrates that carotid endarterectomy can be performed with good results using regional anesthesia, which facilitates intraoperative cerebral function monitoring. Regional anesthesia is associated with a very low incidence of postoperative hypertension and perioperative myocardial infarction.

Key Words • carotid endarterectomy • regional anesthesia • morbidity • mortality

The goal of carotid endarterectomy is to reduce the risk of future stroke, and for this goal to be valid the risk of stroke or death related to the procedure itself must be low. However, the stroke and mortality rates of previously reported series have varied widely over the years;1,4,6,7,9,11-13,15,16,19-23,26,31,35,40,41,43-45,51,52,54-56,58 a stroke rate as high as 15%13 and a mortality rate as high as 7% have been reported. A recent extensive review of the literature documented a mean perioperative stroke rate of 3.5% and a mean death rate of 2.1% following carotid endarterectomy.9

Although a number of anesthetic, cerebral function monitoring, and surgical techniques have been developed in attempts to reduce the risk of stroke and death from carotid endarterectomy,8-10,15,19,22,26-29,34,38,42,45,51,55 there remains no consensus as to the effectiveness of those techniques for that purpose.19 Local or regional anesthesia, which was widely used for carotid endarterectomy early in its development, has largely been replaced by general anesthesia.10,18,22,24 Regional anesthesia has been used extensively for carotid endarterectomy at this institution since 1958, and it remains our preferred method of anesthesia for this procedure. During a recent 5-year period, 91% of the carotid endarterectomies performed by the neurosurgical service at this institution were conducted with regional anesthesia; these cases form the basis for this report.

Clinical Material and Methods

The medical records were reviewed for all patients on whom carotid endarterectomy was performed by the neurosurgical service at the North Carolina Baptist Hospital between January 1, 1981, and December 31, 1985. Among the 306 patients undergoing 337 carotid endarterectomies during the 5-year period of the review were 280 patients in whom 305 procedures (91%) were performed with regional anesthesia. The other 32 procedures were performed under general anesthesia. These patients included 22 who refused regional anesthesia and 10 patients who participated in the general-anesthesia arm of a study in which hemodynamic variables of patients undergoing carotid endarterectomy with general anesthesia were compared to those of patients having regional anesthesia.2,3 Otherwise, all carotid endarterectomies performed with regional anesthesia were consecutive.

The following information was recorded for each patient: age at operation, sex, atherosclerotic risk factors, symptoms, arteriographic findings, type of anesthesia, tolerance of temporary carotid occlusion, post-
operative blood pressure, length of stay in the intensive care unit, and major and minor complications (both neurological and non-neurological) that occurred within 30 days after surgery. The standard protocol used in this series of patients is as follows.

**Anesthetic Technique**

The patient receives minimal or no premedication. Intravenous and intra-arterial lines are inserted and oxygen is administered by nasal cannula. A superficial cervical block is performed with 30 ml of 0.5% bupivacaine instilled along the posterior border of the sternocleidomastoid muscle. The superficial cervical block is supplemented by the surgeon with 1% lidocaine as necessary during the procedure. Very occasionally, intravenous diazepam is administered to control a patient's restlessness. During the period of carotid artery cross-clamping, the patient’s level of consciousness, speech, and neurological function are easily monitored by the surgeon and anesthesiologist.

**Surgical Technique**

Generally, a transverse incision is made in an appropriate skin crease. Once the platysma muscle is incised, one self-retaining retractor is placed perpendicular to the sternocleidomastoid muscle and another retractor is placed parallel to the muscle. This arrangement of retractors provides excellent longitudinal exposure of the artery. The carotid vessels are carefully dissected with as little manipulation as possible, and heparin is given. When necessary, phenylephrine is given to elevate the systolic blood pressure above 160 to 170 mm Hg. The vessels are occluded and, if the patient experiences no neurological deficits during a 2-minute period of test occlusion, the endarterectomy is performed. In the event of neurological dysfunction during the period of test occlusion, the decision to place a temporary shunt or to perform the procedure at a later date under general anesthesia is based on the rapidity with which the deficits occurred. After the plaque is removed, the vessel is irrigated with saline and all loose fragments of atherosclerotic debris are removed. The arteriotomy is closed primarily with a running 6-0 monofilament suture, with patch grafts being reserved for patients with recurrent stenosis. The heparin is not reversed.

**Postoperative Care**

The patient is generally awake at the end of the procedure and any neurological deficits are easily detectable. Blood pressure is carefully monitored: most patients are slightly hypotensive by the time they reach the recovery room or intensive care unit. Phenylephrine is administered as needed to maintain systolic blood pressure at 140 mm Hg for the first 18 to 24 hours postoperatively. Nitroglycerin or nitroprusside is administered to the rare patient with postoperative hypertension. The patient is monitored in the intensive care unit for 1 day and then transferred to the regular nursing floor. Aspirin and dipyridamole are begun on the 1st postoperative day. The patient is generally discharged on the 3rd or 4th postoperative day.

**Results**

**Patient Population**

The 165 men and 115 women undergoing carotid endarterectomy with regional anesthesia ranged in age from 40 to 89 years, with a mean age of 65 years. Risk factors for atherosclerosis and their incidence are presented in Table 1. The degree of surgical risk was graded by the criteria of Sundt, et al.,\(^{49,50,52}\) the incidence of each is shown in Table 2. Operative indications for the 305 procedures included asymptomatic stenosis greater than 80% in 104 patients (37%), amaurosis fugax in 56 (20%), transient cerebral ischemia in 95 (34%), and prior stroke in 25 (9%).

**Tolerance of Temporary Carotid Occlusion**

Three patients had neurological deficits during carotid artery cross-clamping and required the insertion of a temporary indwelling shunt.

**Postoperative Blood Pressure**

Postoperative hypotension (systolic blood pressure requiring the administration of vasopressors for more than 1 hour to maintain it at 140 mm Hg) occurred in 301 cases (99%). Postoperative hypertension (systolic blood pressure requiring the administration of antihypertensive agents for more than 1 hour to maintain it at 160 mm Hg) occurred in 104 cases (37%).

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**Table 1**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>207</td>
</tr>
<tr>
<td>cigarette smoking</td>
<td>144</td>
</tr>
<tr>
<td>prior documented myocardial infarction</td>
<td>61</td>
</tr>
<tr>
<td>diabetes mellitus</td>
<td>37</td>
</tr>
<tr>
<td>hyperlipidemia</td>
<td>19</td>
</tr>
<tr>
<td>no identifiable risk factor</td>
<td>18</td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Definition</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>stable neurologically: no medical or angiographic risk factors</td>
<td>85</td>
</tr>
<tr>
<td>2</td>
<td>stable neurologically: angiographic risk factors; no medical risk factors</td>
<td>54</td>
</tr>
<tr>
<td>3</td>
<td>stable neurologically: medical risk factors with or without angiographic risk factors</td>
<td>111</td>
</tr>
<tr>
<td>4</td>
<td>unstable neurologically with or without medical or angiographic risk factors</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td>known acute internal carotid artery occlusion</td>
<td>2</td>
</tr>
<tr>
<td>total cases</td>
<td></td>
<td>280</td>
</tr>
</tbody>
</table>

* Grade according to Sundt, et al.\(^{49,50,52}\)
Regional anesthesia for carotid endarterectomy

blood pressure greater than 180 mm Hg) occurred in only one patient.

Complications

Transient nonischemic postoperative complications occurred in seven patients (2.3%), and are shown in Table 3. Postoperative neurological complications developed within 30 days after endarterectomy in four patients (1.3%) and are summarized in Table 4. Both of the transient ischemic attacks occurred within the first 4 postoperative days; both strokes were hemorrhagic and were documented in patients with a Grade 4 preoperative surgical risk. One stroke was apparent within 1 hour after surgery, and that patient died. The other stroke occurred on the 2nd postoperative day, and that patient survived.

No patient in the series suffered a myocardial infarction within the 30-day postoperative period. One patient died of a pulmonary embolus occurring 2 weeks after operation. Thus, two patients died among 280 with 305 procedures, for a procedure mortality rate of 0.7%.

Discussion

Proponents of general anesthesia for carotid endarterectomy cite as advantages the more controlled and less hurried environment, the ability to precisely control ventilation and blood pressure, the ability to administer drugs that protect the brain, and the decreased stress of patients. Some do not believe that regional anesthesia has several advantages over general anesthesia for carotid artery surgery, and have documented results equal to or superior to those achieved when the procedure is performed with general anesthesia.

The greatest advantage of regional anesthesia is that neurological function can be monitored in the awake patient during dissection of the carotid vessels, the period of carotid artery cross-clamping, and the crucial immediate postoperative period. General anesthesia imposes the need for some other monitor of cerebral function in order to identify those patients at risk for stroke from hemodynamic factors during occlusion of the carotid artery. Some of the monitoring techniques that have been used are the measurement of carotid stump pressure, electroencephalographic monitoring, and measurement of cerebral blood flow. However, none of these methods are absolutely reliable in identifying patients who are unable to tolerate temporary carotid artery occlusion, and the best monitor of a patient’s ability to tolerate carotid artery cross-clamping and therefore the best determinant of the need for a temporary shunt remains the evaluation of cerebral function of the awake patient during the trial occlusion.

Most strokes related to carotid endarterectomy are embolic and are not related to hemodynamic factors from carotid artery cross-clamping. The number of patients unable to tolerate temporary carotid artery occlusion and who require shunting is actually small. Patients with general anesthesia are selected for shunt placement on the basis of change in an external monitor; however, because patients who require a shunt are precisely identified by a change in cerebral function during regional anesthesia, the number of patients who have a shunt placed is much lower with regional anesthesia than with general anesthesia. This lower number of shunts is important, because the use of a shunt is associated with increased embolic complications during the endarterectomy.

Carotid endarterectomy is associated with a lower incidence of postoperative hypertension if regional anesthesia is used than with general anesthesia. This lower incidence is also important, since hypertension after carotid endarterectomy has been linked to an increased incidence of neurological deficits, myocardial infarction, and mortality. Although carotid endarterectomy with regional anesthesia does frequently result in a hypertensive response during the period of carotid artery cross-clamping, the immediate postoperative period in patients having had regional anesthesia is usually associated with a much lower blood pressure. This early postoperative hypotension with regional anesthesia is most likely due to abnormal carotid sinus activity, but it may also be related to less fluid having been given intraoperatively compared to the amount given to patients with general anesthesia.

Although treatment of postoperative hypertension with vasopressors, particularly metaraminol, has been associated with an increased risk of perioperative myocardial infarction, this problem has not been

| TABLE 3 |

Incidence of transient nonischemic complications of 305 carotid endarterectomies (280 patients)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Cases</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>vocal cord paralysis</td>
<td>3</td>
<td>0.98</td>
</tr>
<tr>
<td>wound hematoma requiring reoperation</td>
<td>2</td>
<td>0.66</td>
</tr>
<tr>
<td>12th nerve palsy</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>deep venous thrombosis</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>total</td>
<td>7</td>
<td>2.3</td>
</tr>
</tbody>
</table>

| TABLE 4 |

Major neurological complications of 305 carotid endarterectomies (280 patients)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Cases</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>transient ischemic attack</td>
<td>2</td>
<td>0.66</td>
</tr>
<tr>
<td>stroke</td>
<td>2</td>
<td>0.66</td>
</tr>
<tr>
<td>total</td>
<td>4</td>
<td>1.32</td>
</tr>
</tbody>
</table>

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encountered at our institution, perhaps because phenylephrine, which causes less cardiac stimulation than metaraminol,\textsuperscript{26,27,39,41} is used preferentially.

A major advantage of regional anesthesia in carotid artery surgery is related to the incidence of postoperative myocardial infarction. Postoperative myocardial infarction is the most significant non-neurological complication of carotid endarterectomy, and it accounts for most of the perioperative deaths.\textsuperscript{20–22,32,49} An estimated 30% to 40% of patients undergoing carotid endarterectomy have symptomatic coronary artery disease and a sizeable number have significant asymptomatic disease.\textsuperscript{14,22,27,35} Regional anesthesia appears to be associated with less cardiac risk than general anesthesia.\textsuperscript{9,10,20,37,39} Peitzman, et al.,\textsuperscript{37} documented a non-neurological complication rate (chiefly related to myocardial infarction) of 12% in patients who had carotid endarterectomy with general anesthesia and of only 2% in patients with regional anesthesia, and Gabelman, et al.,\textsuperscript{20} reported no perioperative myocardial infarctions in patients undergoing carotid surgery with regional anesthesia. The fact that none of the 280 patients in this series suffered a perioperative myocardial infarction after 305 carotid endarterectomies further supports the concept that regional anesthesia carries less cardiac risk than does general anesthesia.

A final advantage of regional anesthesia over general anesthesia may be a decreased operating room time and shorter postoperative stays in the intensive care unit and the hospital.\textsuperscript{18,20} Although this series contained too few patients operated on with general anesthesia to make a valid statistical comparison with the patients undergoing regional anesthesia, the patients who did have general anesthesia remained in the hospital for a slightly longer period.

The use of regional anesthesia requires the cooperation of the surgeon and anesthesiologist, as well as the patient. Most patients will agree to regional anesthesia once its advantages have been explained and once they have been reassured that they will experience little discomfort during the procedure and that supplemental lidocaine will be administered if they do experience pain. The majority of patients who have carotid artery surgery with regional anesthesia are satisfied with the anesthetic technique.\textsuperscript{40} Only rarely has a patient in this institution refused regional anesthesia if carotid endarterectomy on the contralateral vessel or a repeat carotid endarterectomy subsequently became necessary, and none of the 25 patients having bilateral endarterectomies during the review period refused regional anesthesia for the second procedure.

This series demonstrates that morbidity and mortality rates are low when carotid endarterectomy is performed with regional anesthesia, which allows simple but effective monitoring of cerebral function. Regional anesthesia is also associated with a lower incidence of postoperative hypertension, which is a significant complication of carotid endarterectomy with general anesthesia. The risk of perioperative myocardial infarction in this group of patients with a high incidence of coronary artery disease may also be lower with regional anesthesia.

References

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Regional anesthesia for carotid endarterectomy


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