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Symposium: controversies in cerebrovascular disease 5. Improving perioperative management of carotid endarterectomy

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Multiple components of the perioperative course of patients who undergo carotid endarterectomy must be tightly controlled in order to maintain an acceptably low complication rate. These factors include appropriate patient selection, routine assessment of cardiac risk factors, precise control of blood pressure intraoperatively and postoperatively, meticulous surgical technique and reliable monitoring for intraoperative cerebral ischemia. This discussion focuses on the vascular practice patterns at the University of Chicago and emphasizes intraoperative management and the safe utilization of intraluminal shunts.

Il faut contrôler rigoureusement de multiples éléments du protocole périopératoire dans le cas des patients qui subissent une endartérectomie de la carotide afin de maintenir les complication à un niveau bas acceptable. Ces facteurs comprennent une sélection appropriée des patients, l'évaluation de routine des facteurs de risque cardiaques, le contrôle précis de la tension artérielle pendant et après l'intervention, une technique chirurgicale méticuleuse et un contrôle fiable de l'ischémie cérébrale peropératoire. Cette discussion porte principalement sur les tendances de la pratique vasculaire à l'Université de Chicago et met l'accent sur la prise en charge peropératoire et l'utilisation sûre des dérivations endoluminales.

More than 500 000 North Americans suffer cerebrovascular accidents each year, resulting in 175 000 deaths. Patients who survive 1 stroke have at least a 25% chance of sustaining a second one, and 50% of these second strokes are fatal. Recent clinical trials have shown that patients with a high-grade carotid stenosis have a significant reduction in the risk of cerebral infarction when treated with carotid endarterectomy (CEA) in conjunction with antiplatelet therapy.[1,2] Overall, however, the reduction in the risk of stroke attributed to CEA compared to medical management is strongly dependent on low perioperative stroke and death rates. For example, a recent multicentre study concluded that the principal benefit of CEA in reducing the 5-year risk of ipsilateral stroke in patients with greater than 60% asymptomatic stenosis depends on achieving a 3% or lower perioperative morbidity and mortality.[2,3]

Thus, multiple components of the preoperative, intraoperative and postoperative courses of patients who undergo CEA must be tightly controlled to maintain an acceptably low complication rate. These factors include careful patient selection, routine assessment of cardiac risk factors, vigilant anesthetic management, precise blood pressure control intraoperatively and postoperatively, meticulous surgical technique, monitoring for intraoperative cerebral ischemia and appropriate use of intraoperative shunts.

Preoperative evaluation

CEA may be considered in patients who have neurologic syndromes refer-

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able to the middle cerebral artery distribution, including transient ischemic attacks, amaurosis fugax and completed but not severely disabling strokes. Nonlateralizing symptoms or symptoms referable to the vertebral-basilar systems are less well accepted indications. CEA may be indicated in asymptomatic patients with significant carotid stenosis who are a low surgical risk in centres having a proven low complication rate for CEA.

Assessment of cardiac reserve is an important component of the preoperative evaluation of patients being considered for CEA. There is a significant correlation between carotid atherosclerotic disease and coronary artery disease. In 1 series, coronary angiographic examinations were performed in all patients who underwent CEA. Severe, surgically correctable coronary artery disease was discovered in 37% of patients suspected of having coronary artery disease and in 16% of patients in whom there was no clinical suspicion of heart disease.[4] Cardiac evaluation includes a thorough history-taking and physical examination, during which specific attention is paid to signs and symptoms consistent with angina, congestive heart failure, peripheral edema, arrhythmias and dyspnea upon exertion. Electrocardiograms are obtained for all patients; cardiac stress tests or coronary angiography is reserved for those patients who have unstable angina.

Patients with moderate and stable coronary symptoms who present with symptomatic carotid stenosis generally can undergo CEA without further cardiac work-up. In these patients, intraoperative transesophageal echocardiography is utilized to closely monitor the patient's cardiac status during CEA.[5] Regional abnormalities of cardiac wall motion are indicative of myocardial ischemia, which signifies the need for altered anesthetic management.

Preoperative definition of the anatomy of the carotid artery lesion is critical. Until recently, 4-vessel and aortic arch cerebral angiography was performed in all patients before they underwent CEA. However, many recent series have shown that the accuracy of carotid duplex arterial scanning approaches that of cerebral angiography without the associated risks of cerebrovascular accident, renal failure or local complications of arterial puncture.[6–8] Cerebral angiography is indicated for any of the following situations: (1) uncertainty regarding the degree of stenosis, (2) uncertainty as to whether the internal carotid artery is completely occluded, (3) lack of clarity regarding the etiology of the patient's symptoms.

Surgical technique

Perhaps in no other operation is the technical performance of the reconstruction so closely related to its immediate clinical result. Since stroke during CEA can be a consequence of both embolic and ischemic events, strict adherence to the principles of surgical exposure, preservation of cerebral blood flow and construction of a smooth intraluminal surface are essential for achieving successful outcomes.

The common carotid artery (CCA), internal carotid artery (ICA) and external carotid artery (ECA) are exposed through an anterior oblique sternocleidomastoid incision. To minimize the risk of cerebral embolization, the carotid bifurcation is not manipulated until control of the distal ICA is obtained. Care is taken to ensure that the hypoglossal, vagus and glossopharyngeal nerves are not injured during the dissection. Muscular arterial branches from the ECA to the sternocleidomastoid muscle can be ligated to allow further mobilization of the hypoglossal nerve for better exposure of the distal ICA. In the unusual circumstance that further distal exposure of the ICA is required, the posterior belly of the digastric muscle can be divided and the styloid process removed with a rongeur. Preoperative subluxation of the mandible can be considered if a high carotid bifurcation or distal ICA exposure is anticipated.

The distal ICA, proximal CCA, the ECA and the superior thyroid artery are all circumferentially dissected free and isolated with vessel loops. If dissection of the proximal ECA is likely to require undue manipulation of the carotid bifurcation, the vessel is simply exposed anteriorly to allow later placement of a vascular clamp after the ICA is clamped.

After systemic heparinization (100 units/kg body weight), vascular clamps are applied sequentially to the ICA, CCA and ECA. With the ICA clamp in place, the risk of distal embolization is markedly decreased and the carotid bifurcation is mobilized. An arteriotomy is made in the lateral aspect of the CCA and extended past the distal edge of the carotid plaque. Unencumbered visualization of the distal plaque end point is essential to minimize the risk of intimal flap formation or distal embolization. The CEA is performed with the elevation of the plaque in the deep media layer of the artery, with distal "feathering" of the plaque into the ICA. If there is any question regarding the distal portion of the endarterectomy, interrupted fine monofilament tacking sutures are placed to secure the distal intima and prevent flap formation. If the proximal end point in the CCA is significantly thickened, it, too, is tacked to prevent movement and lifting with pulsatile flow.

The carotid arteriotomy is closed primarily or with a prosthetic or vein patch. Indications for patch closure include lengthy extension of the arteriotomy onto the ICA, ICA smaller than 3.0 mm in diameter and patients who are active cigarette smokers. In women, who generally have smaller carotid arteries, the indication for patching is liberalized such that 50% to 75% are patched. When using a patch, the surgeon must take care not to enlarge the arterial diameter and produce an aneurysm.

Before closure of the arteriotomy site, each of the carotid vessels are back bled to remove any accumulated fine debris or clot. Flow is restored initially to the ECA and then finally to the ICA to allow potential debris to be embolized into the ECA. Final surveillance of the endarterectomy site can be performed with a hand-held Doppler, intraoperative duplex evaluation or completion arteriography.

Detection and treatment of cerebral ischemia during carotid endarterectomy

Many studies have shown that 15% to 25% of patients will have significant intraoperative cerebral ischemia during CEA.[9,10] Unfortunately, no preoperative evaluation can reliably indicate which patients are likely to suffer this complication. Because of this limitation and the potential inaccuracies of the various monitoring techniques, some surgeons have advocated the routine use of an intra-arterial carotid shunt. They argue that this practice allows a greater familiarity with shunt placement, thus minimizing the risks of its use. Unfortunately, complications can occur during shunt placement, including embolization, injury to the distal ICA and decreased visualization of the distal plaque end point during endarterectomy. The shunt can also become occluded during the operation by angulation against the artery wall or by malpositioning of the balloon over the lumen of the shunt. We prefer to use the shunt "selectively," based on electroencephalographic (EEG) criteria. Electroencephalography also confirms proper shunt function, with resolution of cerebral ischemia after shunt placement.

The EEG analysis is facilitated by power-spectral analysis of the raw signal, which allows for precise quantification of the amplitude and power of the high-, middle- and low-frequency waveforms. The high-frequency activity is most sensitive to reduction in cerebral blood flow.[11] In our experience, it is extremely rare that a change in the low- and mid-range frequencies occurs without first observing a change in the high-range frequencies. Loss of the high frequencies and the beginning of loss of the mid-range frequencies are consistent with significant cerebral ischemia, and should prompt the pharmacologic elevation of the blood pressure by 10%. If cerebral ischemia persists, an intra-arterial shunt should be employed. Any reduction in amplitude of 50% or more in the frequency waveform is also indicative of significant cerebral ischemia and warrants shunt placement.

In the absence of electroencephalography, other techniques may be utilized. Measurement of ICA stump pressure allows for some assessment of the collateralization to the ICA but, unfortunately, does not necessarily reflect middle cerebral artery (MCA) perfusion pressure. One study has shown that stump pressure is neither specific nor sensitive.[12] Transcranial Doppler ultrasonography allows direct assessment of MCA flow during CEA but is extremely technician-dependent. In an occasional patient, the MCA cannot be well visualized by this technique.

In some centres, CEA is performed using a combination of scalene regional anesthetic block and local anesthesia, enabling continuous neurologic assessment of the awake patient. With this technique, evidence of cerebral ischemia with carotid clamping (aphasia, paraparesis or loss of consciousness) would prompt the placement of an intra-arterial shunt. Acceptable results have been reported with this technique; however, it requires a calm and cooperative patient and consistent anesthetic expertise.

Shunt insertion technique

If insertion of an intraluminal shunt is required, the arteriotomy in the ICA is extended beyond the distal aspect of the plaque. The clamp on the distal ICA is removed and arterial flow is controlled with tension on the vessel loop. The distal aspect of the balloon-tipped intraluminal shunt is gently inserted into the distal ICA beyond the level of the vessel loop. Retrograde flow through the shunt confirms appropriate positioning and allows washout of any debris or air. The balloon is gently and minimally inflated to decrease the risk of injury to the distal ICA; the device is kept in place by double looping with the vessel loop. If the diameter of the ICA is small, the balloon may not need to be inflated. The CCA is then unclamped and controlled with digital pressure and the vessel loop. The proximal aspect of the balloon-tipped carotid shunt is inserted into the CCA. The blood is allowed to flush freely through the side-arm of the shunt. The proximal balloon is gently inflated and secured in place with a vessel loop. Once the proximal limb is adequately flushed, the entire shunt is inspected to ensure that there are no air bubbles or debris, and flow is restored to the ICA. Intermittent aspiration of the side-arm of the shunt during the endarterectomy confirms patency.

Throughout the procedure it is important to remember that the speed of shunt insertion is of limited importance. Ischemic injury is unlikely even if insertion times are 2 to 3 minutes. Distal ICA injury or cerebral embolization will have a much more adverse effect. At all times, shunt insertion should be deliberate and unhurried.

Conclusions

CEA continues to be an effective modality for the treatment and prevention of a cerebrovascular accident. Perioperative complications can be minimized by a comprehensive preoperative evaluation and meticulous surgical technique. Recognition and treatment of cerebral ischemia during carotid occlusion are important components of the procedure.

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