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Evidence overview for shunting, patching, type of endarterectomy and anesthesia during carotid surgery

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Carotid endarterectomy has been shown to reduce the risk for stroke in patients with symptomatic or selected asymptomatic severe internal carotid artery stenosis. Although the basic aims of surgery are always the same, the exact techniques used to achieve them vary between surgeons. This paper summarizes the current evidence based optimal technical management of patients with an indication for carotid surgery, focusing on shunt use, patching, eversion *versus* longitudinal endarterectomy, and type of anesthesia applied. For each subtopic discuss, the text is accompanied by a table summarizing the key points.

Key words: Endarterectomy, carotid - Stroke - Coronary stenosis.

Carotid endarterectomy (CEA) has been shown to reduce the risk for stroke in patients with symptomatic or selected asymptomatic severe internal carotid artery (ICA) stenosis. Although the basic aims of surgery are always the same, the exact techniques used to achieve them vary between surgeons.[1] As the complication rate following CEA has gradually fallen, every effort should be made to try and further reduce the risk of perioperative stroke and death even further. The optimal surgical technique for treatment of patients with carotid artery stenosis has puzzled surgeons and remains a subject of extensive debate. Several international societies and associations have published guidelines for the management of carotid patients. Although these recommendations are based on the very same literature evidence, difference in interpretation of available knowledge has often led to different or even conflicting recommendations.

This paper summarizes the current evidence based optimal technical management of patients with an indication for carotid surgery.

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Shunting

The controversy

Few aspects of carotid surgery create more controversy than the use of an intraluminal shunt. In general, three policies are advocated: routine shunting, never shunting, or selective shunting.[1] Although there is argument for all perspectives, most surgeons will agree that in some cases the presence of a shunt will prevent the development of inadequate intraoperative cerebral perfusion and subsequent procedural stroke. To objectively evaluate the utility of shunts we should be able to identify the number of strokes prevented by shunting, *versus* strokes, that may be caused by the shunting process itself. However, valid data comparing different methods are difficult to obtain because the overall stroke rate is low and only a part of these are hemodynamic and therefore potentially preventable by shunt use. Clinical practice reflects this lack of agreement about shunting, as surveys found that about one third of surgeons routinely used a shunt, one-third never did, and one-third used them selectively. The most relevant question remaining therefore is: which patient does really require a shunt?

Hemodynamic background

Hemodynamic failure from carotid cross-clamping (CC) may comprise 20% of all strokes.[2] Shunts aim to reduce this risk by maintaining adequate cerebral perfusion during CC. The normal cerebral hemisphere can withstand ipsilateral CC due to cross-cerebral flow from the collateral extracranial vessels via the Circle of Willis (CoW). However, atherosclerosis frequently affects these collaterals and the CoW may be (congenitally) incomplete. The brain is also more sensitive to inadequate perfusion in patients with previous infarction. Although the need for shunting in patients with contralateral carotid occlusion (CO) is higher, most patients with CO tolerate CC without the need of a shunt.[1]

The need for an intra-arterial shunt appears to be most accurately assessed with the patient awake, reflected by shunt use being lowest in patients operated under local anesthesia (LA) as compared to alternative monitoring approaches. However, although this is probably an accurate approach, the fraction of patients with clinical changes who would suffer an intraoperative stroke is not known since these patients are always shunted.

Advantages and disadvantages

In performing CEA, four different approaches with regard to cerebral protection can be chosen:

— general anesthesia (GA) with no shunt;

— GA with continuous electro-encephalo graphy (EEG) monitoring, transcranial-Doppler (TCD) or carotid stump pressure (SP), shunting only patients with clinical changes – selective shunting;

— LA, shunting only patients with a change in neurologic status – clinical shunting;

— GA plus shunting in all patients.

Performing CEA under GA without a shunt relies on data suggesting that few patients are at risk for "shunt-preventable" stroke. The argument is that shunt placement can cause strokes in some cases and thus the risks outweigh the benefits. The main problem with this method is that some strokes are preventable with use of a shunt and thus in a sense with this approach these strokes are being allowed to occur. It appears, therefore, that the practice of never shunting is becoming obsolete. The controversies then lie in the areas of routine *versus* selective shunting, and, for the selective shunters, in the optimal means of cerebral monitoring.

The arguments in favor of routine shunting are straightforward. It is claimed that the surgeon benefits from the time for a thorough endarterectomy, that this policy therefore reduces the risk of intraoperative stroke, and that it facilitates the training of junior surgeons.[1] In support of this argument, the European Carotid Surgery Trial (ECST) reported better results for those operations that lasted for more than one hour. Routine shunt use also ensures familiarity with shunt insertion, which can prove vital in a difficult situation, and is considered to obviate the need for cerebral monitoring.

It is well-recognized, however, that shunt insertion prolongs the operation time and may make the procedure more difficult because obstructing the visualization of especially the distal endpoint of the endarterectomy. Also, shunt insertion related embolism, intimal dissection, and restenosis due to intimal damage, have been reported. However, accurate data on these risks seem limited and mostly anecdotal.[3] The most important objection to routine shunting is that shunts are in place in at least 80% of patients who "do not need it". On the contrary, selective shunting may avoid the potential risks associated with routine shunting, and anatomically difficult cases (high bifurcation) will be more manageable when a prophylactic shunt is not needed per se. The main problem with adopting a policy of selective shunting pivots around how to identify which patients need a shunt. Preoperative tasks such as carotid compression (Matas test) or interpretation of the CoW on preoperative imaging are unreliable. A number of intraoperative cerebral monitoring techniques have been developed,[4] but unfortunately, apart from awake testing, none of the methods are infallible. In practice, shunts seem to be required in only 10-15% of patients operated upon under LA as opposed to up to 40% in patients under general anesthesia when based on high threshold SP.[5] Even more relevant, there a surprising lack of correlation between these clinical signs and EEG changes. Studies revealed that both EEG monitoring and SP seem normal in one quarter of patients who developed a clear-cut clinical change upon CC. On the other hand, EEG changes may develop in 10% of patients in the absence of any clinical change.

Randomized trials

The Cochrane Group in 1996 identified only two trials in which routine shunting was compared with no shunting, suggesting a promising but non significant 25% reduction in both death and stroke within 30 days of surgery in favor of routine shunting. However, both included trials were severely flawed. In 2009, an update included four trials: three trials involving 686 patients compared routine shunting with no shunting observing no significant difference in the rate of all stroke, ipsilateral stroke or death up to 30 days after surgery, although data were limited.[6] The fourth trial involving 131 patients compared shunting with a combination of EEG and SP measurement with shunting by SP alone, and also found no significant difference between the risk of ipsilateral stroke although again the data were limited. It was suggested that large scale randomized trials between routine shunting *versus* selective shunting were required. However, the small number of outcome events and because only a small percentage of intraoperative strokes will be related to preventable hypoperfusion mean that a trial with the power to confirm this finding would require approximately 5000 patients. As a consequence, the data available today are too limited to guide clinical practice and to either support or refute the use of routine or selective shunting in CEA.

Which shunt?

Numerous shunt designs are available, ranging from simple tubes held in position with silastic slings, tapered shunts (*e.g.*, the Javid) which are held in position with special clamps and shunts which are held in position by proximal and distal balloons (*e.g.*, Pruitt-Inahara). The Javid and Pruitt-Inahara shunts have become the most commonly used shunts in clinical practice, but this practice is not evidence based.

Training and education

For shunt insertion, the key point is in the proper conduct of the procedure. Wide exposure with special attention to the distal ICA is mandated. Furthermore, not only the surgeon self but the whole (surgical) team should be trained to adequately assist. It should not be forgotten that just because a shunt has been inserted does not mean that it is working. Therefore, it is imperative that in any case of carotid revascularization some form of monitoring (*e.g.*, TCD) is used to ensure optimal shunt function. Current guidelines state that there is no evidence for the routine use of shunts during CEA.[7]

Table I.—*Shunt - Key points.*

– Routine non-shunting is not a reliable means of cerebral protection
– There is no randomized data showing the superiority of routine shunting over selective shunting in terms of clinical neurological outcome
– With routine shunting, in at least 80% of operations, the shunt is unnecessary
– There is no infallible means for cerebral monitoring other than awake patient evaluation
– There is little evidence to support the preferential use of one form of cerebral monitoring over another in selecting patients requiring a shunt
– There is no evidence that one shunt type is preferable to another

Conclusions – Key points

The available evidence suggests that either routine shunting or selective shunting is preferable to a policy of routine no-shunting (Table I). Awake monitoring seems the most reliable method of predicting who needs a shunt during clamping. For those that apply GA, no one method of monitoring in selective shunting has been shown to produce better outcomes.

Patching

The controversy

The role of patching, as in shunt policy, makes surgeons usually fall into three camps: routine patching, selective patching, or routine primary closure. Excellent results have been published by each group of proponents. As generally agreed on, the postoperative risk for adverse events after CEA is critically dependent upon achieving a smooth endarterectomized surface, a smooth and gradually tapered distal endpoint, and precise closure. However, despite general consensus on these goals to achieve, still controversy persists regarding the optimal method for closure of the arteriotomy. This is reflected by the fact that considerable heterogeneity in frequency of use and type of patch angioplasty at the individual surgeon, national, and international levels remains.[1]

Advantages and disadvantages

The use of a patch, as opposed to primary closure, has been suggested to improve hemodynamics by providing an increase in the caliber of the endarterectomized segment and particularly the most distal transition zone. A transverse width of 5-10 mm has been proposed as ideal in terms of flow patterns. Patch closure, intuitively, facilitates closure in small arteries by allowing for more accurate placement of sutures without causing narrowing. The main concerns regarding patch closure include prolonged carotid occlusion time and patch material related complications. The additional clamping time with patching has been estimated at about 10 min without shunt use, and up to 15 min with shunt use, but the available evidence to date does not show any increased perioperative risk associated with hemodynamic failure.[1]

The concept of selective patching is based on the assumption that only certain patients really need a patch. Intuitively, these include patients with a narrow ICA (mostly women) or an arteriotomy that extends long into the ICA. If one would adopt a policy of patching on the basis of 5 mm diameter, approximately 50% of patients would receive patch repair.

Randomized trials

A meta-analysis has demonstrated that routine primary closure is associated with a three-to fourfold excess risk of early postoperative stroke or carotid thrombosis.[8] However, the included studies were flawed by the low overall statistical power, and included bilateral procedures. All RCTs included concentrated on comparing primary closure with patching. None, however, compared selective patching with routine patch closure. Accordingly, for proponents of selective patching, there is no evidence whether patching is relatively more preferable in certain situations, such as small-caliber artery (<5 mm) or a very long arteriotomy.

The Cochrane review included both randomized and quasi-randomized trials (10 trials involving 1967 patients undergoing 2157 operations) comparing patch angioplasty *versus* primary closure.[9] Patch angioplasty was associated with a reduction in the risk of ipsilateral stroke during both the perioperative period (OR=0.31) and long-term follow-up (OR=0.32). It was also associated with a reduced risk of restenosis during long-term follow-up (OR=0.24). However, the sample sizes were still relatively small, and there was significant loss to follow-up. Very few procedural complications including hemorrhage and infection were recorded with either patching or primary closure. No significant correlation was found between use of patch angioplasty and the risk of either perioperative or long-term all-cause mortality rates.

Significant recurrent stenosis (>50%) occurs in 0-15% of patients within 5 years of surgery, with only a minority of patients suffering any neurological sequele. Several studies have documented that patch closure is associated with a reduced risk of restenosis. The Cochrane meta-analysis showed that primary closure was associated with a threefold excess risk of >50% restenosis,[8] with a non-significant trend towards a reduction in perioperative any stroke rate and all-cause mortality.

Patch type

The advantages of vein may include ease of handling and insertion, and provision of endothelialized tissue that theoretically reduces the risks of thrombosis, neointimal hyperplasia, and infection.[1] Complications associated with the use of autogenous vein include patch rupture, and side effects related to the harvest site of the vein, and by using up a valuable source of vein for future cardiovascular procedures, which may be needful in 15% of patients.

The advantages of prosthetic patches such as Dacron or polytetrafluoroethylene (PTFE), include instant availability and preservation of vein for further use while the principal disadvantage is the risk of infection. There is no evidence, to date, that either vein or prosthetic patches are superior. The bovine pericardium patch has been reported with promising results in case series but has never been tested compared to vein patching. Existing evidence from RCTs therefore suggests that patch type, whether prosthetic or vein, has no influence on short term clinical outcome in terms of neurovascular events.[10]

Training and education

Visualization of especially the distal endpoint of the endarterectomy is crucial to prevent an residual stenosis, and the "parachute patching technique" is acknowledged to achieve a smooth transition zone. Although mostly anecdotal, patch rupture has been reported in observational studies, and may be more likely if the vein is harvested from the ankle side. Guidelines suggest to use the proximal part of the saphenous vein from the groin, but this advice is not evidence based. Guidelines conclude that patch angioplasty reduces the risk of occlusion and restenosis, as well as the risk for future combined death/stroke rate. Further evidence should prove whether vein should be preserved or not, and compare venous patch *versus* new synthetic and biomaterial patches. As differences between the outcomes with different patch materials are small, more data than currently available would be required to draw firm conclusions.[7]

Conclusions – Key points

Routine carotid patch angioplasty is preferable to primary closure because it reduces the risk for early and late ipsilateral recurrent stenosis and consequently the long-term risk for ipsilateral ischemic stroke (Table II). However, there is no systematic evidence on the benefit of selective patching, nor that patch type, whether prosthetic, bovine or vein, influences outcome after CEA. It is likely that the differences in outcome between different types of patch material are small both on the short and long term.

TABLE II.—*Patching – Key points.*

- Routine patching but also selective patching is preferable to routine primary closure
- Randomized trial comparing routine *versus* selective patching has not been performed
- There is no evidence whether selective patching is relatively more preferable in certain situations, such as small-calibre artery or long arteriotomy
- There is no evidence that vein patching is superior over prosthetic patching
- The risk of vein patch rupture is very small and considered to be similar to the risk of prosthetic patch infection

Surgical technique

The controversy

There are two widely recognized surgical technical options for carotid desobstruction comprising conventional (CCEA) and eversion carotid endarterectomy (ECEA). The first (and most commonly used) technique, commonly referred to as the "conventional technique", includes a standard longitudinal arteriotomy from the common into the ICA with or without patch angioplasty. Currently practiced ECEA was first described in 1959 and involves the oblique transection of the ICA at its origin in the carotid bulb, followed by removal of the plaque using the eversion maneuver, and reimplantation of the latter into the CCA at the same original level. There is an enduring debate as to whether one of the techniques is significantly superior.

Advantages and disadvantages

Some recognized benefits of the eversion technique include shorter clamping time and avoidance of a (prosthetic) patch, both leading to a quicker operation, of particular benefit when performing surgery under LA. ECEA is especially useful when the ICA is coiled or kinked, as the ICA can be shortened by segment resection before being reinserted, thereby straightening the course.[1] The potential disadvantages of ECEA include difficulty in visualizing the endpoint, the need for a complete mobilization of the ICA, and more extensive dissection in the vicinity of the bifurcation and bulb, and it is more technically demanding in cases when a shunt is required.

ECEA has a perceived lower incidence of recurrent stenosis, although data to support this contention are conflicting. Regarding possible mechanisms underlying the supposed superiority of ECEA in terms of restenosis, it has been postulated that the incision at a wider portion, which is the bulb, may be associated with decreased possibility for restenosis.

ECEA cannot avoid the transsection of the longitudinal nerve fibers of the carotid sinus nerve, which, in prior studies, has been associated with loss of the baroreceptor reflex and postoperative hypertension, as human carotid baroreceptors are mainly localized in the medial portion of the proximal ICA. Patients with ECEA have been observed to have a significantly increased postoperative blood pressure, that may persist for several days, and require more frequent antihypertensive medication, compared with patients having CCEA.

Randomized trials

ECEA has been validated in prospective randomized trials, the largest being the Eversion Carotid Endarterectomy Versus Standard Trial (EVEREST) including some 1353 patients. EVEREST found no statistical difference in late outcome (stroke, death, or restenosis) between standard (patch and primary closure) as opposed to ECEA. Subgroup analysis showed that restenosis rates were statistically comparable (2.8% *vs.* 1.5%) for eversion and patch closure respectively, while both had significantly lower restenosis rates than primary closure.[11] In 2002, a systematic review by the same authors (five trials, 2500 patients) found that ECEA was associated with a lower risk of restenosis when compared with conventional (patch) CEA, albeit that rates of clinically relevant outcomes such as stroke and death were equal.[12]

The Cochrane meta-analysis also pointed to the equivalence of ECEA with CCEA in terms of perioperative death, stroke, miocardial infarction (MI), but also equivalence in cranial nerve injuries, neck hematoma and carotid occlusion, as well as regarding late stroke.[13] Noticeably, a borderline superiority of ECEA had emerged concerning late restenosis rates. Of interest, the Cochrane review did not address early restenosis, perioperative transient ischemic attack, late death and late occlusion.

The Cochrane review, updated in 2003, concluded therefore that "*there is at present insufficient evidence from randomized trials to reliably determine the relative risks and benefits of eversion versus conventional CEA. Until further evidence is available, the choice of technique should depend on the experience and familiarity of the individual surgeon*". Notably, Cochrane included only randomized studies. Since then, one additional randomized study appeared [14] whereas the considerable pool of 17 non-randomized studies was only evaluated in the analysis by Antonopoulos *et al.* in 2011.[15] The conclusions of this analysis predominantly showed a (statistically significant) shorter clamping time for ECEA, a finding supported by the EVEREST trial.[11]

In a recent interesting substudy of the Stent Protected Angioplasty *versus* Carotid Endarterectomy (SPACE) trial,[16] the outcome of 563 patients within the surgical randomization arm of the trial was analyzed by surgical technique subgroups: ECEA *versus* CCEA with patch angioplasty. Shunt frequency was higher in the CCEA group (65% *versus* 17%; $P<0.0001$). The risk of ipsilateral stroke or death within 30 days after surgery was significantly greater with ECEA (9% *versus* 3%; $P=0.005$). Conventional CEA thus appeared to be associated with better periprocedural neurological outcome than ECEA. These findings should, however, be interpreted with caution noting the limitations of the *post hoc*, non-predefined and, therefore, non-randomized nature of this subanalysis.

Training and education

While eversion offers distinct advantages in certain anatomic circumstances, adoption of ECEA with the aim of decreasing restenosis is not warranted. Concerns with carotid eversion include difficulty in visualization of the endarterectomy endpoint, increased technical demand, difficulty when a shunt needs to be used, and the possibility that a distal flap may remain if the endarterectomy endpoint is not properly performed. With regards to the use of a shunt, reports from multiple groups with extensive experience have described the safety and feasibility of shunting during carotid eversion. However, shunt use remains more cumbersome and technically demanding when using the eversion technique. ESVS guidelines recommend that the choice of CEA technique should depend on the experience and familiarity of the individual surgeon. In tandem lesions, eversion of the ICA might not be able to completely take out the most distal part of the plaque and result in incomplete plaque removal. Furthermore, in redo surgery, CCEA may be preferable to ECEA especially since the need for complete ICA mobilization might cause cranial nerve lesion.

Conclusions – Key points

Both ECEA and CCEA are safe and durable techniques for treatment of ICA stenosis. It is a case of the individual surgeon's experience and choice as to which technique is employed (Table III).

TABLE III.—*Surgical technique – Key points.*

– There is equivalence of ECEA with CCEA in terms of perioperative death, stroke, and MI
– When only CEA with patch (and not primary closure) is compared with eversion endarterectomy, there is no statistically significant difference between the two techniques in terms of restenosis rate
– The choice of CEA technique should depend on the choice of the individual surgeon

Type of anesthesia

The controversy

In the early 1960s, the initial reason for using LA rather than GA was to observe directly the neurologic status of the patient during CC. Operating on the conscious patient has been crucial in allowing accurate differentiation between the various mechanisms of perioperative stroke, especially the distinction between clamping ischemia and non-specific cerebral embolization. Although proponents from each point of view of anesthetic technique often use perioperative stroke rates to support their position, it has become clear that perioperative neurologic complications are more often related to etiologies other than clamping ischemia, and include postoperative thrombosis at the endarterectomy site, intraoperative embolization, and reperfusion injury.[17]

Anesthetic techniques for carotid surgery

Anesthetic techniques for carotid surgery are: 1) GA with inhaled or total intravenous anesthesia and 2) LA with a deep or superficial block or both or cervical epidural anesthesia.

Goals of anesthetic management include the prevention of ischemic injury to the brain and heart by maintaining adequate cerebral perfusion and hemodynamic stability during and after CC (Table IV).

TABLE IV.—*Anesthetic technique - Key points.*

– The incidence of serious complications related to the administration of the anesthetic itself is extremely low
– There is no clear evidence todate, that CEA under LA is safer than GA and associated with reduced cardiovascular risk
– CEA under LA will not protect against stroke due to technical error unless some other method of quality control assessment is employed
– Not all patients will be suitable for CEA under LA and an anesthesiologist must always be present to intubate patients if indicated

Advantages and disadvantages

The main advantages of GA are a safe airway throughout the procedure with controlled ventilation. Propofol and sevoflurane cause similar reduction in cerebral metabolism, but cerebral blood flow and cerebral blood volume are both lower with propofol. Furthermore, propofol disturbes the readability of EEG. However, currently, there is no outcome-based evidence favoring any particular general anesthetic agent. The disadvantages of GA range from airway problems to minor complications including headache and sore throat. More importantly, the residual effects of GA can potentially mask the symptoms or signs of neurologic complications from surgery in the early postoperative period.[1]

The advantage of “awake” over GA is the ability to continually assess the patient’s neurological status. This is generally accepted as a sensitive monitor of cerebral function and can detect clinically significant cerebral ischemia even when other monitoring techniques such as EEG remain unchanged. Furthermore, CEA under LA has been associated with improved early postoperative cognitive function compared with GA. LA therefore is associated with a better assessment of neurologic function not only during but also after surgery.

Each regional technique has its complications ranging from intravascular injection to recurrent laryngeal nerve block to hypotension/bradycardia and respiratory failure.[1]

Surgery under LA requires a cooperative, non-claustrophobic patient. Patients not to be considered for a regional block also includes patients patients with a short and or fat neck. Although LA appear to be patient preference, reportedly, up to 10% of patients refuse CEA under LA. Furthermore, it would seem sensible to have an anesthesist present in the theatre throughout the operation, as unexpected conversion to GA during the course of surgery occurs in up to 10% of cases. Not to forget, surgeons may find performing surgery under LA stressful.

Randomized trials

Evidence from several non-randomized studies suggests that CEA under LA offers considerable benefits, including reduction in mortality and major morbidity.[5] A meta-analysis including 17 non randomized (5970 patients) and only 3 randomized studies (143 patients) showed that LA was associated with a lower risk of perioperative death, stroke, and MI.[5] The updated meta-analysis published in 2007 again reported favorable results for LA, and this analysis included both retrospective (34) and prospective (14) studies and all together included 17,028 procedures.[18] LA reduced the incidence of any new neurologic impairment stroke or death (OR=0.62), and MI (OR=0.50). When all studies were considered together, there were reduced incidences of arrhythmia, respiratory complications, and length of surgery. However, the number of patients included in RCTs or even in prospective (randomized or nonrandomized) studies was still too low to allow definitive conclusions on the differences in outcome between these two anesthetic techniques.

The General Anesthesia *versus* Local Anesthesia for carotid surgery (GALA) trial included 3526 patients with symptomatic or asymptomatic carotid stenosis.[19] GALA showed no definite differences in quality of life, length of hospital stay, or the primary outcome (*i.e.*, stroke, MI, or death between randomization and 30 days after surgery).[19] A non-significant increased rate of MI (local *vs.* GA 0.5% *vs.* 0.2%; effect difference 0.3% CI -0.2% to 0.8%) was observed. LA might offer an advantage in terms of the primary outcome for patients with a contralateral occlusion. However, results from the GALA study did not answer the question whether it is safe to perform CEA under LA in the group of patients at “high risk” for cardiovascular complications. A 2009 meta analysis of only randomized studies (10 studies; 4335 patients including 3526 from GALA) showed, therefore, that there was no evidence of a reduction in the odds of operative stroke, death, and MI between the two types of anesthetic technique during CEA.[20] Although there was a trend toward lower operative mortality with LA (OR=0.62) neither GALA nor the pooled analysis was powered to detect an effect on mortality reliably.

Hemodynamic instability

One of the most important proposed benefits of CEA under LA may be greater cardiovascular stability throughout the perioperative period. Unfortunately, to date, the evidence appears contradictory. Blood pressure control is considered more difficult to achieve during and immediately after GA than LA. In each of the RCTs, blood pressure fell following induction of GA. Hypotension requiring treatment in the perioperative period was significantly more likely to be encountered in GA patients than in LA, whilst hypotension was more commonly encountered in the early postoperative period in patients undergoing surgery with LA.[21] A possible explanation would be the frequent need for intervention measures to decrease blood pressure during surgery, but no hard evidence exists to support this. In contrast, under GA, relative hypotension is observed intraoperatively followed by postoperative hypertension, persisting during the first 96 hours after surgery, resulting in the more frequent use of vasoactive drugs. This however does not seem to have negative effect on the operative outcome per se. In addition, it has never been clearly shown that GA carries a higher cardiac morbidity than LA.

Training and education

Most vascular surgeons would probably concede that having the patient asleep, quiet and stable is the ideal way to perform CEA. This means that the surgeon can take as long as needed to do the operation, there is no difficulty in extending the operation either proximally or distally and there is ample opportunity to teach younger colleagues.

For those who routinely shunt, awake testing will warn of shunt malfunction, however, reliance on awake testing is no substitute for obsessional secure surgical technique because clamp ischemia is a relatively rare cause of operation related stroke. Awake testing will not prevent a thromboembolic stroke, which is the principal cause of CEA related operative morbidity. ESVS guidelines suggest that the anesthesist and surgeon, in consultation with the patient, should determine the method of anesthesia.[7] Whichever anesthetic technique is chosen, cerebral blood flow should be optimized, cardiac stress minimized, and the risk of ischemia decreased by maintaining a normal-to-high perfusion pressure.

Conclusions

The best anesthetic technique for an open carotid endarterectomy is debatable. Having an awake and appropriately responsive patient is clearly the most sensitive monitor of adequate cerebral perfusion, but with respect to the major complications of stroke, MI, and death, there is no evidence of advantages of one anesthesia technique over the other. Because of that, several additional outcomes need to be taken into account when choosing the technique.

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