Large, randomized controlled trials have shown that carotid endarterectomy is beneficial for selected patients with significant, recently symptomatic carotid stenosis. However, surgery itself carries a significant risk of stroke and death. Most perioperative strokes are ipsilateral carotid territory cerebral infarcts and some may result from the temporary interruption of blood flow that occurs while the carotid artery is clamped. The duration of interrupted blood flow can be minimized by bridging the clamped section of the artery with a shunt. Although some surgeons advocate routine shunting, others prefer to use shunts selectively or avoid them altogether. Potential disadvantages of shunting include complications such as air and plaque embolism and carotid artery dissection, and an increased risk of local complications such as nerve injury, hematoma, infection, and long-term restenosis. However, reliable data on these risks are limited. We performed a systematic review of randomized controlled trials to determine the effect of a policy of routine or selective shunting on the risk of perioperative stroke, death, and other operative complications. We also tried to identify if any one method of selecting which patients undergoing endarterectomy, under general anesthetic, require a shunt is better than any other.

Methods

Similar search strategies and inclusion criteria were used in the original (up to 1995) and updated reviews (1995 to 2000). Studies were included if they compared any of the following policies: routine shunting versus avoiding a shunt; selective shunting versus routine shunting; selective shunting versus avoiding a shunt—or if they examined different methods for determining the need for a shunt. Recorded endpoints were all strokes, ipsilateral strokes, all strokes and deaths, wound hemorrhage, wound infection, and ipsilateral cranial nerve injuries. The time periods examined were intraoperative, within 24 hours of surgery, within 30 days of surgery, and during the whole follow-up period. If available, long-term outcomes—such as restenosis of the operated artery, cognitive function at the end of follow-up, and the numbers of shunts inserted in trials comparing one method of monitoring with another—were also recorded. Data were analyzed on an “intention-to-treat” basis. If any of the necessary data were not reported, additional data were sought from the trialists. The analyses of surgical complications (including ipsilateral stroke) were based on all arteries randomized, whereas overall stroke and death rates were calculated per patient.

Results

Three trials fulfilled the inclusion criteria. Two trials (590 patients) compared routine shunting with no shunting. Allocation was adequately concealed in 1 trial, and 1 trial was quasi-randomized. There were crossovers between treatment arms in both trials but neither trial excluded patients after randomization, and analysis was by intention-to-treat. The treatment groups were comparable in 1 trial, but no baseline data were available in the other trial. This trial was also potentially affected by the fact that 57% of shunted patients were patched compared with 39% of nonshunted patients ($P=0.0002$). There were no losses to follow up in either trial but the duration was only 30 days. The Figure shows the pooled estimates of the risks and the odds ratios between shunted and nonshunted operations for each complication studied. The overall 30-day stroke and death rate was 5.7%, and the overall risk of death was 1.8%. No significant differences were seen in any of the recorded outcomes for shunted versus nonshunted patients.

The third trial, involving 131 patients, compared shunting on the basis of electroencephalographic (EEG) and carotid pressure measurement alone. The treatment groups were comparable, but the method of randomization, blinding of outcome assessment, and duration of follow-up were unclear. Three of 72 (4.1%) patients in the combined monitoring group had ipsilateral strokes within 24 hours of surgery compared with 2 out of 70 (2.9%) in the stump pressure alone group (OR=1.47, 95% CI=0.25 to 8.68, $P=0.7$). There were no significant differences in wound hemorrhage (4.1% versus...
1.4%, OR = 2.7, 0.37 to 19.58, *P* = 0.3) or nerve palsy (8.3% versus 7.1%, OR = 1.18, 0.35 to 4.02, *P* = 0.8), but combined monitoring resulted in the use of fewer shunts (12.5% versus 25.7%, OR = 0.43, 0.18 to 0.98, *P* = 0.05).

### Discussion and Implications for Future Research

There is still insufficient evidence from randomized controlled trials to support or refute the use of routine or selective shunting during carotid endarterectomy. Further, there is little evidence to support the use of one form of monitoring over another in selecting patients requiring a shunt. A large, randomized controlled trial would be required to assess whether shunting reduces the risk of perioperative and long-term death and stroke. Even a modest 25% reduction in the relative risk of perioperative stroke or death would result in approximately 15 fewer strokes and deaths per 1000 patients undergoing endarterectomy. However, to detect this reliably (80% power, 5% significance level) would require between 3000 and 5000 patients.11 The trial would need to be truly randomized, have long-term follow-up, and have blinded outcome by neurologists.12 Patients should be stratified by age, sex, degree of carotid stenosis, the experience of the surgeon, the use of patching, and, in selective shunting, the method of monitoring of cerebral ischemia. As regards the method of monitoring in selective shunting, until the efficacy of shunting has been demonstrated, further trials of the method of monitoring are probably not merited.

### References

Routine or Selective Carotid Artery Shunting for Carotid Endarterectomy (and Different Methods of Monitoring in Selective Shunting)
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