



Local versus General Anaesthesia for Carotid Endarterectomy – Improving the Gold Standard ?

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Submitted 18 January 2008; accepted 15 March 2008

Available online 15 May 2008

KEYWORDS

Carotid
endarterectomy;
Local anesthesia;
Stroke

Abstract *Objective:* Carotid endarterectomy (CEA) reduces stroke risk among selected patients. To achieve this, low operative risk is crucial. Outcome may depend on whether local (LA) or general (GA) anaesthesia is used. The aim of our study was to assess the risks of CEA under LA compared with that under GA. Primary endpoint was neurological outcome.

Design: Retrospective study, prospective data bank.

Patients and methods: Analysis was performed of hospital charts from 1341 consecutive patients undergoing carotid endarterectomy between January 1995 and December 2004. The patients were divided into two groups according to intraoperative anaesthesia (LA 465 patients or GA 876 patients).

Results: Cerebral complications (transient ischemic attacks and stroke combined) were more common in the GA group (6.9% vs. 3.4%, $p < 0.009$, relative risk 0.48, 95% confidence interval (CI) 0.272–0.839). Mortality was 0.5% (LA) vs. 0.8% (GA). Combined death and stroke rate were not different between groups (4.1% vs. 3.2%). Postoperative hypertension episodes were more common in the LA group (47.7%, vs. GA 20.4%, $p < 0.001$). Haematomas requiring surgery were more common in the GA group (6.4% vs. 3.0%, $p < 0.02$).

Conclusion: CEA can be performed safely under LA. It may improve the results and lead to better neurological outcome as compared to GA. Risk factor analysis did not reveal specific risk groups.

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Introduction

Carotid endarterectomy reduces the risk of stroke among patients with symptomatic^{1,2} and asymptomatic^{3,4} carotid stenosis. The American Heart Association (AHA) guidelines for carotid endarterectomy⁵ laid the foundation for recent

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practice in carotid surgery. Improvements in endovascular techniques and the development of carotid artery stenting (CAS) have caused a paradigm shift in the treatment of carotid stenosis.

Although none of the randomised trials comparing CAS and CEA^{6–10} could demonstrate any significant benefit of stenting over surgery regarding stroke and death, endovascular therapy may have some possible advantages, such as avoidance of general anaesthesia and surgical trauma.

Although CEA was often performed under LA in the 1960's,¹¹ most surgeons prefer to operate on a fully anaesthetised and relaxed patient. Reports from centres of excellence¹² as well as a recent large meta-analysis¹³ suggesting improved outcome of CEA performed under LA are changing the attitudes of many surgeons. The hypothesis of the completed but unpublished randomized GALA (General versus local anesthesia) trial¹⁴ was to show a 50% reduction in stroke and death rates in favour of LA. Recruitment of patients for the trial is completed and results are expected this year.

Local anaesthesia may have some advantages compared to GA, such as a. risk of myocardial infarction rates and pulmonary complications.¹³ Direct neurological monitoring of the awake patient eliminates the necessity for equipment for that purpose. The aim of our study was to analyse the impact of the different anaesthetic techniques (local and general) in CEA on neurological outcome (primary endpoint) and mortality (secondary endpoint).

Patients and Methods

Over a 10 year period (January 1995–December 2004) the hospital records of all 1341 patients consecutively operated on in the two units were collected for analysis. 876 operations under GA and 465 under LA were performed in the two teaching hospitals of Giessen and Dessau. Indications for surgery were asymptomatic carotid stenosis >80% or symptomatic carotid stenosis of >70%. Hospital volume was about sixty operations per year in both units.

Duplex imaging of the carotids was performed in all cases and findings confirmed by angiography ($n = 830$) or magnetic resonance angiography (MRA) ($n = 438$). MRA was more frequently performed during the later years of our study.

The choice of anaesthetic method was based on surgeon and patients' preferences.

For the analysis, the patients were divided into two groups based on anaesthetic procedure. Comparisons were made with respect to preoperative risk factors, intraoperative events such as use of intraluminal shunt, and postoperative complications. Operating time and clamping time of the carotid artery were recorded. All patients were examined by an independent neurologist pre- and postoperatively.

Postoperatively, major stroke was defined as neurologic deficit lasting beyond 30 days and leading to handicap. Minor stroke was defined as any transient focal deficit not leaving handicap (combining transient ischemic attack (TIA) and prolonged reversible ischemic neurologic deficit (PRIND)). All patients with new central neurological deficits underwent computed tomography postoperatively. Another complication noted was significant neck haematoma requiring surgical evacuation.

LA was performed using 0.75% ropivacain. Altogether 15–18 ml were used to infiltrate the skin and underlying tissue. Additional xylocaine was supplemented by the surgeon as needed (1–5 ml). Intravenous sedatives and anxiolytics were used as suggested by the anaesthetist. At the time of carotid clamping, neurology was tested by the patient's ability to squeeze a duck making a sound. Shunting was performed, if the response was inappropriate.

In the GA group, the patients were intubated. Etomidate and propofol were used for anaesthesia with remifentanyl infusion. Somato-sensory evoked potential (SSEP) monitoring was routinely used. Carotid shunting was performed if SSEP showed slowing to 50% of pre-clamping response.

CEA was performed conventionally, using patch closure in all cases. Heparin was administered before carotid clamping (100 I.E. per kg) and was not routinely reversed.

All patients were admitted to the intensive care unit (ICU) for 24 hours. Blood pressure (BP) was recorded directly using a radial artery catheter. Postoperative hypertension was reported when systolic blood pressure remaining higher than 160 mm Hg for >2 hours in spite of medical treatment.

Statistical analysis

Statistical analysis was performed using SPSS 15.0 software (SPSS Inc., Chicago, IL). Comparison of the groups under consideration was performed with χ^2 test for categorical items or t-test for parametric data. Bonferroni-adjusted p values as well as the original p values are given in Tables 1 and 2. A subgroup analysis was performed with respect to the indication for the operation using χ^2 test risk estimate and confidence interval. A stepwise logistic regression analysis was performed in order to investigate the influence of perioperative factors on postoperative cerebrovascular events and mortality. We considered Nagelkerkes squared R as an estimate of the variability explained. We used the Hosmer-Lemeshow-Test as a goodness of fit check. If the p value was >0.05, we concluded that the model did not explain the data adequately.

Results

Patient characteristics are shown in Table 1.

The patients in the LA group were older (mean age was 68.5 vs. 66.5 years, $p < 0.001$). There were no significant differences with regard to coronary or peripheral occlusive arterial disease, hyperlipidemia, renal disease or stenosis on the contralateral side.

There were more symptomatic patients (Combined transient ischemic event and stroke) in the GA group (63.2% vs. 48.6%, $p < 0.001$). The number of previous strokes was not significantly different (23.7% vs. 19.7%). Hypertension and diabetes were more common in the LA group (88.1% vs. 79.7%, $p < 0.01$ and 35.2% vs. 22.6%, $p < 0.001$ respectively). Smoking was more common in the GA group (40.1% vs. 33.5%, $p < 0.02$).

Operative variables in the groups are shown in Table 2.

There was no statistically significant difference in shunt use (GA = 15.9% vs. LA = 13.6%). Total operating time and

Table 1 Patient characteristics

	General anesthesia (<i>n</i> = 876)	Regional anesthesia (<i>n</i> = 465)	<i>p</i> -value
Age (mean)	66.49 (SD: 8.239)	68.40 (SD: 9.008)	<0.001
Sex = male	638 72.8%	343 73.8%	NS
Diabetes	198 22.6%	163 35.2%	<0.001
Occlusive arterial diseases	249 28.4%	110 23.8%	NS
Hypertension	698 79.7%	408 88.1%	<0.001
Smoking history	351 40.1%	155 33.5%	<i>P</i> = 0.02 Bonferroni!!
Coronary heart disease	380 43.4%	224 48.4%	NS
Renal dysfunction	172 19.6%	68 14.7%	NS
Contralateral occlusion	121 13.8%	58 12.5%	NS
asymptomatic	322 36.8%	238 51.4%	<0.001
Transient ischemic attack (TIA)	300 34.2%	112 24.2%	<0.001
Prolonged reversible ischemic neurological deficit (PRIND)	52 5.9%	22 4.8%	NS
Stroke	208 23.7%	91 19.7%	NS

clamping time were shorter under LA (103 min vs. 111 min, $p < 0.001$ and 33 min vs. 39.4 min, $p < 0.001$, respectively).

There was no statistically significant difference in perioperative mortality between the groups (GA 0.5%, LA 0.8%). Cerebral complications were significantly more common under GA (6.9% vs. 3.4%, $p < 0.009$, relative risk 0.478, 95% confidence interval (CI) 0.272–0.839). More strokes (3.5% vs. 2.3%) and transient ischemic attacks (3.4% vs. 1.0%), were seen in the GA group. Combined mortality and stroke rate was not significantly different (4.1% vs. 3.2%, $p = 0.31$, relative risk 0.715, 95%CI 0.374–1.369).

A subgroup analysis of the asymptomatic and symptomatic patients showed that there was no specific advantage for the different anesthetic procedures. For asymptomatic

patients the incidence of any postoperative neurologic event was 1.7% (4/238 patients) after LA and 4.3% (14/322) after GA ($p = 0.077$; relative risk 0.514, 95% CI 0.22–1.22). For the symptomatic patients it was 5.3% (12/225) after LA and 8.5% (47/554) after GA ($p = 0.132$; relative risk 0.687, 95% CI 0.41–1.153).

Episodes of hypertension were significantly more common in the LA group during the first 24 hours (47.7% vs. 20.4%, $p < 0.001$).

Haematomas requiring surgical evacuation were more commonly seen in the GA group (6.4% vs. 3.0%, $p < 0.02$).

To compare and quantify the possible influence of all risk factors and the operation technique on the occurrence of a cerebrovascular event, a backward stepwise logistic regression analysis was performed (Table 3). Hosmer-Lemeshow-Test gave 0.345. The result has to be viewed with caution as the regression analysis, although statistically significant ($p < 0.001$) explains 10.4% (Nagelkerkes R square = 0.104) of the variability. Preoperative neurological events (odds ratio 1.3), operation time (odds ratio 1.02 per minute) and type of anaesthesia (odds ratio 2.3) had a significant impact on postoperative neurological events. In order to predict morbidity and mortality (defined as postoperative mortality or stroke) out of the preoperative and intraoperative variables, the best model (Hosmer-Lemeshow-Significance = 0.498) explained 9% of the variability. Significant predictor of outcome were preoperative cerebrovascular events and total operating time.

Table 2 Operation details

	General anesthesia (<i>n</i> = 876)	Regional anesthesia (<i>n</i> = 465)	<i>p</i> -value
Left side	427 48.8%	238 51.2%	NS
Shunt	139 15.9%	63 13.6%	NS
Operating time	111.38 SD: 30.7	103.98 SD: 26.8	<0.001
Clamping time	39.40 SD: 17.0	33.09 SD: 15.6	<0.001

Table 3 Regression analysis

	Sig.	Exp (B)	95% CI Lower boundary	95% CI Upper boundary
Age	0.199	1.021	0.989	1.053
Preop. neurol. Event	0.003	1.343	1.106	1.630
Hypertension	0.158	1.712	0.812	3.607
Sex	0.145	1.484	0.872	2.527
Occlusive arterial diseases	0.919	1.029	0.593	1.786
Smoker	0.338	1.295	0.763	2.197
Renal dysfunction	0.893	1.040	0.589	1.834
Coronary heart disease	0.505	0.843	0.509	1.394
Diabetes	0.767	1.058	0.729	1.536
Operation time	0.002	1.014	1.005	1.022
Clamping time	0.594	0.995	0.975	1.015
Type of anesthesia	0.007	2.374	1.261	4.470
Constant	0.000	0.000		

B = Regression coefficient; Sig. = significance; Exp (B) = Odds Ratio; CI = Confidence Interval.

Discussion

The introduction of carotid stenting has resulted in a paradigm shift in the management of carotid stenosis, although no clear benefits of CAS has been demonstrated.^{6–10} One of the most obvious advantages of CAS is the possibility to perform the procedure under local anaesthesia. If the aim is a fair comparison between CEA and CAS, it probably should be made between CEA performed under LA rather than GA. Our aim was to investigate whether CEA performed under the two types of anaesthesia differ in outcome.

We included 1341 consecutive patients in our study, making this one of the largest of its kind. The study was retrospective, the choice of anaesthetic method was based on surgeon and patients' preference.

There were slight differences between the groups with regard to clinical characteristics. The patients in the LA group were older ($p < 0.001$). There were more diabetics ($p = 0.001$) and hypertensive patients ($p < 0.01$) in the LA group. There were more symptomatic patients in the GA group ($p < 0.001$), but the number of patients with previous stroke was not significantly different (Table 1).

One of the most important advantages of CEA performed under LA is thought to be the monitoring of the awake patient. Patient co-operation is important during an operation lasting for up to two hours and neurological monitoring calls for an experienced anaesthetist. Operating on an awake patient becomes more difficult with a restless patient and in case of a sudden neurologic deficit immediate shunting becomes necessary. Nevertheless there may be the advantage of accurate selection of the patients' requiring shunts which may explain the lower incidence of cerebrovascular complications ($p < 0.009$). Shunt use is thought to be reduced under LA.^{15,16} Differences in carotid shunting have also been reported by Watts *et al.*¹⁷ In their study, shunt use was significantly more common in the GA group (83% vs. 9%). In our study, there was no difference

in shunt use (16% vs. 14%), which reflects the use of SSEP monitoring in the GA group and very selective shunting. Routine shunting is naturally an option, but there may be advantages in selective shunting,¹⁶ such as fewer embolic events due to minimised manipulation of the artery. It has been postulated that more shunt use means longer clamping and operating times,¹⁷ but shunt use has not been shown to be related to neurologic complications. Shunt use and monitoring methods are currently debated.¹⁶

Gabelman *et al.*¹⁸ have confirmed the benefits of performing CEA in awake patients by showing less operative time and intensive care unit stay compared to those operated on under GA. In our study, operative time and clamping time were significantly shorter in the LA group. Connections between operating or clamping time and neurological outcome have not been reported so far, but in our series total operating time had a significant impact on neurological outcome in regression analysis (odds ratio 1.014).

Other assumed advantages of operating under LA include fewer cardiac and pulmonary complications.¹³ In our study, the incidence of myocardial infarction (MI) and pneumonia were lower than 1% in both groups.

Some surgeons fear that sudden conversion from LA to GA may be dangerous. However, conversion has been reported to be very rare.¹⁹ In our study the rate was 1.3% ($n = 6$), and conversion did not lead to added mortality or morbidity.

Blood pressure variability between the anaesthetic regimes has been reported in several studies.^{18,20,21} Most studies report higher BP variability in patients operated on under GA. However, in our study the LA group had higher systolic BP values in the ICU (48% vs. 20%, $p < 0.001$). The same finding was also reported by Forsell *et al.*²² In our study, all pressure recordings were performed continuously and intra-arterially on an intensive care unit, making the data very reliable. However, there were more hypertensive patients in the LA group, which may at least partially explain our findings. Another factor is that the patients in the LA group were older. On the other hand, patients recovering from general anaesthesia may simply get more attention from the ICU personnel.

In the study by Watts *et al.*,¹⁷ there was no difference in postoperative bleeding between the groups. Rerkasem *et al.*¹³ found local haemorrhage significantly more associated with general anaesthesia in the meta-analysis of the reviewed studies. Surgical evacuation of a haematoma was more commonly performed in patients operated on under GA in our study (6% vs. 3%, $p < 0.02$). There was no difference in heparin use between the groups.

The most relevant result of our study is the significantly better neurological outcome in favour of local anaesthesia. Cerebral complications were significantly more common after GA (6.9% vs. 3.4%), More strokes (3.5% vs. 2.3%) and transient ischemic attacks (3.4% vs. 1.0%), were seen in the GA group. Regression analysis shows that preoperative neurological events, operation time and type of anaesthesia have a significant impact on postoperative neurological events. The result should be viewed with caution as the regression analysis, although statistically significant, explains 10.4% of the variability. Clearly, other factors influence the neurological outcome as well, but using this

less known but well-accepted statistical method, GA can be shown to increase the odds of a postoperative cerebrovascular event by a factor of 2.3.

A retrospective study by Watts *et al.*¹⁷ reported no difference between LA and GA with regard to neurologic complications among 582 patients. Our experience in a much larger series suggests LA is safer for CEA.

Our study has some obvious limitations. The form of anaesthesia used was not randomised. However, prospective data collection was used. The data is based on a rigorous analysis of a large population of patients operated on consecutively. Certain patient selection bias is possible as well, but a wide range of variables were considered.

Conclusion

Carotid endarterectomy performed under local anaesthesia can be performed safely and may lead to a better neurological outcome as compared to general anaesthesia. Risk factor analysis did not reveal specific risk groups.

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