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ABSTRACT: Purpose. Carotid artery stenosis accounts for approximately 10% of all ischemic strokes, causing significant morbidity and mortality. Historically the standard of care for surgical candidates for carotid stenosis was carotid endarterectomy, traditionally done under general anesthesia. As carotid stenting becomes an established less invasive modality of treatment, we investigated carotid endarterectomy under local anesthesia as an alternative option. **Methods.** We conducted a retrospective review of medical charts for patients undergoing carotid endarterectomy at a large community hospital from July 2007 to June 2010. 30-day postoperative myocardial infarctions and strokes were evaluated for patients undergoing carotid endarterectomy under local anesthesia, compared to carotid endarterectomy under general anesthesia. Carotid artery shunting and preoperative stroke were also evaluated as risk factors for postoperative myocardial infarction and stroke. Fisher exact tests were calculated to compare postoperative outcomes between patient groups. **Results.** A total of 407 carotid endarterectomies under local anesthesia and 256 carotid endarterectomies under general anesthesia were included in the analysis. Age, sex, and occurrence of preoperative stroke were similar between study groups. General anesthesia patients were more likely to receive a shunt (82% vs 11%, *P*<.001). General anesthesia patients had higher rates of postoperative myocardial infarction (1.2% vs 0%, *P*=.057) and stroke (2.3% vs 0.7%, *P*=.095), but these differences were not statistically significant. Patients with a shunt also had non-significantly higher rate of postoperative stroke (2.3% vs 0.7%, *P*=.096). **Conclusions.** Our evidence suggests that carotid endarterectomy under local anesthesia can be an effective alternative for carotid stenosis with a possibly better safety profile than carotid endarterectomy under general anesthesia. Larger randomized studies are needed to further evaluate these complications.

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Key words: common carotid artery, carotid occlusive disease, carotid endarterectomy, carotid stenting, stroke

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Currently 3 main operative modalities are used in the treatment of carotid artery stenosis: carotid endarterectomy (CEA) under general anesthesia (GA), carotid artery stenting, and carotid endarterectomy under local anesthesia (LA). Carotid endarterectomy was described as an effective modality used to prevent strokes in patients with carotid artery stenosis in 1954.[1] It has since been recognized as the gold standard operation for surgical candidates with carotid artery stenosis, causing carotid revascularization procedures to rise over the past 2 decades. Approximately 150,000 carotid endarterectomies are performed annually in the United States alone.[1-3]

Multiple randomized trials have established the benefit of carotid endarterectomy in select symptomatic and asymptomatic patients.[1,3,4] The NASCET (North American Symptomatic Carotid Endarterectomy Trial) showed a significant reduction of ipsilateral stroke in patients with greater than or equal to 70% stenosis, from 26% to 9% at 2 years for patients who underwent CEA as compared with patients managed only medically.[1] The Asymptomatic Carotid Atherosclerosis Study (ACAS) revealed that in patients with a greater than 60% narrowing of the carotid artery, the 5-year risk of stroke or death was reduced from 11% in patients treated only medically to 5.1% in patients undergoing CEA.[3]

Another treatment modality for carotid artery stenosis that came into practice in 1994 is carotid artery stenting (CAS). It progressively became an alternative for carotid endarterectomy (CEA) in select patient populations. CAS became even more established with the CREST study. It was regarded as an effective and less invasive procedure for carotid artery revascularization that would result in similar outcomes to CEA. The rate of myocardial infarction (MI) was lower for CAS vs CEA (1.1% and 2.3% respectively, *P*=.032) but a higher instance of stroke in the CAS group was observed when compared to the CEA group (4.1% vs 2.3%, *P*=.012).[4]

With the rise of CAS as an established treatment modality, it is important to study CEA factors that might affect patient outcomes, such as shunt placement and anesthesia used, namely GA compared to LA. Studies have yet to delineate significant differences in the outcomes that are observed when LA or GA is used during CEA. The recent GALA study could not report a statistically significant difference between LA and GA in CEA patients when specifically looking at stroke, MI, and death outcomes. These primary events occurred in 4.5% of patients under LA when compared to 4.8% under GA.[5]

GA compared to LA has always been studied among the different surgical subspecialties with many studies reporting favorable outcomes that encourage the use of LA. Studies across the different surgical subspecialties show LA having the advantage of decreased postoperative pain, nausea, and a shorter postanesthesia care unit stay in ambulatory surgery. Other studies report regional anesthesia reducing postoperative cardiac and respiratory complications in cardiac surgery patients.[6,7]

Our study compared myocardial infarction and stroke rates in patients who underwent carotid endarterectomy done under GA to carotid endarterectomies performed under LA. It was hypothesized that the type of anesthesia is a contributing factor to the risk of having a postoperative MI or stroke within 30 days of CEA.

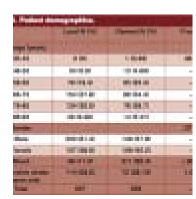
Patients and methods

The study was conducted in a large community hospital setting using a retrospective study design over a 3-year period from July 1, 2007 to June 30, 2010. The study compared outcomes between CEA performed under LA to CEA under GA. CEA procedures under LA were performed by 2 board-certified vascular surgeons who routinely perform the procedure under LA. CEA procedures with GA were performed by a group of 20 surgeons, including vascular surgeons, cardiothoracic surgeons, general surgeons, and neurosurgeons. The study was approved by the Inova Health System Human Research Protection Program (Institutional Review Board).

Chart reviews were performed for all subjects who underwent carotid endarterectomy under LA or GA. Age, sex, history of stroke, the occurrence of a postoperative MI or stroke within 30 days of the procedure, and the use of a shunt during the procedure were recorded for each of these subjects.

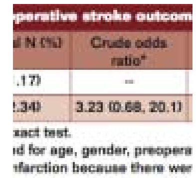
For the purposes of this study there were 2 study groups: carotid endarterectomy procedures with LA and CEA procedures using GA. Subsequent CEA procedures performed on the same patient were rare, and these were included as separate cases for the reported analysis. Fisher exact tests were calculated to evaluate differences in demographics, procedure characteristics, and patient outcomes between CEA procedures using LA and GA. Preoperative stroke and shunt placement were also evaluated as predictors of postoperative MI and stroke using the Fisher exact test. Multivariate logistic regression models were calculated to further compare postoperative MI and stroke between LA and GA procedures, while adjusting for age, gender, preoperative stroke, and shunt placement. Because some patients had multiple CEA procedures, all observations were not independent. Therefore, multivariate logistic regression models were calculated using clustered sandwich variance estimation to account for correlations within each set of repeated observations among individual patients. Statistical analyses were conducted using SAS v.9.2 and STATA v.10 statistical software. Statistical significance was assessed at *P*<.05.

Results



[4]During the study period, 686 CEA procedures were performed at the study hospital. This study focused on CEA done under LA only by surgeons who perform the operation routinely. We defined the LA experienced surgeons as those who perform CEA under LA more frequently than CEA under GA, and 2 vascular surgeons met those criteria. LA procedures performed by surgeons who did more CEA under GA than LA (n=23) were excluded from the study. The final analysis included 407 CEA procedures done under LA and 256 CEA procedures done under GA. A total of 614 individual patients received these 663 CEA procedures, as some patients underwent multiple operations. Age, sex, and occurrence of preoperative stroke were similar between study

groups (Table 1). Shunt placement was significantly more common in GA procedures compared to LA (82% vs 11%, $P<.001$) with routine shunting used consistently by most surgeons who performed CEA under GA in our study.



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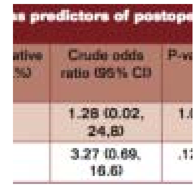
[5]Table 2 presents 30-day MI and stroke outcomes by study group. The rate of postoperative MI in patients who had LA was 0% (n=0) vs 1.2% (n=3) for patients who underwent GA ($P=.057$). Logistic regression models could not be estimated for the anesthesia-MI relationship because there were zero MI events in the LA group. Although not statistically significant at the .05 level, patients under LA were less likely to have a postoperative stroke than those under GA (0.7%, n=3 as compared to 2.3%, n=6 respectively; OR=3.23; $P=.095$). Significance of this trend was dramatically reduced after adjusting for age, gender, preoperative stroke, and shunt placement (adj OR=2.18; $P=.437$).



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3.27 (0.69, 16.6) | .1

[6]Additional risk factors for postoperative MI and stroke are evaluated in Table 3. Higher rates of postoperative stroke were observed in patients who received a shunt with a stroke rate of 2.3% (n=6) as compared to nonshunted patients 0.7% (n=3), OR=3.2; $P=.096$. Patients with preoperative same-side stroke had a higher rate of stroke compared to patients with no preoperative same side stroke (OR=3.3; $P=.126$). However, these associations were not significant at the .05 level. Shunt placement and preoperative stroke were not associated with postoperative MI. Preoperative stroke was not a significant predictor of shunt placement in this study (OR=1.24; $P=.249$).

Discussion

In a 2009 Cochrane meta-analysis review by Rerkasem et al, LA in carotid endarterectomy has not been shown to have significant reductions in postoperative MI within 30 days of the operation. Consistent with the Cochrane review and the GALA study findings, our study demonstrated that CEA under LA was not associated with a statistically significant decreased risk of developing acute MI when compared to CEA under GA.[5,8] However, a trend was noted for decreased incidence of MI in the LA group as compared to the GA with absence of MI in LA and 1.2% incidence in the GA group ($P=.057$). This trend might become statistically significant with a larger sample size.
No significant differences were observed in terms of postoperative stroke in LA group as compared to GA group 00.7% vs 2.3%; $P=.095$). Similar postoperative stroke rates have been reported in the literature for LA and GA groups.[8] A non-statistically significant decreased trend was noted in our study for postoperative stroke in LA group as compared to GA. An important confounding factor that might have contributed to the difference seen might be more liberal shunt usage in GA group as compared to LA (11.3% vs 82.4%; $P<.0001$) because selective shunting has been reported to decrease postoperative stroke rate9 and this would be another advantage of LA as shunt usage is more selective, and in our study patients who had shunting under LA were those who had intraoperative findings suggestive of brain malperfusion.

In our study there was a non-statistically significant trend toward increased postoperative stroke rate in patients who had shunting with an odds ratio of 3.21 ($P=0.096$). These findings correlate with the recent Cochrane review by Rerkasem et al (2009) that reports no significant difference between the use of shunting vs no shunting in terms of postoperative stroke rate.[10]
The study could not delineate a significant difference in outcomes between patients who had CEA for preoperative stroke as compared to those who had CEA for transient ischemic attacks (TIA) or asymptomatic carotid stenosis in terms of postoperative MI and stroke. Subjects who had a preoperative stroke were 1.24 times more likely to have a shunt during the procedure as

compared to those who had not had a preoperative stroke (*P*=.249).

Limitations in our study included the use of only one institution and a retrospective study design. The low number of MI and stroke occurrences limited statistical power to detect differences in the outcomes.

Another factor that might contribute to differences in outcomes between the two groups is the heterogeneous nature of the operators. We were unable to measure and statistically adjust for differences in surgeon experience level. Our study included only vascular surgeons who were experienced with performing CEA under LA compared to general surgeons, cardiothoracic, neurosurgeons, and vascular surgeons who performed CEA under GA. These differences in surgeon experience could affect postoperative MI and stroke as specialty, specifically general surgery, and low case volumes can adversely affect the CEA outcomes.[11]

Other potential advantages of LA that were not evaluated in our study include less postoperative pain which allows patients to have earlier ambulation, and better pulmonary toilet as reported from other surgical specialties.[6,7] Finally, it should be noted that the advantages of LA must also be weighed against the possible patient anxiety during the procedure due to maintaining consciousness, or the possibility of a difficult lesion extending the operating time and increasing patient discomfort.[12]

Conclusion

A third alternative to CEA under GA and CAS does exist in CEA under LA. This study shows that CEA under LA is as effective as CEA under GA, and it might carry a decreased morbidity in terms of incidence of postoperative MI and stroke, larger population studies are needed to assess the advantages of this technique. Another arm for patients that underwent CAS could also be included to equally examine all the modalities potentially utilized for this patient population. Surgeons that have the ability to perform CEA under GA and LA besides CAS should consider the modality that has the least amount of morbidity in their hands when patient factors are not influential.

Finally, it should be noted that the results of the study were well below the reported numbers in the CREST study in terms of stroke rate of 2.3% for CEA and 4.1% for CAS.[4] Because the guidelines for operative intervention on patients with carotid artery stenosis are dependent on the postoperative benefit as well as adverse outcomes, studying risk factors contributing to adverse outcomes and how to avoid them might entail revision of the current guidelines for operative intervention for patients with carotid artery stenosis.

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