Anesthesia type determines risk of cerebral infarction after carotid endarterectomy

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ABSTRACT

Objective: Silent and symptomatic cerebral infarctions occur in up to 34% of patients after carotid endarterectomy (CEA). This prospective study compared the risk of new brain infarctions detected by magnetic resonance imaging (MRI) in patients with internal carotid artery stenosis undergoing CEA with local anesthesia (LA) vs general anesthesia (GA).

Methods: Consecutive patients with internal carotid artery stenosis indicated for CEA were screened at two centers. Patients without contraindication to LA or GA were randomly allocated to the LA or GA group by ZIP code randomization. Brain MRI was performed before and 24 hours after CEA. Neurologic examination was performed before and 24 hours and 30 days after surgery. The occurrence of new infarctions on the control magnetic resonance images, stroke, transient ischemic attack, and other complications was statistically evaluated.

Results: Of 210 randomized patients, 105 underwent CEA with LA (67 men; mean age, 68.3 ± 8.1 years) and 105 with GA (70 men; mean age, 63.4 ± 7.5 years). New infarctions were more frequently detected on control magnetic resonance images in patients after CEA under GA compared with LA (17.1% vs 6.7%; $P = .031$). Stroke or transient ischemic attack occurred within 30 days of CEA in three patients under GA and in two under LA ($P = 1.000$). There were no significant differences between the two types of anesthesia in terms of the occurrence of other complications (14.3% for GA and 21.0% for LA; $P = .277$).

Conclusions: The risk of silent brain infarction after CEA as detected by MRI is higher under GA than under LA. (J Vasc Surg 2018;■:1-10.)

Keywords: Carotid artery; Endarterectomy; General anesthesia; Local anesthesia; Magnetic resonance

Carotid endarterectomy (CEA) is a therapeutic option for patients with severe internal carotid artery (ICA) stenosis, preventing primary and secondary stroke in >60% and >50% of cases, respectively.[1] The efficacy of CEA depends on the possibility of minimizing the rate of perioperative complications, such as stroke, myocardial infarction, or death, which varies between 2% and 7%.[1-10]

Several factors can influence the outcome of CEA: local anesthesia (LA) vs general anesthesia (GA), routine vs selective use of shunts, monitoring of brain function during the procedure, direct vs patch closure after endarterectomy, and completion imaging.[1,11] Although several studies have found that use of LA is associated with a reduced incidence of perioperative hemodynamic changes[12,13] or cardiac events and that testing of brain function while the patient is awake under LA during carotid artery clamping more reliably alerts the surgeon to the need for a shunt than the various indirect techniques used under GA,[14-16] the prospective controlled randomized GA vs LA for carotid surgery (GALA) trial[17] and systematic review of the literature[18] failed to show significant differences in 30-day morbidity and mortality between the two anesthesia approaches.

Some limitations of the GALA trial could influence interpretation of the results. First, the expected stroke and death rates after CEA were very low, and the predicted difference in the risk of stroke, myocardial infarction, or death between LA and GA 30 days after surgery was improbably high. Moreover, evaluation of cerebrovascular and cardiovascular complications may have been biased because it was based on investigators' subjective

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evaluation. It was therefore unlikely that the GALA trial would reveal significant differences between LA and GA. Second, the influence of statins was not considered. Third, intraoperative shunt use rates varied considerably between the two groups, and no information was provided about the type of shunt used.

Diffusion-weighted magnetic resonance imaging (DW-MRI) is used to assess clinical outcomes after CEA.[19-25] The advantages of DW-MRI over clinical evaluation of complications are the following: a higher incidence of ischemic lesions by DW-MRI, detected in 6% to 34%[4,24-28] compared with 2% to 7% of cases of transient ischemic attack (TIA), stroke, and myocardial infarction; the reduction of subjective bias, especially if DW-MRI results are evaluated by a blinded radiologist; and the fact that even clinically silent DW-MRI ischemic lesions might negatively influence cognitive functions and increase the risk for development of dementia.[29] Therefore, DW-MRI may be a more appropriate tool for assessing the safety and efficacy of CEA under LA vs under GA.

In this prospective controlled study, we assessed the risk of new cerebral ischemic lesions detected by DW-MRI in patients undergoing CEA with LA compared with GA. We also evaluated the incidence of stroke/TIA, myocardial infarction, and death within 30 days of CEA; the occurrence of local and other complications; and the factors influencing the risk for development of DW-MRI ischemic lesions, stroke, or TIA.

ARTICLE HIGHLIGHTS

- **Type of Research:** Two-center prospective randomized study
- **Key Findings:** In 210 patients, new brain infarctions on control magnetic resonance images after carotid endarterectomy were detected in 17.1% patients under general anesthesia compared with 6.7% patients under local anesthesia.
- **Take Home Message:** Carotid endarterectomy performed under local anesthesia was associated with a lower risk of silent ischemic lesions on control brain magnetic resonance images compared with that performed under general anesthesia.

METHODS

Ethical approval of the study protocol. The study was carried out in accordance with the Declaration of Helsinki of 1975 (revised in 2004 and 2008), and the protocol was approved by local ethics committees (424/2015-FNO and 236/69-MNUL). All patients provided written, informed consent before enrollment.

Patients. Inclusion criteria for this study were as follows: ICA stenosis ≥50%, as detected by duplex ultrasound[30] and confirmed by computed tomography angiography (CTA) with accurate stenosis measurement; indication for CEA according to criteria set by the American Heart Association[31]; no contraindication to MRI or CTA; age of 40 to 85 years; and signed, informed consent.

Consecutive patients were enrolled during 15 months (October 2015-December 2016) and assigned to CEA under LA or GA. A ZIP code-based 1:1 randomization approach was used to allocate patients to different therapeutic groups; patients with a ZIP code between 10000 and 49999 were assigned to the LA group, and those with a ZIP code between 50000 and 79999 were assigned to the GA group. Two ZIP code areas with similar lifestyle and socioeconomic factors, accessibility, and quality of medical care were selected (available at: https://www.czso.cz/csu/czso/regions_towns).

Evaluation of carotid stenosis. The grade of ICA stenosis was evaluated by duplex ultrasound[30] and confirmed by CTA according to the criteria of the North American Symptomatic Carotid Endarterectomy Trial (NASCET).[32]

CEA. Surgery with direct carotid artery suture was performed under LA or GA. Patients were receiving long-term treatment with acetylsalicylic acid (100 mg/d) in primary stroke prevention or clopidogrel (75 mg/d) in secondary stroke prevention or a prophylactic dose of low-molecular-weight heparin (at a dose dependent on body weight) as a temporary substitution for warfarin or direct oral anticoagulants in patients with permanent anticoagulation at the time of enrollment, and medication was continued during the perioperative period. Statin was used in patients after stroke or in patients with hypercholesterolemia in primary prevention if there was no contraindication.

A dose of 5000 to 10,000 units of unfractionated heparin (heparin léčiva; 100 units/kg body weight; Zentiva, Prague, Czech Republic) was administered intravenously 3 minutes before flow arrest. Protamine (protamin meda-ampullen; Legacy Pharmaceuticals, Birsfelden, Switzerland) was administered 5 minutes after ICA flow restoration in patients treated with >5000 units of unfractionated heparin (1 mL per 2000 units). Bard Brenner carotid shunts (14F tapered to 8F; Bard Ltd, Crawley, UK) were used selectively. Perioperative hypotension was defined as a decrease of mean arterial pressure below 69 mm Hg.[33] Ephedrine or norepinephrine was administered intravenously in the case of hypotension to optimize blood pressure. In total, nine neurosurgeons and four anesthesiologists were involved in the study.

LA. Operations were performed under the following conditions: cervical plexus block and local infiltration (bupivacaine [Marcaine]; AstraZeneca, Cambridge, UK) of the skin, performed by an anesthesiologist; and additional infiltration (trimecaine [Mesocain]; Zentiva)

of the operative field, performed by the surgeon if necessary.[34] The deterioration of neurologic status (quantitative or qualitative state of consciousness, speech, comprehension, and movement of contralateral limbs) after carotid artery clamping was an indication for shunt use in the LA group.

GA. Patients under GA received either gaseous volatile anesthetic agents and muscle relaxant or total intravenous anesthesia (type and dose depending on anesthetist and protocol).[35] In this group, a shunt was indicated in the case of >50% decrease in somatosensory evoked potential amplitude recorded from the contralateral median nerve or >70% decrease in peak systolic velocity in the ipsilateral middle cerebral artery detected by continual transcranial Doppler monitoring during carotid artery clamping.

MRI. Magnetic resonance images were acquired within the 24 hours before surgery and 24 ± 4 hours postoperatively using a 1.5T Avanto system (Siemens, Erlangen, Germany). The protocol comprised four sequences: (1) T2-weighted spin echo (echo time, 100 milliseconds; repetition time, 4310 milliseconds; section thickness, 5.0 mm; matrix size, 192 × 256; gap 0.5 mm; field of view [FOV], 250 mm; FOV ph, 75%; echo train length, 9; number Q3 of excitations, 1); (2) DWI (echo time, 130 milliseconds; repetition time, 4500 milliseconds; b, representing a factor of diffusion-weighted sequences b ¼ 0 and b ¼ 1000 s/mm^2; section thickness, 5.0 mm; gap, 1 mm; matrix size, 192 × 192; FOV, 255 mm; FOV ph, 100%; number of excitations, 4; echo spacing, 0.93 millisecond; bandwidth, 1240 Hz/pixel) with apparent diffusion coefficient maps; (3) T2 star-weighted gradient-recalled echo sequence for detection of bleeding (including microbleeds); and (4) fluid-attenuated inversion recovery (echo time, 109 milliseconds; repetition time, 8000 milliseconds; inversion time, 2500 milliseconds; section thickness, 5.0 mm; matrix size, 256 × 151; gap, 0.5 mm; FOV, 250 mm; FOV ph, 77.0%; number of excitations, 1; echo train length, 5). Sequences were applied at an identical level with the same slice thickness and cut number. Slice thickness comprised the cut thickness (5 mm) plus gap (10%). The standard number of slices was 25. The standard slice level was considered to be a modified level of the skull base because of minimalization of the distant-artifacts echo planar imaging sequence. In accordance with previous studies,[36-38] new ischemic brain lesions were defined as hyperintense regions on postintervention diffusion-weighted images that were not present on pretreatment images. The location, number, and volume of hyperintense lesions on diffusion-weighted images were evaluated by a radiologist blinded to treatment allocation. Volume was calculated as the total hyperintense area in each single slice multiplied by effective slice thickness. Enlargement of a previous lesion was not considered a new ischemic lesion. New ischemic lesions in the brain were characterized according to the Szabo classification.[38] Briefly, pattern I corresponded to territorial infarction (large lesion involving the cortex), pattern II to subcortical infarction (subcortical lesion with or without additional smaller lesions), pattern III to territorial infarction with fragmentation (large lesion involving the cortex with additional smaller lesions), pattern IV to several disseminated small lesions, and pattern V to border zone infarction (small lesions in hemodynamic risk zones).

Clinical examinations. Presence of comorbidities (arterial hypertension, diabetes mellitus, hyperlipidemia, ischemic heart disease, and atrial fibrillation), current medication (antiplatelet drugs, anticoagulants, and hypolipidemic agents), time between symptom onset and surgery in patients with symptomatic stenosis, surgeon, type of perioperative monitoring, side and degree of ICA stenosis, and complications were documented. Physical examinations evaluating neurologic deficits were conducted before and 24 hours and 30 days after CEA by a blinded certified neurologist.

End points for study analyses. The primary end point was the incidence of new ischemic lesions on brain MRI diffusion-weighted images 24 hours after CEA under LA or GA. Secondary end points were incidence of stroke or TIA within 30 days; occurrence of death, stroke/TIA, or myocardial infarction (as defined in the Third Universal Definition of Myocardial Infarction[39]) within 30 days; frequency of carotid shunt use; and occurrence of local and other complications.

Statistical analysis. The sample size was based on an expected 50% reduction in new ischemic lesions on control MRI diffusion-weighted images in the LA group (estimated prevalence, 10%) compared with the GA group (estimated prevalence, 20%). Prestudy calculations using the χ^2 test with a continuity correction showed that a minimum of 105 patients were needed in each group to reach a statistically significant difference with a two-tailed *P* value of .05. Categorical variables were compared with Fisher exact test. Continuous variables were compared with the Mann-Whitney *U* test. The following variables were included in univariate and multiple logistic regression analyses to identify possible predictors of new cerebral ischemic lesions detected on control MRI diffusion-weighted images or of stroke/TIA in the 30 days after surgery (using the 'Enter' method followed by the 'Forward stepwise' method to eliminate multicollinearity): age, sex, arterial hypertension, diabetes mellitus, coronary heart disease, atrial fibrillation, hyperlipidemia, statin use, occlusion side, severity, symptoms of treated ICA stenosis, time from symptom onset to intervention, carotid shunt use, and type of anesthesia.

All tests were carried out with a two-sided significance level of .05. Data were analyzed using SPSS version 22.0 software (IBM Corp, Armonk, NY).

RESULTS

A total of 210 patients were included in the study (Fig). Patients were randomly allocated to the LA or GA group. Clinical and procedural variables were well balanced between the groups except for age, time from symptoms to intervention, and use of antithrombotics (Table I). All patients underwent control MRI examination, and no patient was lost to follow-up.

New ischemic lesions were less frequently detected by DW-MRI in the LA than in the GA group (6.7% vs 17.1 %; $P = .031$). In the LA group, no new ischemic lesions were classified as Szabo I-III, whereas five were classified as Szabo IV and two as Szabo V. In the GA group, 3 new ischemic lesions were classified as Szabo III, 5 as Szabo IV, and 10 as Szabo V (Table II). One of 2 patients in the LA group and 5 of 10 patients in the GA group with new ischemic lesions classified as Szabo V had incomplete circle of Willis. Time between stroke onset and intervention did not differ between LA patients with new ischemic lesion (26.0 ± 26.0 days) and GA patients with new ischemic lesion (43.0 ± 46.8 days; $P = .177$).

Two (1.9 %) and three (2.9 %) strokes or TIAs were recorded in the LA and GA groups, respectively, during 30 days ($P = 1.000$). There was no death or myocardial infarction in either group. Local and other complications after surgery were recorded in 22 (21.0%) and 15 (14.3%) patients in the LA and GA groups, respectively ($P = .277$; Table II).

Intraoperative hypotension occurred in one patient in the LA group and five patients in the GA group, but the influence of hypotension on the development of new MRI lesions was not demonstrated (Table III). Patients with perioperative somatosensory evoked potential monitoring had significantly higher incidence (25.0%) of new cerebral ischemic lesions on control MRI diffusion-weighted images compared with perioperative transcranial Doppler monitoring (9.4%; odds ratio [OR], 3.458; 95% confidence interval [CI], 1.440-9.834) or perioperative clinical monitoring (6.7%; OR, 4.667; 95% CI, 1.732-12.571; $P = .004$; Table III). Patients using statins had significantly lower risk of stroke or TIA in the 30 days after surgery (OR, 0.113; 95% CI, 0.012-0.997; Table IV).

DISCUSSION

This study showed that silent brain infarctions detected by DW-MRI were more frequent after CEA performed under GA than under LA. However, there was no significant difference in 30-day morbidity and mortality between the two types of anesthesia, which is in accordance with the results of the GALA trial,[17] a review of the literature,[18,40] other studies,[25,26,32,41] and American Heart Association recommendations.[31] Most new DW-MRI ischemic lesions were silent; however, these may potentially affect cognitive functions.[35,41-46]

More than half of new ischemic lesions found on control MRI diffusion-weighted images in patients after CEA under GA were border zone infarctions (type V) according to the Szabo classification,[38] which likely arose from hypoperfusion. Only one-quarter of lesions were classified as Szabo type IV (ie, due to embolization). In contrast, a quarter of new ischemic lesions present in patients after CEA under LA (in which shunts were more frequently used) were classified as Szabo type V (hypoperfusion etiology), whereas three-quarters were classified as Szabo type IV (embolization etiology). This is in agreement with the results of other studies demonstrating that use of carotid shunts increases the risk of brain embolization.[47-51]

Our results also highlight the effectiveness of evaluating clinical status by indirect methods to monitor brain hypoperfusion after shunt placement. Of the 15 parameters evaluated, only the monitoring method used for shunt indication after carotid artery clamping was identified as a predictor of cerebral ischemia risk. Patients monitored by somatosensory evoked potentials had a higher incidence of silent brain infarctions compared with those monitored by transcranial Doppler during GA or LA. Therefore, evaluating and comparing the different monitoring methods used during CEA could increase the safety of this procedure; further studies assessing this topic are needed.

Only one factor was identified as a predictor of stroke or TIA risk after CEA. Patients continuously treated with statins had lower risk of stroke/TIA within 30 days of CEA. The positive effects of statins have been reported,[52,53] but these require confirmation in large, randomized controlled trials.

This study had some limitations. First, patients in the LA and GA groups differed in terms of age, use of antithrombotic drugs, and time between symptom onset and surgery because of the ZIP code method of randomization that was used. Patients in the LA group were older, used antithrombotic drugs less frequently, and had a shorter time between carotid artery symptoms and CEA. However, none of these factors was identified as a predictor of new ischemic lesions on control MRI diffusion-weighted images or of stroke/TIA in the 30 days after CEA.

Second, the sample size in this study was smaller than that in the GALA trial[17] and the Cochrane database review.[18] Although this did not affect the detection of differences in incidence of new ischemic lesions by DW-MRI, a larger study sample is required to assess changes in the frequency of clinical events such as stroke, TIA, myocardial infarction, and vascular death.[17]

Third, standard collection of blood pressure data before, during, and after CEA was not stated. Nevertheless, published studies found no relationship between

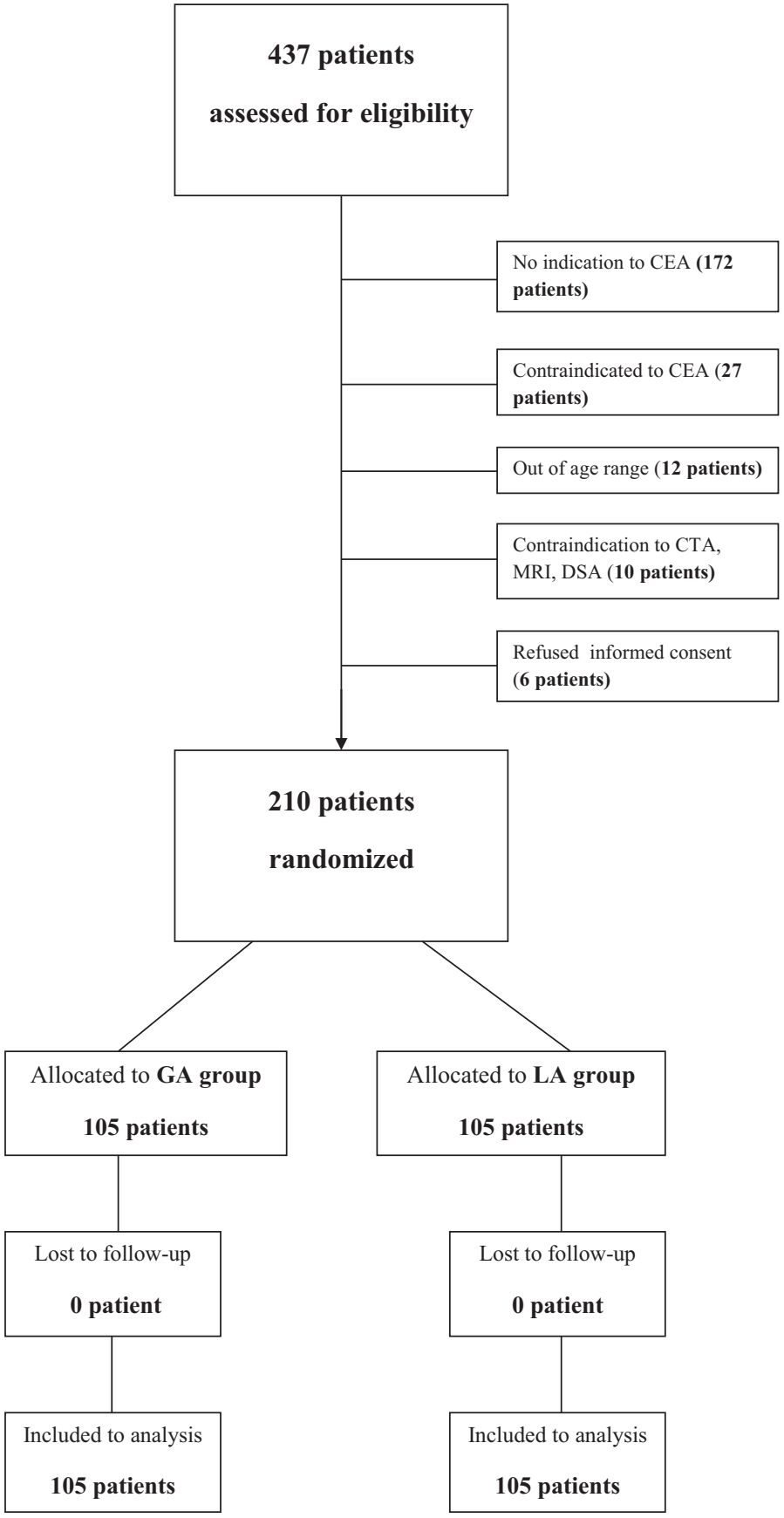

Fig. Study flow chart. *CEA*, Carotid endarterectomy; *CTA*, computed tomography angiography; *DSA*, digital subtraction angiography; *GA*, general anesthesia; *LA*, local anesthesia; *MRI*, magnetic resonance imaging.

Table I. Patients' demographic data

	LA group	GA group	*P* value
No. of patients	105	105	NA
Age, years	68.3 ± 8.1	63.4 ± 7.5	<.001
Male sex	67 (63.8)	70 (66.7)	.772
Right-sided stenosis	51 (48.6)	54 (51.4)	.783
Severity of stenosis evaluated using CTA, %	81.3 ± 10.8	82.8 ± 9.5	.345
Symptomatic stenosis	63 (60)	63 (60)	1.000
Carotid shunt use	13 (12.4)	7 (6.7)	.239
Arterial hypertension	89 (84.8)	90 (85.7)	1.000
Diabetes mellitus	40 (38.1)	33 (31.4)	.385
Hyperlipidemia	56 (53.3)	69 (65.7)	.091
Ischemic heart disease	40 (38.1)	32 (30.5)	.309
Myocardial infarction	14 (13.3)	8 (7.6)	.260
Atrial fibrillation	6 (5.7)	4 (3.8)	.748
Time between stroke onset and intervention, days	35.4 ± 44.8	50.9 ± 44.4	.001
Time between enrollment and intervention, days	1.10 ± 0.45	1.06 ± 0.39	.879
Antithrombotics	98 (93.3)	104 (99.0)	.033
Antiplatelets	86 (81.9)	102 (97.1)	
Acetylsalicylic acid	37 (35.2)	44 (41.9)	
Clopidogrel	49 (46.7)	58 (55.2)	
Anticoagulation	6 (5.7)	2 (1.9)	.001
Both	6 (5.7)	0 (0.0)	
None	7 (6.7)	1 (1.0)	
Statin use	70 (66.7)	72 (68.6)	.883

CTA, Computed tomography angiography; *GA*, general anesthesia; *LA*, local anesthesia; *NA*, not applicable.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

Table II. Study results

	LA group, No. (%)	GA group, No. (%)	*P* value
New brain ischemic lesion	7 (6.7)	18 (17.1)	.031
Szabo I-III	0 (0.0)	3 (17.0)	
Szabo IV	5 (71.4)	5 (27.5)	
Szabo V	2 (28.6)	10 (55.5)	
Stroke or TIA	2 (1.9)	3 (2.9)	1.000
Death or myocardial infarction	0 (0.0)	0 (0.0)	1.000
Local and other complications	22 (21.0)	15 (14.3)	.277
Local hematoma	9 (8.6)	2 (1.9)	
Swallowing problems	3 (2.9)	1 (1.0)	
Vocal cord paresis	2 (1.9)	6 (5.7)	
Other peripheral nerve paresis	7 (6.7)	3 (2.9)	
Carotid artery dissection	1 (1.0)	2 (1.9)	

GA, General anesthesia; *LA*, local anesthesia; *TIA*, transient ischemic attack.

intraoperative hypotension and postoperative stroke with several different definitions of hypotension, including raw systolic blood pressures below thresholds of 100, 90, 80, and 70 mm Hg; MAPs <70, 60, 50, and 40 mm Hg; and decreases in both systolic and mean blood pressure by 10%, 20%, and 40% from baseline, except time spent >30% below baseline blood pressure.[33,54]

Table III. Influence of recorded variables on the incidence of new ischemic lesions on control diffusion-weighted magnetic resonance imaging (*DW-MRI*)

	New ischemic lesion on control DW-MRI	No new ischemic lesion on control DW-MRI	*P* value
No. of patients	25	185	NA
Age, years	68.3 ± 8.1	63.4 ± 7.5	.457
Male sex	19 (76.0)	118 (63,8)	.269
Right-sided stenosis	14 (56.0)	91 (49.2)	.671
Severity of stenosis, %	83.0 ± 9.9	81.9 ± 10.2	.654
Symptomatic stenosis	19 (76.0)	107 (57.8)	.126
Carotid shunt use	3 (12.0)	17 (9.2)	.714
Arterial hypertension	24 (96.0)	155 (83.8)	.137
Diabetes mellitus	12 (48.0)	61 (33.0)	.179
Ischemic heart disease	9 (36.0)	63 (34.1)	.826
Myocardial infarction	3 (12.0)	19 (10.3)	.732
Atrial fibrillation	0 (0.0)	10 (5.4)	.612
Time between stroke onset and intervention, days	37.6 ± 43.3	44.1 ± 45.6	.793
Perioperative monitoring			
Clinical neurologic status	7 (28.0)	98 (53.0)	
Transcranial Doppler	5 (20.0)	48 (25.9)	.004
Somatosensory evoked potentials	13 (52.0)	39 (21.1)	
Perioperative arterial hypotension			
Mild (MAP 60-69 mm Hg)	3 (12.0)	23 (12.4)	
Moderate (MAP 50-59 mm Hg)	3 (12.0)	18 (9.7)	.748
Severe (MAP <50 mm Hg)	0 (0)	0 (0)	
Antithrombotics			
Antiplatelets	23 (92.0)	165 (89.2)	
Anticoagulation	0 (0)	8 (4.3)	.736
Both	1 (4.0)	5 (2.7)	
None	1 (4.0)	7 (3.8)	
Statin use	19 (76.0)	123 (66.5)	.495
Surgeon (each number means a different surgeon)			
1 — 5.3%	1 (4.0)	18 (9.7)	
2 — 4.0%	1 (4.0)	24 (13)	
3 — 15.2%	5 (20.0)	28 (15.1)	
4 — 12.0%	3 (12.0)	22 (11.9)	
5 — 25.0%	1 (4.0)	3 (1.6)	.600
6 — 16.9%	10 (40.0)	49 (26.5)	
7 — 22.2%	2 (8.0)	7 (3.8)	
8 — 10.0%	1 (4.0)	9 (4.9)	
9 — 3.8%	1 (4.0)	25 (13.5)	

MAP, Mean arterial pressure; *NA*, not applicable.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

Finally, the relationship between type of circle of Willis and risk of silent ischemic lesions was not studied. Ten types of anterior portion of the circle of Willis and 14 types of posterior portion of the circle of Willis were defined.[55] The limited number of enrolled patients did not allow the influence of the particular types of circle of Willis on the risk of silent ischemic lesions to be assessed.

CONCLUSIONS

CEA performed under LA was associated with a lower risk of silent ischemic lesions on control brain MRI diffusion-weighted images compared with those performed under GA. The main factor influencing this difference was perioperative monitoring by somatosensory evoked potentials, which detected new cerebral ischemic

Table IV. Influence of recorded parameters on the incidence of stroke or transient ischemic attack (*TIA*) during 30 days after carotid endarterectomy (CEA)

	New stroke/TIA	Without new stroke/TIA	*P* value
No. of patients	5	205	NA
Age, years	68.3 ± 5.0	65.9 ± 8.2	.369
Male sex	3 (60.0)	134 (65.4)	1.000
Right-sided stenosis	2 (40.0)	103 (50.2)	1.000
Severity of stenosis, %	85.0 ± 10.0	82.0 ± 10.2	.493
Symptomatic stenosis	5 (100)	121 (59.0)	.160
Carotid shunt	0 (0.0)	20 (9.8)	1.000
Arterial hypertension	5 (100)	174 (84.9)	1.000
Diabetes mellitus	2 (40.0)	71 (34.6)	1.000
Ischemic heart disease	2 (40.0)	70 (34.1)	1.000
Myocardial infarction	0 (0.0)	22 (10.7)	1.000
Atrial fibrillation	0 (0.0)	10 (4.9)	1.000
Time between stroke onset and intervention, days	29.4 ± 19.5	43.7 ± 45.8	.837
Perioperative monitoring			
Clinical neurologic status	2 (40.0)	103 (50.2)	
Transcranial Doppler	2 (40.0)	51 (24.9)	.841
Somatosensory evoked potentials	1 (20.0)	51 (24.9)	
Antithrombotics			
Antiplatelets	4 (80.0)	184 (89.8)	
Anticoagulation	1 (20.0)	7 (3.4)	.428
Both	0 (0.0)	6 (2.9)	
None	0 (0.0)	8 (3.9)	
Statin use	1 (20.0)	141 (68.6)	.039
Surgeon			
1	0 (0.0)	18 (9.3)	
2	0 (0.0)	25 (12.2)	
3	0 (0.0)	33 (16.1)	
4	0 (0.0)	25 (12.2)	
5	0 (0.0)	4 (2.0)	.596
6	3 (60.0)	56 (27.3)	
7	0 (0.0)	9 (4.9)	
8	1 (20.0)	9 (4.9)	
9	1 (20.0)	25 (12.2)	

NA, Not applicable.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

lesions on control MRI diffusion-weighted images at a higher rate than by transcranial Doppler or clinical monitoring. In agreement with the results of the GALA trial, 30-day morbidity, mortality, and incidence of stroke or TIA did not differ according to the type of anesthesia. Statin treatment was identified as the only independent predictor of reduced risk of stroke/TIA after CEA.

AUTHOR CONTRIBUTIONS

Conception and design: MO, TH, DS
Analysis and interpretation: MO, TH, JH, DN, RH, KL, DS
Data collection: MO, TH, MS, PV, AH, DO, JH, DS
Writing the article: MO, TH, DS
Critical revision of the article: MS, PV, AH, DO, JH, DN, RH, KL
Final approval of the article: MO, TH, MS, PV, AH, DO, JH, DN, RH, KL, DS
Statistical analysis: KL
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Overall responsibility: MO
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