Section: Anaesthesia

Original Research Article

AN OBSERVATIONAL CLINICAL STUDY TO COMPARE THE INFLUENCE OF PATIENT CHARACTERISTICS AND TYPE OF ANAESTHESIA ON NEUROLOGICAL OUTCOMES AFTER CAROTID ENDARTERECTOMY.

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ABSTRAC

Background: Carotid endarterectomy is the most effective treatment for reducing the risk of stroke in patients with significant carotid stenosis and can be performed under General anaesthesia or Regional anaesthesia. The comorbidities of these patients combined with peri-operative hemodynamic goals pose unique anaesthesia challenges. **Aims:** To determine the in hospital neurological complications after carotid endarterectomy and its associated risk predictors in patients operated under general and regional anaesthesia.
Materials and Methods: This is an observational study conducted in patients who underwent carotid revascularization through carotid endarterectomy. In-hospital neurological complications, focusing on transient ischemic attacks, major and minor strokes, and cranial nerve injuries, with associated risk predictors under general and regional anaesthesia were assessed.
Results: Findings showed postoperative events in 25% of patients, including strokes (10%) and nerve injuries (15%). Major strokes occurred in those under general anaesthesia (10%), while nerve injuries were more prevalent under regional anaesthesia (66.7%). Prolonged clamp time correlated with neurological events (p-value 0.056). Preoperative neurological deficits (p-value 0.02), diabetes (p value 0.01), hyperlipidemia (p value 0.01), use of tobacco (p value 0.01), history of coronary artery disease (p value 0.03) were independent risk factors.
Conclusion: CEA remains the gold standard, but proactive screening and risk factor management are crucial. General anaesthesia was linked to major strokes, while regional anaesthesia correlated with more cranial nerve injuries. The choice between regional and general anaesthesia remains debatable and one should consider surgeon, anaesthetist and patient preferences, satisfaction, and hospital conditions for the same.
Keywords: Carotid endarterectomy, Carotid stenosis, Neurological deficits.

INTRODUCTION

Carotid stenosis is caused by atherosclerotic plaques that develop at the carotid bifurcation, resulting in the narrowing of the artery. Embolization of atheromatous material or thrombotic occlusion of the vessel can occur, resulting in transient ischaemic attacks (TIA), amaurosis fugax or cerebral infarction. The risk of such events is greatest in patients who are already symptomatic and in those with a greater degree of stenosis of the artery.[1] Carotid endarterectomy (CEA) is the standard procedure for stroke prevention in patients with atherosclerotic carotid stenosis.[2] The goals of CEA are to prevent cerebral infarction due to carotid artery stenosis and to relieve neurological symptoms, thereby improving

the quality of life of patients. However, CEA itself carries some risk of stroke and death. Stroke is directly related to age and is the leading cause of disability and the third most common cause of death in the United States after heart disease and cancer.[3] The superiority of CEA over other medical treatments for the prevention of major strokes has been demonstrated in cases of asymptomatic stenosis of >70% and ipsilateral symptomatic stenosis of >50%.[4] The surgical intervention may be performed under either general (GA) or local-regional anaesthesia (LRA). The main aim of the anaesthetic management should represent the protection of the brain and heart from ischemic events. LRA is an alternative to GA which has attracted considerable attention amid claims of a reduction in operative morbidity and mortality.[1] Many reports have compared the impact of the two anaesthetic techniques on the patients' postoperative outcome without a certain conclusion being reached.[5] Factors contributing to carotid artery disease and atherosclerosis include age, hypertension, diabetes, high levels of low-density lipoprotein cholesterol, low levels of high density lipoprotein cholesterol, family history of atherosclerosis, smoking, obesity, hyperhomocystinemia, and sedentary lifestyle.[6]

Complications related to CEA have significantly declined over the years because of the advances in intraoperative management and postoperative care. CEA is effective in low-risk surgical patients and decreases the risk of stroke, but there are risks of general anaesthesia, infection, myocardial infarction, hyper perfusion syndrome, cervical hematoma, cranial nerve injury, restenosis, embolization, stroke, and even death.[7] Several modifiable and non-modifiable risk factors contribute to the risk of stroke after carotid stenosis, including age, hypertension, previous stroke/TIA, absent collateral flow, irregular or ulcerated plaque morphology, and micro embolic signals on transcranial Doppler.[8]

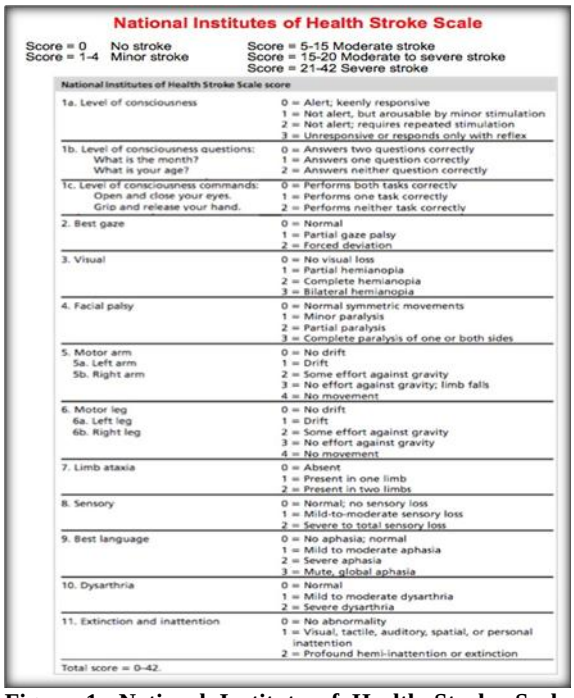
Risk of a new cerebral vascular accidents is increased due to the presence of atherosclerotic plaques in other arterial territories.[9] Literature shows that 25% of stroke patients have a co-existing arterial disease affecting one territory, 40% on various vascular systems and 95% of them have one or more additional morbidity, being at high risk of having a related adverse event.[10] The relation between these elements and a possible risk prediction of CV events has been studied in many articles, but none was able to establish clear results. There is no study comparing the patients risk factors and influence of type of anaesthesia on outcomes after CEA. Therefore we planned to study the influence of patient's characteristics and type of anaesthesia on neurological outcomes after carotid endarterectomy.

MATERIAL AND METHODS

This is an observational study conducted in patients who underwent carotid revascularization through carotid endarterectomy from 2024 January to August.

Risk assessment

Patients' information was collected for demographic and clinical presentation, cardiovascular risk factors and comorbidities. Symptomatic patients were selected to CEA when they had ICA stenosis of 50% or higher and at least an episode of minor or major stroke in the territory of the ipsilateral ICA, amaurosis fugax or TIA, within 6 months before admission to the hospital. Asymptomatic patients were selected if they had ICA stenosis of 70% or higher without any referred episode within 6 months (NASCET criteria). [11] CV risk factors were determined as: hypertension (prior established diagnosis or arterial pressure >140/90 mmHg on the preoperative evaluation); type 2 diabetes mellitus (controlled by diet or oral medication, insulin-dependent or both); history of tobacco use (in the past or present). Comorbidities associated with CS and therefore analysed were: coronary artery disease (CAD: myocardial infarction, history of angina pectoris or coronary revascularization), chronic kidney disease (CKD: serum creatinine 132 micromol/L). Dyslipidaemia was defined as the use of lipid-lowering medications, a fasting total serum cholesterol level > 200 mg/dL, a low-density lipoprotein cholesterol level > 120 mg/dL, a high-density lipoprotein cholesterol level < 40 mg/dL, or a triglyceride level > 150 mg/dL, history of smoking and peripheral arterial disease.



National Institutes of Health Stroke Scale

Score = 0 No stroke
Score = 1-4 Minor stroke
Score = 5-15 Moderate stroke
Score = 15-20 Moderate to severe stroke
Score = 21-42 Severe stroke

National Institutes of Health Stroke Scale score	
1a. Level of consciousness	0 = Alert; keenly responsive 1 = Not alert, but arousable by minor stimulation 2 = Not alert; requires repeated stimulation 3 = Unresponsive or responds only with reflex
1b. Level of consciousness questions: What is the month? What is your age?	0 = Answers two questions correctly 1 = Answers one question correctly 2 = Answers neither question correctly
1c. Level of consciousness commands: Open and close your eyes. Grip and release your hand.	0 = Performs both tasks correctly 1 = Performs one task correctly 2 = Performs neither task correctly
2. Best gaze	0 = Normal 1 = Partial gaze palsy 2 = Forced deviation
3. Visual	0 = No visual loss 1 = Partial hemianopia 2 = Complete hemianopia 3 = Bilateral hemianopia
4. Facial palsy	0 = Normal symmetric movements 1 = Minor paralysis 2 = Partial paralysis 3 = Complete paralysis of one or both sides
5. Motor arm 5a. Left arm 5b. Right arm	0 = No drift 1 = Drift 2 = Some effort against gravity 3 = No effort against gravity; limb falls 4 = No movement
6. Motor leg 6a. Left leg 6b. Right leg	0 = No drift 1 = Drift 2 = Some effort against gravity 3 = No effort against gravity 4 = No movement
7. Limb ataxia	0 = Absent 1 = Present in one limb 2 = Present in two limbs
8. Sensory	0 = Normal; no sensory loss 1 = Mild-to-moderate sensory loss 2 = Severe to total sensory loss
9. Best language	0 = No aphasia; normal 1 = Mild to moderate aphasia 2 = Severe aphasia 3 = Mute, global aphasia
10. Dysarthria	0 = Normal 1 = Mild to moderate dysarthria 2 = Severe dysarthria
11. Extinction and inattention	0 = No abnormality 1 = Visual, tactile, auditory, spatial, or personal inattention 2 = Profound hemi-inattention or extinction
Total score = 0-42.	

Figure 1: National Institute of Health Stroke Scale (NIHSS)

Anaesthesia

Type of anaesthesia was decided by the treating anaesthesiologist.

1. Regional anaesthesia (RA): RA was introduced by an ultrasound-guided deep cervical block consisting of 0.5% bupivacaine (20 mL) and 2% lidocaine (20 mL), which was injected by an anaesthesiologist into the level of the third to fifth transverse processes of the cervical vertebrae.[12] After CEA clamping, we performed the awake test, which included speech, grasping a rubber ball, and toe flexion and extension immediately and every 5 minutes thereafter.
2. General anaesthesia (GA): The induction of anaesthesia was performed with propofol (2mg/kg) and atracurium (0.6mg/kg) followed by tracheal intubation. Anaesthesia was maintained using a 2% sevoflurane concentration with atracurium (0.3mg/kg/hr) and fentanyl infusion (2μg/kg/hr) titrated as required.

Postoperative Events

We studied the in hospital neurological complications namely transient ischemic attacks, major and minor strokes, cranial nerve palsies. Major stroke was defined as neurological deficit lasting more than 24 hours and scored as NIHSS $\geq$ 4,[13] minor stroke defined as a neurological deficit lasting more than 24 hours and scored as NIHSS $\leq$ 3,[13] and TIA as neurological deficit lasting for few minutes without any permanent damage. Other complications studied were myocardial infarction, arrythmias, surgical hematoma. Myocardial infarction was defined as any increase in creatine kinase–myocardial band or cardiac troponin I above the upper limit of the reference range, with either chest pain, symptoms consistent with ischemia, or electrocardiographic evidence of ischemia (i.e., new ST segment depression or elevation, or > 1 mm elevation in two or more contiguous leads).

Statistical Analysis

Statistical software namely SPSS 22.0, and R environment ver.3.2.2 were used for the analysis of the data. Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at p value of $\leq$ 0.05. Student t- test (two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups (Inter-group analysis) on metric parameters. Leven`s test for homogeneity of variance has been performed to assess the homogeneity of variance. Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups and non-parametric setting for qualitative data analysis. Fisher Exact test was used when cell samples are very small.

RESULTS

Over an eight month study period, 40 patients underwent carotid endarterectomy. The mean age was 59.53±10.15 years and 87.5% were men, and 90% of subjects had symptomatic disease with 60% of the procedures having been performed in left ICA. 50% of the patients had severe ipsilateral carotid artery stenosis and 70% of patients had contralateral stenosis. Subjects included in the study had a high prevalence of risk factors: hypertension (80%), diabetes mellitus (57.5%), tobacco usage (75 and history of CAD (12.5%). 62.5% of the patients were operated on under general anesthesia (GA) and 37.5% under regional anesthesia (RA). [Table 1]

Postoperative events occurred in 25% (10% stroke, 15% cranial nerve injuries) of the patients. [Table 2] There was no incidence of myocardial infarction, significant arrythmias, need for re-operation or prolonged hospital stay. There were four cases of a postoperative major stroke. Major strokes were noted in four patients operated under general anesthesia. Nerve injuries were noted in six patients (two patients [33.3%] under GA and four patients [66.7%] under RA). Two patients (5%) in RA had cutaneous sensory nerve injury, one patient had (2.5%) greater auricular nerve injury and one patient (2.5%) had hypoglossal nerve injury. One (2.5%) patient in GA had a hypoglossal nerve injury and one (2.5%) had greater auricular nerve injury. These patients fully recovered before discharge.

Gender, age, body mass index, degree of stenosis, and surgery time did not show a significant association with postoperative neurological complications. Prolonged clamp time showed an increased association with postoperative neurological events (p-value 0.056). On analysis for patient characteristics, pre-operative neurological deficits (p-value 0.02), diabetes (p-value 0.01), hyperlipidemia (p value 0.01), use of tobacco (p value 0.01), history of CAD (p value 0.03) showed independent risk factors associated with post-operative neurological events. [Table 3]

Table 1: Patient characteristics

Patient Characteristics	N	%
Age		
41-50	9	22.8
51-60	16	40
61-70	8	20
>70	7	17.5
Gender		
Male	35	87.5
Female	5	12.5

Neurological Symptoms		
Asymptomatic	4	10
Minor stroke	11	27.5
TIA	9	22.5
Recurrent TIA	8	20
AIS with amaurosis fugax	1	2.5
AIS with left hemiparesis	3	7.5
AIS with right hemiparesis with chronic MCA infarct	1	2.5
Recurrent AIS with right hemiparesis	1	2.5
Recurrent CVA with left hemiparesis	1	2.5
Recurrent CVA with slurring of speech	1	2.5
Comorbidities		
Hypertension	32	80
Diabetes	17	42.5
Coronary Artery Disease	4	10
Hyperlipidemia	17	42.5
Tobacco Use	30	75
Degree of carotid artery stenosis		
Ipsilateral		
Normal	0	0
Mild (<50%)	9	22.5
Moderate (51-69%)	11	27.5
Severe (>70%)	20	50
Contralateral		
Normal	12	30
Mild (<50%)	19	47.5
Moderate (51-69%)	8	20
Severe (>70%)	2	5
Side Of Surgery		
Left	24	60
Right	16	40
Type of anaesthesia		
General anesthesia	25	62.5
Regional anesthesia	15	37.5

Table 2: Association between postoperative neurological complications and type of anaesthesia

Neurological Complications	Type of Anaesthesia	N (%)
Major stroke	GA	4 (10)
Cranial nerve injuries		6 (15)
Cutaneous sensory nerve injury	RA	2 (5)
Hypoglossal nerve injury	GA, RA	2 (5)
Greater auricular nerve injury	GA, RA	2 (5)

Table 3: Association between postoperative neurological complications and patient characteristics

Variables	Yes (N)	No (N)	P Value
Age (years)	66.5 ±14.06	58.75 ±9.57	0.150
Weight (kgs)	62 ±2.94	67.11 ±6.94	0.154
Height (cms)	164 ±8.78	166.83± 4.9	0.324
BMI (kg/m^2)	23.15± 3.63	24.1± 2.16	0.433
Pre-op neurological deficits	6	2	0.02
Diabetes	4	4	0.01
Hypertension	7	1	0.09
Hyperlipidemia	4	4	0.01
Coronary artery disease	3	5	0.03
Tobacco use	5	3	0.01
Surgery time (hrs)	3.00±0.00	2.90±0.31	0.542
Clamp time (mins)	18.5±27.6	34.7±14.3	0.056

DISCUSSION

Long-term stroke prevention is the head goal of intervention for carotid disease. In this study, we conducted an observational study to identify risk factors for the development of neurological complications after CEA. Pre-operative neurological deficits, diabetes, hyperlipidemia, use of tobacco, history of CAD were identified as important risk factors. Our study represents an important complement to other studies of risk factors for complications after surgery such as those reported using the NASCET and ECST clinical trial databases.[14,15]

Our results confirm the well-documented finding that symptomatic patients have twice the risk of peri-operative death or stroke compared to asymptomatic ones.[16] The left-sided stenotic disease is consistently associated with worse outcomes after CEA, being identified as a risk factor for death and stroke in several articles.[17] One explanation can be that, given that the dominant cerebral hemisphere is often the left one, it is more likely to have symptomatic strokes

and, subsequently, more CEA performed on the left side. From surgical point of view, prolonged clamp time was associated with increased incidence of post-operative neurological events. Carotid cross-clamping (CACC), might lead to the intraoperative manifestation of neurologic deficits due to the hypo-perfusion caused by the former and also exposes the patient to further embolism. Prolonged CACC time was demonstrated to augment the risk of 30-day stroke and death, with an OR 1.1 for each 10-minute increase.[18]

Even after a successful CEA, the risk of new cerebral vascular accidents is still increased due to the presence of atherosclerotic plaques in other arterial territories. Contemporary reports defined the risk of AMI, stroke or CV death after CEA as 6–35% at 3-years follow-up, depending on baseline risk profiles of patients.[19] In our study, stroke occurred in 10% of the patients.

Several risk factors identified in our study are consistent with recent multivariate analyses from the NASCET and ECST databases.[14,15] Our finding that coronary artery disease and diabetes increases the risk of complications was expected and consistent with the prior literature on CEA. Following an acute stroke, current clinical and experimental evidence suggests that hyperglycaemia lowers the neuronal ischemic threshold, may increase ischemic volume and is associated with higher morbidity and mortality.[20] In patients undergoing carotid endarterectomy, the prevalence of CAD is 40% to 50%,[21] and there is a risk of stroke is 1.4%-3.8%.[22] Tanner I Kim et al,[23] conducted a study on the presentation and outcomes of carotid endarterectomy in active smokers and found that smoking is a significant modifiable risk factor in the pathogenesis of CEA in active smokers and has been shown to be a predictor of worse outcomes after, similar to our study. In our study hyperlipidaemia was associated with significant predictors of postoperative stroke. This might be attributed to the reduced usage of statin therapy in our patients. Only 47.5% of patients were using statins. The use of statins reduced mortality by all-cause by 2-fold in our study. Their protective effect in the prevention of stroke and death after CEA, as well as its contribution to improved CV outcomes, is well established.[24]

Our striking finding in our study was hypertension was not significantly associated with any adverse outcome, contrary to other studies. In contrast to the results from recent systemic review of CEA outcomes literature and results from ECST, we did not find gender, BMI, peripheral vascular disease as significant predictors of stroke or death.[25]

Specific advantages of general anesthesia include tight arterial carbon dioxide control; cerebral protection afforded by volatile anesthesia and the anesthesiologist preference for general anesthesia because of a secured airway establishment.[26] Benefits of regional over general anesthesia are “gold standard” with respect to cerebral function monitoring, intact cerebral autoregulation, reducing cardiac- and respiratory-related morbidity, lower shunt insertion rate, shorter hospital stay, and lower cost.[26] The impact of the choice of anaesthesia on the outcome of this operation has been extensively studied. The General versus Local Anaesthesia which is the only large randomized control study comparing general anaesthesia (GA) and regional anaesthesia (RA) for CEA, concluded that there is no significant difference with respect to 30-day incidence of myocardial infarction (MI), death and stroke. Hussain et al,[27] using the Michigan Surgical Quality Collaborative database, have shown that GA for CEA is associated with more than two-fold higher mortality compared with RA, while Leichtle et al,[28] have demonstrated that GA is an independent risk factor for postoperative MI, particularly in patients with preoperative neurologic symptoms. Knappich et al,[29] have also shown that local anesthesia is an independent factor associated with lower risk of in-hospital death or stroke, along with shorter clamp time and avoiding shunting. In our study, the patients operated under GA had more incidence of in-hospital stroke. RA was associated with more cranial nerve injuries.

In summary, the rate of complications after carotid surgery in our study appears to be comparable to those found in the large clinical trials of symptomatic carotid surgery. Awareness of the risk factors identified in our study may help clinicians in making decisions about the performance of the procedure and may facilitate quality improvement initiatives in carotid surgery. According to anesthetic technique, RA has been associated with better outcome than GA with respect to the differences in haemodynamic stability, the ease of neurological monitoring and shortened hospital stay.

CONCLUSION

CEA is the gold-standard treatment of carotid artery stenosis and successfully reduces stroke rates in symptomatic and asymptomatic patients. In our study, we found that pre-operative neurological deficits, diabetes, use of tobacco, and hyperlipidemia, history of CAD are associated with postoperative neurological complications. Therefore, it is essential to screen other atherosclerotic diseases when CS is diagnosed and to implement aggressive treatment and risk factors modification. General anaesthesia was associated with postoperative major stroke & regional anaesthesia was associated with more cranial nerve injuries when compared to General anaesthesia. There is no consensus on anaesthetic choice for CEA. At present RA versus GA for patients undergoing CEA is still topic of debate. Improvements in medical therapy, use of cerebral monitoring, better timing for surgery after ischemic events, better surgical techniques, increased use of ultrasound for regional anaesthesia improve procedural outcomes. Despite all, anaesthesia method should be decided by considering the

personal preferences of the surgeons and anaesthesiologists, the patient's satisfaction and the conditions in the hospitals where we work.

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