Sultan Qaboos University Med J, November 2022, Vol. 22, Iss. 4, pp. 561–565, Epub. 7 Nov 22
Submitted 30 Aug 21
Revision Req. 3 Nov 21; Revision Recd. 6 Dec 21
Accepted 6 Jan 22
https://doi.org/10.18295/squmj.4.2022.028

BRIEF COMMUNICATION

Atherosclerotic Carotid Artery Disease

Where to from the emergency room? University hospital experience

Ibrahim Al Kindi,[1] Sara Al Adawi,[1] Edwin Stephen,[1] Saleh Ba Awain,[2] *Arunodaya R. Gujjar,[3] Ibrahim Abdelhedy,[1] Hanan Al Mawaali,[1] Khalifa Al-Wahaibi[1]

abstract: ***Objectives:*** Stroke is the second leading cause of death worldwide, resulting in 5.5 million deaths in 2016. Vascular interventions, including carotid endarterectomy (CEA) and carotid artery stenting, play a major role in stroke prevention, especially when performed early after onset of symptoms. This study aimed to define the role of vascular surgeons in ischaemic stroke management and hence improve referral patterns by creating an algorithm for the referral process. This could reduce time to intervention and optimise patient benefit from intervention. ***Methods:*** This retrospective study reviewed symptomatic and asymptomatic patients with atherosclerotic disease of the carotid artery who were referred to the Vascular Surgery Unit of Sultan Qaboos University Hospital, Muscat, Oman, from April 2018 to March 2020 to examine factors influencing recognition of suitable candidates for intervention. Following analysis of the data, algorithms/protocols were created to simplify the referral process of symptomatic and asymptomatic carotid artery disease for surgical intervention. ***Results:*** A total of 38 patients with ischaemic stroke were recognised as having carotid artery stenosis and were referred to the vascular surgery service during the study period. Only six met the criteria for CEA, four of which underwent the procedure. ***Conclusion:*** Choice of patients for CEA involves multiple steps, with potential for missed opportunities. By involving a multidisciplinary team approach, the recommended protocol aims to lead to early and appropriate referral to a vascular surgeon or an interventional radiologist, resulting in increased and optimised intervention in stroke prevention.

Keywords: Stroke; Transient Ischemic Attack; Carotid Stenosis; Carotid Endarterectomy; Vascular Surgery; Carotid Stent; Oman.

Stroke is recognised as the second leading cause of death worldwide, resulting in 5.5 million deaths in 2016. It is also the second most common cause of enduring disability, with the global burden of stroke estimated to continue to rise.[1] A stroke registry at Sultan Qaboos University Hospital (SQUH), Muscat, Oman, enrolling approximately 600 patients with stroke, recognised poor outcomes in almost 60% of cases and attributed this mainly to large artery or cardioembolic strokes.[2]

Previous experiences at the institute, as obtained through a stroke registry, have demonstrated several difficulties in the process of recognition of appropriate patients who would benefit from revascularisation interventions; this pattern is similar to many centres offering carotid endarterectomy (CEA). These difficulties include recognising the degree of extracranial arterial stenosis; attributing the lesion as the cause of the current vascular event; excluding downstream (intracranial) arterial disease, which may complicate the intervention; pin-pointing other associated modes of stroke in the same patient (e.g. excluding cardio-embolism or small vessel disease as the primary cause of the index stroke); matching severity of residual neurologic deficits with the need for surgery; compliance to future treatment measures; and, lastly, patient acceptance of the intervention. This complex process of patient selection may lead to missed opportunities in offering appropriate surgical intervention to deserving patients with severe cerebrovascular stenosis.

This study aimed to define the role of vascular surgeons in ischaemic stroke management and, hence, improve referral patterns by creating an algorithm for the referral process, which can reduce time to intervention and optimise patient benefit from intervention.

Methods

This retrospective single-centre study included all cases of carotid artery disease referred to the Vascular Surgery Unit at SQUH between April 2018 and March 2020; cases were analysed for possible carotid intervention. The electronic medical records of such patients were reviewed by the authors to extract demographics, presenting symptoms, underlying cause of stroke (large artery disease, cardio-embolism, small artery disease or others), risk factors, treatment received and outcomes. Brain and cerebrovascular imaging studies performed on the patients were reviewed by radiology, neurology and vascular surgery

Departments of [1]Surgery, [2]Radiology and [3]Medicine, Sultan Qaboos University Hospital, Muscat, Oman
**Corresponding Author's e-mail: arunoday@squ.edu.om*

consultants. The degree of stenosis was calculated using the North American SymMRTptomatic Carotid Endarterectomy Trial (NASCET) criteria using syngo.via software (Siemens Healthineers, Erlangen, Germany). The patients were classified into those who received only best medical therapy (BMT) or CEA or were referred for carotid artery stenting (CAS).

This study was approved by the Institutional Review Board.

Results

A total of 38 patients were recognised as having carotid artery stenosis and were referred to the vascular surgery service during the study period. Of these, 31 (81.6%) patients presented with stroke, three (7.9%) with transient ischemic attack (TIA) and four (10.5%) were asymptomatic. Of the symptomatic patients, 29 (85.3%) were admitted through the Emergency Department (ED); three (10.3%) of admitted patients were in-patients and two (6.9%) were referred from a peripheral hospital after initial medical treatment for ischaemic stroke. The time from symptom onset to admission through the ED ranged from 30 minutes to three days, with the average being 24 hours. A total of 11 patients presented within the 4.5-hour thrombolysis window, of whom five met the criteria for and received thrombolysis. Another 11 patients came after the thrombolysis window but before 24 hours, while five came within 24–72 hours and two came after 72 hours [Table 1].

The most common imaging modality that was used to identify carotid stenosis was computed tomography angiography; this was used in 29 patients, with most patients undergoing the scan within five days of admission. Of these patients, three (10.3%) had duplex ultrasound done elsewhere before referral to the centre and five (17.2%) had undergone magnetic resonance imaging. One asymptomatic patient had a coronary angiogram with carotid run when a significant carotid stenosis was recognised.

A total of 10 (26.3%) patients were identified as having significant unilateral stenosis of the extracranial portion of the internal carotid artery (ICA), defined as 70–99% stenosis, while one (2.6%) patient had significant bilateral ICA stenosis. Seven (18.4%) patients had complete unilateral (100%) occlusion of the extracranial ICA, while one (2.6%) had complete bilateral ICA occlusion. Two (5.3%) other patients had significant unilateral stenosis with contralateral occlusion. The remaining 17 (44.7%) patients had non-significant carotid disease [Table 2].

Table 1: Characteristics of symptomatic and asymptomatic patients with atherosclerotic disease of the carotid artery at Sultan Qaboos University Hospital, Muscat, Oman (N = 38)

Characteristic	n (%)
Age in years	
40–49	3 (7.9)
50–59	13 (34.2)
60–69	13 (34.2)
≥70	9 (23.7)
Gender	
Male	22 (57.9)
Female	16 (42.1)
Comorbidity	
None	1 (2.6)
Single	5 (13.2)
Multiple	32 (84.2)
Presentation	
Asymptomatic	4 (10.5)
Transient ischemic attack	3 (7.9)
Stroke	31 (81.6)
Imaging	
CT angiography	29 (76.3)
Carotid duplex	3 (7.9)
MRI	5 (13.2)
Digital subtraction angiography	1 (2.6)

CT = computed tomography; MRI = magnetic resonance imaging.

Table 2: Distribution of degree of extracranial carotid artery stenosis according to the North American Symptomatic Carotid Endarterectomy Trial criteria (N = 38)

Degree of occlusion in extracranial portion	n (%)
Significant unilateral stenosis (70–99%)	10 (26.3)
Complete unilateral occlusion (100%)	7 (18.4)
Significant bilateral stenosis (70–99%)	1 (2.6)
Significant unilateral stenosis with contralateral occlusion	2 (5.3)
Complete bilateral occlusion	1 (2.6)
Non-significant stenosis	17 (44.7)

Among the 10 patients with significant unilateral stenosis, six (60%) were deemed suitable for CEA. The remaining four (40%) were not considered candidates for CEA due to the presence of haemorrhagic

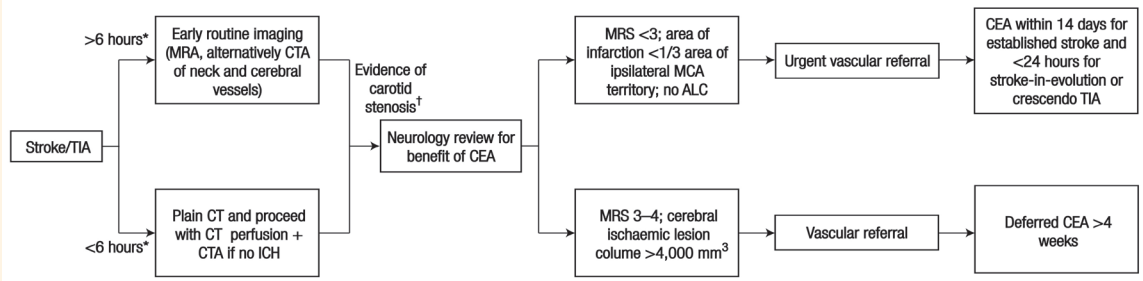

Figure 1: Referral pathway for symptomatic carotid atherosclerotic disease.

TIA = transient ischaemic attack; MRA = magnetic resonance angiography; CTA = computed tomography angiography; ICH = intracranial haemorrhage; CEA = carotid endarterectomy; MRS = Modified Rankin Scale for neurological disability; MCA = middle cerebral artery; ALC = altered level of consciousness.

**Time from onset of symptoms to hospital presentation; †more than 50%.*

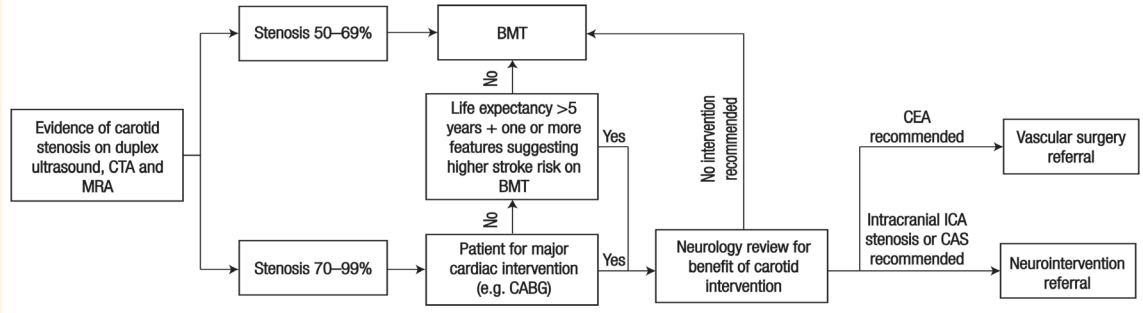

Figure 2: Referral pathway for asymptomatic carotid atherosclerotic disease.

CTA = computed tomography angiography; MRA = magnetic resonance angiography; BMT = best medical therapy; CABG = coronary artery bypass surgery; ICA = internal carotid artery; CEA = carotid endarterectomy; CAS = carotid artery stenting.

transformation of the stroke, severe neurologic deficits with no improvement or concomitant intracranial carotid disease. All six eligible patients were offered CEA; of these, four (66.7%) patients underwent CEA, while two (33.3%) refused.

Median referral time to vascular surgery service from presentation to ED admission for stroke/TIA was five days. Out of those referred due to symptomatic ICA occlusion, three (8%) were eligible for and underwent CEA at 23, 127 and 220 days since onset of symptoms. Delay in intervention in these cases was due to patient hesitancy to undergo CEA; two (5%) patients agreed to undergo surgery only after experiencing a second stroke. Additionally, 10 (26%) patients were found to have total carotid artery occlusion, for which no surgical intervention was indicated; hence, they did not benefit from referral.

Of those not suitable for CEA, one patient was referred for angioplasty of a previous carotid stent and one was advised carotid stenting. The remaining 32 patients were continued on medical therapy, which included aspirin, clopidogrel and statin, in addition to risk factor management.

To address and simplify the management of symptomatic and asymptomatic carotid artery disease, algorithms 1 and 2 were proposed [Figures 1 and 2, respectively].

Discussion

Stroke is the third leading cause of death in Oman, after ischaemic heart disease and road injuries.[3] With the incidence of non-communicable diseases, such as diabetes, hypertension, dyslipidaemia and smoking, projected to increase in incidence globally, incidence of stroke is likely to increase as well.[4–6]

As with other non-communicable diseases, prevention is key to minimising the economic and health burden of stroke. Significant advances in the medical management of patients with stroke have enabled reduction of disability and prevention of future vascular events and mortality. However, one aspect of stroke prevention involves the mandatory role of a vascular surgeon and/or an interventional radiologist. Atherosclerotic stenosis of extracranial carotid and, rarely, vertebral artery, which is severe enough to limit cerebral blood flow and cause symptoms, has been recognised by several studies to benefit from CEA or CAS.[7–9] This benefit of CEA is recognised to be superior to any medical intervention in this context. Therefore, the current situation has mandated the need for studying the vascular anatomy

of almost every patient with TIA or stroke. However, the intervention is associated with risks of procedural stroke as well as mortality. An acceptable balance of benefit and risk is well recognised to be provided by positioning the intervention within about two weeks of onset of an index stroke or TIA.[10] However, the need for recognising suitable surgical candidates for revascularisation surgery emphasises an urgency in completing the evaluation process of such patients.

While many therapies exist for the primary and secondary prevention of stroke, revascularisation is the only interventional modality currently available and can be performed in the form of CEA or CAS.[11] Although atherosclerosis may affect intra- and/or extracranial arteries, only selected stenotic arterial lesions are amenable to CEA.[10] Medical management is accepted as the best option for intracranial arterial stenosis.[12]

The NASCET, European Carotid Surgery Trial and Symptomatic Veterans Affairs Co-operative Study trial collectively showed that for patients with severe carotid artery stenosis, CEA, when compared to BMT alone, reduces the absolute risk (AR) and relative risk of any stroke at five years by 15.6% and 48%, respectively.[13,14] Furthermore, in a landmark trial by Rothwell *et al*., it was found that the AR for periprocedural stroke after CEA decreased from 30.2% to 17.6% after the initial two-week period from onset of symptoms.[14] Based on these findings, early recognition and management of ICA stenosis in stroke/TIA is pertinent to improving outcome and is reflected in the current guidelines by the European Society of Vascular Surgery (ESVS) and Society of Vascular Surgery, which recommend intervention within the first 14 days of onset of symptoms and up to 48 hours in cases of TIA or stroke-in-evolution.[10,15] Some select patients, however, with a more marked neurological deficit (MRS 3 or 4), may benefit from a deferred CEA after four weeks of onset of symptoms.[16]

Several factors appear to influence decision and timing regarding CEA; of those factors, imaging necessary to study the vascular anatomy and degree of stenosis of patients with ischaemic stroke or TIA is either not obtained or delayed. Most patients are evaluated initially with a computed tomography (CT) scan during their admission, with a CT or a magnetic resonance angiogram scheduled only a few days later. However, this practice is changing with the introduction of access to early mechanical thrombectomy, where a vascular imaging at emergent admission is now considered the standard of care for the recognition of a thrombus in a proximal (accessible) segment of major arteries; this would also enable early recognition of carotid stenosis.[17] Another issue is that of patient (and family) acceptance. A surgical intervention in the context of a potentially serious or life-threatening condition, such as stroke, is a major hurdle in most patients' acceptance. Moreover, varied factors are recognised to influence acceptability of such interventions. In the current study, most of the above factors were recognised in several patients and influenced treatment decisions as well as timing to imaging or intervention.

This study aimed to define the role of vascular surgeons in ischaemic stroke management, sought to decrease patients' time to intervention, improve referral patterns to the vascular service, allow more time for patient counselling and the planning of procedures and reduce time spent reviewing cases that would not benefit from intervention. Earlier studies have recognised that a multidisciplinary approach to carotid artery disease can increase the number of patients undergoing urgent CEA while also improving overall outcome in terms of perioperative stroke and death.[18]

Furthermore, the proposed algorithm, which is based on Oman's Ministry of Health and ESVS guidelines for stroke, adds a clear pathway for vascular surgery referrals. In the present study, 11% of referrals were due to asymptomatic atherosclerotic carotid artery disease, most referred from the Cardiothoracic Surgery Unit for patients prior to undergoing coronary artery bypass grafting, or were found incidentally on imaging; hence, a second algorithm was created to facilitate decision making in such asymptomatic patients.

Both algorithms aimed to simplify referring suitable candidates to the vascular surgery unit while leaving more technical aspects of suitability to the neurology and vascular surgery services.

Conclusion

Stroke is a leading and increasing cause of overall morbidity and mortality in Oman. The presence of an adequate framework for vascular surgery referrals for patients with atherosclerotic carotid disease can lead to increased patient benefit from revascularisation interventions, such as CEA and CAS. A multidisciplinary approach to carotid disease will lead to decreased time for patients to undergo these procedures and, hence, increase their overall benefit from the intervention, when indicated. In addition to highlighting the importance of a multidisciplinary team approach to managing stroke in a timely manner, there is also a need for good patient education regarding symptoms of stroke and the importance of early presentation to a hospital and available treatment options.

AUTHORS' CONTRIBUTION

IAK was involved in data gathering, literature review and manuscript writing. SAA was involved in data gathering and manuscript writing. ES contributed to data gathering, literature and manuscript review and final approval. SBA was involved in data gathering and image review. ARG contributed to data, literature and manuscript review and final approval. IA was involved in data gathering and literature review. HAM was involved in data gathering and patient follow-up. KAW was involved in literature review, manuscript writing and final approval.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

FUNDING

No funding was received for this study.

References

1. Katan M, Luft A. Global burden of stroke. Semin Neurol 2018; 38:208–11. https://doi.org/10.1055/s-0038-1649503.
2. Gujjar AR, Nandhagopal R, Jacob PC, Al-Azri F, Ganguly SS, Rana Shoaib H, et al. Ischemic stroke outcomes in Oman: Experience of a university-hospital based stroke registry. J Neurol Sci 2015; 357:e380. https://doi.org/10.1016/j.jns.2015.08.1353.
3. GBD 2016 Healthcare Access and Quality Collaborators. Measuring performance on the Healthcare Access and Quality Index for 195 countries and territories and selected subnational locations: A systematic analysis from the Global Burden of Disease Study 2016. Lancet 2018; 391:2236–71. https://doi.org/10.1016/S0140-6736(18)30994-2.
4. Al-Mawali A. Non-communicable diseases: Shining a light on cardiovascular disease, Oman's biggest killer. Oman Med J 2015; 30:227–8. https://doi.org/10.5001/omj.2015.47.
5. Al-Lawati JA, Mabry R, Mohammed AJ. Addressing the threat of chronic diseases in Oman. Prev Chronic Dis 2008; 5:A99.
6. Al-Lawati JA, Panduranga P, Al-Shaikh HA, Morsi M, Mohsin N, Khandekar RB, et al. Epidemiology of diabetes mellitus in Oman: Results from two decades of research. Sultan Qaboos Univ Med J 2015; 15:e226–33.
7. Randomised trial of endarterectomy for recently symptomatic carotid stenosis: Final results of the MRC European Carotid Surgery Trial (ECST). Lancet 1998; 351:1379–87. https://doi.org/10.1016/S0140-6736(97)09292-1.
8. Mayberg MR, Wilson SE, Yatsu F, Weiss DG, Messina L, Hershey LA, et al. Carotid endarterectomy and prevention of cerebral ischemia in symptomatic carotid stenosis. JAMA 1991; 266:3289–94. https://doi.org/10.1001/jama.1991.03470230047029.
9. Ferguson GG, Eliasziw M, Barr HW, Clagett GP, Barnes RW, Wallace MC, et al. The North American Symptomatic Carotid Endarterectomy Trial: Surgical results in 1415 patients. Stroke 1999; 30:1751–8. https://doi.org/10.1161/01.STR.30.9.1751.
10. Naylor AR, Ricco JB, de Borst GJ, Debus S, de Haro J, Halliday A, et al. Editor's choice – Management of atherosclerotic carotid and vertebral artery disease: 2017 clinical practice guidelines of the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg 2018; 55:3–81. https://doi.org/10.1016/j.ejvs.2017.06.021.
11. Sherzai AZ, Elkind MS. Advances in stroke prevention. Ann N Y Acad Sci 2015; 1338:1–15. https://doi.org/10.1111/nyas.12723.
12. SPS3 Investigators, Benavente OR, Hart RG, McClure LA, Szychowski JM, Coffey CS, et al. Effects of clopidogrel added to aspirin in patients with recent lacunar stroke. N Engl J Med 2012; 367:817–25. https://doi.org/10.1056/NEJMoa1204133.
13. Rothwell PM, Eliasziw M, Gutnikov SA, Fox AJ, Taylor DW, Mayberg MR, et al. Analysis of pooled data from the randomised controlled trials of endarterectomy for symptomatic carotid stenosis. Lancet 2003; 361:107–16. https://doi.org/10.1016/s0140-6736(03)12228-3.
14. Rothwell PM, Eliasziw M, Gutnikov SA, Warlow CP, Barnett HJ. Endarterectomy for symptomatic carotid stenosis in relation to clinical subgroups and timing of surgery. Lancet 2004; 363:915–24. https://doi.org/10.1016/S0140-6736(04)15785-1.
15. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2019; 50:e344–418. https://doi.org/10.1161/STR.0000000000000211.
16. Pini R, Faggioli G, Vacirca A, Dieng M, Goretti M, Gallitto E, et al. The benefit of deferred carotid revascularization in patients with moderate-severe disabling cerebral ischemic stroke. J Vasc Surg 2021; 73:117–24. https://doi.org/10.1016/j.jvs.2020.03.043.
17. Kaesmacher J, Maamari B, Meinel TR, Piechowiak EI, Mosimann PJ, Mordasini P, et al. Effect of pre- and in-hospital delay on reperfusion in acute ischemic stroke mechanical thrombectomy. Stroke 2020; 51:2934–42. https://doi.org/10.1161/STROKEAHA.120.030208.
18. Bazan HA, Caton G, Talebinejad S, Hoffman R, Smith TA, Vidal G, et al. A stroke/vascular neurology service increases the volume of urgent carotid endarterectomies performed in a tertiary referral center. Ann Vasc Surg 2014; 28:1172–7. https://doi.org/10.1016/j.avsg.2013.10.002.