Atherosclerotic Carotid Artery Disease

Where to from the Emergency Room? A University Hospital Experience

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Abstract

Objective: Stroke is the second leading cause of death worldwide, with 5.5 million deaths attributed to this cause in 2016. Vascular intervention, including carotid endarterectomy and carotid artery stenting, play a major role in stroke prevention, especially if intervention is performed early after onset of symptoms. The aim of the paper was to define the role of vascular surgeons in ischemic stroke and hence improve referral patterns by drawing an algorithm for the referral process which could reduce time to intervention and optimize patient benefit from intervention. Methods: This retrospective study reviewed the symptomatic and asymptomatic patients with atherosclerotic disease of the carotid artery referred to the vascular surgery unit of our institution from April 2018 to March 2020, to examine factors influencing recognition of suitable candidates for intervention. Results: A total of 38 patients with ischemic stroke were recognized as having carotid artery stenosis and were referred to the vascular surgery service during the study period. Only 6 met the criteria for carotid endarterectomy; 4 underwent the procedure. Conclusions: Choice of patients for carotid endarterectomy 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 interventional radiologist resulting in increased and optimised intervention in stroke prevention.

**Keywords:** Stroke, TIA, carotid, symptomatic, asymptomatic, referral, vascular, surgery, endarterectomy, stenting, referral.

**Introduction**

Stroke is recognized to be the second leading cause of death worldwide, with 5.5 million deaths attributed to this cause in 2016. It is also the second most common cause of enduring disability. Global burden of stroke is estimated to continue to increase.\(^1\) A stroke registry at our institution, enrolling about 600 patients with stroke, recognized poor outcome in almost 60% of them and attributed this mainly to large artery or cardioembolic strokes.\(^2\)

Previous experience at our institute through a stroke registry (similar to many centres offering CEA) has demonstrated several difficulties in the process of recognition of appropriate patients who would benefit from revascularization interventions. These include: recognition of the degree of extracranial arterial stenosis, attributing the lesion as the cause of the current vascular event, exclusion of downstream (intracranial) arterial disease which may complicate the intervention, pin-pointing associated other 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, patient’s Modified Rankin Score (MRS) or National Institutes of Health Stroke Scale (NIHSS), and lastly patient acceptance of the intervention. This complex process of patient selection may lead to missed opportunities to offer appropriate surgical intervention to deserving patients with severe cerebrovascular stenosis.

This study aimed to define the role of vascular surgeons in ischemic stroke and hence improve referral patterns by drawing an algorithm for the referral process which could reduce time to intervention and optimize patient benefit from intervention.

**Methods**

In this retrospective, single-center study, approved by the institutional review board, all the cases of carotid artery disease referred to the vascular surgery service between April 2018 and March 2020 were analysed for possible carotid intervention. The Electronic Medical Records of such patients were reviewed by the authors to document 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 them were reviewed by both the radiology, neurology and
vascular surgery consultants. The degree of stenosis was calculated using the NASCET
criteria by use of syngo.via software by Siemens Healthineers. Patients were classified into
those who received only best medical therapy (BMT), carotid endarterectomy (CEA) or
referred for carotid artery stenting (CAS).

Results
A total of 38 patients were recognized as having carotid artery stenosis and were referred to
the vascular surgery service during the study period. 31 patients had presented with stroke, 3
with transient ischemic attack (TIA), and 4 were asymptomatic. Of the symptomatic patients,
29 were admitted through the Emergency department (ED), 3 were in-patients and 2 were
referred from a peripheral hospital after initial medical treatment for ischemic stroke. The
time from symptom onset to ED ranged from 30 minutes to 3 days, with the average being 24
hours. 11 presented within the 4.5 hours thrombolysis window, of whom 5 met the criteria for
and received thrombolysis. 11 came after the thrombolysis-window but before 24 hours, 5
came within 24-72 hours and 2 after 72 hours. Patient demographics are described in Table 1.

The most common imaging modality that was used to identify the carotid stenosis was
computed tomography angiography (CTA), in 29 patients, with most patients undergoing it
within 5 days of admission. 3 had duplex ultrasound (US) done elsewhere before referral to
our center, and 5 had magnetic resonance imaging (MRI). One asymptomatic patient had
undergone coronary angiogram (CAG) with carotid run when a significant carotid stenosis
was recognised.

10 patients were identified to have significant unilateral stenosis of the extra-cranial portion
of the internal carotid artery (ICA), defined as 70-99% stenosis, while one patient had
bilateral significant ICA stenosis. Seven patients had unilateral complete (100%) occlusion of
the extra-cranial ICA while one had complete ICA occlusion bilaterally. Two other patients
had significant unilateral ICA stenosis with contralateral complete occlusion. The remaining
17 of the patients had non-significant carotid disease (Table 2).
Among the 10 patients with significant unilateral stenosis, 6 were deemed suitable for CEA. The remaining 4 were not candidates for CEA for reasons such as haemorrhagic transformation of the stroke, severe neurologic deficits with no improvement or the presence of concomitant intracranial carotid disease. All the six eligible patients were offered carotid endarterectomy (CEA): 4 patients underwent CEA while 2 refused.

Based on our data, median referral time to vascular surgery service from presentation to ED for stroke/TIA was 5 days. Out of those referred due to symptomatic ICA occlusion, 3 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 in undergoing CEA, of whom 2 patients agreed for surgery only after experiencing a second stroke. Additionally, 10 patients were found to have total carotid artery occlusion, for which no surgical intervention is indicated and hence, 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 that 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 (figure 1) and 2 (figure 2) were proposed.

Discussion

Stroke is the third leading cause of death in Oman, after ischemic heart disease and road injuries. 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. As with other non-communicable diseases, prevention is the key factor to minimize the economic and health burden of stroke. Significant advances in the medical management of patients with stroke have enabled both reduction of disability, prevention of future vascular events, as well as 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 recognized by several studies to benefit from carotid endarterectomy (CEA) or carotid artery stenting (CAS). This benefit of CEA is recognized to be superior to any medical intervention in this context. Therefore, situation has mandated the need for studying the vascular anatomy of almost every patient with transient ischemic attack or stroke. However, intervention is associated with risks of procedural stroke as well as mortality. An acceptable balance of benefit and risk is well recognized to be provided by positioning the intervention within about two weeks of onset of an index stroke or TIA. However, the need for recognizing suitable surgical candidates for revascularization surgery emphasizes an urgency in completing the evaluation process of such patients.

While many therapies exist for the primary and secondary prevention of stroke, revascularization is the only interventional modality currently available, and can be performed in the form of CEA or CAS. Though atherosclerosis may affect intra- and/or extra-cranial arteries, only selected stenotic arterial lesions are amenable to CEA. Medical management is accepted as the best option for intracranial arterial stenosis. The NASCET, ECST and SVACS trials collectively show that for patients with severe carotid artery stenosis, CEA when compared to best medical therapy (BMT) alone, reduces the absolute risk (ARR) and relative risk (RR) of any stroke at 5 years by 15.6% and 48% respectively. Furthermore, in a landmark trial by Rothwell and colleagues in 2004, it was found that the ARR for peri-procedural stroke after CEA decreased from 30.2% to 17.6% after the initial 2-week period from onset of symptoms. Based on these findings, early recognition and management of internal carotid artery (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 (SVS) 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. Some select patients, however, with a more marked neurological deficit (MRS 3 or 4), may benefit from a deferred CEA after 4 weeks of onset of symptoms.

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 ischemic stroke or TIA were either not obtained or delayed; most patients are evaluated initially with a CT scan, with a CT or MR-angiogram only scheduled a few days later, during
their admission. 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. 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. Varied factors are recognized to influence acceptability of such interventions. In the study, most of the above factors were recognized in several patients and influenced treatment decisions as well as timing to imaging or intervention.

The aim of the study, defining the role of vascular surgeons in ischemic stroke, sought to decrease patient 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 multi-disciplinary approach to carotid artery disease can increase the number of patients undergoing urgent CEA, whilst also improving overall outcome in terms of perioperative stroke and death.

On the background of the previous discussion, the paper proposes an algorithm (figure 1) which is based on Oman’s Ministry of Health (MOH) and European Society of Vascular Surgeons (ESVS) guidelines for stroke, adding a clear pathway for vascular surgery referrals. Furthermore, 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 (figure 2) was created to facilitate decision making in such asymptomatic patients. Both algorithms aim 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. 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 multi-disciplinary 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.

The results of this study, besides highlighting the importance of a multi-disciplinary team approach to managing stroke in a timely manner, also stresses on the need for good patient education regarding symptoms of stroke and the importance of early presentation to a hospital and available treatment options.

**Conflict of Interest**

The authors declare no conflicts of interest.

**Funding**

No funding was received for this study.

**Authors’ Contribution**

IAK was involved in data gathering, review of literature and writing of manuscript. SAA was involved in data gathering and writing of manuscript. ES contributed to data gathering, review of literature/manuscript and final approval. SBA was involved in data gathering and review of images. AG contributed to the review of data, review of literature/manuscript and final approval. IA was involved in data gathering and review of literature. HAW was involved in data gathering and patient follow-up. KAW was involved in review of literature, manuscript writing and final approval.

**References**


Table 1: Patient demographics

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Table 2: Distribution of degree of extracranial carotid artery stenosis by NASCET criteria

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<th>Degree of occlusion in extra-cranial portion</th>
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<td>Complete (100%) occlusion unilaterally</td>
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<td>Complete occlusion bilaterally</td>
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<td>Non-significant stenosis</td>
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Figure 1: Referral Pathway for symptomatic carotid atherosclerotic disease

1: Time from symptoms onset to hospital presentation
a: Transient Ischaemic Attack, b: Magnetic Resonance Angiography, c:Computed Tomography Angiography, d:Computed Tomography, e: Intracranial Haemorrhage, f: more than 50%, g: Carotid Endarterectomy, h: Modified Rankin Scale for Neurological Disability Internal
Carotid Artery, i: Middle Cerebral Artery, j: Altered Level of Consciousness
Figure 2: Referral Pathway for asymptomatic carotid atherosclerotic disease

a: Computed Tomography Angiography, b: Magnetic Resonance Angiography, c: Best Medical Therapy, d: Coronary Artery Bypass Surgery, e: Internal Carotid Artery, f: Carotid Endarterectomy, g: Carotid Artery Stenting