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Case Study

Carotid artery web: a rare cause of recurrent ischemic stroke

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Carotid web, carotid disease, atherosclerosis, stroke, ischemia.

Key learning points
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A carotid web can be the cause for an ischaemic transient ischaemic attack or stroke. This diagnosis is important to consider in young patients with recurrent strokes and without classical risk factors for atherosclerosis. Patients are often at higher risk of recurrence compared to traditional atherosclerotic disease. The diagnosis might require a combination of several imaging techniques. Surgical management (endarterectomy) carries an excellent prognosis, therefore early referral to a vascular centre with experience in carotid web surgery is important.

Abstract

Carotid web is a focal form of fibromuscular dysplasia characterised by an abnormal shelf-like projection of fibrous tissue into the lumen of the carotid artery. It is a rare but important cause of recurrent ischemic stroke particularly in younger patients with few traditional risk factors. Despite that it may cause up to 37% of strokes of uncertain aetiology, an optimal evidenced-based management strategy has not been developed. This case report provides us with the opportunity to highlight this under-recognised cause of recurrent stroke and review the current evidence for its diagnosis and management.

Introduction

An important rare cause of recurrent ischemic stroke is carotid artery web (CW), first described in 1968[1]. CW is a nonatherosclerotic occlusive disease of the extracranial carotid arteries. It is a rare focal form of fibromuscular dysplasia (FMD) characterized by an abnormal shelf-like protrusion of intimal fibrous tissue into the lumen of the carotid artery, most commonly affecting the posterolateral wall of the proximal internal carotid artery (ICA). CW is important underrecognized cause of ischemic stroke of uncertain aetiology, often in younger patients without usual stroke risk factors[2]. Despite evidence that CW may cause up to 37% of strokes of uncertain aetiology[2], an optimal evidence-based management strategy has not been identified.

Stroke is the second leading cause of death and a major cause of disability worldwide[3]. Occlusive carotid disease causes up to 20% of ischemic strokes, most commonly due to atherosclerosis. Though sometimes asymptomatic, atherosclerotic plaques may cause cerebral ischemic events through total vessel occlusion, thrombosis, or embolism. As atherosclerosis is a multi-system disease, patients with carotid stenosis are also at risk of coronary artery disease and peripheral arterial disease. In patients with ischemic events due to severe carotid stenosis, early revascularization with carotid endarterectomy (CEA) or stenting significantly reduces risk of recurrent stroke[4].

The case presented here is a patient who suffered multiple ischaemic strokes due to a CW. The case report is followed by a summary of the presentation, diagnosis and management of this rare condition.

Case Description

A right-hand dominant 57-year-old man presented to the emergency department with acute confusion, slurred speech, difficulty finding words with associated right-sided facial droop and weakness. On examination, there was a right-sided facial droop and right-sided tongue wasting. The patient was oriented but unable to find words. There was no apparent sensory deficit or pain.

Prior medical history was notable for a stroke in 2019, causing right-sided weakness, confusion and expressive aphasia, documented as a left middle cerebral artery (MCA) infarct (M3 branch). Symptoms were largely improved, with some residual longstanding communication issues. He was subsequently investigated for causes of this stroke with a prolonged monitor which did not reveal atrial fibrillation and a transoesophageal echo which did not suggest cardio-embolic sources. Dual antiplatelet therapy (DAPT) was commenced after this event, though aspirin was later stopped. Patient's other past medical history included membranous VSD and subsequent infective endocarditis, and pre-diabetes. There was no family history of note and the patient has never smoked.

A CT Head revealed thromboembolic occlusion of the distal left M1/proximal M2. there was a large area of severe left MCA territory hypoperfusion. CT angiography revealed 50-69% carotid stenosis which was reported as secondary to unstable carotid atheromatous blockade.

He received thrombolysis with alteplase and was subsequently discharged the next day with aspirin 300mg long-term clopidogrel was held). He had mild-moderate receptive aphasia and moderate expressive aphasia.

Two days later, he presented to A&E again with new acute-onset severe facial pain that woke him from sleep, not improved by paracetamol. Since onset, he reported new word-finding difficulties. No new visual changes, weakness, sensory changes or coordination were noted. He additionally reported one episode of vomiting. On examination, word-finding difficulties, right hemianopia and right visual inattention were noted. Further stroke assessment indicated impairment in time orientation, number writing, episodic recognition and executive tasks.

A CT head was suggestive of acute left-PCA infarction. DAPT was re-commenced and vascular surgery consulted for evaluation of recurrent ischemic events secondary to carotid disease. A second look at CT head and prior CT angiograms resulted in an addendum which reported a thin triangular smooth filling defect in the left internal carotid artery (ICA), suggestive of a carotid web causing 50-69% stenosis.

The patient underwent left carotid endarterectomy to remove the carotid web. The patient had a high carotid bifurcation and large calibre vessels (ICA ~7mm diameter). Intra-operative carotid shunting was performed after a test clamp resulted in a reduced consciousness level. Localized web stenosis and some generalized atheroma were observed on gross pathology and endarterectomy was performed. Additionally, a thrombus was found in a "pocket" at the origin of the ICA.

There were no intraoperative or postoperative complications. He was discharged on Day X with a package of care including occupational and physiotherapy for a residual right-sided limb weakness and speech and language therapy for moderate expressive aphasia. Additionally, he suffered some right-sided visual impairment and low mood subsequent to these events.

Carotid Web Pathophysiology

Carotid web (CW) is a rare focal form of FMD, that results in non-atherosclerotic occlusion of the carotid artery. The MR-CLEAN trial suggests that CW accounts for 2.5% ischemic strokes due to large-vessel occlusion[5]. The current case falls into the category of embolic stroke of unknown significance (ESUS). ESUS is a subtype of stroke of uncertain aetiology that describes non-lacunar stroke without identifiable aetiology (e.g. large vessel disease, cardioembolic source); they comprise about 1/6 ischemic strokes[6]. The prevalence of CW is higher in ESUS relative to stroke with an identifiable cause of thrombo-embolism (10.7% vs. 0.7%, $p<0.001$)[7].

Histopathologically, CWs consist of elastic thickening of the arterial intima, forming fibrous tissue that project into the artery lumen, characteristically on the posterior wall distal to the origin of the ICA(Fig.1)[8]. In atherosclerotic carotid disease, stroke is usually caused by occlusion of the vessel by plaque or unstable plaque rupture resulting in thrombosis and embolism. Instead, the CW alters haemodynamics resulting in turbulent blood flow and stasis distal to the web, forming a nidus for thrombus formation and subsequent embolization, as revealed by a recent computational fluid dynamics study[8]. On cerebral angiography, stasis of IV contrast around the web has been reported in multiple instances[9].

Consistent with the first described case of CW[1], studies have found that CW patients are generally young, disproportionately female, with few risk factors for stroke[2,10]. One such case series found median age of 46, and low incidence of vascular risk factors (hyperlipidaemia in 4%, diabetes in 12%, smoking in 8%)[2,9]. The prevalence of

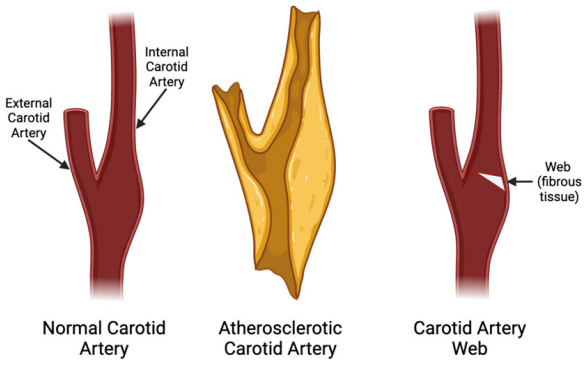

Figure 1: Carotid web pathophysiology. Made with Biorender.com.

CW has been suggested to be 24-fold higher in <55-year-old patients with stroke of uncertain aetiology than in controls[11]. Studies have also reported that between 70-86% of CW patients were African-American[2]. These risk factors require further investigation in large-scale epidemiological work.

Whether CW is congenital and its development throughout a person's lifespan is also unclear. One case series reported that 58% of patients had asymptomatic CW contralateral to the symptomatic lesion[9]. This finding may suggest that a systemic process underlies CW, but is preliminary and cannot be accurately generalized to asymptomatic CW patients. A retrospective review of neck imaging (CTA, DSA, MRA) of 37 paediatric patients with ischemic stroke, found no CWs in the studied population, failing to find evidence that CW is congenital[12], though further work in a larger population is needed.

Clinical Presentation and Diagnosis

Clinically, the presence of multiple ischemic strokes in the territory of one carotid artery in absence of risk factors is suggestive of CW pathology. Given the potential neurological detriment of multiple ischemic strokes, early detection of CW is critical, as it presents high risk for recurrent thromboembolic events, as in the presented case. A high index of clinical suspicion is needed.

As for the current case, other case of patients with ischemic stroke secondary to CW revealed that they were investigated for atrial fibrillation[10]. In both cases, despite no evidence of atrial fibrillation on prolonged ambulatory cardiac rhythm monitoring, patients were not further investigated, unfortunately resulting in recurrent ischemic events. Furthermore, one case was reported in which a 48 year old man with CW was mistreated with MCA bypass for ESUS, as pre-operative imaging did not seek to image the carotid artery[13]. These reports suggest that awareness of CW as a cause of recurrent ischemic stroke is low.

Radiologic investigations include magnetic resonance angiography (MRA), computed tomography angiography (CTA) and digital subtraction angiography (DSA). CW can be identified as an isolated thin (1-2mm) and sharp shelf-like projection in the lumen particularly at the posterior wall of the carotid bifurcation or proximal ICA[11] with a notable absence of calcification, though its appearance can be subtle, especially on axial views[14].

The best imaging modality for accurate diagnosis is debated. High inter-rater reliability of CTA has been consistently reported[5]. DSA has also been described

as “gold standard” for diagnosing CW, but is, however, invasive and less frequently used in current clinical practice. Importantly, CTA is less costly and more widely available. Additionally, multiplanar reformatting of CTA or MRA (e.g. oblique sagittal images) allows for 3-D analysis of filling defects, which is critical for clearly distinguishing the thin triangular often unilateral shelf-like CW from both atherosclerosis and FMD[14]. FMD appears as bilateral “string of beads” appearance on distal and middle ICA and vertebral arteries, whereas atherosclerosis is characterized by concentric calcification[14].

Ultrasound scan (USS) can also be used to identify CW (Fig.2), though USS has limited ability to distinguish between fibrotic CW lesions and atherosclerotic plaques. However, one study has reported that atherosclerosis may cause elevated velocities on Doppler USS, not found in CW[14].

Importantly, atherosclerotic plaques can be difficult to distinguish from CW on imaging[15], especially as the location of CW (posterior wall of proximal ICA) is common for atherosclerotic disease. In the presented case, the CTA was reported as carotid stenosis due to atherosclerosis, but on further retrospective review, it was reported that the CTA in fact was consistent with CW, suggesting that absence of suspicion and insufficient recognition of the image qualities of the disease (described above) are likely contributing factors to missed diagnosis. More detailed analysis of vascular imaging on CTA through acoustic beam direction analysis or 3-D reconstruction are indicated to accurately distinguish CW from atherosclerosis[15]. In summary, a high degree of suspicion combined with detailed imaging analysis (e.g. multiplanar reformatting of oblique sagittal view on CTA, oblique view on DSA), facilitated by widespread awareness of CW disease beyond specialist vascular surgeons, is needed to effectively diagnose CW and prevent recurrent ischemic stroke in these patients.

Management Strategies

Recent new guidance on management of CW has been published for the first time in the ESVS 2023 Carotid Clinical Practice guidelines, which stipulates that for recently symptomatic patients with a carotid web, neurovascular work-up and CEA or carotid stenting should be considered to prevent recurrent stroke[16].

Still, prospective longitudinal data on optimal management for CW is limited. CW can be symptomatic or asymptomatic, and management for these two groups is debated. Treatment of CW is mainly through medical and surgical secondary stroke prevention. Medical options include antiplatelets and anticoagulants. In a 2018 systematic review of CW patients, Zhang et al reported that in 28% of patients managed medically, 56% of these patients had stroke recurrence with median time of recurrent stroke of 12 months[2]. When stratifying by medical management, there was a 54% recurrence rate with antiplatelet therapy, which could be attributed to the limited efficacy of antiplatelet therapy at sites of stasis (ie. around the web)[17]. Alternatively, anticoagulant therapy can be used, which may have higher efficacy due to the fibrin-rich nature of the emboli formed from the CW, but limited data exists on anticoagulant therapy in management of CW. Zhang et al reported 75% recurrence with anticoagulant therapy[2], though anticoagulant sample size was very small, so this result should be interpreted with caution. Recurrent rates of other case series with medical management of CW agree with these results, ranging from 30-70%[9,11].

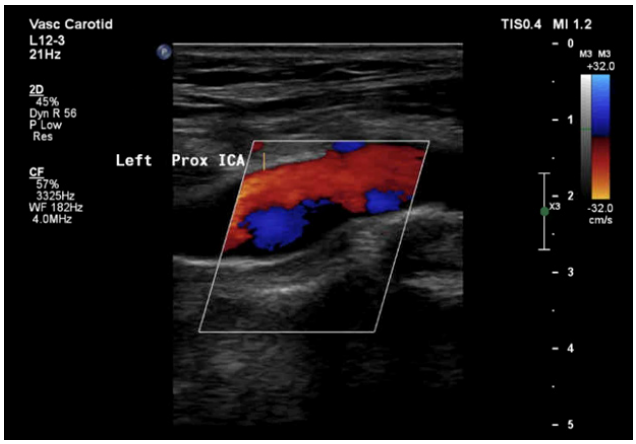

Figure 2: Pre-operative carotid artery duplex USS of Patient X reveals filling defect in left ICA suggestive of carotid web.

Surgical intervention is conventionally through carotid endarterectomy (CEA), but recent data also supports carotid stenting (CAS)[18]. No studies have compared the two. Importantly one study found, 0% recurrence risk with surgical management (CEA and CAS)[2]. No periprocedural complications were reported, likely attributable to the generally younger and more well patient population compared with those who undergo carotid revascularization for atherosclerotic disease. These results are consistent with other retrospective analyses of surgical management of CW[19]. As in the presented case, many patients undergo revascularization after experiencing a stroke despite medical management of CW[2]. The high rate of recurrent stroke with medical therapy compared with surgical therapy suggests a need for aggressive treatment once CW is detected ipsilateral to an acute stroke.

In patients with symptomatic carotid atherosclerosis, it is generally accepted that those with severe (70-99%) or moderate (50-69%) stenosis have a positive risk-benefit ratio for carotid revascularization, particularly within 2 weeks of the presenting event, but those with mild stenosis (<50%) are generally considered unlikely to benefit[20]. In a group of patients with CW causing stroke, 84% had mild stenosis, 10% had moderate stenosis and 6% had severe stenosis. This finding suggests that in CW patients, a lesser degree of stenosis may be more clinically relevant when compared to atherosclerotic disease, which has two important implications. First, degree of stenosis may not stratify risk of ischemic events as it does in atherosclerotic disease. Second, it may be potentially indicated to intervene surgically at milder degrees of stenosis than for atherosclerotic disease to prevent recurrent stroke and subsequent neurological deficits. This would require a high index of clinical suspicion and precise imaging interpretation to reach the accurate diagnosis before intervention. There is a need to further investigate optimal management of CW pathology and to distinguish it from the management protocol for atherosclerotic carotid disease.

Conclusion

Our case demonstrates the risk of recurrent ischemic stroke in younger people due to CW. Increased awareness of CW as a cause of ESUS is needed to facilitate early and accurate diagnosis clinically and on imaging, such that correct intervention is initiated early before devastating neurological deficits occur. In particular,

more widespread understanding of its characteristics on vascular imaging, and more detailed analysis of imaging (e.g. 3D reconstruction) where CW is suspected could be of use to distinguish it from atherosclerosis. There is some suggestion that carotid revascularization may be better definitive management than antiplatelet or anticoagulant therapy and that surgical intervention at milder degrees of stenosis than atherosclerotic disease may be indicated, but further studies are needed to confidently optimize secondary stroke prevention strategies.

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Consent
The patient has consented to the publication of this case study.

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