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Original Article

Carotid webs and ischemic stroke: Experiences in a comprehensive stroke center

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ABSTRACT

Background and purpose. – Carotid webs are intraluminal filling defects at the carotid bulb which are considered rare, though possibly underappreciated entities with recent studies demonstrating a likely casual association with ischemic stroke. The purpose of the study is to describe our recent experience with clinical and imaging manifestations of carotid webs.
Materials and methods. – A retrospective review of CTA neck studies in all adult patients presenting to our institution during the 19-month study interval was performed to determine the presence of carotid webs. Subsequent chart review of these patients with webs was performed to assess their clinical history and to obtain demographic detail.
Results. – A total of 14 patients were identified with carotid webs in the study population. The mean age of patients with webs was 42.1 years (range: 28–54), consisting mostly of African Americans (86%) and females (64%). Ten (71%) of web patients had a history of ischemic stroke, each ipsilateral to the side of web, and at least four of these patients had recurrent ischemic stroke.
Conclusion. – We provide one of the largest sample sizes of webs gathered in a single study. Given its association with ischemic stroke, carotid webs should be assessed for in all patients presenting with ischemic stroke, especially younger African Americans.

Introduction

Carotid webs are shelf-like protrusions arising from the posterior wall of the carotid bulb, most often diagnosed with CT angiography (CTA) [1–3]. These intraluminal filling defects have been described as possible intimal variants of fibromuscular dysplasia based on the histologic finding of intimal hyperplasia [1,4–6]. Carotid webs are theorized to cause stasis of blood flow and thrombus formation; this is supported by examples of superimposed thrombus on pathology [1]. Although considered rare, there is growing evidence that supports a strong association between carotid webs and ischemic stroke, particularly in a younger subset of patients who are without other identifiable risk factors, or "cryptogenics" [7,8]. Recent studies by Coutinho et al. and our group have shown that webs are 8–13 times more likely to occur in young cryptogenic stroke patients than in respective control groups [7,8]. Therefore, this once considered uncommon entity may in fact reflect an underappreciated cause of ischemic stroke.

Since the conclusion of our most recent study [7], the awareness of this entity at our institution has greatly improved, among both clinicians and radiologists, resulting in patients being diagnosed and managed earlier. Still, much remains to be elucidated. Available demographic data, albeit limited, shows an overwhelming predominance in the female and African American populations [1,3,7,9]. To the best of our knowledge, only one study thus far has reported on the mean age of patients presenting with symptomatic carotid webs in adult all-comers (lacking a maximum age limit), demonstrating a mean age of 50 years in a sample of 7 patients [1].

Drawing on the experience from our prior study, the purpose of this current study is to describe our recent experience with the clinical and imaging manifestations of carotid webs at a comprehensive stroke center.

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Table 1
Detailed demographic and clinical features of patients with positive carotid webs.

Patient no.	Age	Sex	Ethnicity	Infarct location and chronicity	Laterality of web	Management
Webs in acute stroke setting						
1	48	Female	Caucasian	Acute left MCA	Left	Medical management
2	45	Male	African American	Acute right MCA	Right	Emergent CEA
3	41	Female	African American	Acute left MCA	Left	IV tPA, CEA
4	39	Female	African American	Acute left MCA	Bilateral	Medical management
5	39	Female	African American	Acute right MCA	Right	Medical management
6	35	Male	African American	Acute right MCA	Right	Medical management
7	46	Female	African American	Acute left MCA	Left	Medical management
Incidental webs						
8	28	Male	Hispanic	N/A	Right	N/A
9	52	Female	African American	N/A	Left	N/A
10	54	Female	African American	N/A	Left	N/A
Outpatients with webs						
11	37	Female	African American	Chronic left MCA	Left	Medical management
12	41	Male	African American	Chronic left MCA	Bilateral	CEA
13	48	Female	African American	Chronic right MCA	Bilateral	Medical management
14	37	Female	African American	N/A	Left	N/A

MCA: middle cerebral artery; CEA: carotid endarterectomy; IV tPA: intravenous tissue plasminogen activator.

Methods

Retrospective study design and patient population

This HIPAA-compliant, single-center, retrospective study was approved by our institutional review board; the need for informed consent from the participants was waived. Our institution is a comprehensive stroke center, considered to be a regional center of excellence in stroke care and research. We reviewed clinical and radiologic data of all patients who presented to our institution and obtained a CTA neck study between September 1, 2015 and March 30, 2017. CTA neck studies which fit the parameters of the inclusion criteria were retrieved using a departmental report search tool using the keywords "CTA neck". Inclusion criteria included patients 18 years of age and above. All patients presenting with an indication of trauma were excluded given the potential difficulty in discerning vascular injury from a carotid web in the post-traumatic setting.

Imaging evaluation

CTA was identified as the optimal modality given its reliability in diagnosing carotid webs as well as its ability to distinguish differential considerations including atherosclerosis and vascular injury [1,3,7]. CTA neck studies were acquired from the aortic arch through the circle of Willis, and obtained on a 64-MDCT scanner with 1 mm thick slices. Scanning parameters included: 120 kVp; 350 mAs. One hundred milliliters of intravenous contrast material (iohexol 300 mg/mL, Omnipaque, GE Healthcare, Chicago, IL) and 50 mL saline flush were administered at a rate of 4 mL/s with a power injector. Images were reconstructed with axial, coronal, and sagittal maximum intensity projections (MIPs). All CTA neck studies which met the inclusion criteria were transferred to the Aquarius Workstation (version 3.6.2.3, TeraRecon, Inc., Foster City, CA), an independent imaging viewer that enables multiplanar reformation as well as MIPs. Each of the retrieved studies were reviewed by a fellowship trained neuroradiologist with greater than 10 years of experience for presence or absence of a carotid web. The reader was blinded to patient age, sex, and presenting symptoms.

A dedicated chart review of all patients with carotid webs was then performed to obtain demographic detail and subsequent management.

Results

A review of 622 CTA neck studies performed at our medical center during the study period demonstrated 14 patients with findings of a carotid web (Table 1). The mean age of these patients was 42.1 years (range: 28–54), consisting of nine (64%) females and five (36%) males. Twelve (86%) of the patients were African American, one was (7%) Caucasian, and one was (7%) Hispanic (Table 2). Ten (71%) of these patients had an associated history of ischemic stroke, with seven presenting in the acute setting and three outpatients with remote history of stroke. Each patient had a carotid web ipsilateral to the side of stroke and at least four (29%) total patients, including three ED/inpatients and one outpatient, had a history of recurrent ischemic stroke per our medical records. Another four patients were found to have asymptomatic carotid webs.

Table 2
Demographic features of all patients with carotid webs.

Characteristic	Carotid web patients ($n = 14$)
Mean age (in years) ± SD	42.1, 7.2
Sex	
Male, # (%)	5 (36)
Female, # (%)	9 (64)
Ethnicity	
African American, # (%)	12 (86)
Caucasian, # (%)	1 (7)
Hispanic, # (%)	1 (7)

N/A: not applicable.

The group of carotid web patients with acute stroke at presentation consisted of three (42.9%) males and four (57.1%) females, with six (85%) African Americans and one (15%) Caucasian. MRI confirmed the presence of recent MCA territory infarction in all seven patients, four with greater than 1/3 territory involvement (Fig. 1) and the remaining three with smaller embolic infarcts. Of important note, none of these patients had associated imaging features of vascular injury or carotid atherosclerotic disease. The average age of patients presenting with carotid web in the acute ischemic stroke setting was 41.9 years. Additional review of the medical history demonstrated no additional relevant risk factors to otherwise explain the cerebral event. In each of these cases, the web was ipsilateral to the side of infarct. The webs were unilateral in six cases (three on the right and three on the left), and bilateral in one case. In addition, three (42.9%) of these patients had a documented history of prior ischemic stroke in the same territory.

Three ED/inpatients had imaging findings of a carotid web, which were deemed as incidental, with none of these patients ultimately having symptoms related to ischemic stroke. Two such patients (patients 8 and 10) are detailed below as illustrative cases.

Another four patients with carotid webs were identified in the outpatient setting. While none of these patients presented in the

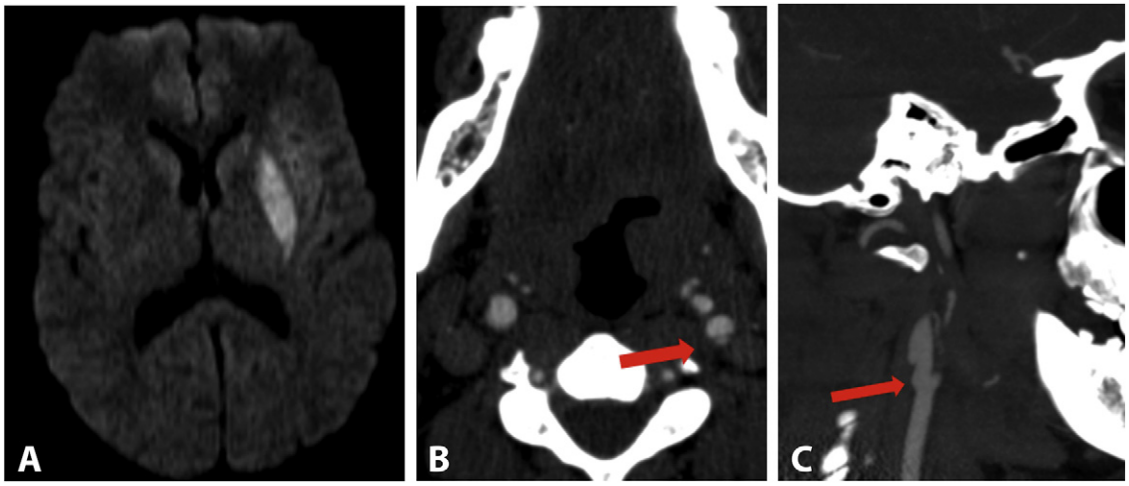

Fig. 1. DWI imaging (A) of a 48-year-old female (patient 1) presenting with right-sided hemiplegia and aphasia shows an acute infarct in the left lentiform nucleus. Sagittal (B) and axial (C) CTA neck imaging, of the same patient showed a focal intraluminal filling defect arising from the posterior wall of the left carotid bulb compatible with a carotid web. No other stroke risk factors were identified.

acute setting, three (75%) had a prior history of ischemic stroke, all in the MCA territory, as verified by CT and/or MR imaging, and one had a history of recurrent strokes. All webs were ipsilateral to the site of ischemic stroke. It is noteworthy that each of these patients previously had no known etiology for their strokes and were classified as "cryptogenics" [10].

All 14 cases (100%) with findings of a carotid web as determined by the reviewer were also reported on the final dictation at the time the study was initially performed, with 0 discordant cases.

Three (21%) of the 14 patients have since proceeded to carotid endarterectomy (CEA). Histopathology in each of these cases showed increased elastic fiber deposition and lack of atherosclerotic disease, making the findings suggestive of intimal changes related to underlying atypical fibromuscular dysplasia, or carotid web (Fig. 2).

Illustrative cases (patient numbers are labelled according to their numbers in Table 1)

Patient 1

A 48-year-old Caucasian female presented to the ED with moderate aphasia and right-sided weakness, initiating a stroke work-up. CTA neck demonstrated a thin, intraluminal filling defect centered in the posterior aspect of the left carotid bulb, compatible with a carotid web. Subsequent MRI brain revealed a left middle cerebral artery (MCA) territory infarct (Fig. 1). Additional review showed a history of cocaine use as well as classic fibromuscular dysplasia (FMD). A detailed work-up by the neurology team determined the carotid web to be the likely cause of the patient's stroke, possibly exacerbated by FMD and cocaine use. The patient was managed conservatively, with aspirin and anticoagulation, with an eventual improvement in neurologic symptoms.

Patient 2

A 45-year-old African American male with no known stroke risk factors presented with a temporal-based headache as well as numbness of the left arm. CTA showed a right-sided carotid web with adherent focal thrombus and a right M2 MCA branch vessel thrombus. MRI brain demonstrated scattered, embolic type acute infarcts in the right MCA territory. The patient underwent emergent CEA, which he tolerated without complication. Histopathology showed intimal fibromuscular proliferation, most compatible with the intimal variant of fibromuscular dysplasia. Subsequent follow-up has shown no concern for recurrent stroke.

Patient 3

A 41-year-old African American female with history of sickle cell trait and migraines presented to the ED with right-sided hemiplegia and aphasia. NIH stroke scale score upon presentation to the ED was 25. Intravenous (IV) tissue plasminogen activator (tPA) was administered with resultant improvement in neurologic symptoms. CTA showed a left sided carotid web with an M2 MCA branch occlusion. MRI brain revealed a large left MCA territory infarct. After initial IV tPA and subsequent course of conservative management, the patient underwent elective CEA with histopathology demonstrating features of intimal variant fibromuscular dysplasia (Fig. 2). The patient tolerated the procedure without major complications, with no report of subsequent stroke on follow-up.

Patient 5

A 39-year-old African American female presented to the ED with left sided hemiplegia and slurred speech. CTA neck revealed a right-sided carotid web with MRI brain showing a large right MCA territory infarct. Review of the patient's history showed diabetes mellitus as well as cigarette smoking. Further evaluation of the patient's history revealed multiple strokes since 2013, all in the right MCA territory, all likely related to the patient's web. The patient was ultimately managed conservatively with aspirin and anticoagulation and has since demonstrated overall improvement in neurologic symptoms.

Patient 8

A 28-year-old Hispanic male presented with concern for recent onset left sided sensory changes, thus initiating stroke work-up. Subsequent CTA neck demonstrated a web at the right carotid bulb, with no imaging evidence of ischemic stroke. A thorough evaluation by the neurology team deemed that the patient's clinical symptoms were actually long-standing and not related to stroke. The patient was conservatively managed for his symptoms, without dedicated management for the carotid web.

Patient 10

A 54-year-old African American female presented to the ED with headache following a syncopal event. CTA neck demonstrated a right-sided carotid web although no clinical or imaging evidence of ischemic stroke. Additional history revealed that the patient had a recent elective lumbar laminectomy procedure with further imaging confirming presence of a cerebrospinal fluid leak, requiring dural repair. The patient's symptoms subsequently resolved, with

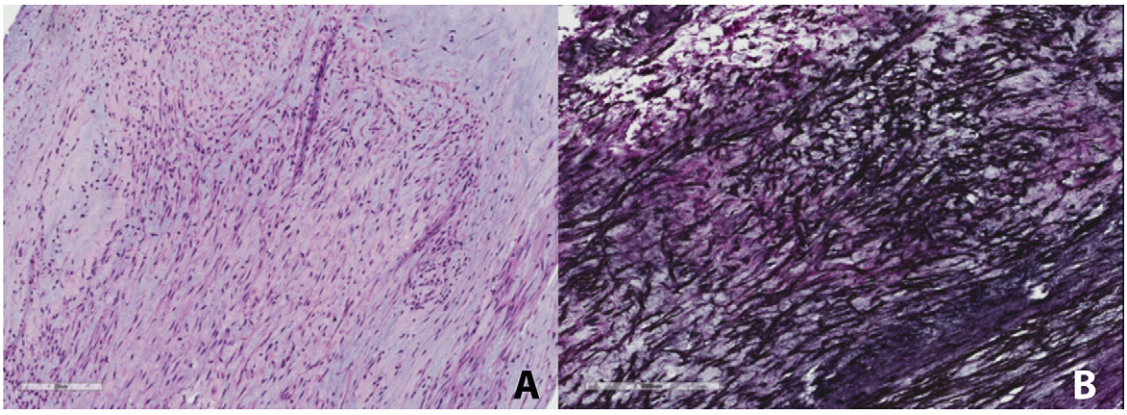

Fig. 2. High power H&E (A) and elastic stain (B) images of the carotid endarterectomy specimens show smooth muscle cell-rich intima with increased ground substance and elastic tissue. Elastic stain further demonstrates the presence of increased elastic fiber deposition, in keeping with intimal changes associated with underlying atypical or intimal variant fibromuscular dysplasia.

no reported history of intervention related to the incidental web finding.

Patient 13

A 48-year-old African American female with no known stroke risk factors initially presented in 2015 to an outside hospital with right-sided hemiplegia, and was ultimately diagnosed with a stroke of unknown etiology. The patient's symptoms did not significantly improve following clinical management and therefore presented to our institution for a second opinion. A subsequent CTA head/neck showed bilateral carotid webs as well as a large region of encephalomalacia in the right MCA territory with separate hypoattenuating foci in the same territory consistent with age-indeterminate infarcts. Additional history revealed that the patient had previously suffered a stroke at the age of 20. Surgical intervention with CEA was discussed, however, the patient deferred in favor of medical management, including anticoagulation.

Discussion

This review reflects the experiences at our institution following the heightened understanding of carotid webs and ischemic stroke, particularly in patients with limited risk factors for stroke. Our study revealed 14 patients with imaging features consistent with carotid web during the study interval that spanned approximately 19 months. Ten of these patients presented with either a recent or remote history of stroke, each ipsilateral to the side of the web, and at least four patients had a documented history of recurrent ischemic stroke. These findings reinforce that carotid webs are an underappreciated phenomenon with evolving importance and a strong, likely causal association with ischemic stroke.

We provide one of the largest sample sizes ($n = 14$) of carotid webs to date. Our findings are in keeping with prior literature [3,7,9] which has shown a strong predominance of carotid webs in African Americans (86%). Our results are also consistent with an increased rate of webs in females, although unlike prior studies, which have shown an overwhelming predilection for females, we show that webs may also represent a relevant concern in the male stroke population (36% males versus 64% females). In addition, the average age of patients with carotid webs presenting in the acute ischemic stroke setting was 42.1 years in our study, which is overall younger than those demonstrated in prior index studies [1,3,9]. For example, Joux et al. showed a mean age of 45.7 years while excluding patients 55 and above [3]. The younger presentation of patients when compared to prior studies is thought to reflect an improved understanding of carotid webs amongst clinicians and radiologists alike, thus leading to earlier detection rates rather than these patients being classified as "cryptogenics". While our prior study demonstrated a mean age of 38.3 years, these findings were limited by an inclusion criterion (excluding patients above the age of 60) as well as a sampler sample size [7]. We believe the mean age in our current study provides a more accurate reflection of the true average age of symptomatic carotid web patients given the broader inclusion criteria and higher sample size. We believe this data provides additional insight into the demographic analysis of this ever-evolving entity and may aid in identifying a group that may be most at risk for ischemic stroke related to a carotid web.

CTA imaging was the sole modality chosen for evaluation of carotid webs because of its proven ability to detect these carotid based filling defects [1]. CTA also provides the advantage of assessing for superimposed features of thrombus while excluding confounders such as atherosclerosis and vascular injury. We strongly believe that given the likely causal association between webs and ischemic stroke, CTA neck should be performed in all patients presenting with stroke like symptoms, particularly in young African American patients who have limited risk factors, regardless of sex, especially once other risk factors have been excluded [10].

Continued increase in awareness of carotid webs will no doubt also improve subsequent management, with the aim of preventing recurrent ischemic strokes. In our study, 3/14 (21%) patients underwent carotid endarterectomy (CEA), with histopathology in each of these cases demonstrating intimal changes related to underlying atypical fibromuscular dysplasia. While CEA is a viable surgical intervention for this entity, there is an emerging role for use of endovascular stenting [11–13].

This study has several limitations including its retrospective approach and overall limited sample size. Our study population was further limited by including only patients who received a CTA of the neck. Although select cases of carotid webs have been reported in patients obtaining conventional angiography, MRA neck, and carotid ultrasound, CTA has become the fastest and most reliable noninvasive technique for diagnosis of carotid webs [1,9,14,15].

Conclusion

Our cases series serves as one of the largest sample sizes of webs gathered in a single study, perhaps due to increased awareness in our institution of this once considered rare entity. Given the potential for ischemic stroke, the presence of carotid webs should be assessed for in all patients presenting with ischemic stroke, especially in younger African Americans, regardless of sex, in the absence of other risk factors.

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Disclosure of interest

The authors declare that they have no competing interest.

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