

# Carotid Strands: Possible Mechanisms and Implications of a Novel Finding



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## INTRODUCTION

The risk for atherosclerosis can be measured according to the quantity and nature of the disease using different modalities, such as coronary calcium scoring and computed tomographic angiography and ultrasound of the carotid and femoral arteries. Ultrasound can characterize atheroma without radiation and identify markers of increased cardiovascular (CV) risk such as increased intima-media thickness (IMT) and plaque thickness, calcification, stenosis, and lucency.<sup>1-5</sup>

*Ultrasound biopsy* and *biomicroscopy* are terms that describe how ultrasound can reveal fine details of the arterial intima-media complex (IMC),<sup>5</sup> especially at high frequency.<sup>6,7</sup> These include breaks in the continuity of the normally smooth echogenic intima-blood interface and clouding or granularity of the normally lucent middle layer that is associated with the media.<sup>5</sup> In this report we describe another ultrasound finding that to our knowledge is novel and consists of a long, mobile, strandlike structure that trails downstream from its anchor at the common carotid artery (CCA)-bulb margin. Three cases of this finding are derived from a CV health screening program. Follow-up images in one case suggest that strands and atherogenesis may be associated.

## CASE PRESENTATIONS

### Case 1

A 50-year-old woman with a strong family history of premature myocardial infarction underwent screening carotid ultrasound fundamental imaging with a 10-MHz linear-array transducer (a 9L, GE Vivid 7 at 10 MHz was used at baseline, 18 months, and 20 months, and a GE Vivid E95 at 8 MHz was used at 10-year follow-up; GE Vingmed Ultrasound, Horten, Norway). On the long-axis image of the right carotid far wall, a fine, mobile strand was detected anchored at the CCA-bulb junction (Figure 1A, Video 1). The strand was very thin and appeared continuous with the innermost layer of a thickened CCA IMC. The normally lucent middle layer of this complex was cloudy. IMT was normal, and no plaque was detected. Eighteen months later, the strand was no longer present, but a new smooth, 3-mm-thick, sessile layer of material was evident in the proximal far wall bulb adjacent to where the previous strand had been present (Figure 1B). Because atheroma rather than thrombus was suspected and low-density lipoprotein was elevated, pravastatin 20 mg was initiated. The subject did not receive antiplatelet or antithrombotic medi-

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## VIDEO HIGHLIGHTS

**Video 1:** Time course of the right carotid artery changes in case 1 with sequential demonstration of right carotid artery strand, extraneous bulb tissue, and resolution of this tissue.

**Video 2:** Video illustration of the right carotid artery findings in case 2 that includes a long mobile strand, discontinuity of the intima, and media granularity.

**Video 3:** Video illustration of the left carotid artery findings in case 2 that includes marked intimal discontinuity and media clouding as well as a depression in the surface of the bulb. Of additional note, there is a suggestion of minute motion of components within the IMC at the site of the depression indicated in Figure 2C.

**Video 4:** Video illustration of the right carotid artery findings in case 3 that demonstrates the strand continuous with the bulb-CCA junction, increased IMT, and diffuse soft atheroma.

[View the video content online at www.cvcasejournal.com.](http://www.cvcasejournal.com)

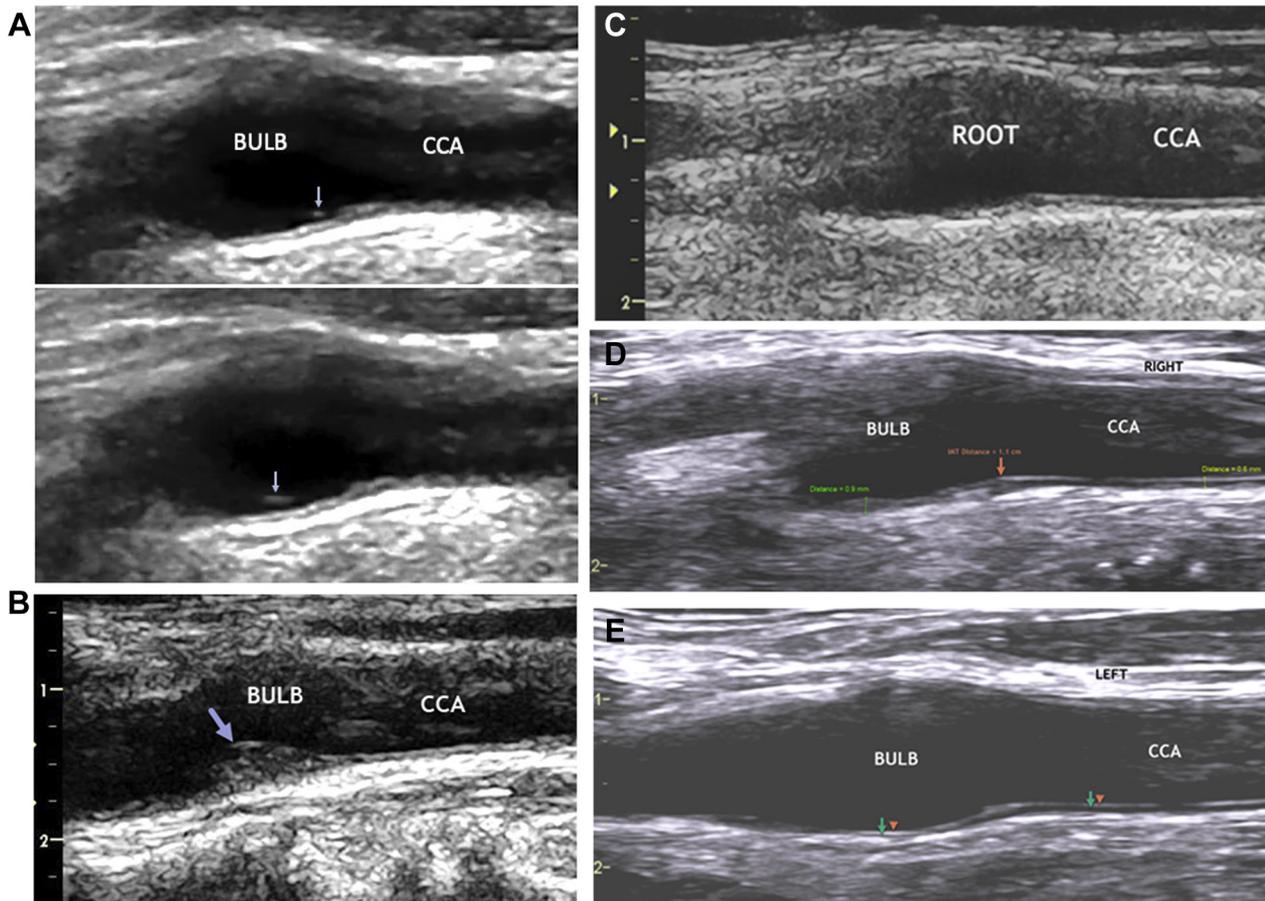
cation. The statin improved the lipid profile (total cholesterol decreased from 234 to 161 mg/dL, low-density lipoprotein decreased from 131 to 80 mg/dL, high-density lipoprotein increased from 49 to 69 mg/dL, and triglycerides decreased from 114 to 80 mg/dL). Repeat ultrasound 2 months later showed the resolution of the presumed bulb atheroma (Figure 1C). A 10-year follow-up study showed no strand or atheroma (Figures 1D and 1E). The subject was healthy and asymptomatic during the interval between baseline and follow-up imaging.

### Case 2

A 60-year-old woman with hyperlipidemia and hypertension underwent carotid ultrasound (9L, GE Vivid 7, 10 MHz) that showed a 6.5-mm-long, fine, mobile strand trailing distally over the right bulb far wall from mild atheroma at the edge of the CCA-bulb junction (Figure 2, Video 2). IMT at the junction was 1.4 mm, which was >50% thicker than the proximal CCA and distal bulb IMT. The junction also showed increased granularity of the media. No strand was present on the left side, but the left bulb IMT was increased at 1.3 mm, and a depression in the far wall intima-blood interface was detected with associated “shimmering” motion of the underlying media (Video 3). No atheroma was detected elsewhere. No follow-up examinations were obtainable.

### Case 3

A 66-year-old man with a history of coronary artery disease, smoking, and hypertension was found to have a fine, mobile strand at the CCA-



**Figure 1** (A) Long-axis images derived from two frames of [Video 1](#) that show a long strandlike structure (*arrows*) that extends from the far wall CCA-bulb junction. (B) Eighteen months later, 3-mm-thick tissue is newly layered on the bulb wall adjacent to the distal CCA. (C) This tissue was no longer present 2 months later with the subject on a statin. (D, E) Ten-year follow-up images of case 1 that show no recurrence of the extraneous bulb tissue. For the involved right carotid artery (D), the CCA IMT is normal proximally at 0.6 mm with intact intimal surface and slight clouding of the media layer. The distal CCA is thickened at 1.1 mm, and the media layer appears more clouded. Images of the bulb show increased media clouding and variable IMC thickness. The echogenic intimal layer is not seen. For the left carotid artery (E), the intima layer appears mostly intact and continuous (*red arrowhead*) for the CCA intima and proximal bulb with underlying lucency of the media (*green arrow*).

bulb junction (GE Vivid E95, 8 MHz; [Figure 3](#), [Video 4](#)). The right CCA IMT was layered with soft atheroma with thickness up to 1.8 mm bilaterally. No follow-up examinations were obtainable.

## DISCUSSION

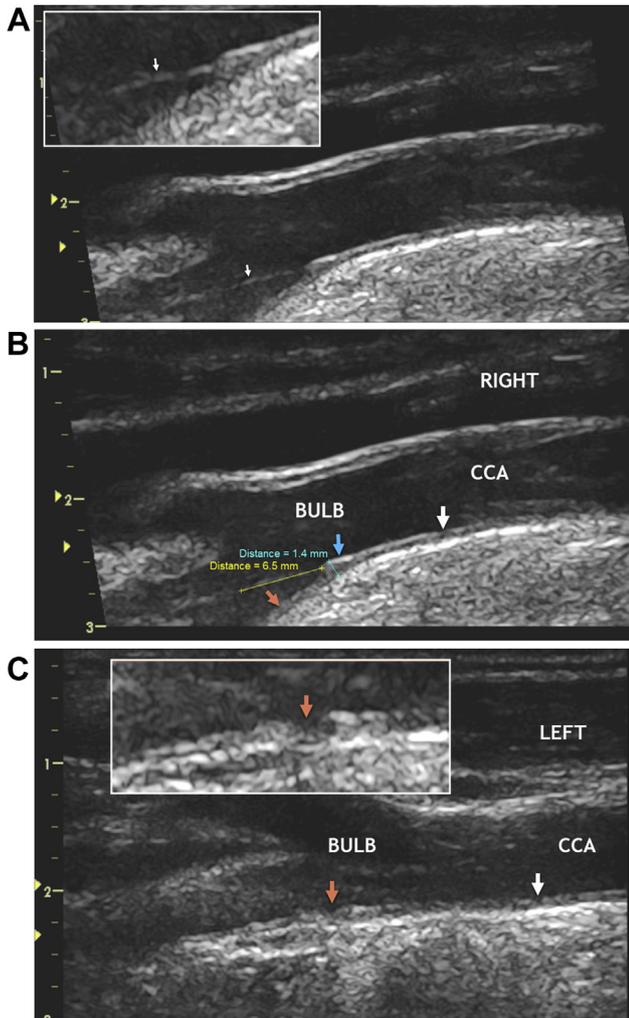
We describe the two-dimensional ultrasound finding of strandlike mobile structures that trailed distally from the CCA-bulb junction in three subjects at risk for or with known atherosclerosis. The strands were subtle and contiguous with either the intima or media. The development of new sessile material in the bulb of one subject that disappeared after initiation of a statin suggests the possibility of atheroma regression. Thrombus disappearance is another possibility, though anticoagulant or antiplatelet medication was not administered. Our cases suggest that carotid ultrasound strands are associated with atheroma and possibly atherogenesis.

The precise histology of the carotid strands we detected is unknown. One possibility is that the strands are fibrin filaments. Another possibility is that strands represent a lifting of the intima-asso-

ciated layer of the very proximal bulb. The continuity of strands with the surface of the IMC is most evident on the images for cases 2 and 3. Strands may be a marker of the disruption of the IMC that tends to occur when CV risk factors are present. Electronic microscopic examination of carotid plaque may show detachment or absence of the endothelium on the basal lamina and cellular infiltration,<sup>8</sup> which may reveal the thrombogenic subendothelium.<sup>9</sup> The location of the strands may also relate to flow disturbances and eddies associated with widening of the carotid artery at the start of the bulb.<sup>10</sup>

Carotid strands may be easily overlooked during the usual focus on the presence or absence of plaque and stenosis. Detection of the strand in the first case was unexpected but primed us to search for this finding in other subjects.

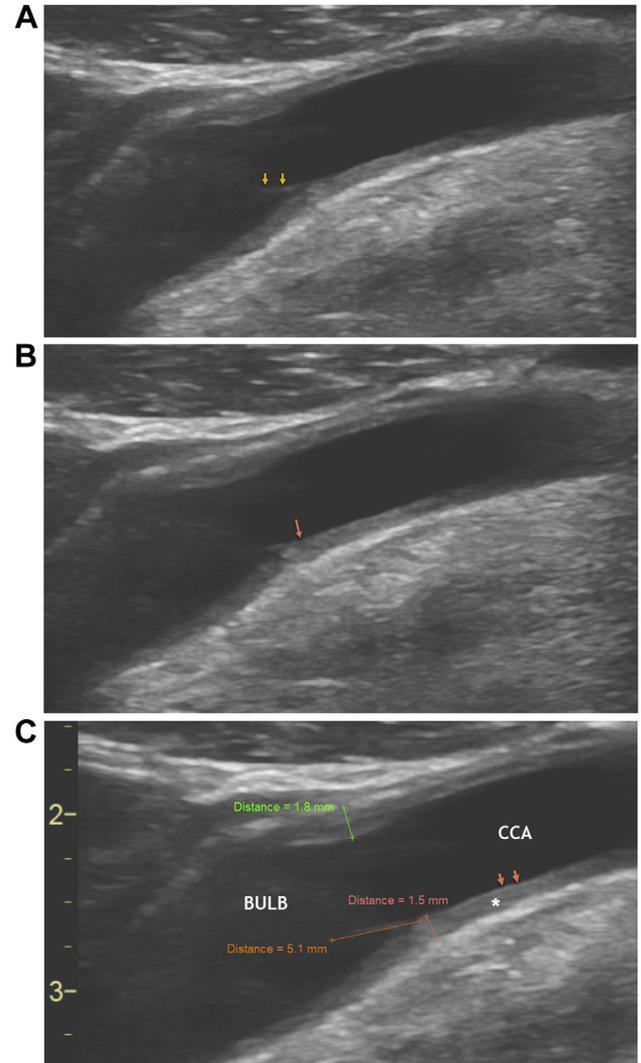
Images were acquired by a registered vascular sonographer at the highest possible transducer frequency and were optimized for clarity according to recommended standards. Harmonic imaging was not used and may not have been helpful because of its decreased axial resolution compared with fundamental imaging. The normal carotid ultrasound examination generates an image with a double-line pattern



**Figure 2** (A) For case 2, a right carotid artery strand (arrow) appears to extend from the intima at the CCA-bulb junction. (B) Labeled image that shows the 6.5-mm length of the strands. The CCA and bulb media layer appear granular, and the proximal bulb IMT is thickened at 1.4 mm. Change in the IMC contour and increased media echogenicity are consistent with mild atheroma at this junction. The CCA intima-associated layer appears discontinuous in the CCA (white arrow), more echogenic at the proximal bulb (blue arrow), and not evident in the more distal bulb (red arrow). (C) The left carotid artery shows worse intima discontinuity and media granularity. Arrows indicate breaks in the intima layer (white arrow) and a surface depression (red arrow).

that consists of a continuous echogenic intima-associated surface layer and adventitia layer sandwiching the lucent media and an IMT that is generally <1 mm.<sup>1,5</sup> Increased carotid IMT has been widely used as a marker of increased CV risk.<sup>2,3</sup>

In addition to increased IMT, Belcaro *et al.*<sup>5</sup> described early changes in these layers in subjects at greater risk for CV events that include breaks in the normally continuous intima-blood interface and increased echogenicity or granularity of the media-adventitia layer. These findings were variably evident in our images and have also been described in other reports. For example, increased grayscale abnormality or inhomogeneity of this layer was found in a pediatric population with heterozygous familial hypercholesterolemia<sup>11</sup> and adults



**Figure 3** For case 3, a strand is present continuous with the surface of the bulb-CCA junction (A at arrows and B at arrow). (C) The strand measured 5.1 mm. Diffusely increased and echogenic (asterisk) IMT and atheroma are present. The normally echogenic intima surface is not visible (arrows).

with coronary artery disease.<sup>12</sup> We also noted evidence of IMC disruption in terms of variable breaks in or disappearance of the bright intima layer and granularity or clouding of the media.

Conventional 5- to 15-MHz ultrasound probes<sup>2,3</sup> enable measurement of IMT but not the individual components of the IMC. The advent of very high frequency imaging at 55 to 70 MHz enables separate measurement of the thickness of the intima and media so that changes can be detected and monitored in vivo.<sup>6,13</sup> Previously, microscopy of excised specimens was needed to visualize the IMC in fine detail. Histologic studies showed an association between radial artery intima hyperplasia and CV risk factors<sup>14</sup> and increased coronary artery intima hyperplasia and extracellular fat and macrophage infiltration.<sup>15</sup> The original high-frequency ultrasound study by Osika *et al.*<sup>6</sup> showed a strong and separate association between peripheral arterial intima and media thickness with age. Osika *et al.* also found increased radial artery intima thickness in patients with peripheral artery disease.<sup>6</sup> Increased radial artery intima and media thickness also occurs in

dialysis patients.<sup>7</sup> In a follow-up study, Dangardt *et al.*<sup>13</sup> found that increased carotid media thickness in children with chronic renal failure decreased 1 year after renal transplantation.

Our images were obtained using an 8- to 10-MHz transducer. Imaging with a higher frequency probe may have demonstrated the strands more clearly and may have yielded additional insights. However, general application of very high frequency ultrasound is limited by its reduced tissue penetration. This would be more of an issue in adults and obese subjects.<sup>13</sup> Other modalities that can generate very high resolution images are invasive, such as optical coherence tomography and intravascular ultrasound. The prevalence of the strands we describe is not known. Strands are a subtle finding that can be easily overlooked. Awareness of the possibility of carotid artery strands may enable additional study of this finding in the future.

## CONCLUSION

Complete ultrasound assessment of the carotid IMC is far more nuanced than IMT measurement alone. In our small series of three cases, we found that carotid ultrasound could generate high-resolution images that enabled the detection of strands at the CCA-bulb junction. These strands are a novel finding that occurred in subjects with atherosclerosis or its risk factors. If the findings in our first case indicate atherogenesis, then the disappearance of material layered in the bulb after statin administration illustrates a more robust example of regression than is generally distilled from clinical trials on IMT and plaque quantification. In addition to technological innovation, awareness of carotid strands' possible presence and features may improve their detection and yield more information about their associations and natural history.

## SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.case.2020.06.004>.

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