Falsely Raised Gradients After Transcatheter Aortic Valve Replacement Obtained with a Nonimaging Probe Due to Brachiocephalic Stenosis

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INTRODUCTION
Aortic stenosis is a common pathology and a major cause of morbidity and mortality, especially in the elderly. Diagnosis of severe aortic stenosis requires integration of multiple imaging parameters, along with clinical evaluation.1,2 Two-dimensional echocardiography, color Doppler, continuous-wave doppler (CWD), and spectral Doppler are combined to establish the valve anatomy, cause, and severity of the stenosis. A specialized nonimaging CWD (NI-CWD) “pulsed-wave echocardiographic Doppler flow velocity” probe is a valuable additional tool to ensure that the highest velocities are recorded and will be recommended in all cases with significant aortic stenosis.1,3,4

Transcatheter aortic valve replacement (TAVR) is an established therapy for severe aortic stenosis in patients at intermediate and high surgical risk. By nature of their surgical risk assessment, these patients are inherently complex, with multiple comorbidities. We present an interesting case that demonstrates some of the pitfalls of the NI-CWD probe. A 83-year-old man who underwent successful TAVR 3 months previously was suspected to have subacute valve thrombosis and valvular dysfunction because of increased gradients noted across the aortic prosthesis, the highest gradients were obtained from the right supraclavicular fossa using the NI-CWD probe. Subsequent transesophageal echocardiography demonstrated that increased gradients were not from the aortic valve level. On review of his previous cross-sectional imaging, a tight stenosis of the brachiocephalic origin was appreciated and was considered to be the cause of the increased gradients detected by the NI-CWD probe.

CASE PRESENTATION
An 83-year-old man was referred for a routine follow-up transthoracic echocardiography following a successful TAVR procedure performed approximately 3 months previously.

Transesophageal echocardiography showed increased pressure gradients and velocities (peak and mean gradients of 91 and 58 mm Hg, respectively) obtained using the NI-CWD probe from the right supraclavicular window (Figure 1). Additionally, one central and one para-valvular jet of aortic regurgitation of mild intensity were noted. The valve leaflets were not very well visualized, although there was no evidence of significant flow acceleration noted with color spectral Doppler (Videos 1 and 2).

Transesophageal echocardiography was requested due to the concern of valvular thrombosis. This showed normal leaflet mobility, with no suggestion of valvular obstruction. Mild paravalvular regurgitation was observed arising at the left coronary cusp (Figure 2, Video 3). Normal hemodynamics of the aortic valve were noted, with an aortic valve maximal velocity of 1.9 m/sec and peak and mean gradients of 15 and 9 mm Hg, respectively, obtained from the transgastric window (Figure 3).

In view of these discrepant findings, a computed tomographic (CT) study performed before TAVR was reviewed. CT imaging showed significant calcification at the brachiocephalic origin, extending from the aortic arch (Figures 4 and 5). The increased gradients obtained from the right supraclavicular window were considered due to significant flow acceleration at the brachiocephalic origin or its downstream branch vessel.

Further vascular ultrasound was undertaken to further confirm the exact location of the increased gradients. Because of technical limitations on accessing the origin of the great vessels via ultrasound, it was not possible to demonstrate the flow velocities at the exact site of the stenosis seen at the brachiocephalic origin on CT imaging. Ultrasound did confirm another severe stenosis, also seen on CT imaging, at a site more proximal to the suspected anomalous Doppler reading detected on transthoracic echocardiography. This was in the proximal right subclavicular artery, with a peak velocity of 532 cm/sec (Figure 6).

DISCUSSION
Aortic stenosis is a common pathology and the cause of significant morbidity and mortality. If patients become symptomatic with severe disease, early mechanical intervention is recommended because of their extremely poor outcomes with medical therapy alone.5,6 TAVR is currently indicated for intermediate- or high-risk patients with severe aortic stenosis, with more recent studies showing promising outcomes in low-risk patients. Many of these patients also are inherently medically complex, with multiple comorbidities. In fact, a higher Society of Thoracic Surgeons risk score is a factor that favors TAVR over surgical aortic valve replacement. A common comorbidity in patients undergoing aortic valve intervention for aortic stenosis is peripheral vascular disease, which can cause stenosis in any vascular bed, including the brachiocephalic artery.

Accurate diagnosis of severity is essential for ideal management. The use of a specialized NI-CWD probe is recommended to
ensure that the highest velocities through the aortic valve are re-coded.\textsuperscript{1,2,4} This probe is a small dual-crystal transducer and is easily manipulated. Work by de Monchy et al.\textsuperscript{3} demonstrated that about 25% of patients were reclassified as having severe stenosis using this probe compared with conventional CWD. The NI-CWD probe requires experience and expertise to use accurately. Correct alignment is vital and is identified by knowledge of the valve location and by using a conventional imaging probe to identify the correct valve and jet, with attention paid to alignment and angulation. The use of this probe is appropriate both before and after intervention.

In this case we describe a phenomenon in which increased velocity through the brachiocephalic artery was detected using the NI-CWD because of the alignment of the aortic valve, the origin of the artery, and the right supraclavicular fossa where the probe was placed. There are no case reports as yet of this phenomenon, though we hypothesize that it may not be infrequent given the patient population.

In retrospect, a key clue to the presence of a spurious source of increased gradients was the discrepancy between the gradients between the apical Doppler (peak and mean gradients of 15 and 10 mm Hg, respectively; Figure 7) and the right supraclavicular fossa (peak and mean gradients of 91 and 56 mm Hg, respectively).

**CONCLUSION**

Although the NI-CWD probe is extremely useful, and indeed recommended for accurate detection of the highest gradient in aortic stenosis, awareness of its limitations is necessary. Given the medical complexity of patients with severe aortic stenosis, clinicians should remain vigilant for sources of spurious increased gradients, particularly those due to peripheral vascular disease.
SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2020.01.006.

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Figure 4 Coronal section of a chest CT scan demonstrating a tight stenosis at the origin of the brachiocephalic artery.

Figure 5 Sagittal section of a chest CT scan demonstrating a tight stenosis at the origin of the brachiocephalic artery.

Figure 6 Color pulsed-wave Doppler of the proximal right subclavian artery showing severe stenosis.

Figure 7 CWD from the apical position on transthoracic echocardiography showing the expected gradients of 15 mm Hg (peak) and 10 mm Hg (mean).