Crit Ultrasound J (2010) 2:87–89
DOI 10.1007/s13089-010-0047-y

CASE REPORT

Emergency department diagnosis of critical aortic stenosis using bedside ultrasonography

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Received: 26 August 2010 / Accepted: 26 October 2010 / Published online: 10 November 2010

Abstract
Introduction An 88-year-old woman with a history of coronary artery disease, hypertension, and a history of a large left upper lobe lung mass presented to the Emergency Department (ED) from a nursing home with rapidly progressive shortness of breath and chest pain over 1 day with a rapid decline in mental status. Bedside color Doppler ultrasound para-sternal long-axis examination of the heart revealed severe aortic stenosis. Bedside pulsed-wave and continuous-wave Doppler ultrasound in the apical 5-chamber view revealed critical aortic stenosis using the simplified continuity equation.
Conclusion Bedside ED cardiac color Doppler, pulsed Doppler evaluation of the left ventricular outflow tract, and continuous-wave Doppler of the aortic valve were used to assist in the diagnosis of critical aortic stenosis.

Keywords Ultrasound · Critical aortic stenosis · Pulsed-wave Doppler · Continuous-wave Doppler · Simplified continuity equation · Aortic valve area

Case report

An 88-year-old woman with a history of coronary artery disease, hypertension, and a history of a large left upper lobe lung mass presented to the Emergency Department (ED) from the nursing home with rapidly progressive and worsening shortness of breath and stuttering chest pain over 1 day with a rapid decline in mental status. Her ED vital signs were temperature 94°F, blood pressure 110/43 mmHg, respiratory rate 38 bpm, and room air oxygen saturation 81% which increased to 99% on 100% oxygen by non-rebreather. Electrocardiogram revealed normal sinus rhythm with a heart rate of 89 bpm and no ischemic changes. On physical examination, she was noted to be a very thin woman in moderate respiratory distress with a right sternal border systolic crescendo-decrescendo murmur and bilateral rhonchi breath sounds. She had no leg edema or tenderness to palpation. Portable chest X-ray showed bilateral pleural effusions and an unchanged left upper lobe lung mass. Initial laboratory studies revealed a BNP of 2,511 pg/mL.

An initial ED bedside ultrasound was performed of the heart (see Video Clips S1, S2, and S3 available as supporting information in the online version of this paper). Examination of the heart with a low-frequency array cardiac probe in the para-sternal long-axis view revealed aortic stenosis, and the left ventricular outflow tract (LVOT) diameter was measured at 1.43 cm (Figs. 1, 2). A color Doppler zoomed-in para-sternal long-axis view of a heavily calcified aortic valve showed severe aortic stenosis (Fig. 3, see Video Clip S2 available as supporting information in the online version of this paper). Apical 5-chamber color Doppler evaluation of the LVOT and aortic valve revealed severe aortic stenosis (Fig. 4 and see Video Clip S3 available as supporting information in the online version of this paper). Pulsed-wave Doppler evaluation using a sample volume of 3 mm at the level of the LVOT in the apical 5-chamber view showed a maximal blood flow velocity (V_{max}) of 72.4 cm/s (Fig. 5). Continuous-wave Doppler evaluation of the blood flow through the stenotic aortic valve (AV) with the blood flow directly parallel to the

Electronic supplementary material The online version of this article (doi:10.1007/s13089-010-0047-y) contains supplementary material, which is available to authorized users.

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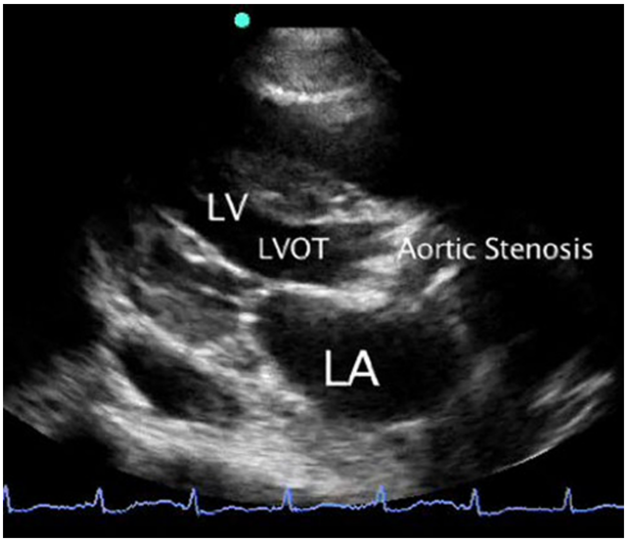

Fig. 1 Critical aortic stenosis parasternal long-axis view

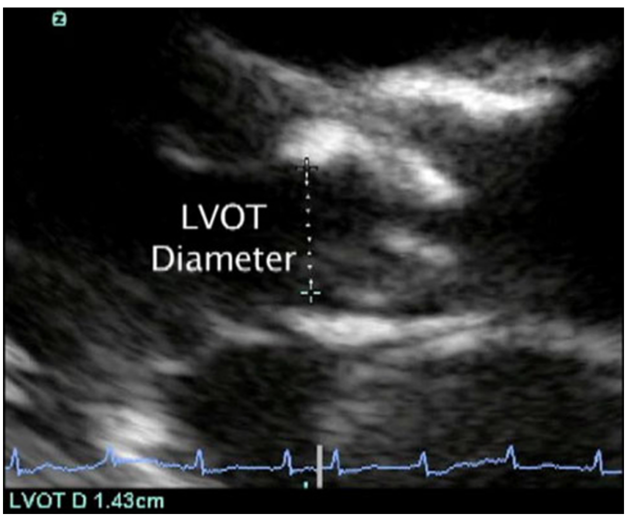

Fig. 2 LVOT diameter measurement

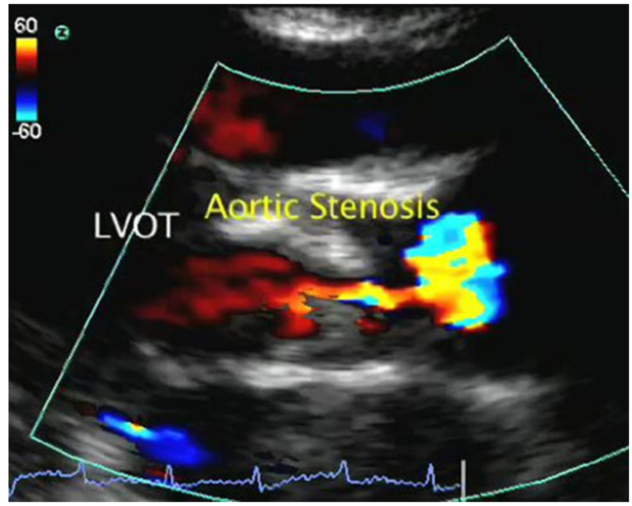

Fig. 3 Critical aortic stenosis color Doppler LVOT view

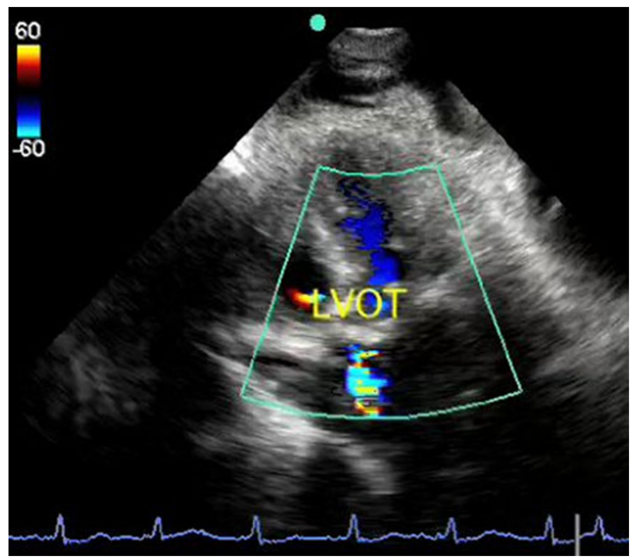

Fig. 4 Critical aortic stenosis color Doppler apical 5-chamber view

probe revealed a maximal blood flow velocity (V_{max}) of 417.9 cm/s (Fig. 6). In the ED, the patient's aortic valve area (AVA) was calculated, using the simplified continuity equation, at 0.28 cm^2 [2]. The patient had a formal echocardiography evaluation performed by the Cardiology department that revealed she had an LVOT diameter of 2.0 cm, stenotic aortic valve blood flow maximal velocity of 410 cm/s, and aortic valve area (AVA) of 0.7 cm^2. The patient was admitted to the hospital for further evaluation for aortic valve replacement.

Discussion

Emergency and critical care physicians should always consider the diagnosis of critical aortic stenosis in elderly patients with new onset shortness of breath, chest pain, and syncope [1–4]. Patients with symptomatic critical aortic stenosis will require surgical aortic valve replacement [1–4]. The American Society of Echocardiography has defined a severely stenotic aortic valve areas less than 1.0 cm^2 [1]. The aortic valve area can be estimated with Doppler echocardiography using the simplified continuity equation [2, 3]:

$$\mathrm{AVA} = \frac{\text{CSA-LVOT} \times \text{Velocity}_{\text{LVOT-Max}}}{\text{Velocity}_{\text{AV-Max}}}$$

where CSA = the cross-sectional area [$\pi(D(\text{diameter})/2)^2$] = $0.785D^2$, LVOT = left ventricular outflow tract, $\text{Velocity}_{\text{LVOT-Max}}$ = Maximal pulsed-wave Doppler velocity at the LVOT, and $\text{Velocity}_{\text{AV-Max}}$ = Maximal continuous-wave Doppler velocity through the AV.

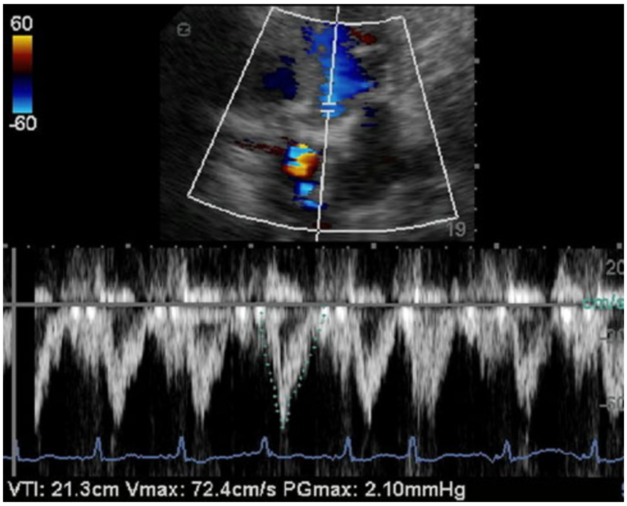

Fig. 5 LVOT pulsed-wave Doppler apical 5-chamber view

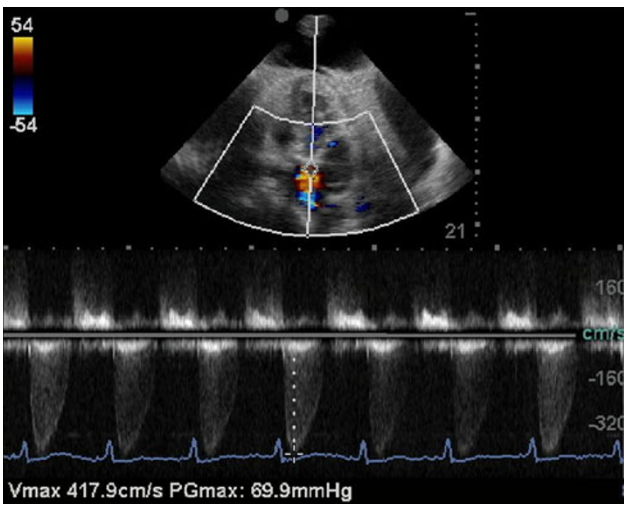

Fig. 6 Aortic valve continuous-wave Doppler apical 5-chamber view

Using the simplified continuity equation, our symptomatic patient's ED calculated AVA area measurement was 0.28 cm^2 and the formal Cardiology calculated AVA measurement was 0.7 cm^2, both considered to be critical aortic stenosis in our patient with chest pain and shortness of breath [1]. Our underestimation of the AVA compared to the Cardiology AVA measurement was due to our underestimation of the LVOT diameter, 1.43 versus 2.0 cm Cardiology LVOT measurement. The LVOT diameter measurement is the most common measurement error when calculating the AVA in patients with aortic stenosis as this inner edge to inner edge measurement can be difficult in patients with severe aortic valve calcification, as was the case in our patient [1]. In addition, because the LVOT diameter measurement is squared [$\pi(D/2)^2$], any LVOT measurement errors are amplified further. Symptomatic patients with critical aortic stenosis are best surgically managed with aortic valve replacement [1–4]. Rapidly identifying a patient with critical aortic stenosis in the ED or intensive care unit can expedite the important cardiothoracic surgical consultation and ultimate surgical treatment that the majority of these patients will require.

Conclusion

Bedside cardiac color Doppler ultrasonography and pulsed Doppler evaluation of the LVOT and continuous-wave Doppler of the aortic valve can assist the emergency physician and the critical care physician in the diagnosis of critical aortic stenosis.

Conflict of interest None.

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