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Turbulence in the Left Ventricular Outflow Tract Caused by an Eccentric Mitral Inflow Jet Masquerades as Aortic Regurgitation

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Echo Rounds

A 48-year-old female with a previous mechanical bileaflet mitral valve replacement was diagnosed with severe mitral stenosis and moderately severe aortic regurgitation by transthoracic echocardiography. She was referred to our institution for surgical replacement of her aortic and mitral valves. Our IRB waived the requirement for patient consent for this report.

In the operating room after anesthetic induction, a transesophageal echocardiographic (TEE) midesophageal four-chamber view confirmed an immobile mechanical mitral valve leaflet causing severe mitral stenosis (Video 1). Mean transmitral pressure gradient measured with continuous wave Doppler was 19 mmHg with a heart rate of 55 beats per minute. A midesophageal long-axis view with color flow Doppler demonstrated severe turbulence in the left ventricular outflow tract (LVOT) during diastole suggesting severe aortic regurgitation (Fig. 1; Video 2). A midesophageal aortic valve short-axis view (partially cut through the LVOT) suggested aortic regurgitation (Video 3). Significant shadowing from the mechanical mitral valve created difficulty in determining whether the jet resulted from aortic regurgitation or mitral inflow. Thus, other echocardiographic measures to differentiate

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Attestation: Data analysis and Manuscript preparation

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Contribution: This author helped prepare and edit the manuscript, and obtain echocardiograms of subject of interest

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the etiology of the diastolic LVOT turbulence were performed. A deep transgastric long-axis view which allowed imaging of the LVOT without shadowing from the prosthetic mitral valve, demonstrated absence of turbulence proximal to the aortic valve, suggesting that LVOT turbulence did not originate from the aortic valve. Furthermore, spectral Doppler demonstrated higher velocity flow, of less than 2.0 m/sec, after mitral valve opening rather than aortic valve closing, consistent with mitral inflow (Fig. 2). Additional echocardiographic evidence inconsistent with severe aortic regurgitation was documented, including aortic valve leaflets without significant abnormalities, a normal-appearing aortic root, and absence of flow reversal in the descending aorta. These findings suggested that diastolic LVOT turbulence was related to an eccentric mitral inflow jet, rather than aortic regurgitation. The patient underwent mitral valve replacement with a 27 mm St. Jude bi-leaflet mechanical mitral valve (St. Jude Medical, St. Paul, MN). TEE performed after separation from cardiopulmonary bypass demonstrated a well-seated mitral valve and a competent aortic valve.

Discussion

Diastolic turbulence in the LVOT related to an eccentric mitral inflow jet can masquerade as aortic regurgitation leading to inappropriate and possibly harmful treatment, including unnecessary aortic valve replacement. Thus correct determination of the etiology of diastolic LVOT turbulence is essential. A detailed two-dimensional and Doppler echocardiographic examination of the aortic and mitral valves can determine the true cause of diastolic LVOT turbulence.

This case demonstrates that relying exclusively on color flow Doppler to identify the cause of LVOT turbulence may lead to an erroneous diagnosis. Although color flow Doppler can delineate the origin and direction of the jet, an excessive signal, characterized by high velocity flow in multiple directions, may obscure true jet direction. Shadowing and reverberation artifacts from the prosthetic mitral valve further complicate delineation of the jet. Furthermore, the color flow Doppler signal from an off-axis midesophageal aortic valve short-axis view incorrectly suggested severe aortic regurgitation. These challenges were overcome by several echocardiographic maneuvers. Increasing the aliasing velocity of color flow Doppler decreased the Doppler signal, allowing closer examination of the jet and identification of its origin. A deep transgastric long-axis view allowed imaging of the LVOT and aortic valve without shadowing and reverberation from the prosthetic mitral valve, where absence of turbulent flow proximal to the aortic valve was inconsistent with aortic regurgitation. Repositioning the short-axis image of the aortic valve excluded the LVOT and demonstrated competence of the aortic leaflets, emphasizing the importance of collecting this image at the appropriate level.

A spectral Doppler tracing also helped differentiate mitral inflow from aortic regurgitation. Spectral Doppler demonstrated opening and closing “clicks” of the mitral and aortic valves, allowing accurate analysis of flow timing. A high-velocity flow signal after mitral valve opening, instead of aortic valve closure, was consistent with mitral inflow rather than aortic regurgitation. Since aortic regurgitation is characterized by longer duration and higher peak velocity averaging between 3.5 to 4 m/sec, a peak velocity of spectral Doppler signal less

than 2 m/sec was consistent with mitral inflow.¹ Though not seen in this case, distinct E and A waves demonstrated by spectral Doppler suggest a mitral origin of the jet.² In addition, pulse wave Doppler can discriminate between aortic regurgitation and mitral inflow when the sample volume is positioned immediately proximal to the aortic valve, where absence of flow suggests that aortic regurgitation is unlikely. Thus spectral Doppler provided evidence that the etiology of the LVOT turbulence was related to transmitral inflow.

Importantly, echocardiographic findings to explain the cause of aortic regurgitation, such as annular dilation or leaflet prolapse are necessary before the diagnosis of aortic regurgitation can be established. In this report, the TEE documented normal aortic valve leaflets and aortic annulus. Proximal flow convergence, vena contracta, and holodiastolic reversal of aortic flow were absent.^{3–5} Holodiastolic flow reversal in the descending aorta corroborates the presence of moderate or severe aortic regurgitation when a mitral valve prosthesis impairs visualization of the LVOT.⁵ Furthermore, an aortic retrograde end-diastolic flow velocity more than 18 cm/s measured below the aortic isthmus predicts severe aortic regurgitation and a regurgitant fraction of more than 40% with high sensitivity and specificity.⁶ In our report, these echocardiographic signs consistent with aortic regurgitation were absent (Table 1).

In conclusion, many factors can complicate identification of the source of diastolic LVOT turbulence. However, the etiology of turbulence in the LVOT can be differentiated by detailed echocardiographic examination including two-dimensional echocardiographic images, color flow and spectral Doppler.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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References

1. Masuyama T, Kodama K, Kitabatake A, Nanto S, Sato H, Uematsu M, Inoue M, Kamada T. Noninvasive evaluation of aortic regurgitation by continuous-wave Doppler echocardiography. *Circulation*. 1986; 73:460–6. [PubMed: 2936529]
2. Rokey R, Kuo LC, Zoghbi WA, Limacher MC, Quinones MA. Determination of parameters of left ventricular diastolic filling with pulsed Doppler echocardiography: Comparison with cineangiography. *Circulation*. 1985; 71:543–50. [PubMed: 3971525]
3. Tribouilloy CM, Enriquez-Sarano M, Bailey KR, Seward JB, Tajik AJ. Assessment of Severity of Aortic Regurgitation Using the Width of the Vena Contracta: A Clinical Color Doppler Imaging Study. *Circulation*. 2000; 102:558–564. [PubMed: 10920069]
4. Willett DL, Hall SA, Jessen ME, Wait MA, Grayburn PA. Assessment of aortic regurgitation by transesophageal color Doppler imaging of the vena contracta: Validation against an intraoperative aortic flow probe. *J Am Coll Cardiol*. 2001; 37:1450–1455. [PubMed: 11300460]
5. Sutton DC, Kluger R, Ahmed SU, Reimold SC, Mark JB. Flow reversal in the descending aorta: A guide to intraoperative assessment of aortic regurgitation with transesophageal echocardiography. *J Thorac Cardiovasc Surg*. 1994; 108:576–582. [PubMed: 8078351]

6. Tribouilloy C, Avinee P, Shen WF, Rey JL, Slama M, Lesbre JP. End diastolic flow velocity just beneath the aortic isthmus assessed by pulsed Doppler echocardiography: A new predictor of the aortic regurgitant fraction. *Br Heart J.* 1991; 65:37–40. [PubMed: 1993128]

Clinicians Key Teaching Points

- In aortic regurgitation (AR) there is a high-velocity, retrograde diastolic flow in the left ventricular outflow tract (LVOT). In a stenosed mechanical mitral valve (MS) the antegrade diastolic blood flow accelerates as it enters the left ventricle, and may be directed away from the malfunctioning disc. As a result, color flow Doppler imaging of the LVOT may reveal a turbulent blood flow pattern.
- Acoustic shadowing and reverberations from a mechanical mitral prosthesis will further complicate LVOT imaging from the midesophageal (ME) position. Additional transesophageal echocardiographic views, such as the deep transgastric long-axis (LAX) view, may be necessary to image the LVOT without the interference of artifacts.
- In this case of a patient with a stenosed mechanical mitral prosthesis and an immobile leaflet, a diastolic LVOT jet imaged in the ME views would not initially be differentiated from significant AR. In the deep transgastric LAX view significant AR was excluded by the absence of a diastolic color Doppler signal at the aortic valve level, and a low continuous wave Doppler jet velocity (<2 m/sec) immediately after the characteristic spectral Doppler mitral prosthetic valve “opening click.” Additionally, there was no diastolic flow reversal in the descending aorta and the aortic valve and root were noted to be normal on 2-dimensional imaging.
- Multiple views, proper color Doppler settings, such as an increased Nyquist limit to decrease the area of the color Doppler signal, close attention to timing, and knowledge of expected spectral Doppler transvalvular velocities (lower in MS, higher in AR) should all be carefully considered to allow differentiation between AR and eccentric MS jets. This is important when deciding which valve is malfunctioning and when planning for the route of cardioplegic solution administration.

Figure 1.

Midesophageal long-axis view demonstrating restricted mobility of the mechanical valve leaflet causing eccentric flow into the left ventricular outflow tract (LVOT). Note significant shadowing from the mechanical mitral valve leaflets. LA = Left Atrium; * = LVOT; RV = Right Ventricular; LV = Left Ventricle; Ao = Aorta.

Figure 2.

Continuous wave Doppler through the left ventricular outflow tract (LVOT) in a deep transgastric long-axis view, which demonstrates higher velocity flow after mitral valve opening rather than aortic valve closing. This finding is consistent with mitral inflow. In addition, the peak flow velocity is less than 2 m/sec, which is also consistent with mitral inflow in a patient with mitral stenosis.

Table 1

Two-dimensional and Doppler echocardiographic findings to determine the etiology of diastolic left ventricular outflow tract (LVOT) turbulence.

	Favors Mitral Stenosis	Favors Aortic Regurgitation
Two Dimensional Echocardiography	<ul style="list-style-type: none"> • Calcified or restricted mitral leaflets • Abnormal motion/restricted opening of prosthetic mitral leaflets • Proximal flow convergence/vena contract with mitral inflow • Diastolic “hockey stick” deformity of anterior mitral leaflet • Left atrial myxoma or other intracardiac mass 	<ul style="list-style-type: none"> • Dilation or dissection of aortic root or ascending aorta • Aortic leaflet prolapse or flail • Restriction, calcification, or perforation of aortic leaflets • Unicuspid, bicuspid, or quadricuspid aortic valve • Proximal flow convergence/vena contracta associated with the aortic valve • Mass/vegetation or abscess formation on the aortic valve • Paravalvular leak of an aortic valve prosthesis
Color and Spectral Doppler Evaluation	<ul style="list-style-type: none"> • Color Doppler jet originating from mitral valve • Absence of PW Doppler signal with sample volume placed immediately proximal to aortic valve • Spectral Doppler flow signal following mitral valve opening “click” • Elevated left atrial pressure and systolic blunting of pulmonary vein flow • Spectral Doppler peak LVOT velocity of 2 m/sec or less 	<ul style="list-style-type: none"> • Color Doppler jet originating from aortic valve • Presence of PW Doppler signal with sample volume placed immediately proximal to aortic valve • Spectral Doppler flow signal following aortic valve closure “click” • Reversal of flow in the descending aorta • Longer duration of spectral Doppler signal and peak LVOT velocity between 3.5–4 m/sec

PW = pulse wave; LVOT = Left ventricular outflow tract.