Cardiovascular Ultrasound

CASE REPORT

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'Color Doppler stripes' make it difficult to diagnose the severity of valvular heart diseases: a report of two cases

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Abstract

Background Echocardiography remains the reference-standard imaging technique for assessing valvular heart disease (VHD), but artifacts like the 'color Doppler stripe' can complicate diagnosis. This artifact is not widely recognized and can mimic severe VHD, leading to potential misdiagnoses. We present two cases where color Doppler stripes mimicked severe VHD, highlighting the need for awareness and accurate interpretation in echocardiographic assessments.

Case presentations Case 1: An 85-year-old patient was referred for mitral valve surgery due to suspected severe mitral regurgitation (MR). Upon evaluation, transthoracic echocardiography (TTE) showed mitral valve prolapse (P3) and a high-echoic, vibrating structure attached to the mitral valve, indicative of chordal rupture. Color Doppler echocardiography revealed strong systolic signals in the left atrium, mimicking severe MR. Transesophageal echocardiography (TEE) also detected the vibrating structure and color Doppler stripes in the left atrium, left ventricle, and outside the cardiac chambers. The PISA method on TEE indicated moderate MR and left ventriculography showed Sellers grade II MR. The artifact was identified as color Doppler stripes caused by the vibrating high-echoic structure from the ruptured chorda. Case 2: A 64-year-old patient with severe aortic stenosis, end-stage kidney disease requiring hemodialysis, and a history of coronary bypass grafting presented for routine follow-up. B-mode echocardiography showed a severely calcified tricuspid aortic valve with a vibrating calcified nodule and restricted opening, corresponding to severe aortic stenosis. During systole, color Doppler signals were observed around the aortic, pulmonary, and tricuspid valves, mimicking significant pulmonary stenosis and tricuspid regurgitation. However, pulmonary stenosis was ruled out as the pulmonary valve opening was normal. Mild tricuspid regurgitation was confirmed in the apical view.

Conclusions These cases highlight the diagnostic challenges posed by color Doppler stripes. Recognizing and understanding this artifact are crucial for the accurate diagnosis and management of VHD, ensuring appropriate treatment and patient outcomes.

Keywords Color Doppler stripe, Artifact, Valvular heart disease

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Introduction

The prevalence of valvular heart disease (VHD), particularly aortic stenosis (AS) and mitral regurgitation (MR), is rapidly increasing in our aging society [1, 2]. Accurate evaluation is crucial for effective decision-making in the management of VHD. Currently, echocardiography is considered the reference-standard imaging technique for assessing VHD [3–5]. Its significance is further amplified in the era of catheter treatment for VHD [6]. However, the presence of artifacts can pose diagnostic challenges [7]. 'Color Doppler stripe', one type of artifact, is not widely recognized in echocardiography. We briefly present two cases in which echocardiography was performed for the assessment of VHD. In the first case, strong color Doppler signals were observed in the left atrium. In the second case, color Doppler signals were detected at the pulmonary and tricuspid valves. We discuss the 'color Doppler stripe,' an artifact that can mimic VHD during echocardiography, and explore how this phenomenon occurs.

Case report 1

An 85-year-old patient who was referred to our institute for mitral valve surgery was suspected of having severe mitral regurgitation. Upon assessment, the patient reported general fatigue, which might not have been related to VHD. Auscultation revealed a Levine grade 2/6 pan-systolic murmur at the apex, without any diastolic rumble or the third heart sound (S3).

Transthoracic echocardiography (TTE) displayed mitral valve prolapse (P3) and a high-echoic, vibrating structure attached to the mitral valve, suggestive of chordal rupture (Fig. 1a and Movie 1). M-mode echocardiography showed that this structure was regularly vibrating and produced a shaggy echo (Fig. 1b).

Color Doppler echocardiography revealed strong color Doppler signals in systole, mimicking severe MR in the left atrium in both parasternal long-axis and apical 4-chamber views (Fig. 1c, d and Movies 2, 3). This pattern was the same when different echocardiography machines, including iE33, Epic CVx (Phillips Medical System, Andover, MA, Netherlands) and Vivid E95 (GE Healthcare, Milwaukee, WI, USA) were used, making it difficult to conclusively determine the severity of MR.

Transesophageal echocardiography (TEE) also depicted the vibrating structure at the mitral valve and color Doppler stripes in the left atrium (LA), left ventricle (LV), and even outside the cardiac chambers (Fig. 2a, b and Movies 4, 5). Notably, the color Doppler signal in the LA was present below the high-echoic structure at the mitral valve

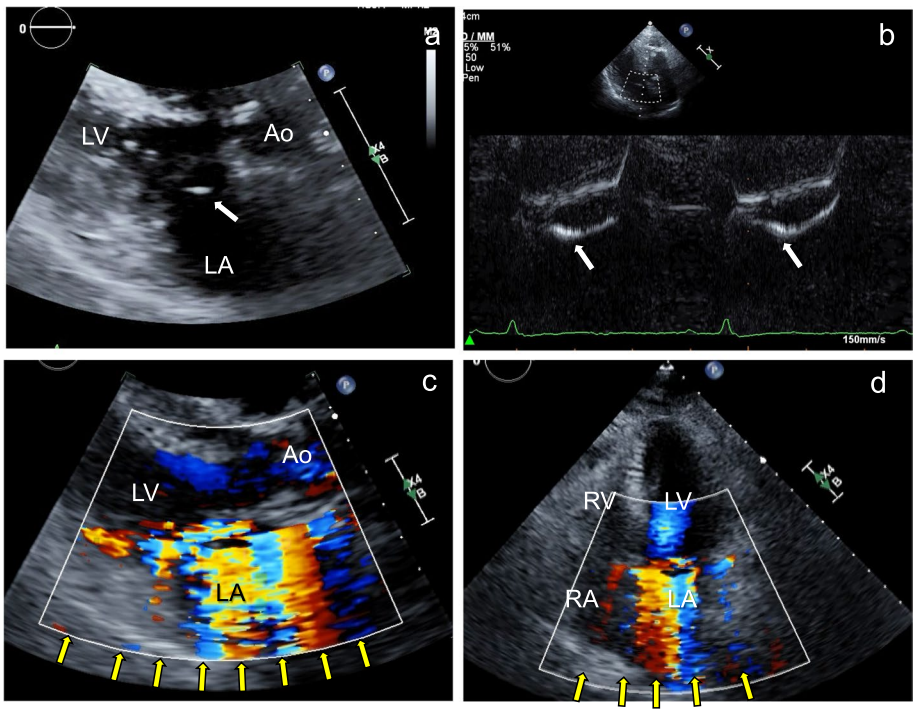

Fig. 1 Transthoracic echocardiography in case 1. B-mode in parasternal long axis view. The arrow shows high echoic structure attached to the mitral valve [mitral valve prolapse (P3)]. M-mode in parasternal long axis view. The arrow shows vibration structure (shaggy eco). Color Doppler in parasternal long axis view. Yellow allows are showed color Doppler stripes. Color Doppler in apical 4-chamber view. Yellow arrows are showed color Doppler stripes. Ao: aorta, LA: left atrium, LV: left ventricle, RA: right atrium, RV: right ventricle

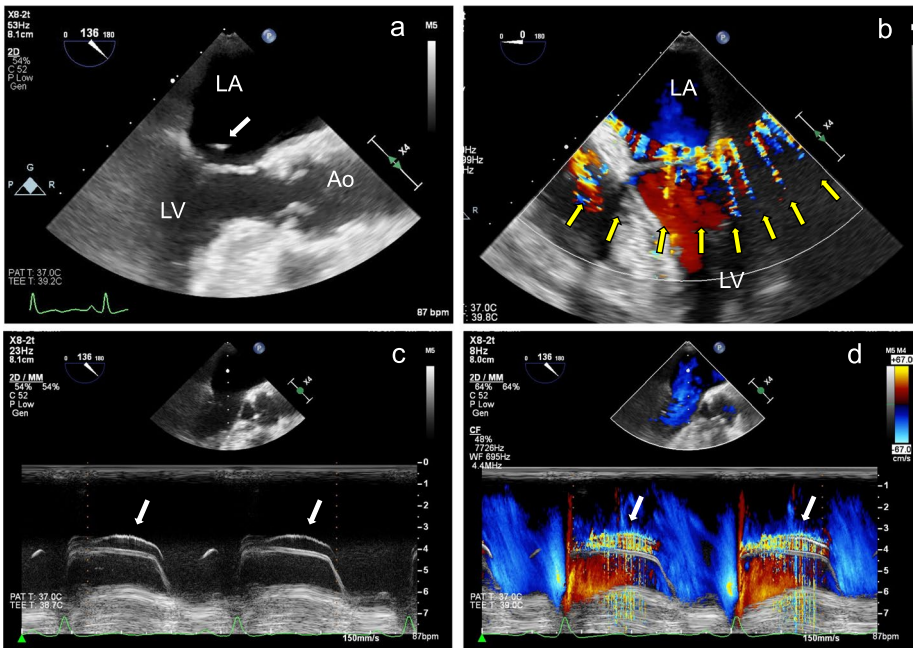

Fig. 2 Transesophageal echocardiography in case 1. B-mode in long axis view. The arrow shows high echoic structure attached to the mitral valve [mitral valve prolapse (P3)]. Color Doppler transesophageal echocardiography. Color Doppler stripes are visible on the annular side within the LA and LV, as well as in the RA and RV. (yellow arrows). M-mode in long axis view. The arrow shows vibration structure (shaggy eco). Color M-mode in long axis view. The arrow shows that color Doppler stripes appear just below the shaggy echo, whether inside or outside of the LV. Ao: aorta, LA: left atrium, LV: left ventricle, RA: right atrium, RV: right ventricle

but not above it. M-mode echocardiography showed a shaggy echo, while Color M-mode displayed a regular fine mosaic (stripe) emanating from just distal to the ruptured chorda (Fig. 2c, d).

Furthermore, TEE revealed MR that appeared to be moderate or greater in severity (Fig. 3a, b, and Movies 6, 7). Quantitative evaluation using the PISA (proximal isovelocity surface area) method on TEE estimated an effective regurgitant orifice area of 0.39 cm^2 and a regurgitant volume of 58 ml. However, due to the eccentric nature of the MR jet and challenges in achieving optimal alignment of the ultrasound beam, these measurements may potentially underestimate the severity. Left ventriculography showed Sellers grade II MR (Fig. 4a, b and Movies 8, 9).

We hypothesize that the color Doppler stripes, caused by the vibrating high-echoic structure resulting from the ruptured chorda, are responsible for this artifact.

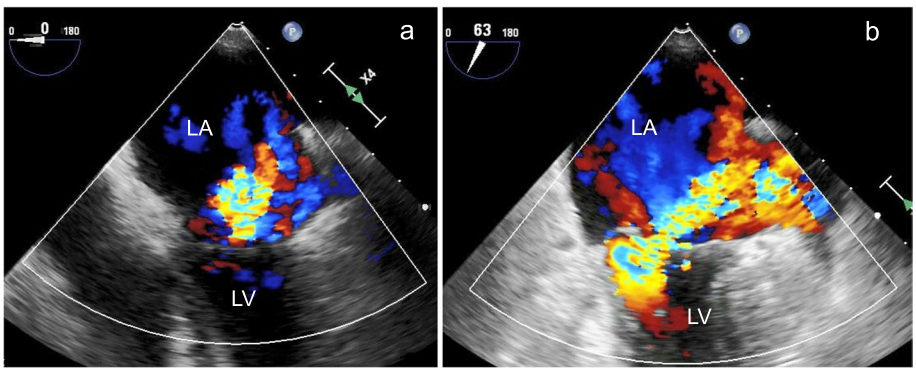

Fig. 3 Transesophageal echocardiography showing moderate MR in case 1. Color Doppler transesophageal echocardiography (0 degree). Color Doppler transesophageal echocardiography (60 degree). LA: left atrium, LV: left ventricle

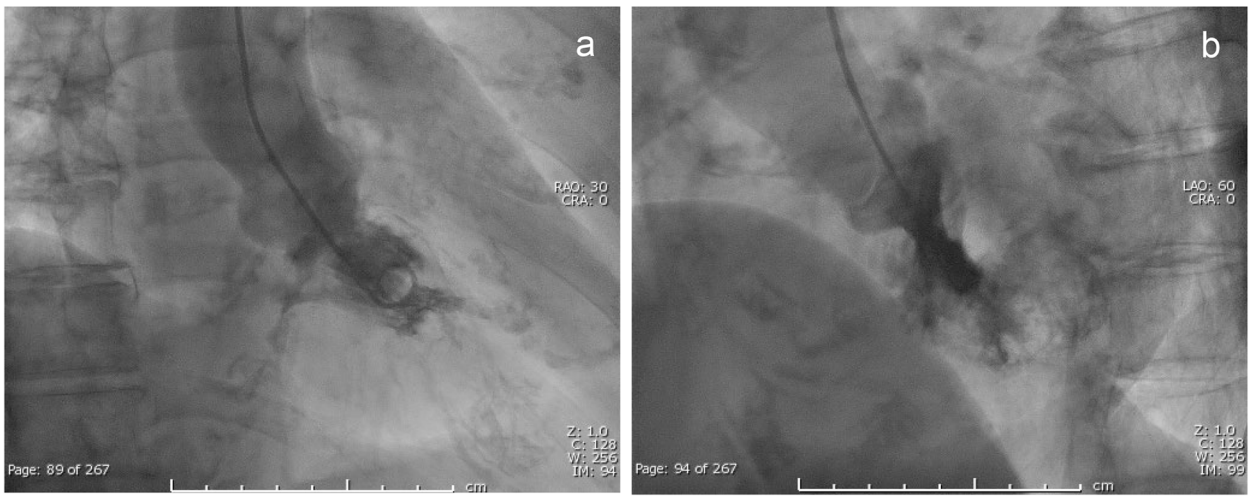

Fig. 4 Left ventriculography showing Sellers grade II MR in case 1. right anterior oblique projection (RAO). left anterior oblique projection (LAO)

Case report 2

A 64-year-old patient who had been diagnosed with severe aortic stenosis visited our echo laboratory for regular follow-up. The patient had a medical history of end-stage kidney disease caused by diabetes, requiring hemodialysis for the past 10 years, and had undergone coronary bypass grafting six years prior. The patient presented with no heart symptoms. Auscultation revealed a Levine grade 3/6 ejection systolic murmur at the third left sternal border (3LSB) but no significant musical murmur.

B-mode echocardiography showed a severely calcified tricuspid aortic valve with a small, vibrating, calcified nodule and severely restricted opening (Fig. 5a and Movie 10). Continuous wave Doppler tracing revealed an aortic valve peak velocity of 4.4 m/s and a mean pressure gradient of 52 mmHg without a fast Fourier transformation (FFT) stripe (Fig. 5b). The aortic valve area was measured at 0.7 cm^2 using the continuity equation. In systole, color Doppler signals were observed in the parasternal short-axis view at the aortic valve level by transthoracic echocardiography. These signals were present not only around the aortic valve but also around the pulmonary and tricuspid valves (Fig. 5c and Movie 11), mimicking significant pulmonary stenosis and tricuspid regurgitation. However, pulmonary stenosis was ruled out as the pulmonary valve opening appeared normal and the peak velocity at the pulmonary valve was only 1.0 m/s. Additionally, only mild tricuspid regurgitation was confirmed in the apical view (Fig. 5d and Movie 12).

Discussion

In this article, we have presented two cases that highlight how color Doppler artifacts can pose challenges in accurately assessing the severity of valvular heart disease (VHD), particularly for clinicians who are less experienced in echocardiography. The presence of color Doppler stripes may lead to potential misinterpretation or overestimation of VHD, underscoring the need for careful evaluation.

Echocardiography, particularly when utilizing color Doppler, is the most widely used imaging modality for evaluating and diagnosing VHD [3–5]. However, due to the physical properties of ultrasound waves and specific aspects of ultrasound image reconstruction, cardiologists and sonographers frequently encounter ultrasound image artifacts [7].

In 1986, the phenomenon of the color Doppler stripe was first and only reported in a Japanese article by Suzuki et al. [8]. In their report, they concluded that, given the close correlation between the color Doppler stripe and the fast Fourier transformation (FFT) stripe, the color Doppler stripe is also a characteristic finding reflecting a regularly vibrating structure. We believe that this phenomenon is not uncommon in daily clinical practice, and most cardiologists and sonographers might already be aware of this artifact. However, the term 'color Doppler stripe' may not be widely recognized. In several articles, we encountered terms such as 'complex reverberation' and 'color Doppler splay.' [9–11] These terms may encompass aspects of the color Doppler stripe phenomenon.

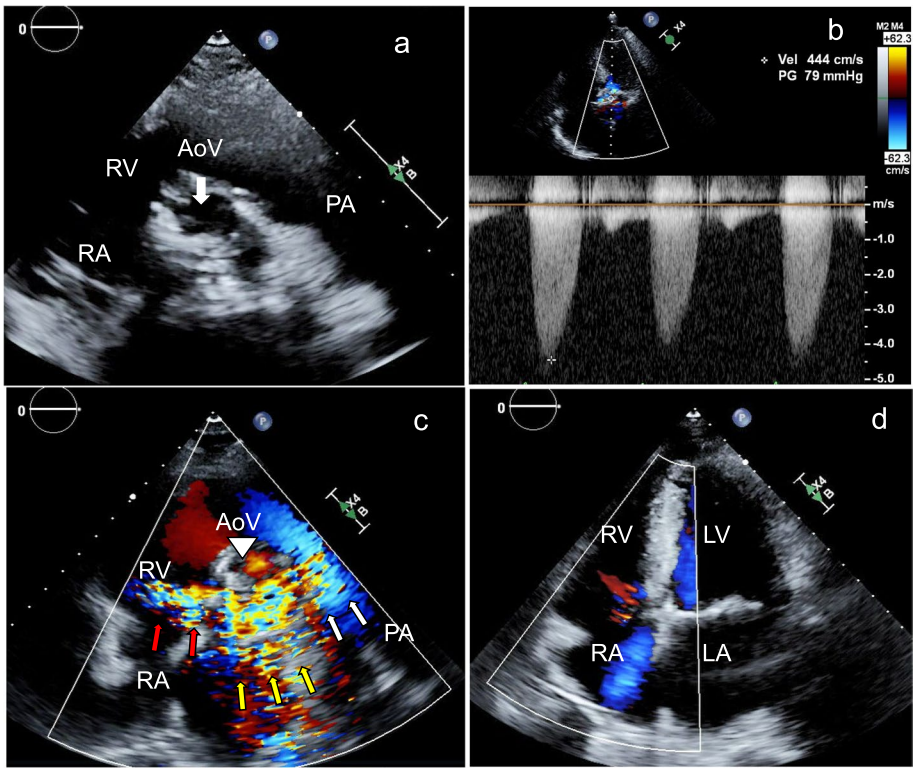

Fig. 5 Transthoracic echocardiography in case 2. B-mode in parasternal short axis view. Severely calcified tricuspid aortic valve with a small, vibrating, calcified nodule, and severely restricted opening. Continuous wave at the aortic valve. A peak velocity at the aortic valve of 4.4 m/s without a fast Fourier transformation (FFT) stripe. Color Doppler in parasternal short axis view. Color doppler stripes appear around the aortic (yellow arrows), pulmonary (yellow arrows), and tricuspid (red arrows) valves. Color Doppler in apical 4 chamber view showing mild tricuspid regurgitation. AoV: aortic valve, PA: pulmonary valve, RA: right atrium, RV: right ventricle

Understanding the specific details of the echocardiography machine is essential for clarifying the actual mechanism underlying the formation of color Doppler stripes [12, 13]. Unfortunately, as of today, manufacturers and vendors do not disclose their algorithms, including information such as the number of pulses and beams that make up a single frame. However, we speculate that the color Doppler stripe may consist of two artifacts: color Doppler sidelobes and multiple reflections. This hypothesis differs somewhat from Dr. Suzuki's original concept of the color Doppler stripe. However, we believe that the term 'color Doppler stripe' is suitable for describing our images.

The distinction between actual regurgitation or acceleration jets and color Doppler stripes is as follows. 1) Color Doppler stripes consist of multiple warm (red) and cold (blue) bands. These typically appear from left to right on the monitor, as most echocardiography machines generate ultrasonic waves in frames composed of several beams from left to right [8]. (e.g., AlOKA SSD-880 ultrasound system: one beam is composed 8 pulses, and 64 beams constitute one frame). 2) The motion of the regularly vibrating structure approximates simple harmonic. At the moment when this moves toward the transducer, a warm (red) color is displayed, and at the moment when this moves backward, a cold (blue) color is displayed [8]. 3) Real regurgitation or acceleration jets typically appear inside a specific cardiac chamber, whereas color Doppler stripes can appear over the chamber or vascular lumen. 4) Color Doppler stripes emerge immediately behind the vibrating structure and never appear in front of it.

It is our hope that the concept of the color Doppler stripe becomes more widely recognized among those involved in echocardiography.

Conclusions

Regularly vibrating structures can produce color Doppler stripes, potentially making it difficult to accurately determine the severity of valvular heart disease. It is crucial for clinicians and sonographers to be aware of this artifact to avoid misdiagnosis of VHD.

Abbreviations

AS	Aortic stenosis
FFT	Fast Fourier transformation
LA	Left atrium
LSB	Left sternal border
LV	Left ventricle
MR	Mitral regurgitation
PISA	Proximal isovelocity surface area
TEE	Transesophageal echocardiography
TTE	Transthoracic echocardiography
VHD	Valvular heart disease

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

Supplementary Material 5.

Supplementary Material 6.

Supplementary Material 7.

Supplementary Material 8.

Supplementary Material 9.

Supplementary Material 10.

Supplementary Material 11.

Supplementary Material 12.

Authors' contributions

Y.B., Y.O., and T.K. conceived the idea for the study and planned the investigations. Y.B., J.K., N.Y., and H.K. undertook clinical investigations of patients. Y.B., Y.O., J.K., A.T. and D.H. examined echocardiography. All authors reviewed the manuscript..

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Availability of data and materials

Individual de-identified participant data will not be shared.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethical Review Board of Kochi Medical School, Kochi University. (approval number: 2021–145). Written informed consent for participating in the study was obtained from the patients.

Consent for publication

Written informed consent was obtained for the publication of any potentially identifiable images or data included in this article.

Competing interests

The authors declare no competing interests.

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References

1. Nkomo VT, Gardin JM, Skelton TN, Gottdiener JS, Scott CG, Enriquez-Sarano M. Burden of valvular heart diseases: a population-based study. Lancet. 2006;368(9540):1005–11.
2. Coffey S, Roberts-Thomson R, Brown A, Carapetis J, Chen M, Enriquez-Sarano M, et al. Global epidemiology of valvular heart disease. Nat Rev Cardiol. 2021;18(12):853–64.
3. Vahanian A, Beyersdorf F, Praz F, Milojevic M, Baldus S, Bauersachs J, et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease. Eur Heart J. 2022;43(7):561–632.
4. Otto CM, Nishimura RA, Bonow RO, Carabello BA, Erwin JP 3rd, Gentile F, et al. 2020 ACC/AHA guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Joint Committee on clinical practice guidelines. Circulation. 2021;143(5):e72–227.
5. Izumi C, Eishi K, Ashihara K, Arita T, Otsuji Y, Kunihara T, et al. JCS/JSCS/JATS/JSVS 2020 guidelines on the management of valvular heart disease. Circ J. 2020;84(11):2037–119.
6. Patel H, Raisinghani A, DeMaria A. Echocardiography in transcatheter structural heart disease interventions. Prog Cardiovasc Dis. 2018;61(5–6):423–36.
7. Bertrand PB, Levine RA, Isselbacher EM, Vandervoort PM. Fact or artifact in two-dimensional echocardiography: avoiding misdiagnosis and missed diagnosis. J Am Soc Echocardiogr. 2016;29(5):381–91.
8. Suzuki J, Sakamoto T, Hada Y, Amano K, Takahashi H, Hasegawa I, et al. Musical murmurs: phonocardiographic, echocardiographic and Doppler echocardiographic study. J Cardiogr. 1986;16(3):689–97.
9. Quien MM, Saric M. Ultrasound imaging artifacts: how to recognize them and how to avoid them. Echocardiography. 2018;35(9):1388–401.
10 Wiener PC, Friend EJ, Bhargav R, Radhakrishnan K, Kadem L, Pressman GS. Color Doppler splay: a clue to the presence of significant mitral regurgitation. J Am Soc Echocardiogr. 2020;33(10):1212–9.e1.
11. Verbeke J, Kamoen V, Calle S, De Buyzere M, Timmermans F. Color Doppler splay in mitral regurgitation: hemodynamic correlates and outcomes in a clinical cohort. J Am Soc Echocardiogr. 2022;35(9):933–9.
12. Allievi L, Bongarzoni A, Tassinario G, Carugo S. Color Doppler splay: a new tool for the assessment of valvular regurgitations? J Am Soc Echocardiogr. 2021;34(9):1021–2.
13. Wiener PC, Friend EJ, Pressman GS, Bhargav R, Radhakrishnan K, Kadem L. Response to: "Color Doppler splay: a new tool for the assessment of valvular regurgitations?" by Allievi et al. J Am Soc Echocardiogr. 2021;34(9):1022–3.

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