A Reverse Mitral A-Wave and a Late Systolic Tricuspid Regurgitation Jet due to Retrograde Atrial Activation

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INTRODUCTION

Blood flow due to atrial contraction is classically seen as an A wave in mitral and tricuspid inflow spectral Doppler interrogation. It is a physiological phenomenon that is required to adequately fill the respective ventricles during diastole. Mechanical contraction of the atria and its critical timing at the end of diastole are crucial to effectively fill the ventricles.[1] Loss of this synchrony results in the improper filling of the ventricles and loss of the classic spectral pattern on Doppler interrogation by echocardiography.[2] We describe a case of junctional rhythm with retrograde P waves, which cause fascinating Doppler flow profiles due to an abnormal atrial electrical activation, leading to an atrial mechanical contraction and relaxation during ventricular systole.

CASE PRESENTATION

A 65-year-old woman with hypertension presented with New York Heart Association functional class I dyspnea. Clinical examination revealed a heart rate of 45 beats per minute. Blood pressure was 150/90 mm Hg, respiratory rate was 14/minute, and temperature was normal. There was a left ventricular (LV) type of apex on palpation, and the second heart sound was loud. There was no murmur, and no third or fourth heart sound. A 12-lead electrocardiogram (ECG) showed a junctional rhythm. Heart rate was 48 beats per minute, and QRS axis was normal. An incomplete right bundle branch block pattern and normal QRS voltage were observed. There were retrograde P waves seen as negative deflections closely following the QRS complexes in alternate cycles (Figure 1). Transthoracic echocardiography (TTE) was performed to assess LV function to evaluate for dyspnea. However, during TTE, there was a junctional rhythm with retrograde P waves after each QRS complex. Varying rhythm during ECG and TTE reflects the transient nature of junctional rhythm.

The TTE examination showed concentric LV hypertrophy; LV wall thickness was increased (septum, 13 mm; posterior wall, 12 mm). Ejection fraction as calculated by biplane Simpson's method was 61%. The left atrium (LA) was enlarged with a calculated indexed volume of 41 mL/m^2 (Video 1). The E velocity was 0.90 m/sec, and deceleration time was 225 m/sec. Tissue Doppler imaging showed an average septal and lateral e′ velocity of 0.09 m/sec, and the E/e′ was 10.0. Peak systolic tricuspid regurgitation (TR) velocity was 3.0 m/sec, and peak systolic gradient was 35.0 mm Hg. The right atrial volume was 36 mL.

Pulsed-wave (PW) Doppler of mitral inflow did not have a typical inflow pattern. Instead, the apical 4-chamber view showed an initial negative wave during systole coinciding with retrograde atrial activation followed by early diastolic E wave (Figure 2). Ineffective mitral valve (MV) closure due to atrial contraction and atrial relaxation, combined with pressure gradient between LV and LA in ventricular systole, was thought to be the underlying mechanism for the negative wave.

Continuous-wave (CW) Doppler interrogation at the MV showed mild MR. Corresponding to the retrograde systolic wave in the PW Doppler as shown in Figure 2, there was a superimposed flow starting well after the initiation of MR. The onset of the second flow spectrum occurs while the first MR flow spectrum is ongoing, resulting in the superimposition on the previous spectrum (Figure 3). Mechanical atrial contraction causes ineffective MV closure, and atrial relaxation combined with pressure gradient between LA and LV augments the MR during the later part of the systole.

Continuous-wave Doppler at the tricuspid valve (TV) recorded a mild TR. The TR jet starts with isometric contraction, which is usual for TR of any etiology, but a second TR jet appears following the retrograde right atrial activation from the atrioventricular (AV) junction (Figure 4). Right atrial mechanical contraction partially opens the TV, and atrial relaxation and pressure gradient between and the right atrium (RA) and right ventricle (RV) augments TR during the later part of systole.

A sinus beat was observed during TTE examination, which had a distinct P wave preceding the QRS and absent retrograde P wave. The CW Doppler TR signal in the sinus beat appeared complete without signal void and no augmentation of the spectrum in the later part of systole as compared with the cycle with retrograde P wave (Figure 5). This also suggests that the retrograde atrial activation is responsible for the second TR jet.

In view of the ECG finding, an ambulatory transient event monitor was placed and did not reveal further arrhythmia or heart block. The patient returned to the clinic after 4 weeks and demonstrated clinical improvement with telmisartan 40 mg, dapagliflozine 10 mg, and eplerenone 25 mg daily.

DISCUSSION

Blood flow in the heart is driven by relative pressure across adjacent chambers, great arteries, and valvular function. Flow occurs from the chamber with higher pressure to the chamber with lower pressure

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VIDEO HIGHLIGHTS

Video 1: Transthoracic echocardiography, apical 4-chamber view, demonstrates an enlarged LA, concentric LV hypertrophy, and good systolic function. The ECG below shows a junctional rhythm with retrograde P waves after QRS complexes.

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because of the pressure gradient. Complete closure of the valves prevents flow from the high-pressure chamber to the lower-pressure chamber, facilitating physiological flow from the atria to the ventricles and then to the great arteries in different phases of the cardiac cycle.[3] This physiological phenomenon requires coordinated electrical activity, resulting in the mechanical contraction and relaxation of cardiac chambers.[4] With conduction disturbance, this coordination is lost, resulting in abnormal mechanical forces that lead to abnormal flow patterns that can be detected by Doppler echocardiography.[5]

In the present case, retrograde atrial activation from the AV junction produces mechanical contraction of the LA. This is responsible for a partial opening or an inadequate or ineffective closure of the MV during the time that the LV pressure is higher than the LA pressure in systole. This results in a pressure gradient from the LV to the LA. The velocity of this wave remains low as the LA contraction force only partially opens the valve. As this wave is secondary to the atrial contraction recorded at the level of mitral leaflets by PW Doppler, it represents the A wave, but in contrast, it occurs in systole and from the LV to LA.

A similar flow is also recorded by CW Doppler across the MV where there was mild MR. A superimposed augmented flow was recorded well after the initiation of MR, corresponding to the retrograde systolic wave in the PW Doppler. This wave occurs consequent to the retrograde atrial activation that produced mechanical LA contraction causing inadequate MV closure that augments the MR in the later part of systole.

This mechanism appears similar to the recording of diastolic MR in high-grade AV conduction blocks and prolonged PR intervals.[6] Delayed initiation of the LV systole after the LA contraction results in diastolic MR in the face of an inadequately closed MV and pressure gradient between LV and LA.[7]

The retrograde atrial activation also results in RA mechanical contraction and relaxation. The RA contraction was responsible for the partial opening of the TV, similar to the MV. A higher pressure in the RV combined with a suction effect from RA relaxation produces a gradient between the RV to the RA in systole, causing a relatively denser second TR jet in the later part of systole. A TR jet secondary to atrial contraction is known to occur in cardiac rhythm disorder.[8]

The difference in the flow profile between the MV and the TV with a similar electrical disturbance is hypothesized to be caused by the difference in pressure between the 2 ventricles in systole. A low-pressure RV opens the TV more than the MV during the retrograde atrial activation, inscribing a more pronounced TR. Dyssynchronous motion of the MV and TV has been described, but in a situation of dissociated electrical activity between atria.[9] Junctional rhythm is a relatively common arrhythmia, but the description of electromechanical association resulting in abnormal Doppler flow parameters could not be found in our comprehensive literature search.

The clinical implication of such an altered flow pattern is not clear. Further observation may shed more light on this interesting Doppler

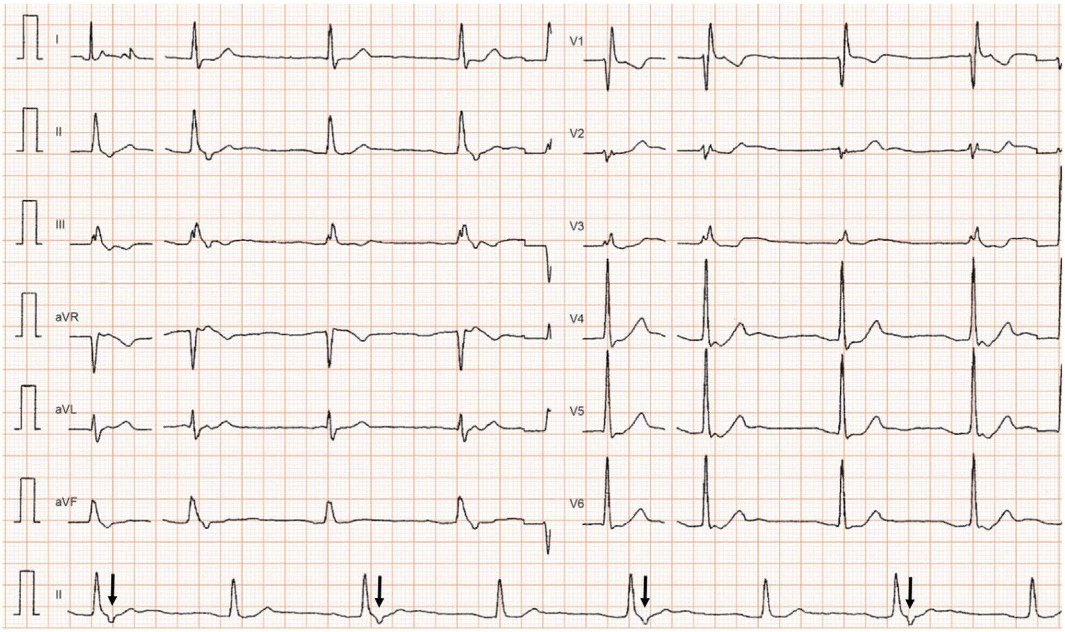

Figure 1 Twelve-lead ECG demonstrates retrograde P waves in alternate cycles (*arrows*) starting with the first QRS complex. Retrograde P waves are seen as negative deflections closely following the QRS complexes.

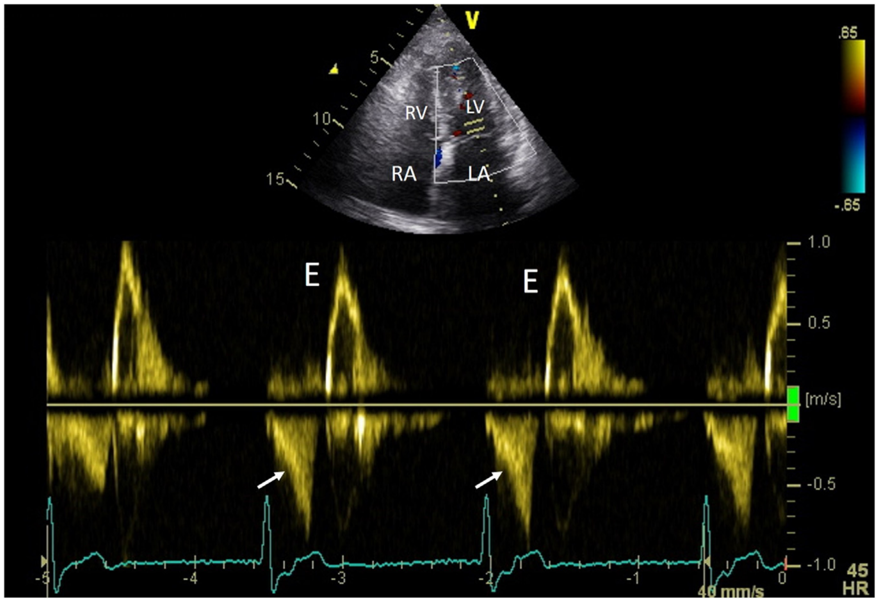

Figure 2 Transthoracic echocardiography, apical 4-chamber view with PW Doppler interrogation of mitral inflow, demonstrates an initial negative wave during systole (*arrows*) followed by the early diastolic E wave. The negative wave coincides with the retrograde P wave in the gated ECG. *LV*, Left ventricle.

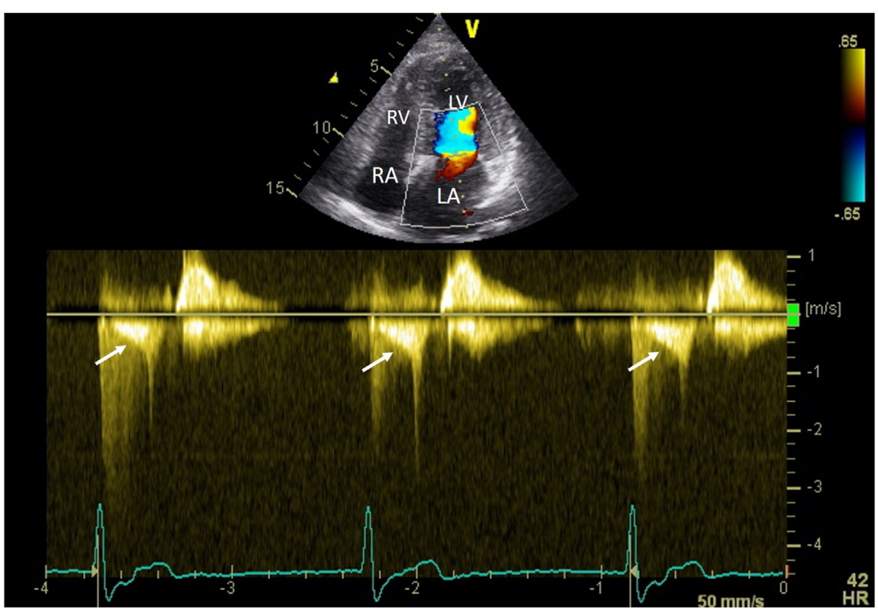

Figure 3 Transthoracic echocardiography, apical 4-chamber view with CW Doppler interrogation across the MV, demonstrates mild MR. There is a superimposed flow (*arrows*) starting well after the initiation of MR corresponding to the retrograde P waves. *LV*, Left ventricle.

flow abnormality in an altered rhythm disorder, particularly to prevent misinterpretation during evaluation of diastolic function, suspected intracardiac or LV outflow obstruction, cardiac shunt or fistula, valve perforation, and pathologic coronary flow anomalies.

Two-dimensional echocardiography with Doppler is known to assist in identifying rhythm disorders.[10] Mitral inflow Doppler helps differentiate between atrial flutter and fibrillation when the surface ECG is not diagnostic. Similarly, an abnormal septal motion helps differentiate between left bundle branch block and intraventricular conduction delays in borderline surface ECG findings. The present case also highlights the importance of echocardiography in identifying AV junctional rhythm.

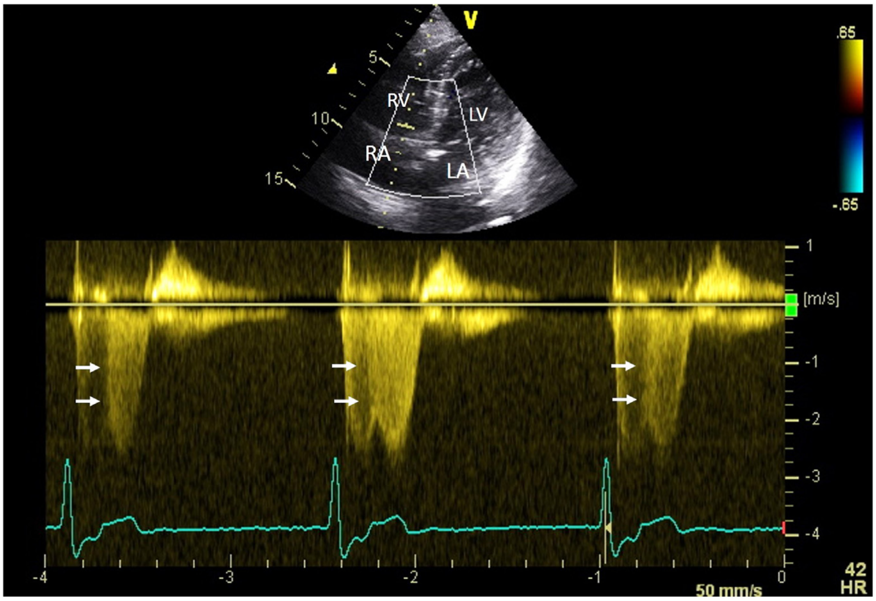

Figure 4 Transthoracic echocardiography, apical 4-chamber view with CW Doppler interrogation across the TV, demonstrates TR. There is a second TR jet (*arrows*) appearing with retrograde P waves. *LV*, Left ventricle.

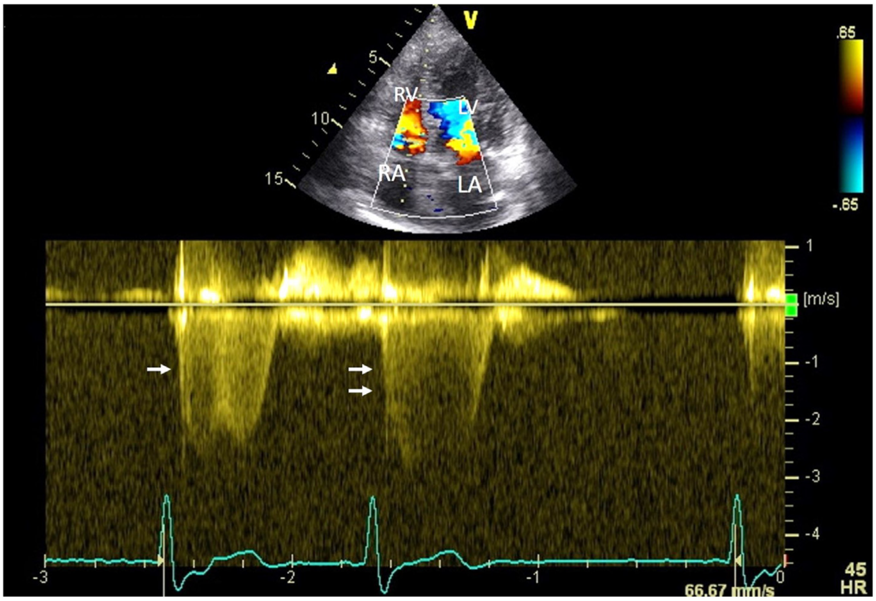

Figure 5 Transthoracic echocardiography, apical 4-chamber view with CW Doppler interrogation across the TV, demonstrates TR. In the first cycle (*single arrow*), there is a second TR jet appearing with retrograde P wave, which is absent in the second cycle (*double arrow*), which is a sinus beat without retrograde P wave. *LV*, Left ventricle.

CONCLUSION

We describe the mitral and tricuspid inflow spectral Doppler pattern during junctional rhythm. The junctional rhythm causes retrograde atrial activation leading to atrial contraction during ventricular systole. Atrial contraction and relaxation during ventricular systole may produce an abnormal flow pattern detectable by Doppler echocardiography. The detection of such flows can prevent misdiagnosis and assist in identifying rhythm disorders.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

CONSENT STATEMENT

The authors declare that since this was a non-interventional, retrospective, observational study utilizing de-identified data, informed consent was not required from the patient under an IRB exemption status.

FUNDING STATEMENT

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2024.04.002.

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