


Right ventricular dominant myocarditis requiring cardiac resynchronization therapy-defibrillator: a case report

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Abstract

Fulminant myocarditis is an inflammatory disease of the cardiac muscle that severely deteriorates cardiac function and often causes haemodynamic collapse in a manner similar to acute coronary syndrome. In rare cases, the myocardium of the right ventricle is dominantly damaged. In cases of lymphocytic myocarditis, a common type of fulminant myocarditis, cardiac function is often recovered after peak myocardial inflammation subsides; however, some cases show irreversible myocardial damage. Herein, we report the case of a 43-year-old woman with irreversible, right-side dominant ventricular myocardial damage; she presented with various cardiopulmonary conditions including complete atrioventricular block, ventricular tachycardia, right heart failure, right ventricular thrombosis, and pulmonary embolism. The patient was successfully treated with medications and a cardiac resynchronization therapy-defibrillator device.

Keywords Myocarditis; Heart failure; Right ventricle; MRI; Endomyocardial biopsy; Mechanical circulatory support; Complete atrioventricular block; CRT

Received: 13 November 2020; Revised: 4 August 2021; Accepted: 1 October 2021

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Introduction

Myocarditis is an inflammatory disease of the cardiac muscle. Fulminant myocarditis usually results in bilateral deterioration of ventricular function accompanied by myocardial oedema and, in the acute phase, is often also accompanied by conduction disturbances and ventricular arrhythmias.¹ There are three main histological subtypes of myocarditis: lymphocytic, eosinophilic, and giant cell.² Lymphocytic myocarditis is mainly induced by viral infection.³ In many cases of lymphocytic myocarditis, ventricular function, conduction disturbance, and ventricular arrhythmias are reversible; however, some cases present with irreversible myocardial damage with related clinical manifestations. Some studies revealed that the right ventricle (RV) is involved in considerable cases of myocarditis.⁴ In rare cases, the RV is dominantly damaged, which is known as RV dominant myocarditis.

Herein, we report a case of RV dominant fulminant myocarditis, suggesting that the combination of endomyocardial

biopsy and cardiac magnetic resonance imaging is useful for the diagnosis and determination of the therapeutic strategy for myocarditis. Written informed consent was obtained from the patient for publication of this case report and its accompanying images.

Case report

A 43-year-old Japanese woman visited a local hospital with a 3 week history of chest discomfort and subsequent dyspnoea, nausea, and epigastralgia. She was previously healthy, had no medical or surgical history, took no regular medications, had no allergies, and had no history of smoking or drinking. Her left ventricular ejection fraction (LVEF) was preserved at 55% on admission; however, she presented with ST elevation in a wide range of leads, troponin T elevation, and pericardial effusion on computed tomography (CT) scan. On the day of

her hospitalization, the patient suddenly collapsed from sustained ventricular tachycardia (VT). VT was first terminated through cardioversion, but soon recurred. VTs were refractory despite repeated cardioversions; thus, the patient was transferred to the angiography room and inserted a peripheral veno-arterial extracorporeal membrane oxygenation (VA-ECMO) circuit under cardiopulmonary resuscitation. VT was controlled by the next cardioversion after starting VA-ECMO, intra-aortic balloon pump (IABP), and continuous amiodarone infusion. RV pacing was started against a complete atrioventricular block (CAVB) after VT termination. Coronary angiography showed no significant stenosis. Bilateral ventriculography revealed RV diffuse systolic dysfunction, whereas left ventricular (LV) function was preserved (LVEF 50%). However, on the following morning, LV function was extremely deteriorated (LVEF 20%), and the aortic valve temporarily closed due to extremely impaired left ventricular function. Therefore, she was transferred to Chiba University Hospital via an air ambulance for evaluation regarding treatment with a ventricular assist device.

On arrival at Chiba University Hospital, the patient was conscious and alert with the support of VA-ECMO and IABP with sustained VT (*Figure 1A*). After the VT was spontaneously terminated, CAVB was present. An electrocardiogram revealed CAVB with ventricular pacing beats and ST elevation in leads III, aVF, and V1 through V4 (*Figure 1B*). The blood pressure was 84/50 mmHg under stable circulation, whereas heartbeat depended on ventricular pacing with a high pacing threshold. Chest radiography revealed a mildly enlarged cardiac

silhouette (cardiothoracic ratio, 60%) without vascular redistribution (*Figure 2*). Transthoracic echocardiography indicated diffusely reduced biventricular wall motion (LVEF 14%) with diffuse myocardial oedema in the LV [interventricular septum (IVS) thickness: 13 mm, LV posterior wall thickness: 12 mm] without significant valvular disease (*Figure 3A*). Plasma brain natriuretic peptide level was 11.9 pg/mL, serum creatinine was 0.41 mg/dL, and C-reactive protein was 1.75 mg/dL. Rheumatoid and antinuclear antibodies were negative. Endomyocardial biopsy (EMB) from the RV-IVS on the day of transfer demonstrated a complete degeneration of cardiomyocytes with massive infiltration of lymphocytes (*Figure 4*). She was pathologically diagnosed with lymphocytic myocarditis, although specific viral antibodies were not detected with paired serum examination.

As LV function gradually improved, the pacing threshold was lowered. However, CAVB persisted and VTs were easily induced once RV pacing was turned off. Finally, VA-ECMO was successfully weaned off on the 8th hospital day, and IABP was removed on the 11th day. RV temporary pacing was stopped on Day 12 because the heart rate was maintained higher than 70 b.p.m. as ventricular escape rhythm and VT had not recurred.

Echocardiography on Day 19 showed RV dilatation with akinesis and high echogenicity in the IVS and RV apex, severe tricuspid regurgitation (TR) with valve separation, and thrombus in the RV apex, whereas LVEF improved to 59% (*Figure 3B*). An oral anticoagulant was initiated, which was switched from continuous intravenous heparin. A diuretic

Figure 1 (A) Electrocardiogram showing ventricular tachycardia on arrival to our hospital; (B) electrocardiogram showing complete atrioventricular block with ST-segment elevation in leads III, aVF, and V1 through V4.

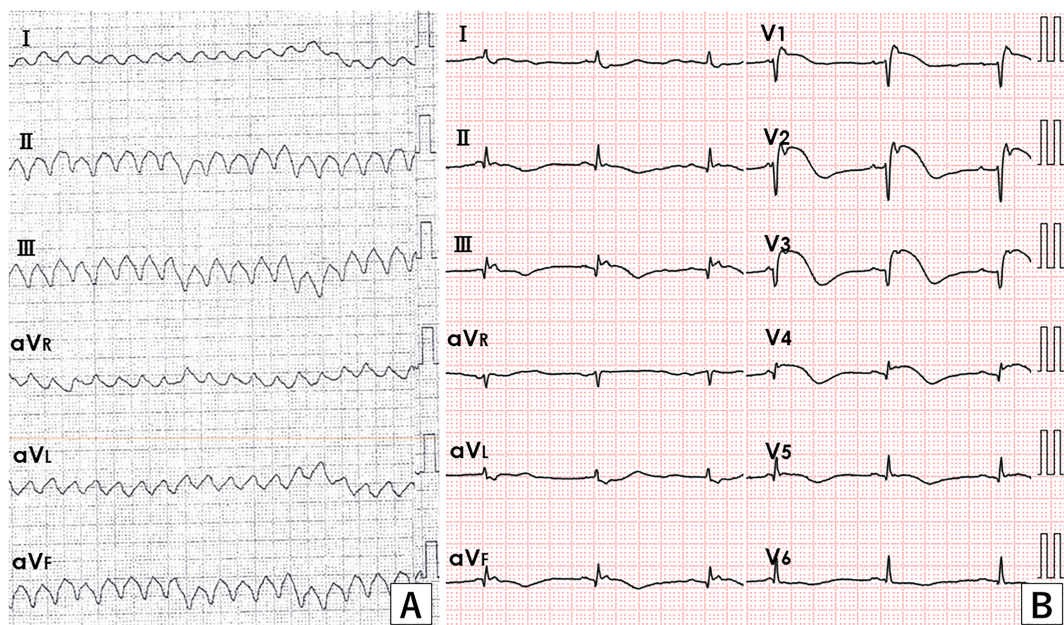


Figure 2 Chest radiograph demonstrating mildly enlarged cardiac silhouette.



Figure 4 Haematoxylin and eosin-stained sections of the interventricular septum demonstrating the complete degeneration of cardiomyocytes with massive infiltration of lymphocytes. Scale bar, 100 μ m.

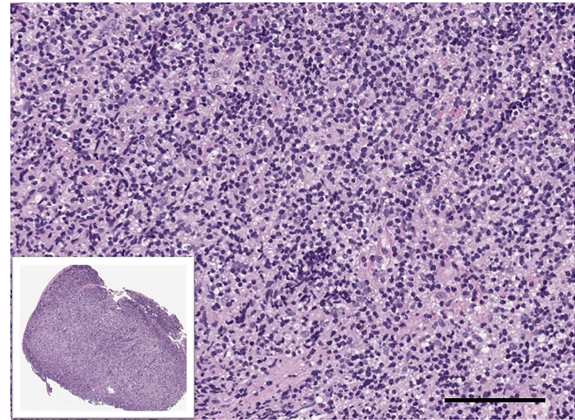


Figure 3 (A) Echocardiography at admission exhibiting diffusely reduced left ventricular and right ventricular wall motion (left ventricular ejection fraction 14%), with diffuse oedema of the left ventricle (A-1: diastolic phase, A-2: systolic phase); (B) echocardiography in the subacute phase. Parasternal short axis (B-1) and apical four-chamber images (B-2) exhibiting right ventricular dilatation with akinesis (asterisk). Severe tricuspid regurgitation with valve separation was also observed.

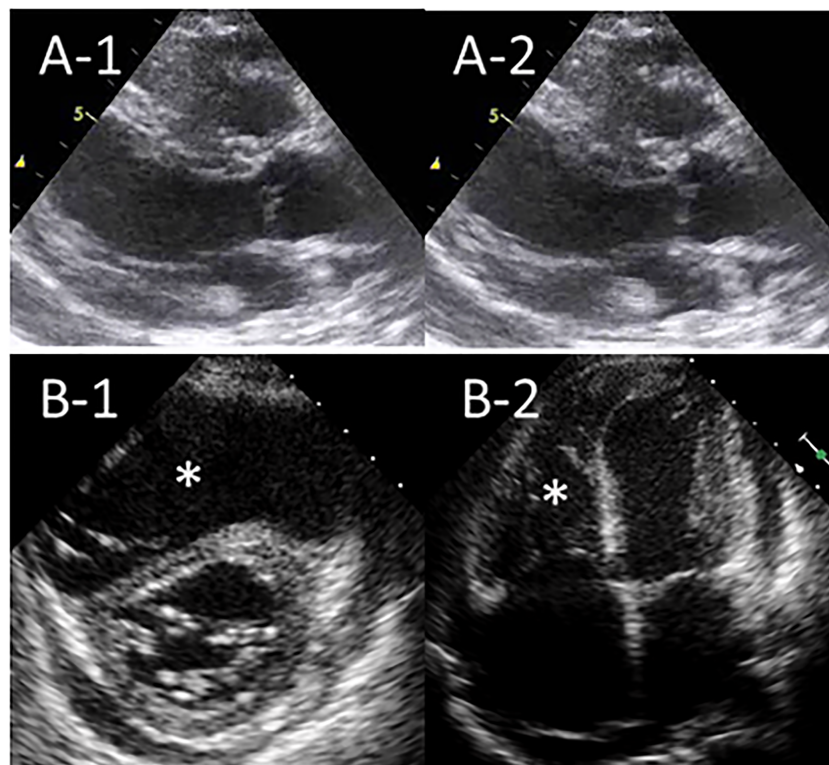
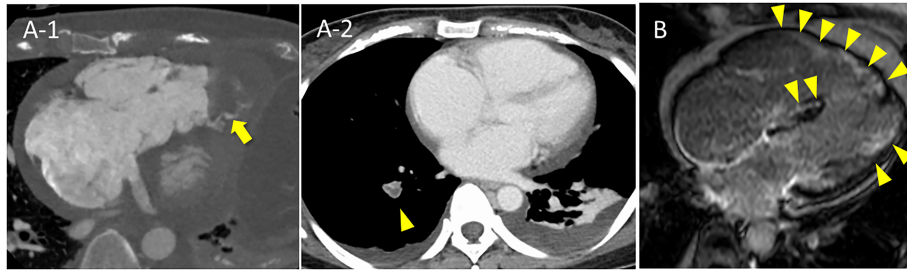


Figure 5 (A) Computed tomography scans depicting thrombus in right ventricular, deep vein thrombosis (A-1) and pulmonary thromboembolism (A-2); (B) cardiac magnetic resonance images showing a wide range of late gadolinium enhancement including at the apex of the right ventricular, left ventricular, and ventricular septum.



was added due to the presentation of right-sided heart failure with concomitant oedema of the extremities, and an angiotensin II receptor blocker was initiated to prevent LV remodelling. On Day 20, contrast-enhanced CT scans indicated pulmonary thromboembolism (PE) along with a thrombus in the RV (Figure 5A) and a deep vein thrombosis. Cardiac magnetic resonance (CMR) on Day 30 showed a wide range of late gadolinium enhancement (LGE), including at the RV apex to free wall, IVS, and LV apex (Figure 5B). After we confirmed disappearance of the RV thrombus via CT scan on Day 42, a cardiac electrophysiological study was performed. R-wave sensitivity was about 1 mV, and pacing threshold was higher than 5 V/0.4 ms in the RV. In addition, refractory VTs were easily induced. Therefore, she required both biventricular pacing and a defibrillator. She was provided with cardiac resynchronization therapy with a defibrillator (CRT-D) device on Day 49 and was discharged in good condition on Day 56. Serial follow-up echocardiography indicated severe RV dysfunction and dilatation with severe TR. LV was deformed by IVS leftward shift, and apparent LVEF had reduced to approximately 30% after 6 months of CRT-D implantation; however, the patient was able to return to work as a hairdresser without any worsening of heart failure.

Discussion

Herein, we report a case of fulminant lymphocytic myocarditis with a unique clinical course. The patient initially presented as typical biventricular failure with myocardial oedema but subsequently displayed RV dominant myocardial damage and associated clinical manifestations including (i) CAVB with high RV pacing threshold, (ii) sustained VTs, (iii) RV failure with severe TR, and (iv) RV thrombosis and PE. She finally required CRT-D implantation due to these clinical features being persistent. To the best of our knowledge, no case has been reported in that resembles this case of fulminant RV dominant myocarditis requiring CRT-D.

Because the efficacy of immunosuppressive therapy with corticosteroids for lymphocytic myocarditis is still controver-

sial, unlike eosinophilic and giant cell myocarditis,⁵ immunosuppressive therapy was not indicated in the present case. However, it is unknown whether avoiding immunosuppressive therapy was associated with the irreversibility of cardiac function.

Myocarditis sometimes involves the RV, as in the present case. Aquaro *et al.* examined 151 myocarditis patients with stable haemodynamics by CMR imaging and reported that signs of RV myocarditis were found in 17.8% cases, and RV LGE was detected in 7.3% cases.⁴ Among these myocarditis cases, RV dominant myocarditis is a rare pathophysiology,⁶ and there are only a few case reports of RV dominant myocarditis indicating VTs, CAVB, or RV failure.^{6–8} The fulminant case was reported only by Moriwaki *et al.*⁸ The RV dominant eosinophilic myocarditis that progressed into cardiogenic shock requiring IABP was successfully treated with corticosteroids without retaining ventricular dysfunction and arrhythmias.

Recently, the usefulness of CMR for the diagnosis of myocarditis has been quite evident.⁹ In most cases of fulminant myocarditis, CMR is unavailable in the acute phase where patients are dependent on mechanical circulatory support. Thus, EMB is necessary for the definite diagnosis of myocarditis in such patients. Moreover, EMB could identify the subtype of myocarditis and, in some cases, could estimate the severity of myocardial injury. In this case, identification of lymphocytic myocarditis suggested unavailability of corticosteroid therapy, and thorough degeneration of the myocardium in the IVS specimen suggested loss of viability at this site. Moreover, Stiermaier *et al.* reported that biventricular EMB is safe and has superior diagnostic performance for myocarditis to selective RV-EMB or LV-EMB.⁹

Nevertheless, CMR is an informative modality in the post-acute phase because CMR could indicate the global extent of myocardial fibrosis as LGE.¹⁰ The LGE of this patient was widely distributed in the RV apex to free wall, IVS (confirmed by EMB), and LV apex but did not involve the LV free wall. Interestingly, LGE distribution was RV 'dominant', but not 'isolated', whereas the clinical manifestation after the acute phase of inflammation suggested RV isolated cardiac injury.

Extensive fibrosis involving the conducting system and RV apex is associated with persistent CAVB, RV pacing failure, and refractory substrate of VTs. Therefore, biventricular pacing with defibrillator therapy is mandatory for the patient.

In summary, herein, we present the case of RV dominant, lymphocytic fulminant myocarditis requiring CRT-D due to persistent CAVB with RV pacing failure and lethal VTs. This case also suggests that the combination of EMB and CMR is useful for the diagnosis and therapeutic strategy for myocarditis.

editage.com) for editing and reviewing this manuscript for English language.

Conflict of interest

None declared.

Acknowledgements

The authors would like to thank Dr. S. Hirano for initial treatment at Asahi General Hospital and Editage (<http://www.>

Funding

This work was supported by JSPS KAKENHI Grant Number 19 K17514.

References

- Kociol RD, Cooper LT, Fang JC, Moslehi JJ, Pang PS, Sabe MA, Shah RV, Sims DB, Thiene G, Vardeny O, American Heart Association Heart Failure and Transplantation Committee of the Council on Clinical Cardiology. Recognition and initial management of fulminant myocarditis: a scientific statement from the American Heart Association. *Circulation* 2020; **141**: e69–e92.
- Sharma AN, Stultz JR, Bellamkonda N, Amsterdam EA. Fulminant myocarditis: epidemiology, pathogenesis, diagnosis, and management. *Am J Cardiol* 2019; **124**: 1954–1960.
- Hare JM, Baughman KL. Fulminant and acute lymphocytic myocarditis: the prognostic value of clinicopathological classification. *Eur Heart J* 2001; **22**: 269–270.
- Aquaro GD, Negri F, De Luca A, Todiere G, Bianco F, Barison A, Camastra G, Monti L, Dellegrottaglie S, Moro C, Lanzillo C, Scatteia A, Di Roma M, Pontone G, Perazzolo Marra M, Di Bella G, Donato R, Grigoratos C, Emdin M, Sinagra G. Role of right ventricular involvement in acute myocarditis, assessed by cardiac magnetic resonance. *Int J Cardiol* 2018; **271**: 359–365.
- Ammirati E, Veronese G, Cipriani M, Moroni F, Garascia A, Brambatti M, Adler ED, Frigerio M. Acute and fulminant myocarditis: a pragmatic clinical approach to diagnosis and treatment. *Curr Cardiol Rep* 2018; **20**: 114.
- Mancio J, Bettencourt N, Oliveira M, Pires-Morais G, Ribeiro VG. Acute right ventricular myocarditis presenting with chest pain and syncope. *BMJ Case Rep* 2013; **2013**: bcr2012007173.
- Hama Y, Funabashi N, Ueda M, Kanaeda T, Uehara M, Nakamura K, Murayama T, Mikami Y, Takaoka H, Kawakubo M, Lee K, Takano H, Komuro I. Images in cardiovascular medicine. right-sided heart wall thickening and delayed enhancement caused by chronic active myocarditis complicated by sustained monomorphic ventricular tachycardia. *Circulation* 2009; **119**: e200–e203.
- Moriwaki K, Dohi K, Omori T, Tanimura M, Sugiura E, Nakamori S, Sawai T, Imanaka-Yoshida K, Yamada N, Ito M. A survival case of fulminant right-side dominant eosinophilic myocarditis. *Int Heart J* 2017; **58**: 459–462.
- Stiermaier T, Fohrenbach F, Klingel K, Kandolf R, Boudriot E, Sandri M, Linke A, Rommel K, Desch S, Schuler G, Thiele H, Lurz P. Biventricular endomyocardial biopsy in patients with suspected myocarditis: feasibility, complication rate and additional diagnostic value. *Int J Cardiol* 2017; **230**: 364–370.
- Friedrich MG, Sechtem U, Schulz-Menger J, Holmvang G, Alakija P, Cooper LT, White JA, Abdel-Aty H, Gutberlet M, Prasad S, Aletras A, Laissy JP, Paterson I, Filipchuk NG, Kumar A, Pauschinger M, Liu P. International consensus group on cardiovascular magnetic resonance in myocarditis. cardiovascular magnetic resonance in myocarditis: a JACC white paper. *J Am Coll Cardiol* 2009; **53**: 1475–1487.