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CASE REPORT

CLINICAL CASE

Heart Transplantation for Uhl Anomaly in an Adult

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ABSTRACT

Uhl anomaly is characterized by the morphologic absence of right ventricular myocardium and is an exceedingly rare cause of nonischemic cardiomyopathy. We report the first case of a successful heart transplantation in a 41-year-old patient who presented in cardiogenic shock from Uhl anomaly causing decompensated right ventricular failure. (J Am Coll Cardiol Case Rep 2024;29:102322) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 41-year-old woman presented following 1 day of palpitations, nausea, vomiting, abdominal pain, and diarrhea. On arrival at the emergency department, the patient was in symptomatic atrial fibrillation with rapid ventricular response. She was afebrile, tachycardic to 130s beats/min, hypotensive to 70/50s mm Hg, with an oxygen saturation of 95% on room air. Physical exam and laboratory parameters were consistent with cardiogenic shock. Transthoracic echocardiography (TTE) revealed a severely dilated and poorly functioning right ventricle (RV). She was successfully converted to sinus rhythm after 3 direct current cardioversion attempts and a bolus of diltiazem. She was started on norepinephrine and diuretics and admitted to the cardiology intensive care unit for persistent hypotension.

LEARNING OBJECTIVES

- To describe morphologic and imaging features of Uhl anomaly.
- To understand the clinical presentation and management options for patients with Uhl anomaly.
- To recognize the role of heart transplantation in end-stage RV failure secondary to Uhl anomaly.

PAST MEDICAL HISTORY

The patient was diagnosed with arrhythmogenic RV dysplasia by chest radiograph at 7 years old. Subsequent cardiac magnetic resonance confirmed the diagnosis of Uhl anomaly with severely thinned and dilated RV walls devoid of myocardium with exception of thin, lacy myocardial fibers across the ventricle. She was followed serially by pediatric cardiology, transitioning to adult cardiology at 28 years old, with regular assessment of functional capacity, symptoms, arrhythmia burden, liver function, and renal function. At 11 years old, the patient was found to have ventricular ectopy by surveillance Holter monitoring, managed on mexiletine and beta-

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ABBREVIATIONS AND ACRONYMS

ARVC = arrhythmogenic right ventricular cardiomyopathy

RA = right atrium

RV = right ventricle

TTE = transthoracic echocardiography

blockers until when she was 29 years old a single-chamber implantable cardioverter-defibrillator was placed for increasing ectopy burden. She then underwent atrioventricular nodal ablation for atrioventricular nodal re-entrant tachycardia and crista terminalis isthmus ablation for atrial tachycardia. Following these procedures, the patient continued to have paroxysmal atrial fibrillation, which was managed on dofetilide and apixaban until the day of presentation. Cardiopulmonary exercise stress testing at 31 years old revealed a peak Vo_2 of 17.1 mL/kg/min (46% of predicted). Family history was notable for a brother with left ventricular dilated cardiomyopathy who underwent a heart transplant as a child and cousin with sudden cardiac death.

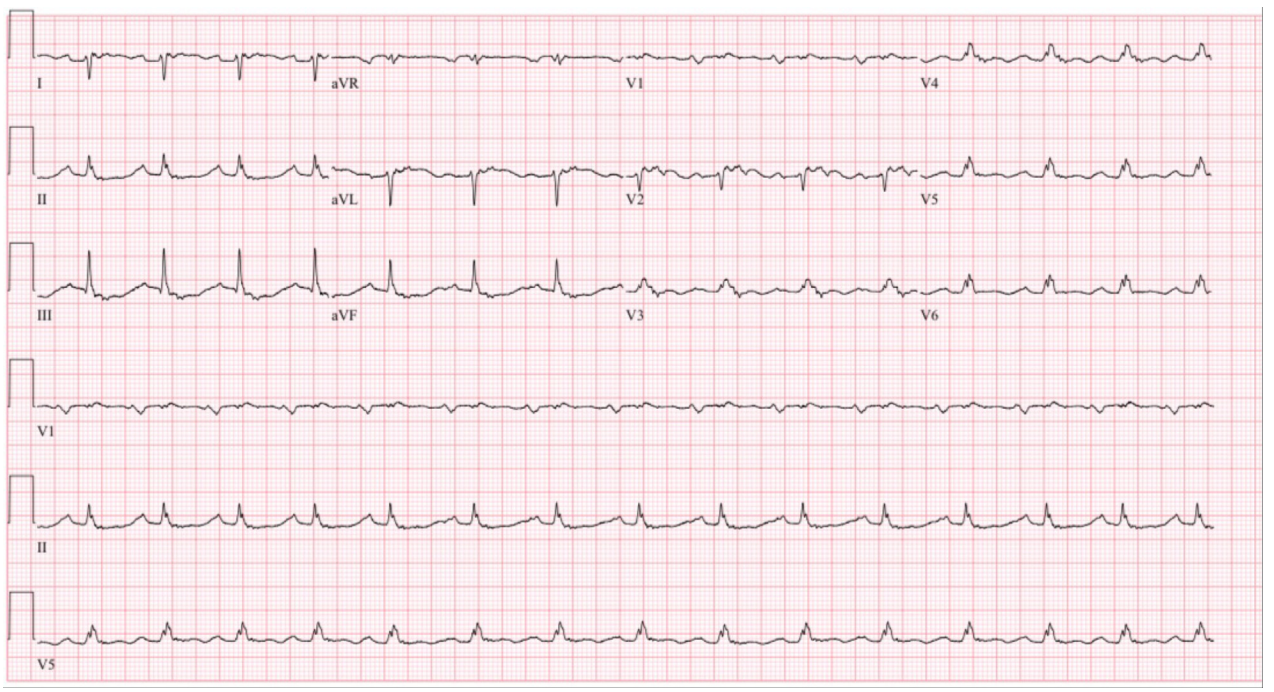
DIFFERENTIAL DIAGNOSIS

The differential diagnosis for nonischemic RV cardiomyopathy includes RV dysfunction secondary to pulmonary hypertension and related disease processes, primary tricuspid or pulmonic valvular pathology, congenital heart defects involving right-sided structures (Ebstein anomaly), infiltrative or inflammatory diseases of the RV, and arrhythmogenic right ventricular cardiomyopathy (ARVC).

INVESTIGATIONS

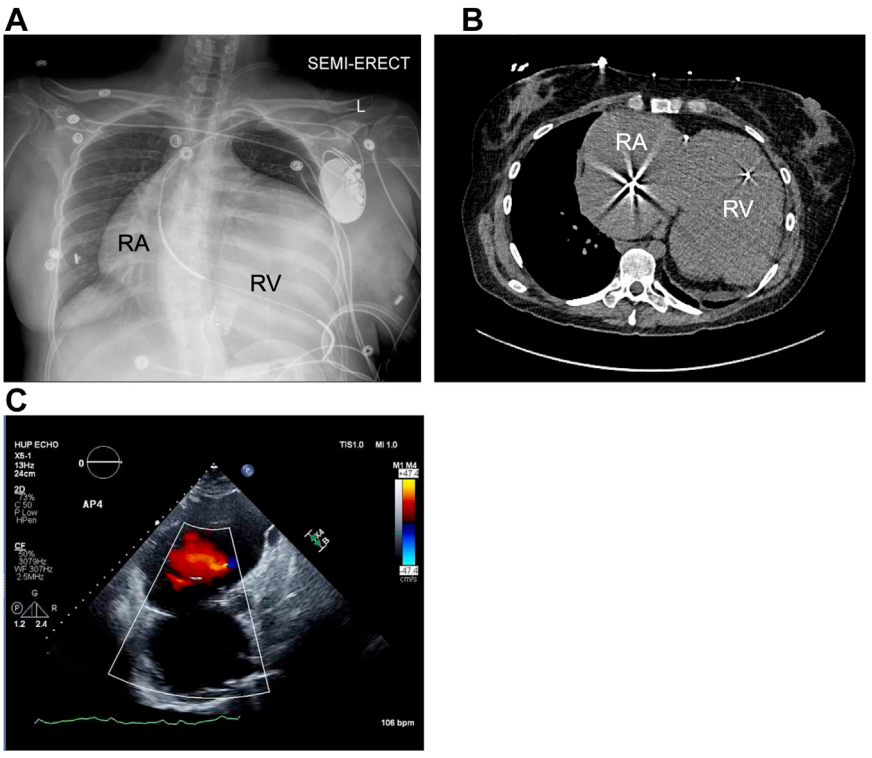
Electrocardiogram after sinus conversion showed right-axis deviation, first-degree atrioventricular block, and epsilon waves in leads V_2 and V_3 (**Figure 1**). Preoperative chest radiograph (**Figure 2A**), chest computed tomography (**Figure 2B**), and TTE demonstrated massive enlargement of the right atrium (RA), apex forming RV with severely depressed systolic function, and torrential tricuspid insufficiency (**Figure 2C**, Supplemental Figure 1, Video 1). There was compression of the left ventricle with left ventricular ejection fraction of 40% (Video 2). Right heart catheterization hemodynamics are listed in **Table 1**. ARVC genetic panel was negative for ryanodine receptor-2, transmembrane protein-43, desmoplakin, plakophilin-2, desmoglein-2, desmocollin-2, and junction plakoglobin-gamma catenin.

FIGURE 1 Preoperative Electrocardiogram



Right-axis deviation, first-degree atrioventricular block, and epsilon waves in leads V_2 and V_3.

FIGURE 2 **Preoperative Imaging**



Severely enlarged right-sided cardiac structures by (A) chest radiograph and (B) noncontrast computed tomographic chest. (C) Transthoracic echocardiography showing a massively dilated, poorly functioning right ventricle (RV) and torrential tricuspid regurgitation. RA = right atrium.

MANAGEMENT

On hospital day 1, following TTE and right heart catheterization, home dofetilide was resumed and an intravenous heparin drip was started. On hospital day 4, milrinone was instituted for additional inotropic support. Despite aggressive rhythm control and diuresis, the patient's hemodynamics did not significantly improve, and an expedited heart transplantation evaluation was initiated. Considerable challenges were noted while attempting to optimize the patient's preoperative volume status. In particular, massively dilated right heart compartments led to expansion of the venous circulation and discordance between measured central venous pressure and overall volume status, limiting the utility of central venous pressure thresholds for guiding diuresis. The patient continued with aggressive diuresis and vasoactive pharmacologic support as needed until a suitable donor organ became available. On hospital day 26, the patient underwent orthotopic heart transplantation.

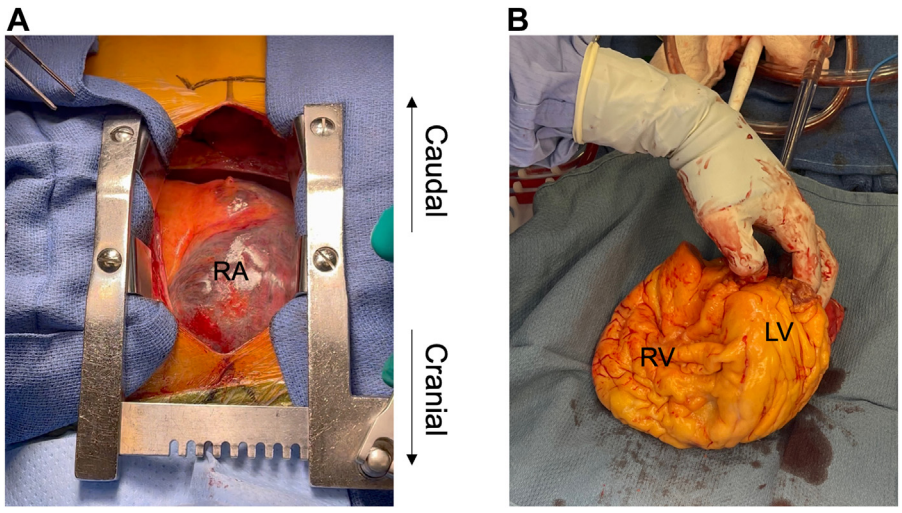
TABLE 1 **Preoperative Hemodynamic Parameters Derived From Right Heart Catheterization**

RA, mm Hg	21
PA, mm Hg	27/16
PVR, Woods units	2.7
PCWP, mm Hg	14
CO, L/min	2.6
CI, L/min/m^2	1.6

CI = cardiac index; CO = cardiac output; PA = pulmonary artery; PCWP = pulmonary capillary wedge pressure; PVR = pulmonary vascular resistance; RA = right atrium.

There were several technical considerations noted during the operation. First, as demonstrated radiographically, the mediastinal anatomy was markedly distorted by RV and RA mass effect. Following sternotomy and pericardial well creation, a massively enlarged and anteriorly displaced RA was encountered, limiting visualization of the ascending aorta,

FIGURE 3 Intraoperative Photographs



(A) Significantly dilated right atrium (RA) following sternotomy and (B) explanted heart with Uhl anomaly. LV = left ventricle.

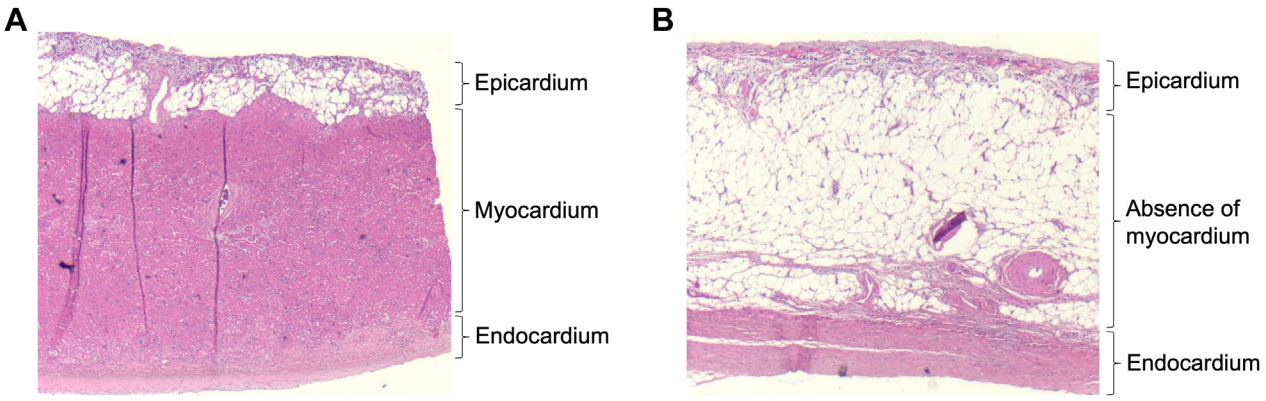
innominate vein, and superior vena cava (Figure 3A). In addition, RA remodeling from long-standing tricuspid regurgitation led to exceptionally thin walls and increased bleeding risk with manipulation. Consideration was given to peripheral cannulation for safe initiation of cardiopulmonary bypass. However, after careful dissection, the patient was able to undergo aortic and central bicaval cannulation and recipient cardiectomy was performed in standard fashion. The explanted Uhl anomaly heart is shown in Figure 3B. Histopathologic analysis shows a segment of normal RV tissue architecture (Figure 4A) and the diseased portion with absence of myocardium (Figure 4B). Given the significant degree of dead space in the pericardial cavity following removal of the recipient heart, close attention was made to ensure that there was no kinking or torsion of the donor heart during surgical implantation. Five chest tubes were placed at the conclusion of the case to facilitate drainage of postoperative effusions from within the mediastinal dead space.

DISCUSSION

Uhl anomaly was first described in 1952 by Dr Henry Uhl and is characterized by partial or complete absence of RV myocardium.[1] Although it was initially hypothesized to result from an embryologic defect in RV development,[1,2] it is now thought to occur secondary to dysregulated apoptosis of postnatal RV myocardium. Owing to the severity of this disease process, most reported cases have been associated with early lethality in infancy or childhood. In the few published reports in adults, patients commonly present with nonspecific sequela of progressive RV failure. The diagnosis is made by advanced imaging (eg, TTE, computed tomography, cardiac magnetic resonance) or postmortem histopathology. Characteristic features include RV thinning and hypokinesis, partial or complete absence of RV myocardium with minimal trabeculations, and severe dilation of the RV and RA.[3-5] Patients often exhibit secondary tricuspid insufficiency from progressive annular dilation. Collectively, these morphologic features distinguish Uhl anomaly from other forms of genetic ARVC, which demonstrate hypertrabeculation and focal fibrofatty displacement of the myocardium.[2,3] In addition, as observed in the present study, patients with Uhl anomaly lack deleterious mutations in desmosome and cellular membrane genes commonly implicated in other forms of ARVC, further supporting that these are distinct disease processes.

Initial management of Uhl anomaly includes generalized pharmacologic approaches to RV failure, because surgical options for these patients are exceedingly limited. Previous reports have described complex surgical repair techniques aimed at exclusion of the diseased RV, including single ventricle palliation and 1.5 ventricular repair approaches.[6-8] Despite varying degrees of success, such repairs have only been attempted in the pediatric population. For those presenting in adulthood, reported surgical

FIGURE 4 RV Histology



(A) Normal right ventricular (RV) histologic architecture showing epicardial, myocardial, and endocardial compartments and (B) area of diseased RV showing absence of myocardium.

options are limited to advanced mechanical circulatory support and cardiac transplantation.[9,10] To our knowledge, the present study is the first to describe a successful heart transplantation for long-standing Uhl anomaly refractory to medical therapy in an adult.

FOLLOW-UP

Postoperatively, the patient developed acute kidney injury requiring a short duration of continuous renal replacement therapy and intermittent hemodialysis. She was discharged home on postoperative day 30 with TTE showing normal biventricular function and no significant valvular abnormalities. Four months postoperatively, the patient continues to demonstrate normal allograft function.

CONCLUSIONS

Uhl anomaly is defined by the partial or complete absence of RV myocardium and is an exceedingly rare cause of heart failure in the adult. Given nonspecific findings of right-sided chamber enlargement by electrocardiogram and chest x-ray, advanced imaging should be used to confirm the diagnosis. Medical management with inotropic support, aggressive diuresis, and dysrhythmia control may be pursued to manage acute decompensation episodes and temporize progressively worsening RV failure. However, as demonstrated in this report, cardiac transplantation can be performed safely and remains a durable, curative therapy for these patients.

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KEY WORDS cardiac transplantation, heart failure, Uhl anomaly

APPENDIX For supplemental figure, videos, please see the online version of this paper.