JACC: CASE REPORTS VOL. 3, NO. 12, 2021

CASE REPORT

INTERMEDIATE

CLINICAL CASE

Uhl's Anomaly With Left Ventricular Noncompaction

Role of Multimodality Imaging in a Rare Association

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ABSTRACT

Uhl's anomaly is a rare congenital heart disease characterized by partial or complete absence of the right ventricle myocardium. We report the first case, in a 21-year-old man, of Uhl's anomaly-associated left ventricular noncompaction. This association represents a unique clinical entity and has important implications for management strategies. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2021;3:1463–1467) © 2021 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 21-year-old man presented with a several-month history of fatigue and progressive dyspnea on exertion. He reported lightheadedness and bluish discoloration of lips and fingernails with minimal exertion. Physical examination was notable for mild respiratory distress, central cyanosis, and digital clubbing. His vital signs were normal, except an oxygen saturation of 92%. He was noted to have elevated neck veins with estimated central venous pressure at 12 cm H_2O. Auscultation revealed a normal S_1, followed by soft systolic murmur heard at the left lower sternal border, a wide fixed split S_2, and a positive S_3. Laboratory evaluation was notable for secondary erythrocytosis (hemoglobin, 19.1 g/dL).

LEARNING OBJECTIVES

- To be able to make a differential diagnosis of patients with central cyanosis and right-to-left shunting.
- To recognize the role of multimodality imaging to diagnose and guide management of congenital heart disease.

PAST MEDICAL HISTORY

The patient had a history of right ventricular (RV) cardiomyopathy. He denied any history of alcohol intake or illicit drug use.

DIFFERENTIAL DIAGNOSIS

Given the presentation of intermittent central cyanosis on exertion, clubbing, and secondary erythrocytosis, the suspected physiology was a right-to-left shunt with possible underlying pulmonary vascular disease (PVD). The presence of the wide

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Estefania Oliveros Soles, MD, served as Guest Associate Editor for this paper.

The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received March 22, 2021; revised manuscript received May 14, 2021, accepted June 4, 2021.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2021.06.042

JACC: CASE REPORTS, VOL. 3, NO. 12, 2021
SEPTEMBER 15, 2021:1463–1467

ABBREVIATIONS AND ACRONYMS

ARVD/C = arrhythmogenic right ventricular dysplasia or cardiomyopathy

ASD = atrial septal defect

EDP = end-diastolic pressure

EF = ejection fraction

LV = left ventricular

LVNC = left ventricular noncompaction

PVD = pulmonary vascular disease

RA = right atrial

RV = right ventricular

TCPC = total cavopulmonary connection

TV = tricuspid valve

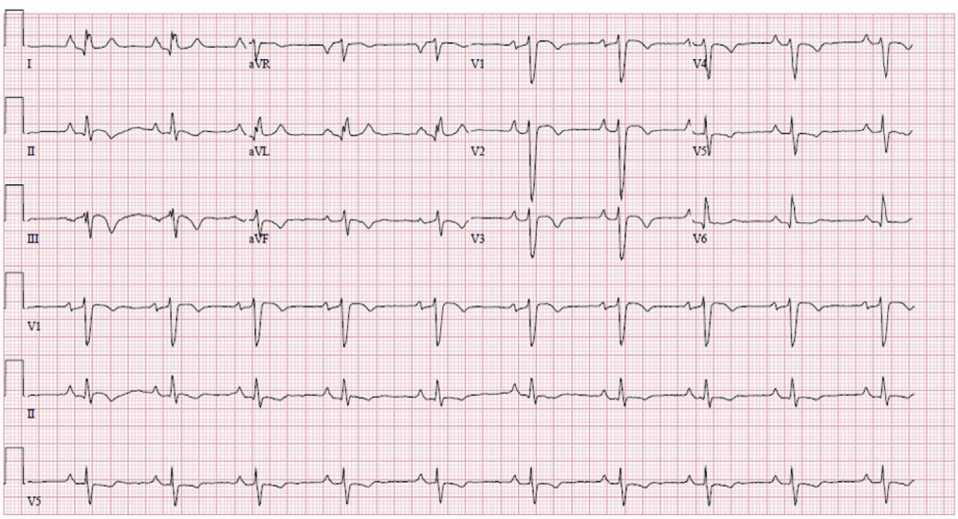
fixed S_2 and the absence of a high-pitched systolic murmur typical of ventricular septal defect made intracardiac shunting at the atrial level (atrial septal defect [ASD]) most likely. Because of the young age of our patient, the absence of an accentuated P2 component of S_2 (which would be expected in PVD), and the presence of S_3, the differential diagnosis of RV cardiomyopathy with ASD was also considered. Ebstein's anomaly and Uhl's anomaly were the 2 main RV cardiomyopathy entities considered, given the young age of the patient, his reported history of RV cardiomyopathy in childhood, and the known associations with ASD.

INVESTIGATIONS

Electrocardiography revealed sinus rhythm with right atrial (RA) enlargement and intraventricular conduction delay (**Figure 1**). Transthoracic echocardiography revealed a severely dilated right atrium, a dysplastic tricuspid valve (TV) with moderate regurgitation, normal predicted pulmonary artery systolic pressure, a moderately dilated and hypertrabeculated right ventricle with severely reduced systolic function, and a large secundum ASD with bidirectional shunting. The left ventricle was hypertrabeculated with a mildly reduced ejection fraction (EF) (40%-45%), suggestive of left ventricular (LV) noncompaction (LVNC) (**Figures 2A to 2D**). Results of the 6-minute walk test revealed limited functional capacity and oxygen desaturation with walking (baseline: 92%, post-test: 86%).

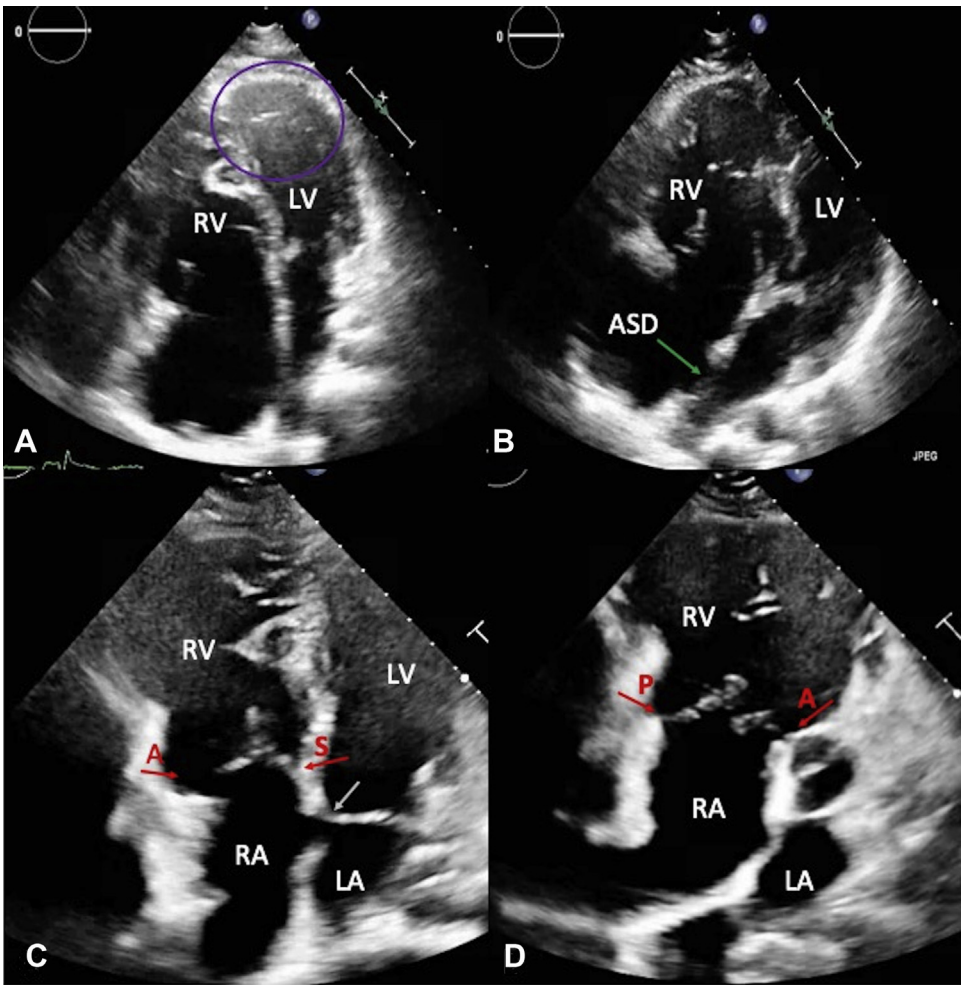
Cardiac magnetic resonance imaging was performed to evaluate the myocardium more accurately. Images revealed complete absence of RV myocardium with no fibrofatty tissue in the RV wall, dysplastic TV leaflets that were arising appropriately from the annulus with moderate tricuspid regurgitation, severely reduced RV EF (24%) with global dysfunction, a moderately dilated right ventricle (RV end-diastolic volume index, 129 mm/m^2; RV end-systolic volume index, 99 mm/m^2), LVNC with an LV EF of 47%, and no late gadolinium enhancement of either ventricle (**Figures 3A to 3D,** Videos 1, 2, and 3). Cardiac catheterization was significant for mildly elevated RA pressures with an accentuated V-wave (A, 9 mm Hg; V, 12 mm Hg; M, 9 mm Hg), mildly elevated RV end-diastolic pressure (EDP) (12 mm Hg), normal pulmonary artery pressure (18/8 mm Hg with mean 14 mm Hg), mean pulmonary capillary wedge pressure of 10 mm Hg, and LV EDP of 10 mm Hg. After obtaining blood samples for oxygen saturations from different chambers, pulmonary blood flow (Qp) and systemic blood flow (cardiac output, Qs) were calculated using the Fick principle revealing bidirectional shunting at the atrial level with a net Qp/Qs ratio of 1.2:1. Pulmonary vascular resistance was 2.2 Wood unit/m^2, systemic vascular resistance

FIGURE 1 Electrocardiogram



Electrocardiogram showing normal sinus rhythm with right atrial enlargement and nonspecific intraventricular conduction block.

FIGURE 2 Transthoracic Echocardiogram



(A to C) Apical 4-chamber view reveals a severely dilated right ventricle (RV), a small left ventricular volume with a trabeculated left ventricle) LV **(purple circle),** and atrial septal defect (ASD) **(green arrow). (C)** Tricuspid valve leaflet insertion sites (anterior [A] and septal [S]) **(red arrows)** and mitral valve leaflet septal insertion **(gray arrow). (D)** Parasternal short-axis view reveals tricuspid valve leaflet (anterior and posterior [P]) insertion sites **(red arrows).** LA = left atrium; RA = right atrium.

was 35.5 WU/m^2, and cardiac index was 2.0 L/min/m^2. A comprehensive cardiomyopathy genetic panel was performed, with no specific genetic mutation identified for inherited dilated cardiomyopathy, arrhythmogenic right ventricular dysplasia or cardiomyopathy (ARVD/C), or LVNC.

MANAGEMENT

On the basis of the foregoing information, the diagnosis of Uhl's anomaly with secundum ASD and LVNC was made. Although ASD transcatheter closure possibly could have improved oxygen saturation, it was not pursued out of concern for worsening hemodynamics with exertion in the setting of significant biventricular cardiomyopathy. Additional management strategies considered included surgical creation of a total cavopulmonary connection (TCPC) with RV exclusion or heart transplantation. The presence of a mildly reduced LV EF in the setting of LVNC made TCPC too high a risk, and the patient is currently undergoing evaluation for heart transplantation.

DISCUSSION

To the best of our knowledge, this is the first reported case of Uhl's anomaly associated with LVNC. Uhl's

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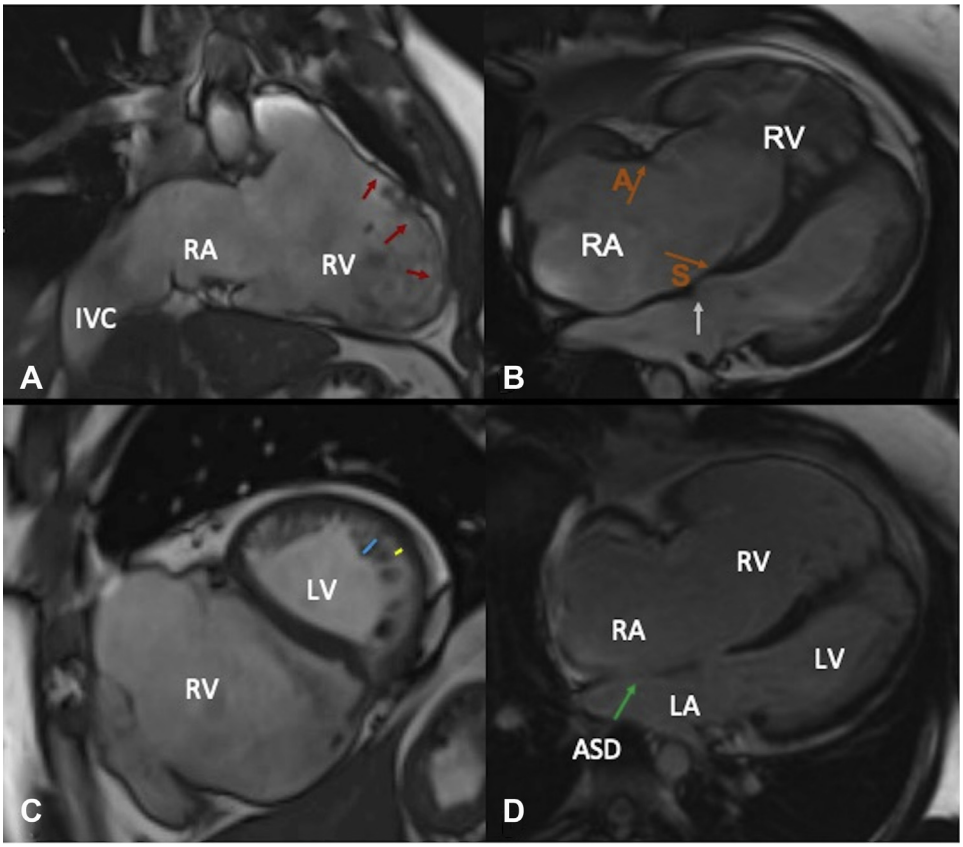
FIGURE 3 Cardiac Magnetic Resonance Imaging



(A) Severely dilated right ventricle (RV) with complete absence of myocardium **(red arrows)** and a dilated inferior vena cava (IVC). **(B)** Dysplastic tricuspid valve (TV) with normal leaflet insertion sites **(orange arrows)** and a mitral valve leaflet septal insertion **(gray arrow). (C)** LVNC **(blue line). (D)** Atrial septal defect (ASD) **(green arrow),** with no delayed gadolinium enhancement of the right ventricle or left ventricle (LV). Abbreviations as in Figure 2.

anomaly is a rare congenital heart anomaly characterized by partial or complete absence of the RV myocardium (1). The etiology of Uhl's anomaly is unknown, although the condition is speculated to be caused by uncontrolled apoptosis of RV myocytes, leading to juxtaposition of the RV epicardium and endocardium without intervening myocardium (2). Secundum ASD or patent foramen ovale was reported in up to 25% of cases, and these anomalies are the most common associated congenital heart defects in these patients (3). Most patients present as isolated cases with no family history to suggest a specific inheritance pattern. Although LVNC has been associated with mutations in *MYH7, MYBPC3,* and *TTN,* there have been no reports for any specific mutations linked to Uhl's anomaly (4).

A primary RV cardiomyopathy such as Uhl's, ARVD/C, or Ebstein's anomaly was suspected on the basis of the clinical presentation. The absence of fibrofatty tissue in the RV wall and the presence of global RV dysfunction rather than focal akinesia or dyskinesia made the diagnosis of ARVD/C unlikely (5). The signature feature of Ebstein's anomaly, apical displacement of TV leaflets, was not present, thus ruling out this diagnosis. The presence of central cyanosis, clubbing, and secondary erythrocytosis in the setting of secundum ASD could be observed in patients with RV cardiomyopathy with normal pulmonary vasculature.

The association of LVNC and Uhl's anomaly has an important clinical implication for determining the appropriate management approach. Surgical RV

exclusion with TCPC has been proposed for patients with Uhl's anomaly, although the outcomes from this approach are unclear (6-9). Thorough evaluation of LV function and left-sided valvular hemodynamics is crucial before considering conversion to TCPC in patients with Uhl's anomaly because this strategy transitions the hemodynamics from a 2-ventricle to single-ventricle circulation with its inherent limitations. Additionally, compromised RV function in the setting of LVNC was associated with increased mortality and the need for heart transplantation in biventricular patients (10). For all of these reasons, heart transplantation was thought to be the most appropriate management option in our patient.

FOLLOW-UP

The patient is currently undergoing evaluation for heart transplantation.

CONCLUSIONS

Uhl's anomaly is a rare cardiac malformation with significant morbidity and limited therapeutics. This is the first reported association of Uhl's anomaly with LVNC, and it poses unique therapeutic considerations. The high risk of surgical management in these patients supports heart transplantation as the most ideal treatment option.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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KEY WORDS atrial septal defect, congenital heart defect, left ventricle, left ventricular noncompaction, right ventricle, cardiac magnetic resonance, Uhl's anomaly

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