

MINI-FOCUS ISSUE: HEART FAILURE

INTERMEDIATE

CASE REPORT: CLINICAL CASE

Cardiogenic Shock in Obstructive Hypertrophic Cardiomyopathy Plus Apical Ballooning



Management With VA-ECMO and Myectomy

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ABSTRACT

A patient with known obstructive hypertrophic cardiomyopathy developed worsening left ventricular outflow tract obstruction, severe mitral regurgitation, and apical ballooning leading to cardiogenic shock, a combination in which treatment of each component could worsen the others. Emergency veno-arterial extracorporeal membrane oxygenation, levosimendan, and noradrenaline transiently restored adequate systemic perfusion and gas exchange. Surgical myectomy offered a more definitive solution. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2021;3:433-7) © 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 49-year-old man, after a few days of high fever due to pneumonia, was admitted to a nearby hospital with

atrial fibrillation (AF), acute pulmonary edema, and hypotension. Admission transthoracic echocardiography (TTE) showed asymmetrical hypertrophy of the basal interventricular septum (18 mm), apical ballooning with hyperkinetic basal segments, an ejection fraction (EF) of 30%, severe left ventricular outflow tract obstruction (LVOTO) (gradient 80 mm Hg), and moderate-to-severe mitral regurgitation (MR) due to systolic anterior movement (SAM). Metoprolol infusion was started to reduce heart rate and the LVOT gradient, but the patient further deteriorated and required intubation and transfer to our cardiac intensive care unit. On admission, he was afebrile, hypotensive despite norepinephrine, had alternating sinus rhythm and high-ventricular response AF, and was hypoxemic (peripheral

LEARNING OBJECTIVES

- To evaluate the multiple factors that can trigger apical ballooning and worsen LVOTO in patients with obstructive HCM, leading to development of CS.
- To consider circulatory support with VA-ECMO in severe CS and pulmonary edema.
- To consider septal reduction therapy in case of persistence of hemodynamical instability in the presence of severe LVOTO despite maximal pharmacological therapy.

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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](#).

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ABBREVIATIONS AND ACRONYMS

- AF** = atrial fibrillation
- CS** = cardiogenic shock
- EF** = ejection fraction
- HCM** = hypertrophic cardiomyopathy
- HF** = heart failure
- LVOTO** = left ventricular outflow tract obstruction
- MR** = mitral regurgitation
- SAM** = systolic anterior movement
- TTE** = transthoracic echocardiography
- VA-ECMO** = veno-arterial extracorporeal membrane oxygenation

capillary hemoglobin oxygen saturation 60% despite fraction of inspired oxygen 100% and high ventilatory supports), with frothy sputum from the endotracheal tube.

PAST MEDICAL HISTORY

The patient had mild dyslipidemia and known obstructive HCM, which was well controlled with nadolol 40 mg twice daily.

DIFFERENTIAL DIAGNOSIS

The diagnosis of cardiogenic shock was clear. The apical ballooning could have been caused by the superimposition of a Takotsubo cardiomyopathy or by the LVOTO itself.

INVESTIGATIONS

TTE showed the apical ballooning, EF of 15%, a peak LVOT gradient of 90 mm Hg, and massive MR due to SAM (Video 1). The electrocardiogram showed sinus rhythm with supraventricular extrasystoles, normal PR, QRS, and QT duration, as well as nonspecific repolarization abnormalities. Blood tests showed N-terminal pro-B-type natriuretic peptide of 13.875 pg/ml and a high-sensitivity troponin T of 165 pg/ml.

MANAGEMENT

Mechanical circulatory support with femoro-femoral veno-arterial extracorporeal membrane oxygenation (VA-ECMO) was started with emergent bedside

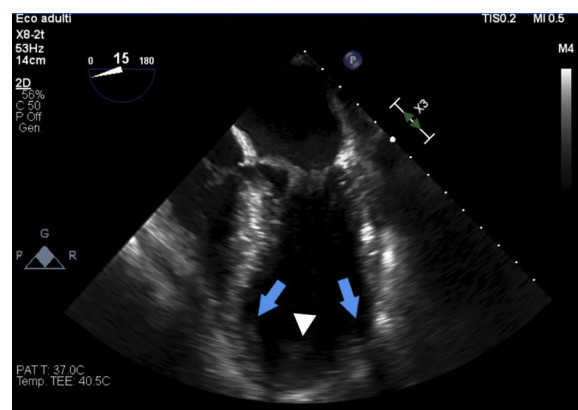
cannulation under transesophageal echocardiography guidance (Figure 1, Videos 2 and 3). Because of the presence of an intraluminal protruding defect suspicious for apical thrombosis, no surgical apical venting or ventricular unloading with Impella (Abiomed, Danvers, Massachusetts) was used. Because the left ventricle was not enlarged, the insertion of an intra-aortic balloon pump was also avoided.

In the first hours, with full VA-ECMO support at 4 l/min, hemodynamics and gas exchange rapidly improved, and the LVOT gradient dropped to 30 mm Hg. Levosimendan (0.05 µg/kg/min), norepinephrine (average dose 0.10 to 0.15 µg/kg/min), and amiodarone (900 mg over 24 h, to reduce ventricular rate) infusions were started. The left ventricular EF improved to 25% with recovery of the contractility of the mid-ventricular segments. On day 3, we started weaning the patient from VA-ECMO and on day 4, with a minimum VA-ECMO support of 1.5 l/min, we observed normokinesia of the mid-apical segments, an EF of 38%, and a LVOT gradient of 15 mm Hg (Figure 2, Video 4). The VA-ECMO was then surgically removed. The patient was initially stable, but 6 h later, self-terminating episodes of AF with high ventricular response recurred, determining a rapid hemodynamic compromise, recurrence of LVOTO (gradient >100 mm Hg), SAM with moderate-to-severe MR, and apical ballooning (Figure 3, Video 5).

Esmolol (50 µg/kg/min) reduced the ventricular rate to 95 to 100 beats/min, but LVOTO (60 mm Hg) and moderate-to-severe MR persisted. After emergent discussion within the Heart Team, the patient underwent cardiac surgery (remodeling of the LVOT with septal myectomy extended to the mid-ventricular portion and a debridging of the anterior mitral leaflet). The surgeon reported the presence of severe fibrosis that extended from the posterior to the anterior trigon, involved the mitral valve, and narrowed the outflow tract, which was probably at least in part responsible, along with the septal hypertrophy, of the elevated LVOT gradient. No apical thrombus was evidenced.

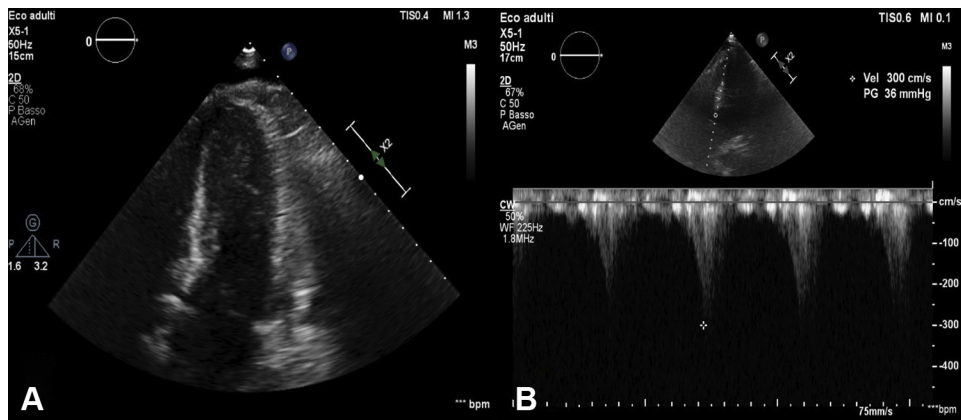
After surgery, LVOTO, MR, and apical ballooning rapidly improved. Left atrial appendix thrombosis was observed with transesophageal echocardiography. The thrombus was monitored until resolution with anticoagulant therapy, and cardioversion was avoided. When the patient woke up, he presented with flaccid plegia of the upper right arm and motor aphasia; a brain computed tomographic scan showed an ischemic hypodense left cortical-subcortical area. On post-operative day 39, he was transferred to a neurological rehabilitation center. The last TTE showed no wall motion abnormality, EF of 56%, mild

FIGURE 1 Transesophageal Echocardiography Findings on Admission



Four-chamber view of the left ventricle in mid-systole showing the apical ballooning (thick blue arrows) and the image suspicious for apical thrombosis (white arrowhead).

FIGURE 2 Transthoracic Echocardiography Findings on Day 4



(A) Apical ballooning is no longer present. (B) Peak left ventricular outflow tract gradient is 36 mm Hg.

MR, and no LVOTO (Figure 4, Video 6). The patient's discharge treatment included metoprolol 50 mg twice daily, ramipril 2.5 mg, amiodarone 200 mg, and vitamin K antagonist.

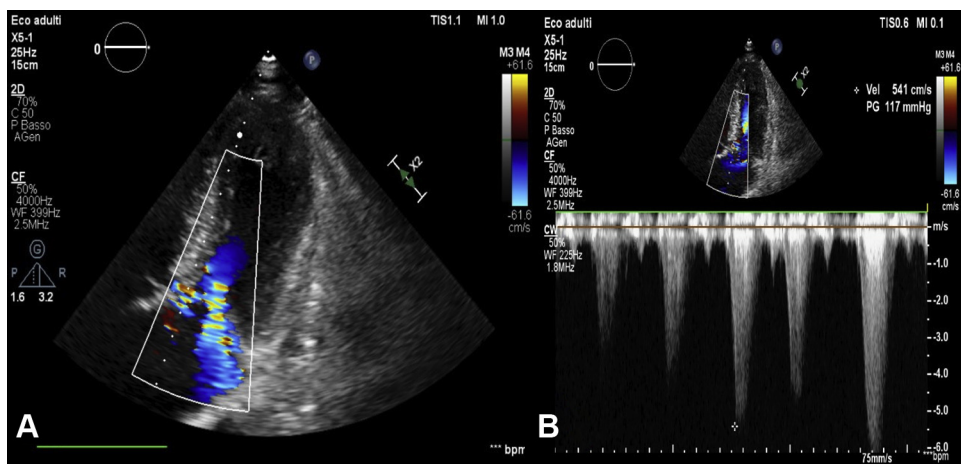
DISCUSSION

HCM is defined a myocardial wall thickness ≥ 15 mm that is not explained by abnormal loading conditions (1). Obstruction is present in 40% to 70% of these patients (2); LVOTO increases LV pressure and work, impairs oxygen supply/demand balance, and determines mid-systolic drop in velocities and flow, as

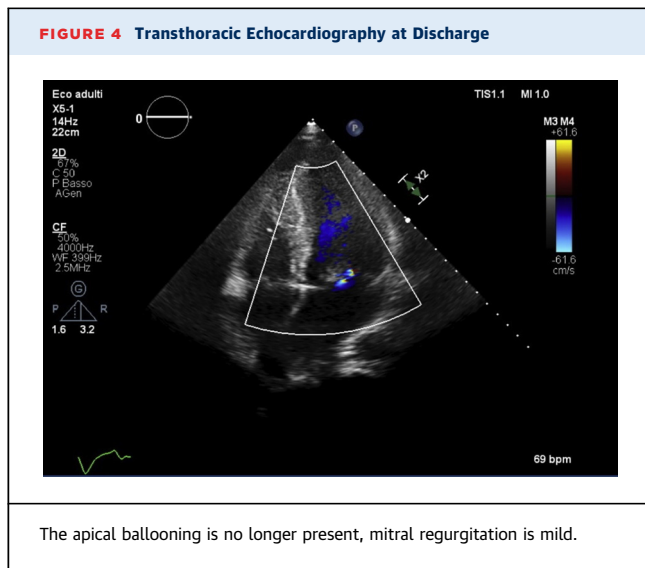
well as MR due to SAM. Late progressive development of heart failure (HF) is frequent in patients with obstructive HCM, whereas acute HF is uncommon (2). The combination of apical ballooning and obstructive HCM is rare, and similar cases were initially considered superimposition with a Takotsubo syndrome (3). A recent hypothesis is that the LVOTO, through afterload mismatch and supply/demand ischemia, is itself responsible for apical ballooning, as supported by the rapid recovery after LVOTO resolution (4).

In this case, it was also possible to attribute the apical ballooning to a Takotsubo syndrome, induced

FIGURE 3 Transthoracic Echocardiography Findings During Atrial Fibrillation Recurrence



(A) 4-chamber view showing de novo apical ballooning and mitral regurgitation. (B) High left ventricular outflow tract gradient (peak 117 mm Hg).



by the infection, or to an increase in the LVOTO due to fever and hypovolemia (4).

Our patient, according to the Society for Cardiovascular Angiography and Intervention classification of CS, was in stage D (hypoperfusion with deterioration, not refractory shock), with an in-hospital mortality rate that exceeded 40% (5). Management of CS, as determined by the coexistence of LVOTO and apical ballooning, is challenging, because drugs beneficial in one setting can worsen the other. VA-ECMO grants full circulatory support; the reduction in preload, which potentially increases the obstruction, is counteracted by the afterload increase (6). There are few reports of patients with obstructive HCM treated with VA-ECMO, and only one of a patient with LVOTO and apical ballooning who underwent this treatment (7), although it is considered an option in cases of Takotsubo when pump failure prevails (8). Venting the LV during VA-ECMO support has the rationale of reducing afterload; therefore, in this particular case, it might have worsened the LVOTO.

Levosimendan is a calcium-sensitizer that also inhibits phosphodiesterase III. In patients on beta-blocking therapy, as in this case, the calcium-sensitizing effect prevails (9). The rationale of its use was to gradually improve the kinetics of the mid-apical segments, avoiding a sudden and extreme hyperreactive response on the septum. Its use in Takotsubo is currently endorsed by an European Society of Cardiology consensus document (8), although its application in obstructive HCM, either with apical ballooning or not, has never been previously described. Furthermore, in multiple reports, the use of levosimendan favors weaning from VA-ECMO.

Noradrenaline was added to counteract the potassium channel mediated vasodilatation and thus the afterload reduction.

Septal reduction therapy is recommended in patients in New York Heart Association functional classes III to IV with a LVOT gradient ≥ 50 mm Hg (1). We found 2 patients with LVOTO, apical ballooning, and CS treated with urgent septal myectomy (4) or alcohol ablation (7). In our case, initial urgent septal myectomy was not considered a feasible option due to severe hemodynamic instability and severe hypoxia; therefore, a 2-step approach with VA-ECMO support, followed by a surgical approach, was chosen. Dysopyramide could have been a pharmacological approach to reduce LVOTO, but no intravenous formulation is available in Italy, and oral administration might have required a too long onset of action to be an option in the acute hemodynamically unstable phase.

VA-ECMO support is associated with several complications that can be caused by the underlying disease or the VA-ECMO itself; stroke occurs in 10% to 20% of the patients (10). In this case, the left atrial appendix thrombosis, the AF, and the dilated left atrium due to the HCM were all factors that increased the risk of cardioembolic stroke, which happened despite well-controlled anticoagulant therapy.

FOLLOW-UP

To date, the patient is asymptomatic and has no LVOTO. He appropriately, yet slowly, expresses himself, and only has difficulties in the fine movements of the right hand.

CONCLUSIONS

The development of reversible apical ballooning in patients with obstructive HCM may precipitate or worsen LVOTO, causing CS that is unresponsive to ordinary measures; prompt VA-ECMO support can be life-saving. The role of levosimendan in this scenario is promising, but more evidence is needed.

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KEY WORDS acute heart failure, cardiac assist devices, cardiomyopathy, inotropes

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