Dobutamine-Mediated Dynamic Left Ventricular Outflow Tract Obstruction Associated with Hypovolemic Shock: Value of Echocardiography and Importance of Early Recognition and Appropriate Volume Substitution

M. Basalus[#,1], S.A.M. Said[1,*], P. Danse[1], H.H. Woltjer[2] and J.H. Fast[1]

Departments of [1]Cardiology and [2]Anaesthesiology, Hospital Group Twente, Streekziekenhuis Midden-Twente, Hengelo, The Netherland

Abstract: A 67-years old woman with no cardiac past history was presented postoperatively after elective surgery for pertrochanteric femur fracture with dyspnea, hypotension, pulmonary congestion, oliguria and tachycardia. Cardiogenic shock was suspected and she was transferred to the Coronary Care Unit (CCU) and treated as such with diuretic and an inotropic agent. No improvement occurred and her condition deteriorated with a new systolic parasternal cardiac murmur. Dynamic left ventricular outflow tract obstruction (DLVOTO) was considered and proven by echocardiographic studies. The inotropic therapy was discontinued and fluid expansion was given. Rapid uneventful recovery occurred. Myocardial infarction was biochemically excluded. Follow-up echocardiography demonstrated mild left ventricular hypertrophy (LVH) without evidence of hypertrophic cardiomyopathy.

Echocardiographic evaluation of critically ill patients deteriorating after the initiation of inotropic treatment for hypotension, especially when a new cardiac murmur is heard, is of pivotal importance since dobutamine-induced DLVOTO, associated with hypovolemia, is conversely treated with discontinuation of inotropic drugs and appropriate volume expansion.

Keywords: Hypovolemic shock, inotropic agents, dynamic left ventricular outflow tract obstruction, echocardiography.

INTRODUCTION

The diagnosis and management are discussed of a patient presenting with postoperative shock unresponsive to the empiric treatment with preload and afterload reduction. Dynamic left ventricular outflow tract obstruction (DLVOTO) was suspected and proven by Doppler echocardiography in the absence of hypertrophic cardiomyopathy (HCM).

DLVOTO is a well-recognised condition which is classically associated with HCM. There are other conditions which can elicit DLVOTO in absence of significant asymmetric septal hypertrophy. One of these conditions is hyperdynamic cardiac state secondary to severe volume depletion [1]. The clinical importance of DLVOTO and its deceptive nature was reason to address this case in a report.

Other important etiologies other than hypertrophic cardiomyopathy inducing DLVOTO are discussed.

CASE REPORT

We present a 67-year-old female patient without antecedent cardiac history who was admitted for elective correction of a pertrochanteric femur fracture.

Shortly thereafter, the postoperative course was complicated with dyspnea, hypotension (85/60 mm Hg), oliguria, tachycardia and hemodynamic instability accompanied by rales over both lung fields. Accordingly, she was transferred to the CCU with suspected cardiogenic shock. Initially, the treatment consisted of diuretics and inotropic support which didn't result in any improvement of her condition. This was the reason for further intensive analysis of this case.

On physical examination, she was febrile (38.4 ˚C), anemic (HB 5.5 mmol/l) with tachycardia (120 bpm), hypotension (85/60 mm Hg) and a grade 2/6 crescendo-decrescendo early-mid systolic murmur was present over the apex radiating to the 2nd right and 3rd left intercostal spaces.

Her ECG demonstrated a sinus tachycardia (120 bpm) with no other abnormalities. Cardiac markers remained negative. Blood chemistry analysis revealed elevated C-reactive protein (128 mg/l, normal 0-10) without leukocytosis and normal renal function and electrolytes. Chest X-ray demonstrated cardiomegaly and bilateral pleural effusion. The combination of signs and symptoms of acute heart failure with no response to diuretic treatment and inotropic support suggested the presence of DLVOTO. This diagnosis was confirmed about one hour after presentation by echocardiography. It is worth mentioning that two-dimensional transthoracic (TTE) and transoesophageal (TEE) echocardiography were conducted under effect of dobutamine (5 μg/kg/min).

The TTE and TEE performed under Dobutamine 210 mcg/min revealed small hyperkinetic and mildly hypertrophic left ventricle with maximal pressure gradient in the left ventricular outflow tract by continuous wave Doppler (Fig. **1A**) of 149 mm Hg and mean pressure of 39 mm Hg and systolic anterior motion (SAM) of the anterior mitral valve leaflet (AMVL) (Fig. **1B**). There was neither pericardial effusion nor signs of cardiac tamponade. Furthermore mild mitral valve prolapse and valvular regurgitation grade II was

*Address correspondence to this author at the Department of Cardiology, Streekziekenhuis Midden-Twente, Geerdinksweg 141, 7555 DL Hengelo, The Netherland; Tel: 074-2905286; Fax: 074-2905289;
E-mail: salah.said@gmail.com
[#]Trainee Cardiology, Medical Spectrum Twente, Thoraxcentre Twente, Enschede, The Netherlands

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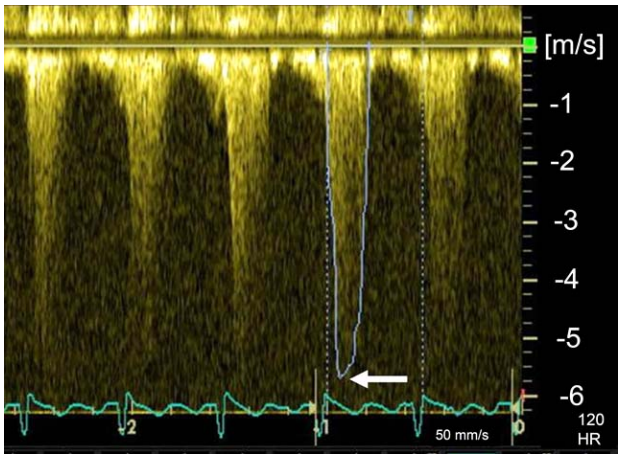
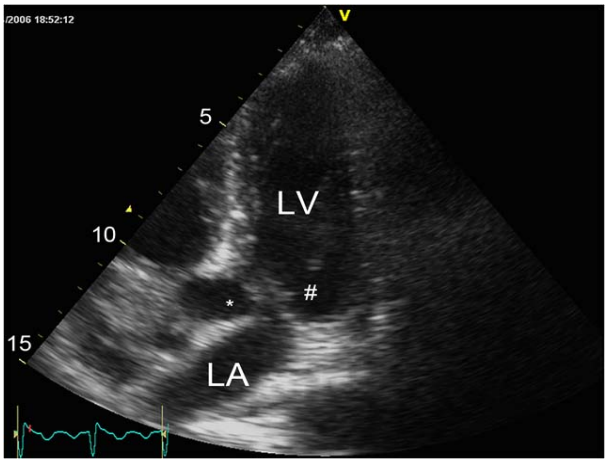


(**A**)



(**B**)

Fig. (1). (1A) During hypovolemia and positive inotropic treatment: The peak pressure gradient measured with continuous wave Doppler in left ventricular outflow tract was 149 mm Hg (arrow) and a mean pressure gradient of 39 mm Hg. The left ventricular cavity was diminished. (1B) Systolic anterior motion of both anterior (*) and posterior (#) mitral valve leaflets is well appreciated.

demonstrated. Care was taken that Doppler alignment was present with flow over the aortic valve. Echocardiography demonstrated significant DLVOTO (Fig. **1A and B**) and resulted in a radical alteration of therapy.

The above mentioned findings confirmed the diagnosis of DLVOTO. Based on this diagnosis, the inotropic support was stopped and volume replacement (19.5 liter of parenteral fluids over 4 days resulted in urine production normalisation from 526 ml/24 hours on day one to 2910 ml/24 hours on day four of her CCU stay) was successfully initiated. She was also treated with an antibiotic course. There was a clear clinical and echocardiographic improvement after fluid substitution with total resolution of symptoms. The clinical improvement was achieved by resolution of dyspnoea, normalisation of blood pressure and normal urine production.

Two weeks later, in absence of exogenous catecholamine stimulation, we conducted a follow-up Doppler echocardiography (Fig. **2A** and **B**) which revealed normal size of the left ventricle, good kinetic in systole, mild LVH and disappearance of left ventricular outflow tract obstruction, mitral valve prolapse and mitral regurgitation.

DISCUSSION

HCM is the most common cause of dynamic LVOTO associated with hypertrophy of basal septum and frequently accompanied with SAM of the AMVL [2].

When a patient presents postoperatively with hypotension together with evidence of peripheral and pulmonary venous congestion, this puts cardiogenic shock on the top of the differential diagnosis [3]. Based on this clinical data, we started the standard treatment for cardiogenic shock due to common causes which included preload and afterload reduction combined with positive inotropic agents. Our patient presented with postoperative shock, dyspnea and pulmonary venous congestion together with a systolic murmur of unknown duration.

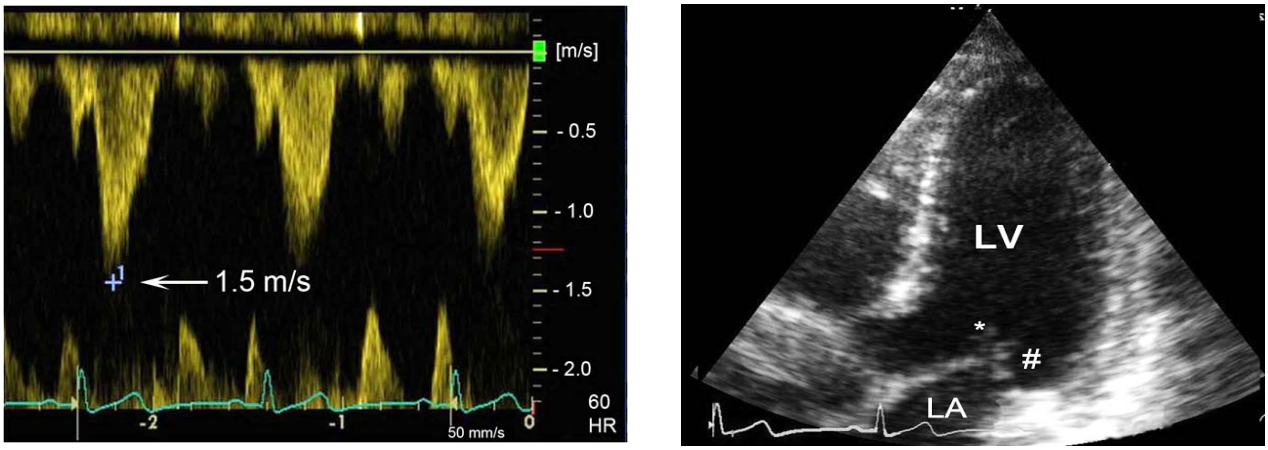
There was no improvement of the clinical condition and the hemodynamic state deteriorated under the chosen treatment strategy. The lack of clinical improvement together with presence of a systolic murmur raised suspicions of DLVOTO.

Because the treatment of DLVOTO works in another direction than the common treatment of cardiogenic shock, we needed a hard evidence to confirm this diagnosis especially in the absence of a history of HCM.

Echocardiography (TTE and TEE) has been recommended to be performed on critically ill patients with unexplained hypotension that is poorly responsive to conventional resuscitative measures [4]. Based on these recommendations we conducted both TTE and TEE. The echocardiographic findings in the form of peak gradient of LVOT (Fig. **1A**) were characteristic for DLVOTO. After discontinuation of the inotropic agent combined with fluid and blood transfusion the pressure gradient returend to normal (1.4 m/sec) (Fig. **2A**).

One of the peculiar aspects of DLVOTO is its treatment strategy which is totally different from treatment modalities of other causes of cardiogenic shock. Treatment strategy of DLVOTO is based on reversing the exacerbating variables. There are several physiologic variables that can potantiate the development of DLVOTO. Obstruction is worsened by a smaller ventricular cavity, decreases in preload [5], increasing ventricular contractility through increases in either endogenous catecholamines or by pharmacologic means [6, 7]. In our patient, based on this therapeutic strategy we started the treatment with volume expansion and discontinuation of the inotropic drug. There was a clear and rapid clinical improvement with normalisation of blood pressure and disappearance of signs of pulmonary congestion. The echocardiographic findings returened to normal.

Sharma *et al*. have shown that patients with end-stage renal disease (ESRD) have high prevalence (12%) of dobutamine-induced significant DLVOTO and the mechanism of DLVOTO was SAM of AMVL and mid cavity obstruction



(**A**) (**B**)

Fig. (2). (2A) After discontinuation of the inotropic agent in combination with parenteral volume supplementation: The pressure gradient returned to normal 8 mmHg. (2B) Systolic anterior motion of both anterior (*) and posterior (#) mitral valve leaflets has disappeared. LA= left atrium, LV= left ventricle.

[8, 9]. Our current case had no renal function disturbances but she had marked hyopvolemia.

Possible mechanism of dobutamine-induced hypotension include ischemic LV dysfunction, systemic vasodilator effect of dobutamine and DLVOT dysfunction.

In our patient, intravasal volume depletion due to postoperative blood loss, a hyperdynamic state resulting from dobutamine administration and predisposing mild LVH represented the most important mechanisms for development of DLVOTO. The finding of a new murmur at the left sternal border and progressive hypotension suggested the presence of DLVOTO.

DLVOTO has been described in a number of other conditions. For example, there are reports of DLVOTO occurring associated with dehydration, hyopvolemia, sepsis, vasodilation, following mitral valve repair or aortic valve replacement, pericardial tamponade and during dobutamine stress tests, excessive sympathetic stimulation, hyperdynamic state resulting from catecholamine adminsitration, hypertensive hypertrophy and pheochromocytoma [1, 5, 6, 10-14].

As in our patient, increased ventricular inotropy can be induced by neurohumoral activation following blood loss, hypovolemia and shock and augmented by pharmacologic intervention with positive inotropic agents.

An understanding of the pathophysiologic processes involved in DLVOTO is required to chose appropriate therapy especially in patients who may be profoundly jeopardized by empiric treatment modalities.

The paradoxical responses to dobutamine in this patient with DLVOTO and hypercontractility can be explained by the physiologic mechanisms and the pharmacologic profile of dobutamine. Dobutamine-mediated inotropic augmentation via stimulation of the beta-receptors (β_1 and β_2 effects) and peripheral vasodilation (β_2 effect) caused enhanced septal thickening. Several physiologic factors may predict the development or worsening of DLVOTO. Obstruction is exacerbated by increased myocardial cortractility due to enhanced septal thickening. Reduction in the ventricular cavity size or in LVOT dimension may all potentiate DLVOTO. DLVOTO secondary to SAM is due to the so-called "Venturi effect" mainly resulting from excessive acceleration of blood leading to sucction phenomenon drawing the mitral valve leaflets inwards toward the interventricular septum causing subaortic obstruction and distortion of mitral valve coaptation [4].

CONCLUSION

When faced with a patient suffering from cardiogenic shock, an almost standard treatment of diuretics and inotropic support is usually started. This treatment modality is widely used because of the importance of quick initiation of treatment. Unfortuntely, some patients remain unresponsive to this treatment modality, but on the contrary they deteriorate. This is what happens in patients presenting with DLVOTO. Because LVOTO can develop even in absence of HCM [15], a high suspicion index is needed to conduct Doppler echocardiographic examinations (TTE and TEE). Doppler echocardiography in the context of cardiogenic shock is life saving when early conducted for unsatisfactory response of shock to the conventional treatment modalities.

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