Refractory pediatric cardiogenic shock: A case for mechanical support

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Abstract

Acute left ventricular dysfunction in children justifies aggressive treatment because of the high potential for complete recovery. The options for providing mechanical support to the failing heart in a child include extracorporeal membrane oxygenation, left ventricular assist devices, and the use of the intra-aortic balloon pump (IABP). The IABP is a commonly used method of temporary circulatory support in adults. However, despite the availability of pediatric size balloons, the usage of IABP for temporary circulatory support in children has not been widespread. Current case report, first from India in pediatric age group, aims to aware the pediatric intensivist about the role of IABP in providing temporary mechanical cardiovascular support in managing patients with refractory low cardiac output state.

Keywords: Cardiogenic shock, intra-aortic balloon pump, myocardial assist device, pediatric shock, refractory ventricular failure

Introduction

Most children with acute myocardial dysfunction requiring mechanical support to maintain blood pressure or perfusion are currently being managed with extracorporeal membranous oxygenation (ECMO) or left ventricular assist device (VAD). However, pediatric intra-aortic balloon pump (IABP) technology is available and its use is feasible for children with acceptable morbidity.[1] The IABP is a volume displacement device designed to provide partial assistance to the failing left ventricle (LV) by inflation and deflation of intra-aortic balloon catheter synchronized to the patient's cardiac cycle. In properly selected group of children with predominantly left ventricular failure, it has been shown to be an effective and lifesaving adjunct to conventional medical treatment of refractory low cardiac output.[1] Herein, we report the successful use of IABP in providing temporary mechanical cardiovascular support in a 13-year-old boy with refractory cardiogenic shock.

Case Report

A 13-year-old boy presented with difficulty in breathing, easy fatigability for last 20 days, and cough with frothy sputum for last 5 days and orthopnea for 2 days. He was a treated case of acute lymphoblastic leukemia and had completed chemotherapy 10 years back. At admission, he had tachypnea, diaphoresis, and features of decompensated shock with fine basal crackles in both lungs and tender hepatomegaly of 5 cm below costal margin. Two-dimensional echocardiography revealed 15% ejection fraction and biventricular dilatation. The serum creatine phosphokinase (CPK), CPK-MB, and troponin I were normal while NT pro B-natriuretic peptide was 1440 pg/ml (n <125 pg/ml). He was diagnosed as a case of cardiomyopathy, possibly anthracycline-induced,

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presenting with acute decompensated heart failure with cardiogenic shock. His hemodynamics were supported with positive pressure ventilation, inotropes, and vasopressors (epinephrine, dobutamine, dopamine, milrinone, and norepinephrine) with maximum vasoactive–inotropic score of 80 on day 5 [Figure 1]. Continuous venovenous hemodiafiltration (CVVHD) was started on day 3 in view of deteriorating renal function (urine output: 0.7 ml/kg/h, blood urea nitrogen: 57 mg/dl, creatinine: 3 mg/dl) and fluid overload (total cumulative positive balance of 2800 ml over initial 60 h). Despite of all these measures, the hemodynamic parameters including blood pressure and perfusion markers were not improving due to persistent poor cardiac contractility. On day 5, intra-aortic balloon (linear 7.5Fr, 34cc, balloon diameter 15 mm, IAB catheter, Datascope

Corp., USA) was introduced through femoral artery under echocardiographic guidance while mechanical ventilation and inotropes were continued. At initiation of IABP at 1:1 frequency with maximum augmentation, there was an improvement in systemic blood pressure and perfusion markers. The inotropes requirement gradually decreased along with lactate levels [Figure 1]. During IABP, intensive monitoring, especially of distal pulses in both lower limbs, peripheral temperature, bleeding from any site, platelet count, and renal function test were continued. The patient developed arrhythmia on day 2 of IABP support which was controlled by amiodarone. CVVHD was continued and renal function improved with adequate urine output. Gradually, inotropes were tapered and then IABP was weaned over 7 days by decreasing the pumping ratio from 1:1 to 1:4 before discontinuation. The child was shifted to oral decongestive drugs; meanwhile, he was extubated and electively taken on noninvasive ventilator support. He developed two episodes of generalized tonic–clonic seizures which were controlled by benzodiazepines and levetiracetam. He remained hemodynamically stable, ejection fraction improved to 35%, and was discharged after 20 days of admission on decongestive measures.
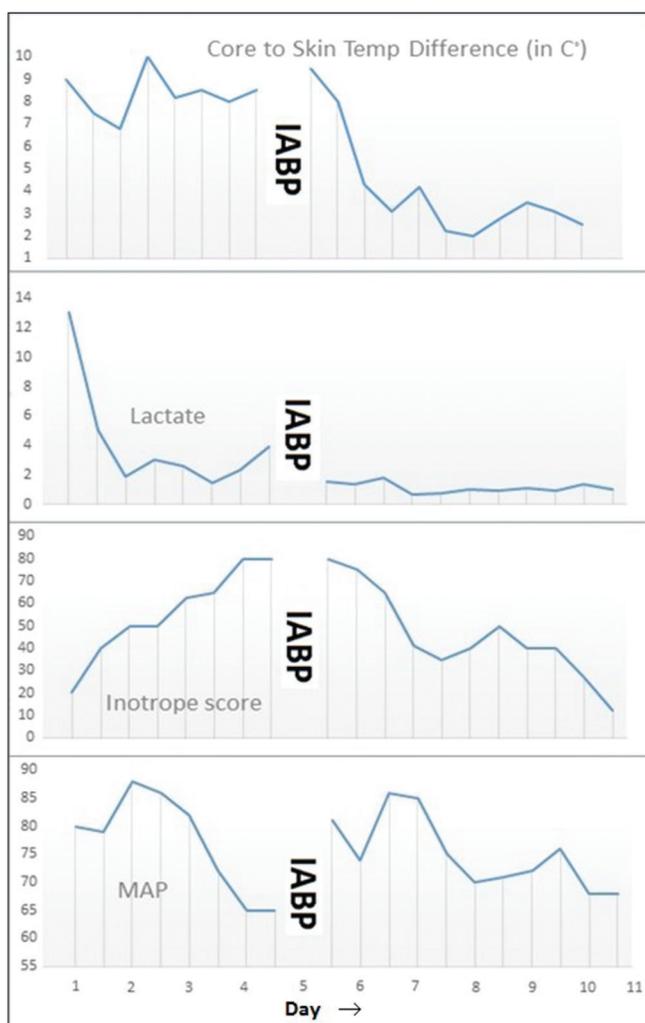
Discussion

To the best of our knowledge and research, the current case report is the first case report from India, describing the successful use of IABP in a pediatric patient suffering with nonsurgical cardiac disease. This was a case of acute decompensated heart failure with cardiogenic shock, secondary to anthracycline-induced cardiomyopathy. As there was no history of fever or symptoms of viral prodrome before the onset of symptoms of heart failure, this case can be presumed to be chemotherapy-induced cardiomyopathy. Anthracycline-induced cardiomyopathy can develop even after 20 years of chemotherapy.[2]

The concept of counterpulsation was first introduced in 1960s wherein rapid withdrawal of arterial blood from the femoral artery during systole and by its reinfusion during diastole resulted in systolic unloading and diastolic augmentation. The basis of this concept was the dependence of coronary blood flow on diastolic blood pressure. This concept further led to the development of IABP by Moulopoulos et al.[3] IABP inflates at the onset of diastole, thereby increasing diastolic pressure and deflates just before systole, thus reducing LV afterload. This results in increased stroke volume and cardiac output ranging from 10% to

Figure 1: Graph showing the trend of mean arterial pressure, inotrope score, arterial lactate levels, and core-to-skin temperature difference, before and after the introduction of intra-aortic balloon pump. Vasoactive-inotropic score: Dopamine dose (µg/kg/min) + dobutamine dose (µg/kg/min) + 100 × epinephrine dose (µg/kg/min) + 10 × milrinone dose (µg/kg/min) + 10,000 × vasopressin dose (U/kg/min) + 100 × norepinephrine dose (µg/kg/min)

40%, decrease in heart rate, pulmonary artery wedge pressures, and augmentation of coronary blood flow. IABP is predominately associated with enhancement of LV performance; however, it may also have favorable effects on the right ventricular (RV) function by complex mechanisms including accentuation of RV myocardial blood flow, unloading LV causing reduction in left atrial and pulmonary vascular pressures, and RV afterload.[4] The ultimate aim is to increase myocardial oxygen supply and decrease myocardial oxygen demand.

Balloon catheters made of polyurethane are available in sizes of 4.5–7.5Fr (balloon volume of 2.5–34 ml) for pediatric use. Balloon sizes are based on the patient's height and when fully expanded should not exceed 80%–90% of diameter of descending aorta. It is inserted percutaneously into the femoral artery using the modified Seldinger technique and then advanced into the descending aorta with its tip 2–3 cm distal to the origin of the left subclavian artery.[5]

Since its introduction in clinical practice in 1960s, the use of IABP has been widespread and well established in adults, particularly in acute myocardial infarction with cardiogenic shock and in high-risk cardiac patients undergoing coronary interventions, both preoperatively and postoperatively.[5] However, its use in pediatric population did not gain widespread importance despite the availability of pediatric balloon catheters and numerous case reports of its successful use in children.[1] ECMO and VADs have been the most prevalent means of mechanical circulatory assistance for children with congenital heart disease. The main reason cited for this is the fact that many congenital heart diseases have biventricular dysfunction along with a component of pulmonary hypertension (e.g., tetralogy of Fallot, single-ventricle physiology lesions) whereas IABP provides support mainly the LV. In these cases, ECMO has been used with greater success as it provides support to both the systemic and pulmonary ventricles and circulations. The success rate of IABP remarkably increases in patients with predominant LV failure (e.g., anomalous origin of the left coronary artery from pulmonary artery, transposition of great arteries, and aortic and mitral valve diseases).[6-10] Apart from surgical conditions, IABP has been successfully used in children with cardiomyopathy, myocarditis, and cardiac trauma.[11,12] Del Nido *et al.* reported the successful utilization of IABP support in a 2 kg infant with low cardiac output of unknown cause.[13]

The rate of complication following IABP use has been comparable to other mechanical devices. Kalavrouziotis *et al.* reported a 16% (4 of 24 patients) incidence of IABP-related complications (transient limb ischemia, mesenteric ischemia, and temporary foot pulse loss). Other complications in their series were related to bleeding (heparin-induced coagulopathy), sepsis, arrhythmia, and pericardial effusion.[1] In our case, apart from one episode of arrhythmia, there were no IABP-related complications.

Being less invasive than ECMO and VAD, simple to use portable equipment and less aggressive anticoagulation needed, IABP gives us the extra advantage for providing LV support as compared to other devices, which require big extracorporeal circuits. Furthermore, it is less expensive than the other modalities.

Conclusion

In selected group of children with predominantly left ventricular failure, IABP can be an effective and lifesaving adjunct to conventional medical treatment of refractory low cardiac output. Being a cost-effective modality, its use may be especially relevant to low income countries.

Conflicts of interest

There are no conflicts of interest.

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