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Transcatheter closure of a patent arterial duct in a patient on veno-arterial extracorporeal membrane oxygenation

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Abstract The presence of a patent arterial duct may complicate the course of the patient on veno-arterial extracorporeal membrane oxygenation (ECMO). While surgical ligation has been traditionally used as a definitive treatment for this problem, transcatheter closure may have advantages. This is the first report of transcatheter occlusion of a patent arterial duct in an infant on ECMO support.

Keywords Extracorporeal membrane oxygenation (ECMO) · Patent ductus arteriosus · Transcatheter closure · Amplatzer device

Introduction

The presence of a patent arterial duct in infants with respiratory failure requiring veno-arterial extracorporeal membrane oxygenation (ECMO) can complicate the late ECMO course [1, 2, 3, 4]. As the lungs recover during the period of mechanical support, so the pulmonary vascular resistance falls, and this can precipitate significant left-to-right ductal shunting with resulting pulmonary oedema. Pulmonary blood flow increases at the expense of systemic perfusion with resulting hypoperfusion of the renal and splanchnic vascular beds and diastolic blood pressure can fall, necessitating the use of additional inotropic and colloid support. This can precipitate a vicious cycle of clinical deterioration, with mesenteric and renal hypoperfusion and worsening pulmonary mechanics.

The traditional approach to ductal closure in the ECMO patient has been surgical ligation. This may be hazardous, because of the risk of haemorrhage in the anticoagulated patient and pulmonary trauma, which is an inevitable consequence of thoracotomy. The use of indomethacin for inducing ductal closure is not recommended during ECMO because of the effects on platelet function.

In children weighing more than 3 kg a transcatheter approach to closure of the patent arterial duct is usually preferable to surgical ligation. This procedure is safe, less invasive and, therefore, involves a shorter recovery period than surgical ligation [5]. Transcatheter duct occlusion may be particularly appealing for the patient on ECMO who will have low pulmonary reserve and is at high risk of bleeding. To our knowledge, there are no reports of this approach in the literature. Recently we encountered an infant who required ECMO, in whom this approach was adopted.

Case report

A 9-month-old, 5.5 kg male infant with Downs syndrome was referred to our centre for management of respiratory failure secondary to respiratory syncytial virus bronchiolitis. Before this acute

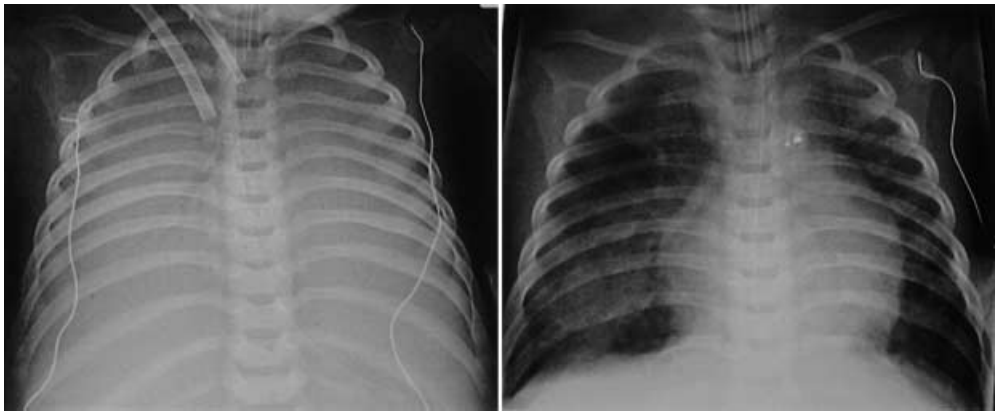

Fig. 1 Chest radiographs which demonstrate a bilateral 'white-out' on day 11 of ICU therapy (day 7 of veno-arterial ECMO) and subsequent clearing of lung fields on day 15 of ICU (the day after decannulation from ECMO)

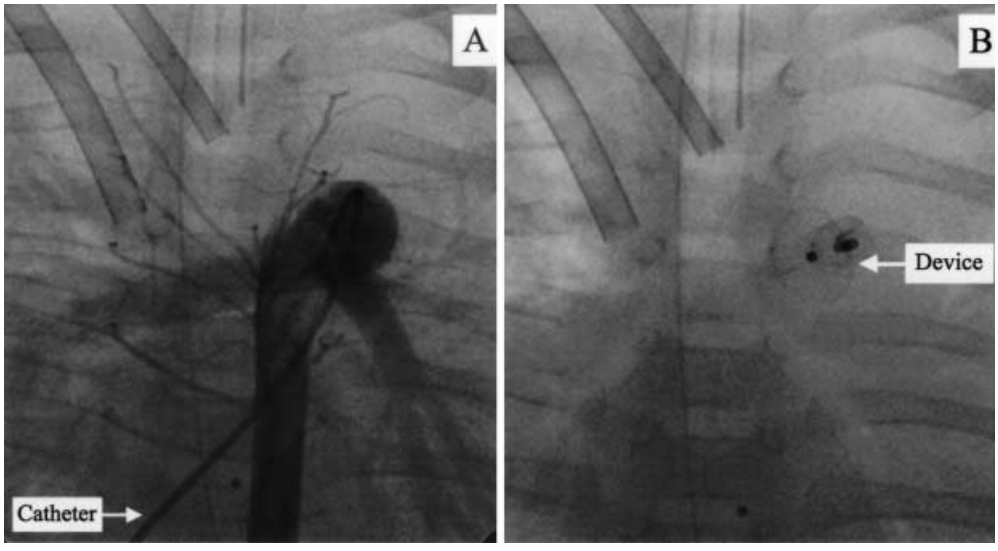

Fig. 2 Angiogram (**A**) via the femoral vein to show the patent ductus arteriosus and angiogram (**B**) demonstrating ductal closure with the Amplatzer device in situ

illness he was known to have a patent arterial duct with left-to-right shunt. At the time of referral the patient had been ventilated for 4 days and had failed to respond to high frequency oscillatory ventilation, surfactant therapy and inhaled nitric oxide. His oxygenation index was 65 and he had systemic hypotension requiring high dose adrenaline and noradrenaline infusions. An echocardiogram revealed a patent arterial duct, now with right-to-left shunting.

The patient was cannulated via the neck vessels for veno-arterial ECMO and inotropic support was discontinued. On day 7 of ECMO support there had been little, if any, change in pulmonary function: lung compliance was negligible and the chest radiograph had, in fact, worsened in appearance with a four quadrant 'white-out' (Fig. 1). The patient was requiring ECMO flows of 150 ml/kg per min and receiving colloid at a rate of 50 ml/kg per day in order to maintain mixed venous oxygen saturations at 60–65%, acceptable mean blood pressure and urine output of more than 1 ml/kg per h. An echocardiogram at this stage demonstrated that ductal flow was now almost exclusively left-to-right, with considerable retrograde blood flow in the descending aorta.

The clinical instability was clearly the result of excessive pulmonary blood flow through the arterial duct, with associated systemic 'steal'. A decision was therefore made to attempt transcatheter closure while on extracorporeal support. The patient was transferred to the cardiac catheter laboratory where duct occlusion was successfully achieved using an Amplatzer device, which was deployed through percutaneous cannulation of the femoral vein (Fig. 2). During the procedure, aortograms were performed by injecting contrast through the arterial limb of the ECMO circuit, thus avoiding an arterial puncture.

Duct occlusion was associated with an immediate increase in the mean arterial pressure from 51 to 61 mmHg and the mixed venous oxygen saturations from 65 to 71%. Within 48 h the pulmonary function had improved with an increase in lung compliance to 0.6 ml/cmH_2O per kg and considerable clearing of the chest radiograph (Fig. 1). The patient was decannulated and placed on conventional mechanical ventilation. He was extubated 10 days after the procedure. A follow-up echocardiogram showed the device to be well-positioned, with no residual ductal flow detectable on colour Doppler.

Discussion

This is the first report of successful transcatheter closure of the arterial duct in a patient on ECMO support. This child was known to have a patent arterial duct, which had previously been associated with a small left-to-right

shunt. The respiratory syncytial virus infection initially resulted in a rise in the pulmonary vascular resistance to supra-systemic levels and a reversal of the ductal shunt (i.e. right-to-left). The pulmonary pressures fell over the first 7 days on ECMO with return of the left-to-right shunt. The difficulties associated with a left-to-right shunt (pulmonary oedema and systemic steal) are exacerbated by veno-arterial ECMO.

We elected to use a transcatheter approach to duct closure because of the potential advantages over surgical ligation, particularly in the context of ECMO – specifically, a reduced risk of bleeding and complete avoidance of pulmonary trauma. Arterial puncture was not necessary because we were able to use the arterial cannula of the ECMO circuit to perform an aortogram, which is necessary to confirm the device position. In our experience, surgical ligation of the arterial duct while on ECMO is associated with a 3-day recovery period. We were impressed by the rapidity of improvement in this patient after transcatheter closure, such that it was possible to decannulate him within 48 h of the procedure.

Left-to-right shunting through a patent arterial duct can undoubtedly complicate lung recovery in patients on veno-arterial ECMO, and we believe that transcatheter duct occlusion may offer important advantages over surgical ligation in this setting.

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