Angiojet thrombectomy for blalock-taussig shunt and pulmonary artery thrombus in an infant with tetralogy of fallot

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ABSTRACT

We describe a new technique for treatment of shunt thrombosis in infants with complex anatomical defects. A 2-month-old girl with Tetralogy of Fallot underwent placement of a modified Blalock-Taussig shunt (MBTS) at day of life (DOL) 6 with revision at DOL 20. Following this surgery, the patient became hypotensive and hypoxic with new evidence of lack of flow through the MBTS on echocardiography. Angiography showed an occluded MBTS and right pulmonary artery with patent distal branches with normal pulmonary venous return. Balloon angioplasty was attempted but failed to fully recanalize the right pulmonary artery (RPA) and MBTS. An AngioJet catheter was then passed through the shunt and RPA to perform rheolyticthrombectomy. Subsequent angiogram showed a widely patent RPA and MBTS. An echocardiogram at 1-month post-thrombectomy showed a widely patent MBTS with continuous flow seen entering both branch pulmonary arteries. The AngioJet system for thrombectomy provides a viable option for complex thrombus removal in patients refractory to other methods.

Keywords: Angiojet rheolytic thrombectomy, infant, pediatric interventional cardiology, shunt thrombosis, tetralogy of fallot

INTRODUCTION

Shunt thrombosis remains a devastating complication that occurs in 7-9% of patients receiving the modified Blalock-Taussig shunt (MBTS).[1,2] We report the use of the AngioJet rheolytic thrombectomy system to restore patency to both a MBTS and right pulmonary artery (RPA) in a 2-month-old infant.

CASE REPORT

A 2-month-old (3.4 kg) girl with a history of Tetralogy of Fallot (TOF) with severe pulmonary stenosis and hypoplastic branch pulmonary arteries (PA) underwent placement of a MBTS at day of life (DOL) 6. This was complicated by shunt thrombosis two weeks later requiring shunt revision and augmentation of her branch PAs.

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On postoperative day 16, the patient underwent a gastrostomy. Aspirin (8 mg/kg every other day) was not withheld prior to surgery. Postoperative day 1 following gastrostomy, she developed hypotension, hypoxia, and respiratory distress. An echocardiogram was not able to visualize flow through the MBTS. Under high suspicion for MBTS occlusion, the patient was taken to the catheterization suite for diagnosis and thrombectomy.

The blood gas in the cardiac catheterization suite from the right radial arterial line showed a pH 7.32, PCO_2 53 mmHg, PO_2 56 mmHg, hemoglobin 16.1 g/dL, and a measured oxygen saturation of 89%.Venous access was obtained in the right femoral vein. A left radial arterial line was placed by anesthesia for intravascular monitoring. A standard dose of heparin was given after vascular access with therapeutic-activated coagulation time of 230 seconds. Angiograms demonstrated occlusion of the MBTS and RPA [Figures 1-4].

Use of thrombolytic agents was ruled out due to the patient's recent cardiac surgery and evidence of an intracranial bleed. Using a hydrophilic-coated end-hole catheter and wire via antegrade course through pulmonary valve, the thrombus in the RPA and MBTS was easily crossed. We first chose to balloon angioplasty as a method of mechanical thrombectomy. Dilation of the thrombus in the RPA was performed using a

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4 mm × 15 mm Emerge Percutaneous Transluminal Coronary Angioplasty (PTCA) Dilatation Catheter (Boston Scientific, Quincy, MA) with four inflations ranging from 2-4 atmospheres. A larger balloon, 5 mm × 2 cm Tyshak Mini (B Braun Interventional Systems, Bethlehem, PA), was used and inflated to four atmospheres on two occasions without residual waist [Figure 5]. The PTCA Dilatation Catheter, used previously, was placed in the MBTS for two inflations each at four atmospheres. Angiography after the balloon dilation of the MBTS [Figure 6] demonstrated partial filling defects from residual thrombi despite serial dilations. We deemed this method failed to re-establish full patency of the RPA and MBT. We therefore elected to proceed with rheolytic mechanical thrombectomy.

The indwelling wire's course was deemed not tortuous for the rheolytic thrombectomy system. A 4-Fr AngioJet (MEDRAD Interventional, Indianola, PA) catheter was passed through the MBTS in two passes with 5 seconds per run. It was then passed through the RPA with one pass. During each run, our patient experienced extreme bradycardia (heart rate 40-60 beats per minute) and hypotension. The bradycardia spontaneously resolved when the AngioJet was turned off. Repeat angiograms after rheolytic thrombectomy showed a widely patent and brisk flow through MBTS [Figure 7A] and RPA [Figure 7B]. The patient's FIO_2 was weaned to 60%. The arterial blood gas showed a pH 7.27, PCO2 63mmHg, PO2 80 mmHg, hemoglobin 12.1 g/dL, and measured oxygen saturation 97%.

The patient was started on a therapeutic heparin infusion after the procedure that was continued for 48 hours. In addition to aspirin therapy, the patient was transitioned to subcutaneous injections of low molecular weight

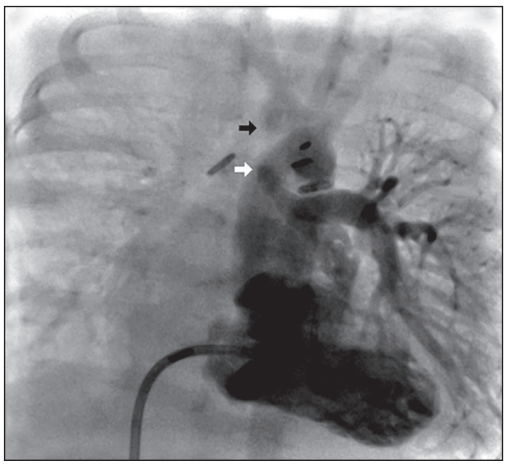

Figure 1: Right ventriculogram demonstrates complete occlusion of the MBTS (black arrow) and right pulmonary artery (white arrow)
MBTS: Modified Blalock-Taussig shunt

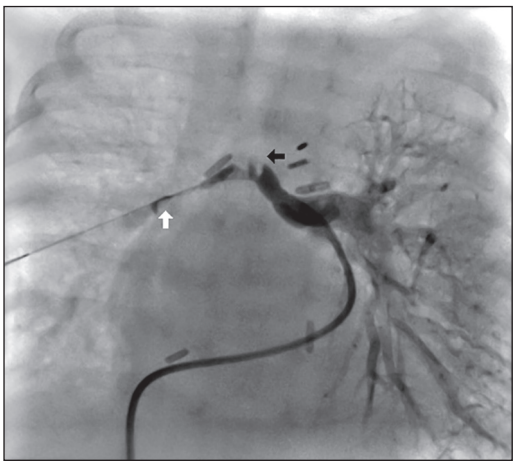

Figure 2: Selective right pulmonary angiogram at the proximal RPA clarifies thrombus formation in the RPA (white arrow) and MBTS (black arrow)
RPA: Right pulmonary artery, MBTS: Modified Blalock-Taussig shunt

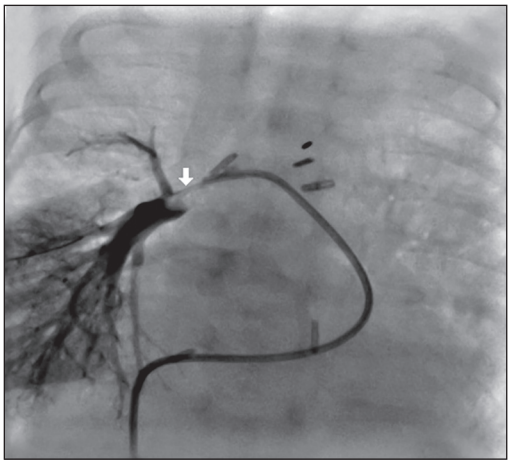

Figure 3: Right pulmonary arteriogram demonstrates a large thrombus occluding the RPA (white arrow) with normal distal branch patency. Pulmonary venous return can be seen returning normally to the right sided pulmonary veins
RPA: Right pulmonary artery

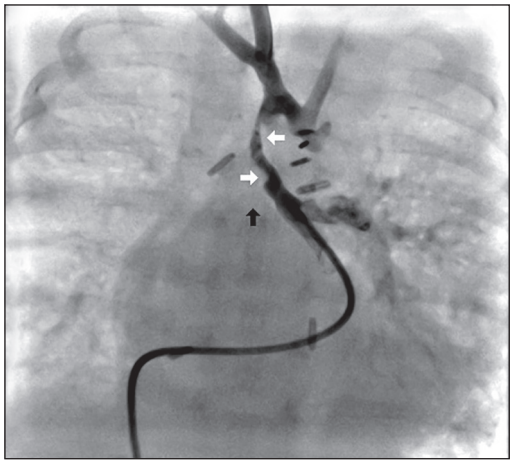

Figure 4: Retrograde angiogram in the MBTS demonstrates multiple filling defects with near occlusion of the MBTS (white arrows). Black arrows represent areas of RPA occlusion
MBTS: Modified Blalock-Taussig shunt

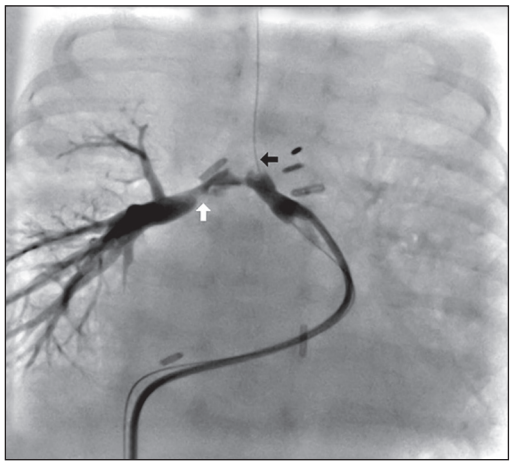

Figure 5: Post balloon angioplasty arteriogram demonstrates patency in the RPA with residual obstruction (white arrow). The mass of the thrombus displaced into the MBTS causing complete occlusion (black arrow)
RPA: Right pulmonary artery, MBTS: Modified Blalock-Taussig shunt

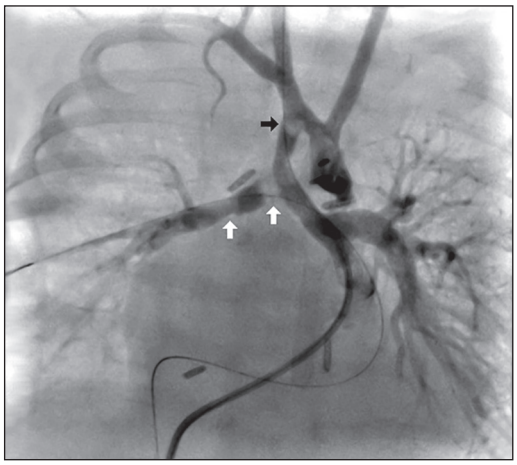

Figure 6: Angiography after the balloon dilation of the MBTS demonstrates improved flow through the MBTS. During the retrograde injection of the contrast into the MBTS, a large mobile thrombus nearly dislodges from the MBTS into the innominate artery (black arow). The RPA has almost complete re-occlusion (white arrows) after angioplasty of the MBTS
RPA: Right pulmonary artery, MBTS: Modified Blalock-Taussig shunt

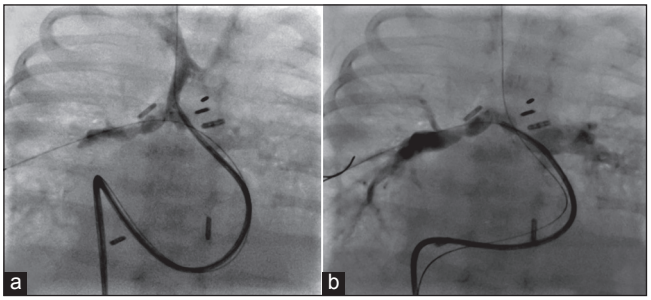

Figure 7: Angiograms after balloon angioplasty and rheolytic mechanical thrombectomy demonstrate a widely patent MBTS (a) and RPA with minor filling defect (b)
RPA: Right pulmonary artery, MBTS: Modified Blalock-Taussig shunt

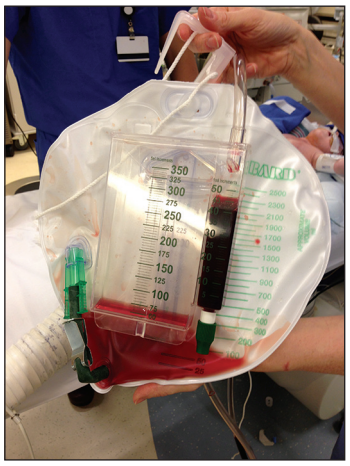

Figure 8: Hemoglobinuria from hemolysis after rheolytic thrombectomy has same appearance as hematuria
RPA: Right pulmonary artery, MBTS: Modified Blalock-Taussig shunt

heparin therapy for 6 months until her definitive TOF surgery. Vasopressin and epinephrine were weaned off by post-procedure day 4. Immediately after the procedure, the patient was visually noted to have gross hematuria [Figure 8]. This, in fact, was hemoglobinuria as a result of hemolysis from the AngioJet. Patient was treated with volume repletion with bicarbonate to alkalinize the urine and mannitol diuresis. The patient suffered no other complications and was discharged home 1 month after the procedure without supplemental oxygen with oxygen saturations in the mid 80% by pulse oximetry. At 1 month post-thrombectomy, an echocardiogram as well as a chest computed tomography scan revealed a widely patent MBTS with continuous flow seen entering both branch pulmonary arteries.

DISCUSSION

Shunt thrombosis remains the most frequent complication following the MBTS procedure.[1] In this case, thrombolytic therapy was a high-risk option which led us to seek an alternative approach. Since the patient had PA continuity with antegrade flow through the pulmonary valve, stent placement in the RPA along with the pulmonary and subpulmonary valve region could have relieved the outflow tract obstruction inherent to TOF anatomy and was considered.[3] However, the risks associated with placing a stent that potentially could not be surgically removed in the future were also considered. We therefore elected to use the AngioJet rheolytic thrombectomy system.

The AngioJet system uses Bernoulli's principle of high flow resulting in low pressure to create a vacuum effect for thrombus removal. The high flow jet from the tip of the AngioJet catheter fractures thrombus formation into smaller fragments before suctioning it into the catheter. This method promotes thrombi that are larger than the catheter to be removed from the vessel. Newly

formed thrombi are easier to remove with this approach in comparison to more organized thrombi. Removing excess thrombus material from the vessel before balloon angioplasty or stent placement can reduce the risk of thromboembolism to unaffected vessels during balloon dilation. The remaining obstructive thrombi can be treated with balloon angioplasty and/or stent therapy.

Risks associated with the AngioJet system include bradycardia and hypotension, which are hypothesized to occur due to cell lysis and release of adenosine during suctioning. Others have reported heart block and hemolysis resulting in acute kidney injury.[4,5] Acute renal failure can result from renal ischemia from hypotension and by direct toxicity of hemoglobin deposition in the glomeruli. Our patient did experience hemoglobinuria associated with hemolysis, yet prompt treatment prevented progression to renal failure.

While reported use of the AngioJet system in neonates and infants remains limited, successful treatment of MBTS and PA thrombosis has been described.[6-8] Here, we report the first use of the AngioJet system to remove thrombus from both the shunt and RPA in a single setting in an infant with TOF and an occluded MBTS. As use of the AngioJet system becomes more prevalent, incidence and complications can be further delineated.

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