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Stenting of the ductus arteriosus originating from the innominate or left subclavian artery in patients with a right aortic arch

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ABSTRACT

We describe our experience with stenting the patent ductus arteriosus originating from the left subclavian artery or innominate artery in patients with a right aortic arch. Patent ductus arteriosus stenting is an alternative to surgical shunt placement in patients with congenital cardiac malformations. Four patients with an elongated patent ductus arteriosus arising from either the left subclavian artery of the innominate artery underwent implantation of multiple stents. The diameter of the stents ranged from 3.5 to 4.5 mm and the length from 8 to 15 mm. Three neonates had tetralogy of Fallot and a right aortic arch, and one 14 month-old patient had discontinuous pulmonary arteries, a right aortic arch, and a ventricular septal defect. In the three neonates with tetralogy of Fallot, we employed an antegrade venous approach. Stent implantation was successful acutely and without complications in all four patients. One patient developed stent restenosis and underwent two additional stent re-dilations 2 months and 5 months after the initial procedure, respectively. The 14 month-old patient underwent planned re-dilation of the stents one month later. All the patients underwent successful complete repair ranging from 149 to 338 days after stent placement. Patent ductus arteriosus stenting in patients with a right aortic arch and a ductus arising from the left subclavian or innominate artery can be performed successfully using multiple stents, particularly in newborns and from a femoral venous approach. Complete repair can be postponed for several months.

1. Introduction

Patent ductus arteriosus (PDA) stenting is an alternative to a surgical systemic-to-pulmonary artery shunt in patients with congenital cardiac malformations. The procedure was first described by Gibbs et al. [1]. Early experience by Gewillig et al. [2] and Kappanayil [3] demonstrated good results in cases with relatively straight PDAs. Subsequently, Alwi et al. [4] and Schneider et al. [5] showed the feasibility of stenting more complex and tortuous PDAs. Usually, the PDA arises from the proximal descending aorta or the underside of the aortic arch. In patients with a right aortic arch, the PDA may originate from the innominate or a subclavian artery. In these patients, the PDA may be amenable to stenting from either a venous or arterial access. In this series, we describe our experience with PDA stenting in 4 patients with a right aortic arch and the PDA arising from the left subclavian artery or the innominate artery. In 3 neonates, the procedure was performed from a venous approach.

2. Methods and results

Informed, written parental consent was obtained prior to each catheterization or surgical procedure.

2.1. Case 1

A newborn male with tetralogy of Fallot (TOF), right aortic arch, severe infundibular stenosis, a PDA from the left subclavian artery and no evidence of a vascular ring was started on prostaglandin E1. He underwent a cardiac catheterization at 3 days; his weight was 3.5 kg. A 4 French sheath was placed in the right femoral vein and a 3 French sheath was placed in the right femoral artery. The patient received 300 units of heparin. A 4 French 2.0 right coronary catheter advanced through the venous sheath was placed in the ascending aorta and advanced into the left subclavian artery. A hand angiogram was performed with 2 ml of contrast. It showed a relatively tortuous, 19-mm long PDA, originating from the left subclavian artery. The minimal diameter was 1.3 mm; the maximal diameter 1.8 mm (Fig. 1A and B). A

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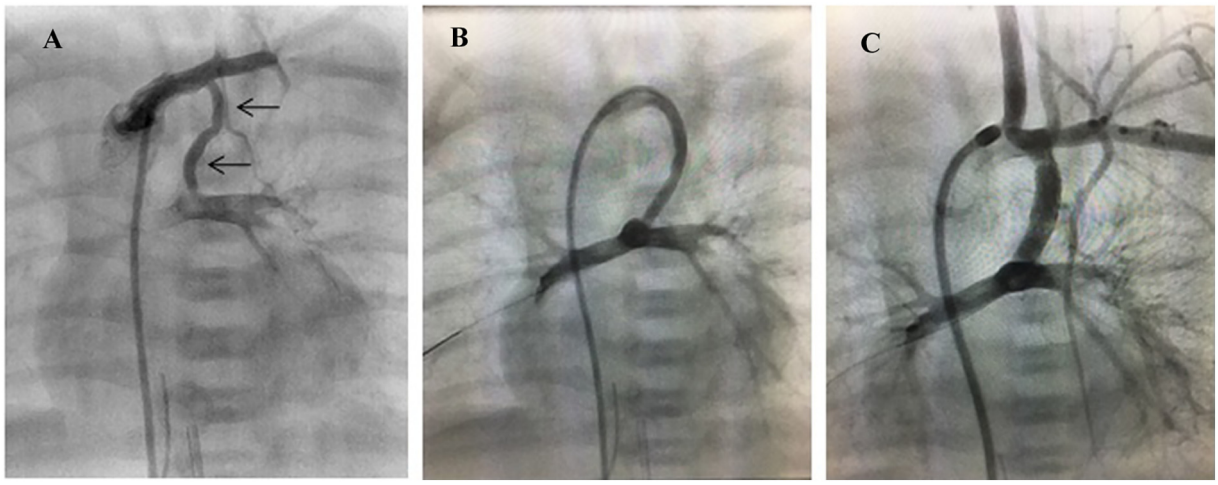

Fig. 1. A. Left subclavian arteriogram showing a small and tortuous PDA (arrows). B. Angiogram in the PDA. C. Innominate arteriogram after stent implantation.

0.014 medium strength coronary wire (Balance Middleweight Universal II, Abbott, Santa Clara, CA) was placed in a distal right pulmonary artery branch. A 4 French 45 cm Check-flow Performer (Cook, Bloomington, IN) sheath was placed in the left subclavian artery. A 3 mm × 10 mm Sprinter balloon (Medtronic, Minneapolis, MN) was used to dilate the PDA. The balloon catheter was removed; an Integrity 3.5 mm × 12 mm stent (Medtronic, Minneapolis, MN) was delivered in the distal PDA, with an inflation pressure of 12 atm. A second stent of the same size was deployed in the proximal PDA with an inflation pressure of 16 atm, achieving a diameter of 3.75 mm. An angiogram was performed in the left subclavian artery (Fig. 1C). The aortic saturation increased from the high 60's to 88%. The prostaglandin infusion was discontinued. A heparin infusion was started and was later transitioned to daily oral aspirin. At 5.5 month of age, complete repair was performed with a limited trans-annular patch, division of the PDA, pulmonary arterioplasty and division of right ventricular muscle bundles. At 11 months, an echocardiogram showed a right ventricular to main pulmonary artery peak instantaneous gradient of 19 mmHg, moderate pulmonary insufficiency and good-sized pulmonary artery branches.

2.2. Case 2

A newborn female with CHARGE association, TOF, pulmonary atresia, right aortic arch and a PDA arising from left innominate artery was placed on a prostaglandin E1 infusion. A catheterization was performed at 15 days; she weighed 2 kg. A 5 French sheath was placed in the right femoral vein. A 3 French sheath was placed in right femoral artery and a 3 French pigtail catheter was used to monitor systemic pressure. A 5 French end-hole catheter was advanced through the venous sheath to the ascending aorta, where an angiogram showed a PDA with a maximal diameter of 4.7 mm proximally, a stenosis measuring 2.6 mm (Fig. 2 A) and a length of 21 mm. A 0.014 medium strength coronary wire (Balance Middleweight Universal II, Abbott, Santa Clara, CA) was advanced into a distal right lower lobe pulmonary artery branch. A 5 French Ansel sheath (Cook, Bloomington, IN) was placed in the PDA. A hand angiogram was performed through the sheath. A 4.0 mm × 12 mm Veriflex stent (Boston Scientific, Marlborough, MA) was placed in the distal PDA. A second stent measuring 4.5 mm × 12 mm was placed in the mid portion of the PDA. A third stent measuring 4.5 mm × 8 mm was placed in the proximal PDA, utilizing an inflation pressure of 17 atm. A final angiogram was performed through the sheath (Fig. 2B). The aortic saturation was 91%. The prostaglandin infusion was stopped. Lasix and Lovenox were started; the latter was transitioned to daily oral aspirin. At 9 months of age, a catheterization showed unobstructed blood flow across the stents. At 11.5 months, the patient underwent repair with closure of the ventricular septal defect, division of the PDA, pulmonary arterioplasty, and insertion of a 14 mm right ventricle to pulmonary artery aortic homograft. At 3.3 years of age, she underwent replacement with a 19 mm right ventricle to pulmonary artery homograft. The most recent echocardiogram at 3.5 years of age showed an unobstructed right ventricle to pulmonary artery conduit, no significant pulmonary regurgitation, unobstructed bilateral proximal branch pulmonary arteries and normal left ventricular function.

2.3. Case 3

A newborn female with TOF, pulmonary atresia, right aortic arch, PDA arising from the left innominate artery, bilateral superior vena cava, duodenal atresia and malrotation underwent repair of duodenal atresia and a Ladd procedure on the first day of life. A catheterization was performed at 5 days of age; her weight was 3.4 kg. A 5 French sheath was placed in the femoral vein and a 3 French sheath was placed in the femoral artery. An angiogram confirmed the PDA arising from the left innominate artery and supplying confluent pulmonary arteries. The diameter of the PDA was 3.1 mm distally and 4.5 mm proximally (Fig. 3A), the length was estimated at 16 mm. A 5 French wedge catheter was advanced through the venous sheath into the ascending aorta and the PDA into a right lower lobe pulmonary artery. Over a guidewire, a 5 French 45 cm-long Ansel sheath (Cook, Bloomington, IN) was placed in the PDA. A 3.5 mm × 15 mm long Multilink Vision stent (Boston Scientific, Maple Grove, MN) was deployed distally in the PDA with an inflation pressure of 14 atm, attaining a diameter of 3.8 mm. A second 3.5 mm × 12 mm stent was delivered into the proximal PDA with the same inflation pressure. A hand angiogram showed unobstructed flow through the stents (Fig. 3B). At 2.5 months, the patient developed episodes of desaturation to the 70's and was referred for re-catheterization. An angiogram showed evidence of neointimal growth inside the stents, with a minimum diameter of 2.4 mm (Fig. 3C). The stents were re-dilated with a 4.5 mm × 15 mm balloon (Fig. 3D). The aortic saturation increased to the high 80's. The patient underwent a second re-dilation of the stents at 5.5 months of age with a 6 mm balloon, resulting in a diameter of 5.2 mm (Fig. 3E and F). A month later, she underwent complete repair with a 16 mm right ventricle to pulmonary artery homograft and ligation of the PDA. At 5.5 years of age, an echocardiogram showed mild to moderate homograft stenosis and mild homograft valve insufficiency.

2.4. Case 4

A 14-month old male presented with a late diagnosis of large