Endovascular stent implantation for coarctation of the aorta in children and young adults: intermediate follow-up results from Turkey

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The aim of this study was to report the intermediate follow-up results of stent implantation for coarctation of the aorta in children from Turkey. Patients with native or postoperative coarctation, who had abnormal flow at the descending aorta exceeding diastolic phase on Doppler echocardiography or upper extremity hypertension, underwent endovascular stent implantation. Ten patients with a mean age of 12.4±5.5 years (6-23 years) underwent stent implantation between January 2001 and September 2006. Of these, three had previous surgical repair, and the remainder were native coarctation. Palmaz, Genesis and Numed CP stents were used. All the implantations were successful and there was no major complication during the procedure. The follow-up period was 8-72 months and only one patient needed re-dilatation during this period. Stent implantation may be a feasible alternative to balloon angioplasty and surgery for adolescents. Patients who have previous surgical repair, high surgical risk, unfavorable anatomy, or refuse consent for surgical intervention are the best candidates for stent implantation. However, longer follow-up and new studies are necessary especially in younger patients.

Key words: coarctation of aorta, recoarctation, stents, congenital heart defects, stent implantation.

Coarctation of the aorta is a congenital narrowing of the descending thoracic aorta, resulting in pathological obstruction of blood flow in the aorta. Until 1981, surgery had been the only choice of therapy in coarctation of the aorta; later, balloon angioplasty was added as a viable alternative to surgery. However, in some cases, like tubular coarctation, the shape and structure of coarctation are not suitable for balloon angioplasty. Residual/recurrent coarctation is also a problem seen after balloon angioplasty or surgery[1-4].

Endovascular stents have been used in various locations since the 1980s and have been used in adolescents and adults for the treatment of coarctation of the aorta since the 1990s[5,6]. We report our experience in using stents for coarctation of the aorta in children and young adults, and offer this approach as an alternative to balloon angioplasty or surgery.

Material and Methods

Patients who had abnormal flow at the descending aorta exceeding diastolic phase on Doppler echocardiography or upper extremity hypertension were considered as candidates for intervention. During the study period, our recommendations were as follows: both surgery and stent implantation were recommended as the treatment of choice in children with native coarctation who weighed more than 25 kg who had not yet reached adult size. Decision was given by the parents in these patients. However, in adult-sized adolescents and adult patients with native coarctation or in patients weighing more than 25 kg with recurrent coarctation, stent placement was recommended as the first choice.

After femoral artery access, an aortogram using a marked pig-tail catheter and catheter pullback from the ascending to descending aorta was

obtained to reveal the coarctation anatomy and pressure gradient. Aortic isthmus before coarctation, coarctation site, distal aorta and aortic diameter at diaphragmatic level were measured. The length of the coarctation site was also noted. We used balloons equal to or 1-2 mm larger than the aortic isthmus and longer than the stents. The stents were chosen according to aortic diameter at the isthmus, coarctation site and coarctation length. We used bare stents, with manual crimping onto the balloons. After the crimping procedure, a multipurpose catheter and an extra-stiff exchange guide wire were advanced to the left or right subclavian artery and finally brachial artery. In some cases, the guide wire was placed in the ascending aorta. A long sheath, >1F larger than balloon-stent diameter, was advanced over the wire and the tip was located at the aortic isthmus. The dilator was then withdrawn and the balloon-stent introduced over the wire. During this procedure, we looked for stent movements. When the balloon-stent reached the end of the sheath, the sheath was pulled back to leave the balloon-stent complex in place. Several hand injections through the side arm of the long sheath were performed and we inflated the balloon with a pressure controlled hand injector, when the balloon-stent was confirmed to be in good position. After stent implantation, we carefully withdrew the balloon to prevent stent migration. Pressure gradient and an aortogram were obtained. In some cases, larger balloons were used to enlarge the stent or to obtain more stent flaring proximal and distal to the coarctation site. The patients were discharged the following day. Aspirin was given as 3-5 mg/kg for six months. In some patients, a second cardiac catheterization and balloon dilatation of the stent were performed more than six months following stent implantation. The patients were followed by echocardiography at every visit and computerized tomography (CT) angiography to reveal any stenosis or aneurysm formation.

Results

Between January 2001 and September 2006, 10 patients (1F, 9 M; mean age: 12.4±5.5 years [6-23 y], mean weight: 35.8-±15.2 kg [17-62 kg]) with coarctation of the aorta underwent cardiac catheterization and stent implantation at our institution.

Coarctations included one tubular and nine discrete coarctations. Of the 10 patients, three had previous surgical repair, and the remainder were native coarctation. Stent implantation was performed in only one case with recoarctation weighing less than 25 kg, who was unresponsive to balloon angioplasty, since the parents strongly refused reoperation. Characteristics of the patients are summarized in Table I.

Angiographic measurement of coarctation revealed minimum coarctation size of 5 mm and maximum of 12 mm (mean: 6.7 mm), isthmus size of 7 to 17 mm (mean: 13.8 mm), and descending aorta size at diaphragm level of 10 to 25 mm (mean: 18.0 mm). Stents preferred were Palmaz-Schatz (n=6), Genesis 3910p (n=3) and Numed CP 8 zig 28 (n=1) stents.

Table I. Patient and Clinical Data

Age (y)/ Weight (kg)	BP before (mmHg)	Pressure gradient Before/after	Additional defects	CoA size	Isthmus size	AA size	Stent type
10/25	135/80	40/0		4.7	12	17	Palmaz 2512
8/24	130/90	24/2		12		14	Palmaz 308
15/62	140/90	33/14		7	17	25	Genesis Pg3910
6/17	130/60	35/4			7	10	Palmaz 308
9/39	140/85	20/12	PDA	9.5	17		Numed CP 28*8
19/60	135/85	36/0	Aortic insufficiency	5	14	18	Palmaz 308
15/40	140/80	42/17	Operated PDA	7.1	17	18	Palmaz 308
23/75	130/75	16/4		6	17	24	Genesis Pg2910
11/29	120/70	30/5	MVP + Mitral regurgitation		16	20	Palmaz 3012
8/37	125/70		Bicuspid aortic valve	2	11	16	Genesis 2910

AA: Abdominal aorta at diaphragm level. BP: Blood pressure from right arm. CoA: Coarctation of the aorta. MVP: Mitral valve prolapsus. PDA: Patent ductus arteriosus.

Comparison of peak systolic gradient measured with echocardiography before and after the stent implantation revealed the effectiveness of stent implantation (Fig. 1). All of the patients were hypertensive before the stent implantation. No patient had reflex hypertensive crises and at the most recent follow-up, no antihypertensive medication was needed.

All implantations were successful and there was no major complication during the procedure (Fig. 2). The follow-up period was 8-72 months and only one patient (N4) needed re-dilatation during this period. In this patient, during the second balloon dilatation of the stent (Palmaz 308) we could not exit from the femoral artery due to balloon tear. The balloon was removed by arteriotomy. This patient underwent arcus to descending aorta bypass using a tubular graft.

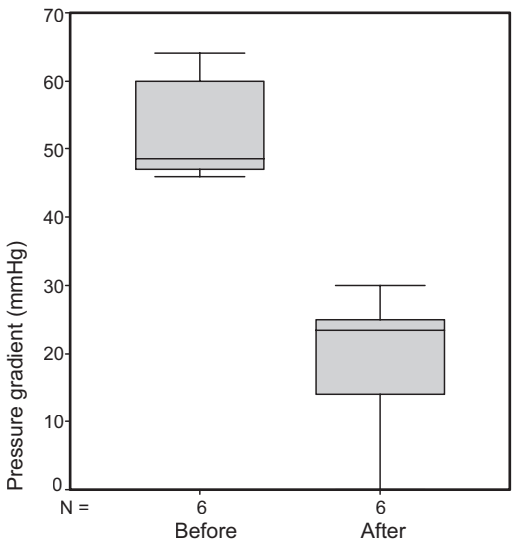

Fig. 1. Comparison of peak systolic gradients before and after the stent implantation ($p<0.05$).

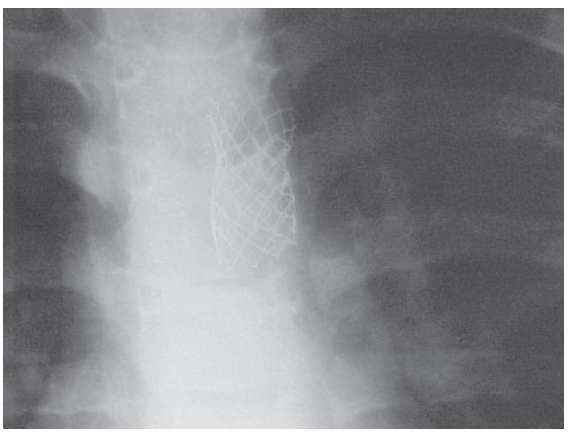

Fig. 2. Palmaz 308 stent after implantation.

Discussion

Surgical repair for coarctation of the aorta has been the only treatment of choice since 1945. Balloon angioplasty emerged as an alternative therapy for coarctation of the aorta in 1982. However, residual/recurrent coarctation, aneurysm formation and aortic dissection are the main disadvantages of balloon angioplasty[1-4]. Moreover, elastic recoil of vessels and unfavorable anatomy such as long tubular narrowing or hypoplasias of the isthmus are the main causes of failure[3].

Balloon expandable endovascular stents have been used in various locations since the 1980s[1], and have been used in coarctation of the aorta in humans since 1989[5,6]. The most common criteria for treating coarctation of the aorta with stents have been previous surgical repair, high surgical risk, refusal of consent for surgical intervention and unfavorable anatomy for balloon angioplasty (tubular long segment, hypoplastic isthmus and hypoplastic distal arch)[7]. Stents provide a homogeneous framework for smooth endothelial growth along the aortic wall that reduces the risk of thrombosis, neointimal hyperplasia and subsequent restenosis. Young age, hypoplastic isthmus and distal aortic arch represent the major drawbacks for balloon angioplasty and also stent implantation[8,9]. In the present study, the patients had undergone previous balloon angioplasty or surgery and had residual or recurrent coarctation.

There are some complications with endovascular stents related with technique, and these affect the aorta and other vasculature. Technique complications are migration or fracture of the stent, rupture of the balloon, and brachiocephalic vessel obstructions[9]. Aortic dissection or rupture of the intima media and aneurysm formation are rare but important complications[3,9]. Although emergent surgical intervention can be lifesaving in the case of severe dissections, dissections may be treated successfully with placement of additional stents, especially covered stents. In the present study, since covered stents were not available during the study period in our center, stent implantation was considered in a very select group of patients with native coarctation to avoid these kinds of complications. In other words, patients with severe and/or very long

segment coarctations having a high risk of aneurysm or aortic rupture during bare stent implantation were directly referred to surgery. Complications related with vascular access are vascular injury, embolism and cerebrovascular attacks. During stent implantation, the vascular injury rate is higher than with balloon angioplasty because of the larger diameter of the material used in stenting. However, lower restenosis risk and aneurysm rates, and re-dilatability make the stent implantation popular. In our series, balloon rupture occurred during the re-dilatation of the Palmaz stent for neointimal hyperplasia. Restenosis may be seen in stents due to the growth of the child, intimal hyperplasia and fracture or compression of the stent.

In recent studies, research is underway on breakable and bioabsorbable-biodegradable stents for clinical use. Newer biodegradable stents are being used in infants today[10-13].

In conclusion, stent implantation may be a feasible alternative to balloon angioplasty and surgery in adolescents. Patients with previous surgical repair, high surgical risk, unfavorable anatomy, or refusal of consent for surgical intervention are the best candidates for stent implantation. However, longer follow-up and new studies are necessary especially in younger patients.

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