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Endovascular management of coarctation of the aorta in adult patients

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ABSTRACT

Background: Coarctation is a congenital heart defect with an incidence of 5–8%, more frequent in boys; however, the overwhelming majority of patients undergo surgery earlier as pediatric patients. Currently, the treatment of choice in adolescents and adults is endovascular management.

Method: We used all three common catheter-based techniques: simple balloon dilatation, stent placement, and stent-graft placement. All treated patients underwent pre- and post-procedural CT angiography.

Group of patients: Between 2004 and 2014, we treated a total of 10 patients with coarctation. They included seven men and three women, with a mean age of 41.1 (21–59) years. Eight patients were treated for native coarctation, and two for re-coarctation. Dominant features included hypertension (eight patients) and left-sided heart failure (four patients); some patients presented with multiple conditions at a time. Simple dilatation was performed in two patients while four had both stent and stent-graft placement.

Results: All procedures were technically successful, with a long-term beneficial effect seen in all patients. All patients with hypertension showed improvement, with medication either reduced or completely discontinued in four cases.

Introduction

The term, coarctation, refers to a narrowing of the aortic isthmus or, in rare cases, of the thoracic or abdominal aorta. It is a local ridge bulging from the posterior and lateral aortic walls toward the ductal orifice, and formed by thickened media or, possibly, intima. Coarctation occurs in 5 to 8% of congenital heart defects, more commonly in boys than in girls, at a ratio of 2–5:1 [1–3]. Its exact cause is unknown. Coarctation should be distinguished from tubular hypoplasia, the latter being a narrowing of the proximal segment of the aortic arch to 60%, distal aorta to 50%, and aortic isthmus to 40%. Unlike coarctation, tubular hypoplasia is characterized by a normal wall structure. Critical aortic narrowing in infants and neonates is associated with completely different hemodynamic and clinical presentations, compared with coarctation in older children and adolescents. Neonates require urgent treatment, which is predominantly surgical given the long-term

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failure rate of balloon dilatation [4]. The currently preferred technique used in adolescents and adults is endovascular treatment, particularly in those with re-coarctation. Our paper presents our experience with this technique.

Materials and methods

All our patients underwent pre-procedural CT angiography and anatomical findings were used to decide on the size of material and technique employed. All patients underwent scheduled, non-urgent procedures.

We used the three standard techniques for catheter-based management: simple balloon dilatation, balloon dilatation with stent placement, and stent-graft placement with additional balloon dilatation. In each case, the decision on the particular technique to be used was made based on the following criteria: (a) simple dilatation with stenoses of borderline significance, anatomically unsuitable for stent placement; (b) stent placement with significant stenoses localized close to arch branches, and in younger patients; (c) stent-graft placement with tight stenoses, older patients, and post-stenotic dilatation. All procedures for endovascular management began with catheterization, an uncomplicated task with less significant stenosis. A challenging problem was trying to pass through the very tight stenoses and post-stenotic dilatation. In this case, we had to use a pre-shaped catheter and to manoeuver a steerable guide-wire within the dilated aorta, which can be difficult, given the small slit provides poor support for the catheter.

The therapeutic strategy changed over the 10-year period, with more sophisticated instruments being used. While simple dilatation was commonly used in the early endovascular era, the currently preferred technique is stent or stent-graft implantation. As the original stents required the use of thick 18–20 F sheaths, actual placement was performed from the femoral artery – similar to stent grafts – using a cut-down approach. Previously, we used custom-made, steel, self-expandable stents made by ELLA, a Czech manufacturer based in Hradec Králové. At present, we use nitinol, laser-cut, self-expandable Sinus-XL stents (OptiMed, Ettlingen, Germany) adapted for 0.035-inch sheaths. The stent size ranged from 28 to 36 mm in diameter, and 40 to 60 mm in length; given the availability of 10 F sheaths, there was no need for groin cut-down. The procedures were performed exclusively under local anesthesia, with bleeding after sheath removal stopped by compression using a Femostop system (OptiMed, Ettlingen, Germany). The same approach was adopted with balloon dilatation using 7 F sheaths for balloon catheters measuring 14 mm in diameter. The type of anesthesia used with stent grafts and stents requiring inguinal cut-down was at the anesthesiologist's discretion, depending on whether epidural anesthesia or general anesthesia was performed. Given the pain associated with dilatation, particularly with tight native stenoses, patients received analgesics (opiates) during the procedure, after which administration continued for as many as several days post-procedurally. Heparin was only administered in patients who developed pelvic artery obstruction that resulted in blood flow reduction due to the thick sheath systems. The stent grafts used in our center were either Valiant (Medtronic, Santa Rosa, CA, USA) or Relay (Bolton Medical, Inc., Sunrise, FL, USA), invariably using the shortest lengths available (100 mm), as all the lesions were short. Both products are identical in design (endograft) featuring a nitinol skeleton on a woven fabric (Dacron). All stent grafts were tubular and of the same width at their proximal and distal ends. The stent-graft diameter was invariably chosen in order to be 20% larger than the diameter of the aorta at its anchoring site.

When opting for simple balloon dilatation, the technique was similar to that employed in percutaneous transluminal angioplasty. Caution had to be exercised in keeping the necessary dilatation pressure in the balloon, since the large-diameter balloon catheters are more prone to rupture. Even tight stenoses were successfully dilated at pressures of 4–6 atm.

When using a stent, dilatation was first undertaken with a smaller-diameter (usually 10–12 mm) balloon, followed by stent placement. The stent diameter was about 10% larger than that of the aorta. The dilatation was subsequently performed using a larger balloon, measuring up to 24 mm in diameter and invariably 20–30% smaller than the diameter of the intact aorta.

The third option for endovascular treatment was stent-graft placement via the femoral artery. Again, the first step was to dilate the tight aortic stenosis with a smaller (10–12 mm) balloon catheter, with the partly dilated stenosis subsequently covered with the fabric component of the stent graft. When necessary, the left subclavian artery was covered, either completely (in patients with a patent right vertebral artery and developed circle of Willis) or partly, to make sure brain perfusion would not be impaired. Prior to opening the stent graft, systolic blood pressure was decreased to a level below 100 mmHg to avoid possible stent-graft migration due to blood flow. Next, the stenosis site was dilated using a balloon catheter, again 20–30% smaller than the diameter of the intact aorta.

Prior to and after the procedure, we performed a direct measurement to determine the pressure gradient, firstly as a confirmation of indication of the procedure, and secondly as the main indicator of technically successful coarctation management. The minimum level of the systolic pressure gradient for the endovascular procedure was 20 mmHg. The measurement was most often made by withdrawal of a pigtail catheter with the values measured above and under stenosis. Less often, pressure was measured with the tip of the catheter above the stenosis in the aortic arch, with the second pressure value obtained from the sheath with the distal end in the iliac artery. Pre-procedurally, the pressure gradients ranged between 20 and 100 mmHg, with the highest post-procedural gradient being 12 mmHg. Our definition of technical success was absence of narrowing of the stent graft (non-significant at most) in the form of residual stenosis or recoil and decrease in the systolic pressure gradient at less than 15 mmHg.

Clinical success was defined as more readily controlled hypertension (reduction of antihypertensive medication or non-pharmacological normalization of blood pressure), absence of claudication or prolongation of the claudication interval, and remission of signs of left-sided heart failure. Post-procedural follow-up included CT assessment. The first