REVIEW
DOI 10.4070/kcj.2009.39.7.261

Print ISSN 1738-5520 / On-line ISSN 1738-5555

Use of Covered Stents to Treat Coarctation of the Aorta

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ABSTRACT

Transcatheter treatments for coarctation of the aorta include balloon angioplasty and stent implantation. However, balloon angioplasty has its limitations and may be associated with complications, such as, recoarctation, dissection, and aneurysm formation, in adult patients. Bare metal stent implantation has offered an alternative during the last decade or so, but covered stents have been used with increasing frequency more recently, to the extent that covered stent implantation is the preferred treatment in correctly selected patients. Primary stent insertion, whether bare metal or covered, prevents elastic recoil of the aorta and may provide better and more predictable results than balloon angioplasty. Furthermore, stents are preferable for the treatment of complex aortic arch obstructions, but their usage is limited to older patients, because of limitations associated with growth. **(Korean Circ J 2009;39:261-263)**

KEY WORDS: Aortic coarctation; Stents.

Aortic coarctation has a wide morphological spectrum that varies from transverse arch and isthmal hypoplasia, which are seen most commonly in newborn infants, to discrete stenosis or membrane like obstructions just beyond the left subclavian artery, which are typically observed in older patients. Occasionally tubular hypoplasia affects a long segment of the thoracic aorta. Blood pressure control can be improved in adult patients after relieving the stenosis, and thus, despite age at presentation, coarctation of the aorta must be addressed to improve long-term outlook.[1]

The techniques of surgical repair of aortic coarctation include excision of the obstruction and end-to-end anastomotic repair, and on occasions, patch repair or even the insertion of a tube bypass graft when the anatomy is more complex. In older patients, surgery can be challenging, and complications include spinal cord damage, pleural effusion, paradoxical hypertension, and infection.[2][3]

Balloon dilation was the earliest form of non-surgical intervention adopted, and was first used in 1982.[4] However, even now the technique has its opponents, because histological data shows that successful relief of stenosis is accompanied by damage to the aortic intima and media, which are difficult to control. In addition, in adult patients, a markedly tortuous aortic segment may involve the coarctation or aortic wall thinning, and cystic medial necrosis may be present.[5] In older patients, calcification of the aorta may also be present. Accordingly, these factors may predispose adult patients to dissection and aneurysm formation or even rupture.

Because of these many concerns, bare metal stents were used to avoid dissection or over-dilation or elastic recoil of the aorta. Stenting may result in less vascular injury than balloon angioplasty alone.[6] Stents also tack intimal flaps to the wall of the aorta, which allows healing to occur without causing intimal dissection, and which reinforces weakened areas. Moreover, this combination of factors could reduce the incidence of aneurysm formation. Stents were first used in 1991 to treat aortic coarctation and have become the procedure of choice in many institutions.[7] However, after obtaining good initial results with stents, a residue of important complications remained, such as, aneurysm formation. It was considered that these complications were due to the full dilatation of tight coarctations with a stent in a single procedure, and thus, the technique was modified to reduce the incidence of aneurysm formation. This modification involved partially inflating a stent during an initial procedure to 60-70% of its planned final diameter, and redilating it fully 6-12 months after initial implantation.[8][9] However, in cases of bare metal stenting, complications, such as, aneurysm formation, stent malposition, and vascular complications, occur even af-

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ter making these modifications, although death and the need for emergency surgery are rare.[10][11] Despite a lack of data in the literature, acute procedural results indicate that stenting produces more predictable results and is safer than balloon angioplasty. Furthermore, the stenting of aortic coarctations is effective at achieving acute and sustained reductions in blood pressure gradients. Usually a residual obstruction is caused by unsuspected transverse arch hypoplasia. Complications, such as, deaths may occur in 0-1.4% of cases after stenting, and neurological damage in 0-3.7%, although the vast majority of studies have reported no neurological damage following treatment. Aneurysm formation occurs in 0-17% of cases after bare metal stenting, but stent fracture is uncommon and is usually of no clinical significance. Other complications during stent insertion may be related to vascular access, and include avulsion, stenosis at the entry site, false aneurysm formation, thrombosis, stent migration, balloon rupture, paradoxical hypertension, and endocarditis.[10][11] On the other hand, although neo-intimal proliferation may occur, it is rarely a significant problem.

A variety of covered stents are available for clinical use in Europe. These include the covered Cheatham-Platinum stent, the Jomed covered stent, the recently commercialized Atrium stent, and various stent grafts used to treat atherosclerotic aneurysms of the aorta.[12] The covered stent most commonly used to treat aortic coarctation is the covered Cheatham-Platinum stent.[13-15] This stent has been used as a rescue treatment in patients with aneurysms or with previous stent-related complications, or as primary treatment in patients with an elevated risk of developing complications due to a complex anatomy (e.g., near interruption or a tortuous aortic arch), or in patients beyond the third decade.[16-19] In many cases, covered stents also tend to be dilated to about 70% during the first procedure, and no attempt is made to match the stent to the dilated aorta by flaring. Nevertheless, in the region of the coarctation, a covered stent should be apposed to the aortic wall.

Additional indications for covered stent placement include adult patients with a localised or long-segment native aortic coarctation, aortic recoarctation after previous treatment, aneurysms that have previously undergone surgical or interventional treatment, and patients with coarctation associated with a patent arterial duct.[20-23] Furthermore, in patients with a long affected segment or a near atretic coarctation, covered stents can be implanted safely with good results.[24][25] One study reported on nine patients, in whom, indications for covered stenting included; a tight or atretic native coarctation, an age of over 50 years of age, a patent arterial duct, an aneurysm, or a fractured previously implanted stent.[26] In two patients over 35 years of age with an aneurysmal ascending aorta, aneurysm formation was ascribed to implanted stents at follow up.

Covered stents cannot be substantially re-expanded, and thus, should be avoided in growing children, but in one study, stents were re-dilated 6 months after initial under-dilation and residual gradients were abolished. However, in one of the four patients involved, a stent fractured and the implantation of another covered stent was required.[24] Butera et al.[27] also demonstrated the feasibility of re-dilating covered stents in 7 children at a mean 20 months after initial implantation. No complications were encountered.

Dissection or rupture of the aorta is an important indication for the need for re-implantation, and thus, covered stents should be available for bail-out purposes. However, it is noteworthy that aortic rupture can occur even with implantation of stents.[28][29]

Covered stents have also been used to treat pseudoaneurysms which form after the conventional stenting of an aortic coarctation.[30] Kenny et al.[31] used both self-expanding and balloon-expandable covered stents to treat aortic coarctation in 37 patients aged from 9 to 65 years, and encountered aortic rupture in one patient. However, few reports are available that address the use of covered stents as a primary treatment for coarctation, rather than for aneurysm formation. In a study of 22 patients, one patient required a further covered stent because of rupture of the aortic wall.[29] Nevertheless, it is encouraging that no report has been issued on aneurysm formation after covered stent placement.

The use of covered stents presents the risk of spinal cord injury due to possibility of occlusion of spinal arteries, although these arise well below the level of coarcation, usually at the level of T9-12 vertebrae. Furthermore, clinical anxieties related to spinal cord injury due to covered stents are not substantiated by the literature on the stent grafting of distal atherosclerotic aortic aneurysms, during which considerable segments of the aorta are covered, and for which the risk of spinal cord damage appears to be 1-4%.[32]

Covering the origin of the subclavian artery may be of concern, although ideally a reasonable distance between the origin of the subclavian artery and the site of coarctation is needed, in many patients the left subclavian artery is too close to the coarctation and covering its origin cannot be avoided. Surgical data from patients in whom the subclavian artery is used as a flap, and thus sacrificed, and recent experience with stent-graft implantation for distal aortic disease, which invariably involves covering the origin of the left subclavian artery, suggest that complications are rare. Nevertheless, ischaemia of the right arm has been reported in an adult patient, in whom an anomalous origin of the right subclavian artery was covered intentionally with a stent graft, which was implanted because of false an-

eurysm formation after repair of an aortic coarctation. In this case, the ischaemic arm was treated conservatively and symptoms improved.[33]

Indications for the use of covered stents to treat aortic coarctation and its related complications are wide ranging and continue to expand. Indeed in adults, covered stents may be considered the primary treatment of choice for native aortic coarctation.

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