Stent Implantation in Congenital Heart Disease: 
A New Therapeutic Modality

AKT CHAU

Abstract

Vascular stenoses and hypoplasia in children are often associated with congenital heart disease or occur as a residual lesion or complications after surgical repair. Among these lesions, branch pulmonary artery stenoses are the commonest, other lesions include coarctation of aorta, stenosis of systemic veins after Fontan repairs, post-operative pulmonary venous stenosis, aortopulmonary collateral artery or shunt stenosis and post-operative conduit stenosis. They are usually associated with significant mortality or morbidity if untreated. Conventional surgical repair for these vascular stenoses may be difficult, carries a high operative risk or is associated with disappointing outcome. Some of the lesions may even be surgically inaccessible. Balloon angioplasties may be effective in relieving obstruction in some of these lesions. It can achieve successful dilation in about 60% of branch pulmonary arterial stenoses but the success rate may be lower in other lesions. Furthermore, the effects of balloon angioplasties in many lesions are often temporary and restenosis as a result of elastic recoil or subsequent scarring and fibrosis is common. Implantation of a stent provides a firm support and maintain patency of the vessels after balloon dilatation. Both balloon-expandable and self-expanding stents have been used to treat various vascular stenoses but available evidence suggests that the former is more suitable for use in children as it can be redilated to a higher diameter to keep pace with growth and is associated with fewer complications. The clinical application of stent implantation to treat various vascular stenoses and congenital heart diseases has been continuously widened since the late 1980s. It has replaced surgery as the treatment of choice in branch pulmonary arterial stenoses, post-surgical recoarctation of aorta that are unresponsive to balloon angioplasty, systemic venous obstruction and systemic venous baffle obstruction in Mustard or Senning operations. In native coarctation beyond young infancy, stenting is increasingly accepted as a primary treatment in adolescence and adults to avoid the higher surgical risks in this group of patients. In young children who do not respond to primary balloon angioplasty for native coarctation, stent implantation has also become an accepted treatment provided a stent that allows redilation to the adult aortic diameter is used. Stent implantation in conduit stenosis can prolong the life span of the conduit and delay the time of reoperation. In complex heart diseases where there is aortopulmonary shunt or aortopulmonary collateral artery stenoses, stent implantation serves as an effective alternative to surgical treatment. Stenting of the arterial duct has been increasingly incorporated into the management strategy of complex pulmonary atresias and hypoplastic left heart syndrome. Transcatheter approach using stents to complete the Fontan palliation may avoid multiple operations in patients with univentricular heart. Percutaneous pulmonary and aortic valve implantation to treat the

Division of Paediatric Cardiology, Department of Paediatrics & Adolescent Medicine, Grantham Hospital, The University of Hong Kong, 125 Wong Chuk Hang Road, Aberdeen, Hong Kong, China

AKT CHAU (周啟東) FRCP(Edin), FRCPCH, FHKAM(Paed)

Correspondence to: Dr AKT CHAU

Received April 21, 2005
Background of Development of Endovascular Stents

Vascular stenoses and hypoplasia in children are often associated with congenital heart disease or occur as a residual lesion or complications after surgical repair. These vascular obstructions can occur in arteries or veins of both the pulmonary and systemic circulations. Among these lesions, branch pulmonary artery stenoses are the commonest, other lesions include coarctation of aorta, stenosis after cavopulmonary shunt or Fontan repairs, post-operative pulmonary or systemic venous stenosis, stenosis of aortopulmonary shunts or collaterals, and post-operative conduit stenosis. Untreated vascular stenoses cause significant mortality and morbidity and will severely affect surgical outcome.

Though conventional surgical repair is effective in some of these vascular stenoses, the operations may be difficult, carries high operative risks or are associated with disappointing outcome. Recurrence of stenoses requiring reintervention is also common. Furthermore, some of the vascular stenoses may be located at surgically inaccessible sites. Therapeutic cardiac catheterisation, therefore, has been developed for more than two decades as alternatives to surgical repair.

Balloon angioplasty or dilation of the stenotic vessel is effective in many lesions. It works by tearing the intima and part of the media to allow remodeling or growth of the stenosed vessel at a higher diameter. Varying degrees of success has been reported for different lesions. Although immediate results may be satisfactory, sustained relief of obstruction can be achieved in only a certain proportion of patients. Restenosis is common. It is due to elastic recoil of the stenosed vessels, subsequent scarring and fibrosis, or external compression. This has urged clinicians and researchers to look for new interventional transcatheter procedures to relieve vascular stenoses.

The concept of using a rigid framework, like a metallic framework, to support the stenosed vessel after balloon angioplasty and thereby preventing restenosis caused by elastic recoil or scarring was first introduced by Dotter as early as 1969, using a coil spring endarterial tube graft implanted into a canine popliteal artery to relieve obstruction. However, because of many unresolved technical issues, progress was slow in the following decade. With subsequent advances in technology, Palmaz reported successful use of a metallic, expandable stent, the Palmaz stent (Johnson & Johnson Interventional Systems, Warren, New Jersey), to relieve obstruction in aorta, carotid, iliac and renal arteries, which was followed by its use in intrahepatic porto-caval shunt in dogs in 1985. In 1987, Schatz, from the same group of researchers, reported success of balloon-expandable intra-coronary stenting in adult dogs. Success in animal studies prompted a series of clinical trials. In 1988, Palmaz reported a multicentre trial of intra-luminal stent implantation in atherosclerotic iliac artery stenosis. Thereafter, stent application to treat coronary artery stenosis has become widespread.

As for congenital heart disease, Mullins et al first described in 1988 successful stent implantation in pulmonary arteries and veins in an experimental model. Subsequently, O'Laughlin et al from the same institution reported in 1991 the first success of stent implantation in patients with congenital heart disease. Since then, stents have been used to treat a variety of cardiac lesions including complex congenital heart disease with encouraging results.

Types of Stents and Techniques of Implantation

Two basic types of stents are currently available. They are the balloon-expandable and self-expanding stents (Figure 1). As vessel diameters in congenital heart disease