Use of self expanding stents in stenotic aortopulmonary shunts in adults with complex cyanotic heart disease

R Bader, J Somerville, A Redington

Abstract

**Objective**—To describe the use of self expanding stents in treating long segment stenosis of aortopulmonary shunts (APS) in adults.

**Design**—Clinical records, catheterisation data, cineangiograms, and operation notes of four consecutive patients undergoing stent implantation since December 1994 were studied retrospectively.

**Setting**—A tertiary referral centre for cardiac disease.

**Subjects**—Four patients underwent cardiac catheterisation because of clinical deterioration. Their age ranged between 23 and 32 years. The underlying diagnosis was complex cyanotic heart disease in all. Three had a stenotic interposition graft, and one had a classic Blalock shunt.

**Results**—There was one technical failure owing to migration of the stent distal to an ostial stenosis. The ability index, resting oxygen saturation, and exercise tolerance improved in the remainder. Their medium term results have been excellent.

**Conclusions**—This technique may further palliate adult patients with complex congenital heart disease, though the long term patency of stents is unknown.

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Keywords: congenital heart disease; stents; aortopulmonary shunt

The use of endovascular stents for the treatment of pre- and postoperative stenotic pulmonary arteries and other vessels is now widely reported in congenital heart diseases. Stents may be particularly relevant to the adult with congenital heart disease, and may avoid the need for demanding surgical intervention. The use of balloon expandable stents in occluded or stenosed Blalock-Taussig shunts has been reported in a small number of infants. In this report we describe the use of self expanding stents, which may have inherent advantages, particularly when treating long segment stenosis of multiply stenotic vessels in older patients.

**Methods**

**Patients**

Four patients undergoing cardiac catheterisation to investigate increasing cyanosis were included in the study. Their underlying condition, previous surgery, and anthropometric data are given in table 1.

All had previously undergone at least one systemic arterial to pulmonary artery shunt procedure: one classical Blalock-Taussig shunt, two modified (Impra graft) Blalock-Taussig shunts, and one central ascending aortic to left pulmonary artery shunt. Patients were considered for stent implantation if they had stenotic shunt lesions which could not be relieved adequately by standard balloon dilatation.

**Technical Details**

The technical details were the same in each case and similar to those described previously. Cardiac catheterisation was performed under general anaesthesia in all. Following the diagnostic part of the procedure, a retrograde arterial catheter was passed through the stenotic systemic arterial to pulmonary arterial shunt. A 0.035 inch exchange length guide wire was placed in the distal pulmonary arterial tree. The desired length of the self expanding stent was assessed by withdrawing the indwelling catheter across the area to be stented, taking the distance removed at the groin as the desired length of the deployed stent. The desired diameter was assessed either from the original size of the implanted prosthetic material, or the desired size of the communication (in the patient with the classic Blalock shunt). The self expanding stent delivery system (Wallstent-Schneider) was passed through the indwelling femoral arterial sheath retrogradely into the shunt. It was then deployed in the usual way, taking care that both the distal and proximal ends were in the ideal position. In general, the distal end of the stent was opened distal to its ultimately desired position, and when 50% or so of the device had been deployed it was pulled back into optimal position. The delivery system was then withdrawn and repeat

**Table 1** Anthropometric and diagnostic data from each patient

<table>
<thead>
<tr>
<th>Case</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Diagnosis</th>
<th>Procedure/AOP (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>32</td>
<td>DILV, VA discordance, congenital valvar PS</td>
<td>Modified left BTS (8 mm)/29</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>23</td>
<td>CPA, non-confluent PA</td>
<td>Central aortic to pulmonary shunt (6 mm Gortex)/23</td>
</tr>
<tr>
<td>3</td>
<td>Female</td>
<td>24</td>
<td>CPA</td>
<td>Modified right BTS (6 mm Gortex)/5; Conduit RV–PA (8 mm)/15</td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>28</td>
<td>TGA, VSD, sub-PS, hypoplastic RV, straddling TV</td>
<td>Successful right pulmonary artery balloon angioplasty/22</td>
</tr>
</tbody>
</table>

AOP, age at operation in years; BTS, Blalock-Taussig shunt; CPA, complex pulmonary atresia; DILV, double inlet left ventricle; PS, pulmonary stenosis; RV, right ventricle; TGA, transposition of great vessels; TV, tricuspid valve; VSD, ventricular septal defect; VA, ventriculoarterial.
haemodynamic measurements and angio-
graphy was performed in the usual way. All
patients were subsequently heparinised until
they were fully anticoagulated with warfarin to
 maintain an international normalised ratio of
between 2.5 and 3.5.

Results
The haemodynamic variables, oxygen satura-
tion values, exercise tolerance, and follow up
are given in table 2. Four stents (6–8 mm
diameter, 37–55 mm length) were implanted.
 There was one procedural failure (patient 2).
In this patient, stent implantation to relieve an
ostial as well as multiple distal stenoses of an
ascending aorta to left pulmonary artery shunt
was initially satisfactory. However, during the
first five to 10 minutes after implantation, the
stent migrated distally, so that the ostial steno-
sis was unrelieved. Despite this there was some
improvement in the distal pulmonary artery
pressure, although resting oxygen saturation
values were unchanged. No other procedural
problems were encountered, the stenosis being
completely relieved in the remainder (table 2).

Pre- and postprocedural angiograms from
patient 4 are shown in fig 1.

FOLLOW UP
Follow up has extended from 1.6 to 3.5 years
(table 2). Patient 2 (see above) underwent a
modified Blalock-Taussig shunt distal to the
migrated stent with good e
V ect. Two patients
have had a sustained, excellent symptomatic
relief. One patient was non-compliant of treat-
ment, and decreasing oxygen saturations were
noted approximately six months after stent
implantation. At restudy there was a 30%
reduction in stent lumen owing to thrombus.
Interestingly the distal pulmonary artery pres-
sure (39/10/21 mm Hg) was higher than the
immediate post-stent values and he has re-
mained well palliated (resting oxygen satura-
tion 80% at 2.9 years follow up), having
reinstituted warfarin treatment.

Discussion
We describe four consecutive patients in whom
stenting of a stenotic systemic arterial to
pulmonary arterial shunt was attempted.
There was one technical failure (case 2) in
whom the stent migrated beyond the most
proximal stenosis at the ostium of the shunt,
at its aortic origin. In this patient the stent was
placed so as to minimise the amount of stent
projecting into the ascending aorta. A self
expanding system was chosen because of the
long segment stenosis (39/10/21 mm Hg) was higher than the
immediate post-stent values and he has re-
mained well palliated (resting oxygen satu-
ration 80% at 2.9 years follow up), having
reinstituted warfarin treatment.

Table 2 Procedural results with outcome data

<table>
<thead>
<tr>
<th>Case</th>
<th>Before stent</th>
<th>After stent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Resting O2 sat (%)</td>
<td>ET (min) / O2 sat (%)</td>
</tr>
<tr>
<td>1</td>
<td>69</td>
<td>100 m/62</td>
</tr>
<tr>
<td>2</td>
<td>82</td>
<td>50 m/50</td>
</tr>
<tr>
<td>3</td>
<td>62</td>
<td>5/48</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
<td>2.5/42</td>
</tr>
</tbody>
</table>

† where exercise tolerance was very poor, metres walked was used as the exercise tolerance measure.

ABI, ability index; ET, exercise tolerance on modified Bruce protocol or walking flat; FU, follow up; O2 sat; oxygen saturation in room air (pulse oximeter); PDS, pressure distal to stenosis; stent size (mm), diameter × length.

Figure 1  Angiograms done (A) before and (B) after stent insertion in patient 4. A single (8 mm × 4.1 cm) self expanding stent completely relieves the multiply stenotic vessel.
of 5 atmospheres or less. On this occasion, although the stenosis was balloon dilatable, the inflation pressure was not measured and this clearly was a mistake. Subsequently, however, at the patient’s choice, successful surgery was performed (a modified Blalock-Taussig shunt distal to the stenosed shunt).

In the other three patients, successful deployment was associated with marked improvement in oxygen saturation and exercise tolerance. As such, the results are similar to those found in our previous study of patients with complex pulmonary atresia. In those patients, stenting of stenotic naturally occurring aortopulmonary collaterals also led to improvement in pulmonary blood flow and exercise tolerance. The medium term results in the current study have been excellent in the two patients who were compliant of oral anticoagulation. In the other (case 3), there was a late deterioration in oxygen saturation, coincident with failure of compliance with anticoagulation therapy. Although this patient remains well palliated, this further underscores our impression that oral anticoagulation is mandatory in patients in whom a relatively small stent has been placed in areas of relatively sluggish flow and in the presence of marked erythrocytosis and cyanosis. Indeed, a similar outcome was observed in the only patient non-compliant of anticoagulation in our previous report.

We feel our data support the continued use of stents in this situation. While it is probable that multiple overlapping balloon expandable stents could have been used in all of these patients (in whom there were long segment and multiple stenotic lesions), self expanding stents are ideally suited for the type of stenoses often seen in these patients, with the one caveat noted in patient 2. There remain unanswered questions, however. Even though the medium term results are promising, the long term patency of the stents, even with anticoagulation, is not yet known.

In summary, we have described the successful application of self expanding stents to the treatment of stenotic aortic to pulmonary shunts. This technique seems to have a role in the further palliation of adult patients with complex congenital heart disease.

We thank Ms Julia Peatling for her invaluable help in the preparation of this manuscript.

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