Coarctation of the aorta: nonsurgical treatment using stent implantation

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INTRODUCTION Coarctation of the aorta (CoA) accounts for 5%–8% of all congenital heart defects.\textsuperscript{(1-3)} When CoA is significant, it requires surgical or endovascular intervention. If left untreated, most patients with significant CoA will have varying degrees of morbidity (e.g. hypertension, stroke, formation of collateral vessels, ventricular hypertrophy and heart failure) and may not survive beyond the fourth decade of life.\textsuperscript{(2)}

Generally, the indication for intervention in CoA is a more than 50% decrease in lumen diameter at the narrowed site and/or a pressure gradient of more than 20 mmHg at rest. Although CoA is usually detected in children, it may recur or be diagnosed in adolescents and adults. Surgical treatment of CoA was first described in 1945,\textsuperscript{(4,5)} and till today, remains the treatment of choice. However, recently, less invasive methods such as balloon dilatation and/or stent implantation have been used to treat CoA in elderly patients.\textsuperscript{(4,5)}

Compared to balloon angioplasty, stent implantation has a reduced risk of aortic tears, and results in a lower residual gradient.\textsuperscript{(4,5)} Stent implantation also improves luminal diameter, sustaining the procedure’s haemodynamic benefit,\textsuperscript{(6-12)} though hypertension may persist in some patients.\textsuperscript{(14,15)} Even though CoA stenting is effective,\textsuperscript{(14-16)} it is a technically challenging procedure, and local data on the approach is needed. Therefore, we aimed to study a series of patients with CoA treated nonsurgically, focusing on their resultant CoA gradient and CoA diameter, so as to document the implementation of this procedure in a local centre.

METHODS We retrospectively reviewed four patients (2 men and 2 women; age range 20–41 years) who underwent CoA stenting under general anaesthesia for the treatment of native CoA or restenosis of CoA at our institution. Three patients had a 40-mm Palmaz stent inserted, while one had a 39-mm Cheatham-Platinum covered stent inserted. Angiography and measurement of pressure gradients were performed before and after stent implantation to ensure good treatment outcomes.

RESULTS The patients’ treatment outcomes were good, with a significant reduction in pressure gradients across the narrowed segments. Angiography showed relief of CoA. The patients were followed up for 1–3 years, during which no complications were noted.

CONCLUSION This is the first reported series in Singapore on the nonsurgical treatment of CoAs in adult patients using stents during interventional cardiac catheterisation. This less invasive procedure may lead to a new paradigm shift with regard to the treatment of CoA.

Keywords: angiogram, aortic coarctation, cardiac catheterisation, pressure gradients, stent
RESULTS
The demographics of the four patients are presented in Table I. CoA is strongly associated with bicuspid aortic valve; in our study cohort of four patients, three had concomitant bicuspid aortic valve. A stent was implanted in each patient. Three patients had a 40-mm Palmaz (Cordis Corporation, Johnson & Johnson, Miami, FL, USA) stent implanted, while one had a 39-mm Cheatham-Platinum (NuMED Inc, New York, USA) covered stent implanted. One patient required re-dilation of the stent one year later to achieve a more optimal result at the narrowed site. The treatment outcomes were good, with significant reduction in pressure gradient across the narrowed segments. After the procedure, two patients had no significant pressure gradient (i.e. < 5 mmHg) across the stent. One patient with a post-stenting pressure gradient of 14 mmHg underwent further re-dilation of the stent a year later with good results. At the time of writing, the patient with a post-stenting pressure gradient of 11 mmHg was in the midst of being followed up on, and may need re-dilation of the stent in the near future (Table II). Angiography revealed relief of CoA in all patients. For all the patients in our study cohort, the post-stenting diameter was significantly increased compared to the pre-stenting diameter (Table II). There was no significant complication either during or immediately after the procedure, except for Patient 1, who developed right common femoral artery thrombosis. However, Patient 1 recovered well after thrombectomy. The patients in our cohort were followed up for 1–3 years, with no complications noted. None of the patients required antihypertensive treatment before or after endovascular stenting.

DISCUSSION
The treatment outcomes of the nonsurgical treatment for CoA were good in our study cohort. There were no major complications noted during the short- to mid-term follow-ups. To the best of our knowledge, this is the first report of nonsurgical, transcatheter stent implantation in adult patients in Singapore for the treatment of CoA. In our literature search, similar encouraging results have been reported in other countries – Harrison et al[4] found that the mean peak pressure gradient of 46 ± 20 mmHg at baseline was reduced to a mean gradient of 4 ± 6 (range 0–26) mmHg at follow-up 1–3 years later. In Hamdan et al’s study,[5] the peak systolic pressure gradient measured at catheterisation decreased from 32 ± 12 mmHg to 4 ± 11 mmHg, while the echocardiographic Doppler gradient decreased from 51 ± 26 mmHg to 13 ± 11 mmHg at follow-up. Other similar reports showed significant improvement in the pressure gradients[19-21] and CoA diameters[14,19,20] before and after stent implantation.

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The patient in our study cohort who needed re-dilation had severe CoA, with a pressure gradient of 24 mmHg. Re-dilation has also been reported in other series.[4,5,20,22] A higher initial pressure gradient is indicative of a more severe CoA, which may be predictive of a future requirement for re-dilation. It is also

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**Table I. Summary of patient demographics.**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>4</td>
</tr>
<tr>
<td>Median age (range) (yrs)</td>
<td>29.3 (20–41)</td>
</tr>
<tr>
<td>Male to female ratio</td>
<td>2:2</td>
</tr>
<tr>
<td>Ratio of native CoA to restenosis*</td>
<td>2:2</td>
</tr>
</tbody>
</table>

*Postsurgical repair. CoA: coarctation of the aorta

**Table II. Pre- and post-stenting coarctation of the aorta (CoA) gradients and diameters.**

<table>
<thead>
<tr>
<th>Patient</th>
<th>CoA gradient (mmHg)</th>
<th>CoA diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-stenting</td>
<td>Post-stenting</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>34</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>4*</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>Mean</td>
<td>22</td>
<td>7</td>
</tr>
</tbody>
</table>

*Patient 4 underwent re-dilation of the stent

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**Fig. 1** Aortograms show the method for stenting. (a) Discrete coarctation of the aorta (CoA). (b) The stent is crimped onto the inflating balloon catheter and delivered to the narrowed site. (c & d) The balloon catheter is inflated at the narrowed segment to abolish CoA.

**Fig. 2** Repeat angiogram and pressure measurement performed after stent implantation shows an increase in the diameter of the aorta till the desired size is achieved, via stent implantation.
safer to be more conservative with the initial balloon inflation, and return later for re-dilation with a larger balloon, which can usually be done successfully. Pre-dilation before stenting may also be helpful in cases of very severe CoA.2(6)

One patient in our study developed a post-procedure complication associated with right common femoral artery thrombosis. Another well-recognised complication is the persistence of hypertension in patients with CoA.19,20,23 Serious complications have also been reported with stent implantation.18 The complications associated with CoA stenting include damage to the femoral artery and thrombus formation due to the large sheaths and balloon catheters required. Balloon catheter rupture is another potential complication. At the time of stent implantation, there is also the risk of inappropriate placement and/or stent migration following balloon dilation. As stents are frequently placed near carotid vessels, there is also a risk of cerebrovascular events.26 Other possible complications include acute aortic rupture, aortic dissection and aneurysm formation.

Our data suggests that there is significant improvement in both CoA gradient and diameter after stent implantation, similar to what has been previously reported.4,5,14,19-22 However, in stent implantation, the suitability of the procedure in relation to the age of the patient is an important consideration. The small calibre of vessels in children would make stent implantation difficult, possibly rendering surgery or balloon angioplasty a better option in children with CoA. In adolescents and adults, stenting would confer advantages such as superior and longer lasting results than that attained through balloon angioplasty. Indeed, either balloon angioplasty or stent implantation may be applicable to native CoA or restenosis following previous CoA surgery. Native CoA in adults is rare as patients are now diagnosed and treated early. However, stent implantation is typically not performed in children. This is because as the aorta continues to grow as the child grows, multiple attempts at re-dilation would have to be performed. The consequences of multiple attempts at stent re-dilation is unknown. Another disadvantage of stenting is the use of large sheaths to accommodate the balloon catheter and stent, which may damage the femoral vessels in young children. However, the femoral artery and aorta are larger in older patients, making such patients more suitable candidates for this technique.

In conclusion, therapeutic treatment of CoA through the use of stents during interventional cardiac catheterisation represents a new paradigm of treatment in Singapore for older patients with CoA, a condition that previously required surgical management. With increased expertise, improved techniques and better devices, it is envisaged that stenting for CoA will become a desired treatment option in suitable patients in the future.

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REFERENCES