Supra-aortic hybrid endovascular procedures for complex thoracic aortic disease: Single center early to midterm results

Yiu Che Chan, BSc MB, BS, MD, FRCS, Stephen W. K. Cheng, MB, BS, MS, FRCS, Albert C. Ting, MB, BS, MS FRCS, and Pei Ho, MB, BS, FRCS, Hong Kong, China

Background: Hybrid technique with open surgical supra-aortic extra-anatomical bypasses (to provide a suitable proximal landing zone) and simultaneous or staged thoracic endovascular stent grafting is less invasive than open surgery in the treatment of complex aortic arch pathology. The aim of this study is to report our hybrid experience.

Methods: Retrospective review of prospectively collected computerized database. All patients had regular clinical and radiological computed tomography follow-up.

Results: Sixteen patients (13 males and 3 females) with mean age of 64.8 (range 51-79) were treated with hybrid techniques between May 2005 and September 2007. There were nine elective, two urgent (within 2 weeks of presentation), and five emergency cases. Thirteen patients had arch or proximal descending thoracic aortic aneurysms, and six patients had aortic dissections. All extra-anatomical bypasses were performed simultaneously with stent grafts, with mean operating time of 331.2 (range 195-540) minutes. Eight patients had right to left carotid-carotid cross-over graft, five had bifurcating grafts from ascending aorta to innominate and left carotid artery, two had left carotid to left subclavian artery, and one had left carotid to aberrant right subclavian bypass graft. All patients had Cook Zenith thoracic stent grafts. Deployment success was 100%, with no endoleak on completion angiogram. There was no mortality. Three patients had postoperative nondebilitating stroke and no paraplegia. The mean follow-up was 14 (range 1-27) months. One reintervention was required, and two patients had type II endoleak treated conservatively.

Conclusion: Supra-aortic hybrid procedures in treating aortic arch pathology are safe and effective, and early- to midterm results are encouraging. (J Vasc Surg 2008;48:571-9.)

The management of thoracic aortic arch diseases continues to be a surgical challenge. Conventional open surgical techniques in the repair of aortic arch aneurysms or dissections require cardiopulmonary bypass and deep hypothermic circulatory arrest and are associated with a high perioperative mortality and morbidity, especially in the elderly.1,2 The operative period is usually long, and complications such as significant blood loss, coagulopathy, and hemodynamic instability are common.3,4 Large series have shown that despite refinement of operative techniques and surgical expertise, the perioperative mortality remains substantial at around 10% for elective procedures5,6 and is much higher for emergencies. Even with brain protection and selective cerebral perfusion, these procedures are associated with a high incidence of permanent neurological injury such as stroke or paraplegia reported as 3% to 19% and 6% to 11%, respectively.7

Since the world’s first reported case in 1988 by Volodos et al,8 endovascular treatment of aneurysms and aortic dissection involving the descending thoracic aorta has been shown to be an excellent alternative to open surgery. This new technique is less invasive than open surgery, avoids the need for open thoracotomy, and aortic cross-clamping, and can be performed under local or regional anaesthesia.7,9 Although the question of long-term durability and outcome still exists, recent advances in stent graft design have permitted the treatment of more complex anatomy, which has previously been considered to be contraindicated for endovascular repair because of a lack of proximal (and distal) landing zone (segment of normal aorta for the stent graft to conform to proximal and distal to the pathology).

Specifically for the aortic arch, knowledge of local anatomy such as the curvature and the presence of the supra-aortic branches (innominate, left carotid, and left subclavian arteries) are crucial while planning for endovascular treatment. In order to achieve an adequate proximal landing zone for a stent graft in the aortic arch, it may be necessary to cover the origins of some or all of supra-aortic branches. Adjunctive open surgical extra-anatomical supra-aortic bypasses may be required to provide an adequate proximal landing zone, and such combined open and endovascular (hybrid) surgery is a valuable alternative for patients with aortic arch pathology, especially for those patients who are medically unfit for open surgical repair or who have unfavorable patho-anatomy for endovascular treatment alone. Hybrid surgery increases the therapeutic armamentarium in the management of aortic diseases, especially in cases where landing zones are lacking.

As this supra-aortic hybrid endovascular approach for treatment of aortic arch aneurysm or dissection has become
more common, isolated reports or case series are beginning to emerge.10-17 Short- and midterm results of such hybrid procedures are encouraging. The aim of this study is to examine our results in patients who underwent simultaneous hybrid procedures with Cook Zenith stent grafts (Cook, Bloomington, Ind) for complex aortic arch disease. The Zenith thoracic device has as not yet obtained FDA approval in the United States, but has undergone a US phase II multicenter trial and is commercially available in Europe, Australia, and Canada.18,19

METHODS

A consecutive cohort of all the patients who underwent supra-aortic hybrid endovascular repair of complex aortic arch pathology between May 2005 and September 2007 were included in this study. The open bypasses and endovascular procedures were performed simultaneously in the same operating setting in the surgical operating room. Cardiothoracic surgeons were involved in the cases which required sternotomy.

All the patients had detailed preoperative anesthetic, vascular, and/or cardiothoracic assessments and were deemed high risk or medically unfit for conventional open surgical repair. All the patients had preoperative multi-slice fine-cut computed tomographic (CT) angiograms with Digital Imaging and Communications in Medicine reconstruction, analyzed using three-dimensional modeling. Most CT angiograms included enough of the vertebral arteries to determine dominance, as shown by larger size. In addition, all the patients had carotid and subclavian duplex ultrasound studies preoperatively (none had hemodynamically significant carotid stenoses to necessitate carotid endarterectomy). The dominance of the vertebral artery in these studies was determined by the larger size, antegrade direction and increased flow, as judged by experienced vascular ultrasound technologists.

These patients were not suitable candidates for conventional endovascular repair as a result of anatomically unsatisfactory or inadequate proximal landing zones. We regard the minimal length of an adequate proximal landing zone to be at least 1.5 cm of normal aorta proximal to the pathology being treated. The aortic diameters at the proximal and distal landing zones were measured electronically on the CT angiogram, and we routinely used 20% stent graft oversize for aneurysms, and 10% to 15% stent graft oversize for aortic dissections.

Data was collected prospectively on a vascular departmental computerized database and analyzed retrospectively. The written and electronic hospital records of all the patients were manually searched. All the patients were referred for management of complex aortic arch pathology, where the proximal landing zone was considered unsatisfactory without supra-aortic extra-anatomical bypasses. Operations were classified as elective, urgent (for symptomatic disease), or emergency (symptomatic with haemodynamic instability, end organ ischemia, or neurological compromise, treated within 24 hours of presentation).

The duration of operation and the intraoperative and postoperative course were noted. Various outcome variables were considered: 30-day mortality, major morbidity (including local morbidity such as bleeding, return to theatre, sepsis, stenosis, or failure of graft), and general morbidity such as cardiac events [arhythmias, angina, myocardial infarct, cardiac arrest], cerebrovascular events, paraplegia, respiratory failure, renal impairment [transient or permanent], lower limb complications, and multi-organ failure.

The open and endovascular procedures took place in the surgical operating theatre, with the extra-anatomical bypasses performed simultaneously in the same surgical setting prior to the deployment of the stent grafts. General anesthesia was used in all the cases. All the patients had oblique groin incisions with open exploration of the common femoral arteries. All the endovascular devices were delivered via the femoral access, except for one patient with a calcified 7 mm diameter common femoral artery that failed to admit a 24F dilator, who required an additional right common iliac artery conduit. All the endovascular procedures were performed in the operating theatre under image guidance using mobile distal fluoroscopy (OEC 9800, General Electric Company, Fairfield, Conn). All the Cook Zenith stent grafts were commercially manufactured, with two patients requiring a custom made size of 46 mm diameter. Postoperatively, all the patients were nursed in the intensive care unit or in high dependency unit until stable, before transferring to vascular surgical ward.

All the patients had a regular follow-up protocol that included regular clinical examination and computed tomography scans at 1 month, every 6 months for 2 years, and then yearly afterwards.

RESULTS

Between May 2005 and September 2007, 16 patients (13 males and 3 females) with mean age of 64.8 (range 51-79) presented to our institution with complex thoracic aortic pathology. Two patients presented with acute symptomatic type B aortic dissections without aneurysmal changes and 14 patients had aortic arch aneurysm (four of whom were symptomatic with pain, one with computed tomographic CT evidence of leak, and four had evidence of aortic dissection). One patient with an aortic arch aneurysm also had an intramural hematoma and there was one Marfan patient with arch aneurysm and dissection (Table 1). Five patients had had previous aortic surgery (1 had a tube graft from the proximal descending thoracic aorta to the supra-coeliac aorta, 1 had endovascular infra-renal aortic aneurysm repair, 1 had Bentall operation for type A dissection, 1 had ascending aorta tube graft repair for type A dissection, and 1 had open repair of infra-renal aortic aneurysm), and 1 patient had simultaneous endovascular repair of descending aortic aneurysm not continuous with the arch aneurysm. There were nine elective, two urgent (within 2 weeks of presentation), and five emergency cases (Fig 1).

All 16 patients were considered to have an inadequate proximal landing zone for endovascular repair of the aortic pathology. Five patients required stent grafts covering the
Table I. Patients’ demographics, comorbidity, and pathology

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Age</th>
<th>Sex</th>
<th>Significant past medical history</th>
<th>Anatomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>63</td>
<td>male</td>
<td>HT, open type III thoraco-abdominal aortic aneurysm repair, COPD</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>2</td>
<td>63</td>
<td>male</td>
<td>Elective infrarenal (5 cm) EVAR, cardiac arrhythmias</td>
<td>Symptomatic intramural hematoma &amp; aneurysm</td>
</tr>
<tr>
<td>3</td>
<td>64</td>
<td>male</td>
<td>HT, angina</td>
<td>Arch aneurysm with dissection</td>
</tr>
<tr>
<td>4</td>
<td>77</td>
<td>male</td>
<td>HT, angina, COAD</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>5</td>
<td>66</td>
<td>male</td>
<td>HT</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>6</td>
<td>51</td>
<td>female</td>
<td>HT, angina</td>
<td>Acute type B dissection with transient left leg weakness</td>
</tr>
<tr>
<td>7</td>
<td>56</td>
<td>male</td>
<td>HT, Bentall operation</td>
<td>Arch aneurysm with dissection</td>
</tr>
<tr>
<td>8</td>
<td>70</td>
<td>male</td>
<td>HT, COAD, sleep apnea</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>9</td>
<td>63</td>
<td>male</td>
<td>HT, lipid, CRF-CAPD, AF</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>10</td>
<td>53</td>
<td>male</td>
<td>HT, Type A dissection with ascending aortic surgery</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>11</td>
<td>57</td>
<td>male</td>
<td>HT, open repair of ruptured infrarenal AAA</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>12</td>
<td>73</td>
<td>female</td>
<td>HT</td>
<td>Symptomatic type B dissection</td>
</tr>
<tr>
<td>13</td>
<td>56</td>
<td>male</td>
<td>HT, COAD</td>
<td>Arch aneurysm with dissection</td>
</tr>
<tr>
<td>14</td>
<td>79</td>
<td>female</td>
<td>HT, COAD</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>15</td>
<td>78</td>
<td>male</td>
<td>HT, angina, pneumonia</td>
<td>Arch aneurysm</td>
</tr>
<tr>
<td>16</td>
<td>67</td>
<td>male</td>
<td>radical cystectomy for Ca bladder, HT, stroke</td>
<td>Arch aneurysm with dissection</td>
</tr>
</tbody>
</table>

AAA, Abdominal aortic aneurysm; COPD, chronic obstructive pulmonary disease; HT, hypertension; EVAR, endovascular aneurysm repair; COAD, chronic obstructive airway disease; CRF-CAPD, chronic renal failure–continuous ambulatory peritoneal dialysis; AF, atrial fibrillation.

Fig 1. Chest radiograph and computed tomography (CT) in a patient with leaking aortic arch aneurysm. Hematoma is apparent on CT.
Table II. Number of patients with hybrid procedures and proximal landing zones (different zones as shown in the diagram)

<table>
<thead>
<tr>
<th>No.</th>
<th>Bypass from</th>
<th>Bypass to</th>
<th>Landing zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Ascending aorta</td>
<td>Innominate, left carotid</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Bentall graft*</td>
<td>Innominate, left carotid</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Right carotid</td>
<td>Left carotid</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Left carotid</td>
<td>Left subclavian</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>Left carotid</td>
<td>Aberrant R subclavian</td>
<td>2</td>
</tr>
</tbody>
</table>

The patient with the Bentall graft was the only one in the study to require extracorporeal cardiopulmonary bypass and deep hypothermic systemic cooling (146 minutes cardiopulmonary bypass, systemic cooling to 20°C).

origins of all the supra-aortic arteries (the innominate artery, the left common carotid artery, and the left subclavian artery) in zone 0. Eight patients required stent grafts covering the origins of the left common carotid artery (zone 1), two required covering the origin of left subclavian artery (zone 2), and one required covering the origins of left subclavian artery and an aberrant right subclavian artery (zone 2) (Table II).

All the extra-anatomical aortic arch reconstructions were performed prior to the endovascular stent graft deployment in the same operating session, with mean operating time of 331.2 (range 195-540) minutes. Five patients had bifurcating grafts from the ascending aorta (including one from a previous Bentall graft) to the innominate and left carotid arteries using Dacron Hemashield bifurcated 14 mm/7 mm grafts (Fig 2). Eight patients had right to left carotid-carotid bypass grafts (all with retropharyngeal tunnels) (Fig 3), two had left carotid to left subclavian artery bypass grafts (Fig 4), and one had a left carotid to aberrant right subclavian bypass graft bypass graft. Five patients had midline sternotomy, but only one patient (previous Bentall operation) required extracorporeal cardiopulmonary bypass (of 146 minutes) and systemic cooling to 20°C. All the other patients who had bypass grafts from the ascending aorta had side-biting aorta clamps during the proximal anastomosis.

Cook Zenith stent grafts were used in all cases, with two patients requiring custom made devices with proximal diameters of 46 mm. Seven patients required a single stent graft, 8 patients required 2 stent grafts, and 1 patient required 3 stent grafts. Technical success was 100%, with no endoleaks demonstrated on completion angiograms.

There was no perioperative or late mortality with a mean follow-up period of 14 (range 1-27) months. Cardiac complications occurred in three patients: two had atrial fibrillation, and one patient developed cardiac arrest 5 hours postoperatively due to hypovolemia, and was successfully resuscitated. Pulmonary complications occurred in five patients, and two required temporary tracheostomy. There were no procedure-related renal complications (two patients were already on renal supportive therapy preoperatively, and one patient had an infarcted left kidney due to type B dissection). The median postoperative stay in intensive care unit was 3 (range: 0-48) days, and the median in-hospital length of stay was 15 (range: 4-100) days.

Three patients returned to operating theatre for hemostasis. The first was a 56-year-old man with Marfan’s syndrome, who previously had a Bentall graft in 1988 for type A aortic dissection. He underwent hybrid repair of 7.5 cm aortic arch dissecting aneurysm with aorto-innominate and left common carotid bypass, and endograft covering of the arch (landing zone 0). Despite a technically successful operation, he developed shock and cardiac tamponade on day 1 postoperatively, requiring reopening of the sternotomy and hemostasis for a small puncture hole in the jugular vein and bleeding from the sternal edges. The second patient was a 63-year-old man who underwent right to left carotid-carotid bypass and endograft placement for 6.5 cm (landing zone 1) distal arch aneurysm. Three hours postoperatively, he developed upper airway obstruction with suspected cervical hematoma. The neck wounds were explored, but only a tiny bleeder was identified from the right carotid anastomosis. The third patient was a 78-year-old man who had hybrid repair of 6 cm symptomatic aortic arch aneurysm with aorto-innominate and left common carotid bypass, and the endograft covering the arch (landing zone 0). He developed cardiac tamponade postoperatively, and emergency re-sternotomy showed multiple small bleeding points from the aorto-carotid anastomosis, which were sutured.

There were three nondebilitating postoperative strokes. The first was a 51-year-old woman who had an acute type B dissection with sudden onset back pain and transient weakness of the left leg, who underwent emergency left carotid to aberrant right subclavian bypass (to preserve a dominant right vertebral artery) and emergency stent graft placement (landing zone 2). She developed diplopia immediately postoperatively, and an emergency brain CT scan showed a left thalamic infarction, probably as a result of left posterior circulation hypoperfusion. These symptoms improved over the next few months. The second patient was a 63-year-old man who underwent right to left carotid-carotid bypass and endograft placement for 6.5 cm (landing zone 1) distal arch aneurysm. Three hours postoperatively, he developed shock and cardiac tamponade on day 1 postoperatively, requiring reopening of the sternotomy for aortic aneurysm with aorto-innominate and left common carotid bypass, and endograft covering of the arch (landing zone 0). He experienced immediate postoperative left arm discomfort and brain CT showed a small cerebellar infarction, probably due to a posterior circulation stroke. He made a good recovery with no residual neurological deficit. The third patient with a 7 cm distal arch aneurysm had right to left carotid-carotid bypass and stent graft placement (landing zone 1). He experienced immediate postoperative left arm discomfort and brain CT showed a small cerebellar infarction, probably due to a posterior circulation stroke. He made a good recovery with no residual neurological deficit. The third patient with a 7 cm distal arch aneurysm had right to left carotid-carotid bypass and stent graft placement (landing zone 1). He had sudden onset of left leg weakness on postoperative day 2 after a period of systolic hypotension but brain CT did not show any abnormality. This recovered slowly after 2 months, and there were no further delayed neurological symptoms or paraplegia. Overall, none of our patients who had ascending aortic to innominate and left carotid artery bypass had postoperative strokes, and two out of three of our stroke patients had right to left carotid-carotid bypasses.

On follow-up CT, all the extra-anatomical bypass grafts were patent (Fig 5). One patient had a type 1b endoleak successfully treated with distal extension. None of the
patients had type 1a endoleak, but two patients had type 2 endoleaks that are being treated conservatively. There were no distal device migrations, device-related complications, or septic complications.

**DISCUSSION**

The aim of the extra-anatomical supra-aortic bypasses is to provide an adequate proximal landing zone for the stent graft to conform to an area of normal aorta proximal to the aortic pathology, thus allowing endovascular repair of complex aortic arch pathology. In this Cook Zenith stent graft study, we have shown that this combined approach is safe and effective in the management of aortic arch pathology in high risk patients with no mortality, at least in the short- to midterm. However, there are still many specific concerns about the durability of this approach as long-term follow-up data is still lacking.9,20

Crucial to the success of hybrid treatment of aortic arch disease is a sound knowledge of the anatomy of the aortic arch aneurysm or dissection in relation to the origins of the great supra-aortic arteries. Good quality CT angiograms with three-dimensional reconstruction are essential in planning. It is also helpful to divide the thoracic aorta into different landing zones.21,22 The Criado classification of the thoracic aortic landing zones is important,21 as it provides a uniform nomenclature: zone 0 is the ascending aorta from the aortic valve to just beyond the origin of the innominate artery, zone 1 from just beyond the origin of the innominate to just beyond the origin of the left common carotid artery, zone 2 from just beyond the origin of the left common carotid artery to just beyond the origin of the left subclavian artery, and zone 3 from just beyond the origin of the left subclavian artery to the start of the descending thoracic aorta. The complexity and invasiveness of the extra-anatomical bypasses increases as the desired proximal landing zone for the stent graft moves proximally towards the aortic valve. In this study, we have five zone 0 patients, eight zone 1 patients, and three zone 2 patients.

For zone 0 patients who require aorto-innominate bypass grafts, total arch revascularization is performed through a midline sternotomy using a side-biting clamp on the ascending aorta for the proximal anastomosis without extracorporeal cardiopulmonary bypass or systemic hypothermia. If the ascending aorta is mildly dilated, an additional Dacron strip is used as an external aortic band at the proximal landing zone (only one of our patients required this). We used reversed bifurcated Dacron grafts to bypass to the innominate artery and left carotid artery. Careful tailoring of the Dacron grafts should be done to avoid a long redundant main body, so as to prevent kinking once the sternotomy is closed. Similar techniques have been used by Czerny et al with good midterm results.23 In our study, all these anastomoses were performed in the chest, apart from one patient (who did not have any neurological deficits postoperatively) where the anastomosis with the left common carotid artery was performed in the neck due to proximal left common carotid stenosis with poor backflow. An alternative revascularization method would be a straight

![Fig 2. Per-operative photograph and corresponding completion angiogram in a patient with aortic arch aneurysm. Hybrid procedure with bifurcating graft from ascending aorta to innominate and left carotid artery, followed by endovascular stent graft repair (landing zone 0).](image-url)
graft from the ascending aorta to the innominate artery, followed by a right to left carotid-carotid bypass.

For zone 1 patients, all our patients had right to left carotid-carotid bypass grafts using two small neck incisions, and a retropharangeal tunnel for the graft. We prefer this tunnel to the sub-platysmal route as septic complications may be reduced should these patients require prolonged postoperative ventilation with tracheostomy. All of our patients tolerated the retropharangeal tunnel well without any neck discomfort or feelings of dysphagia or odynophagia. The carotid-carotid bypass allows the origin of the left carotid artery to be covered. Follow-up CT scans have shown that all these grafts are patent. Published series have previously shown that the carotid-carotid bypass grafts are safe and durable, with patency rates of 88% at 3 years and 84% at 5 years, and primary assisted patency rates in excess of 90%.24,25

Many case series suggest that it may be safe to cover the origin of the left subclavian artery (zone 2) routinely without the risks of left arm ischemia, subclavian steal syndrome, posterior circulation stroke or type II endoleak; so that pre-emptive revascularization is not usually required.14,26-28 The muscular arterial branches in the neck and shoulder girdle serve as collaterals to the left arm and vertebro-basilar circulation.27 However, this is debatable as others have argued that it is safest to revascularize the subclavian artery routinely in all cases in which it is covered. In our institution, we chose to selectively revascularize the left subclavian artery in cases where the left vertebral artery was dominant (ie, appears larger on preop CT or duplex scans), where the patient is left arm dialysis dependent, or where the patient has had a previous left internal mammary artery coronary bypass graft.9,29 Furthermore, we believe that in cases of more extensive debranching, the routine addition of a left carotid to left subclavian bypass may increase the morbidity and length of the procedure. In our study, three patients (out of 16) had revascularization of the subclavian arteries: two had left carotid to left subclavian artery bypass grafts, and one had left carotid to aberrant right subclavian bypass graft bypass graft with a dominant right vertebral artery. Despite this, that patient had a thalamic stroke postoperatively.

Paraplegia and stroke are well-recognized complications associated with thoracic aortic arch endovascular intervention. The mechanism of stroke following endovascular treatment of thoracic aortic pathology is likely to be multifactorial, and as yet, poorly defined, as the blood flow hemodynamics in the aortic arch and to the carotid and vertebral arteries are changed dramatically after hybrid surgery and are heavily dependent on an intact Circle of Willis with adequate collateral flow. Cerebral magnetic resonance angiography was not routinely performed in this study due to constraints imposed by waiting times, availability, and relative urgency of the hybrid procedures. Regardless, the three nondebilitating postoperative neurological complications in this study were most likely posterior circulation strokes caused by cerebro-hypoperfusion rather than from carotid emboli, although the precise etiology can never be

Fig 3. Per-operative photograph (a) of a right to left carotid-carotid bypass graft, with pre- (b) and post-stent graft (c) deployment angiograms.
defined. Out of these three patients, one had revascularization of aberrant right subclavian artery. None of our patients had prophylactic or therapeutic spinal cerebro-spinal fluid drainage, and none developed paraplegia.

In this study, all our patients had open bypasses and endovascular procedures performed simultaneously in the same operating setting. This is our preference and we believe this has the advantage that in the event of an unsatisfactory completion angiogram with an endoleak, an open surgical treatment option is available: for instance, external banding of the proximal landing zone. However, simultaneous procedures often require much longer operating times, and are more stressful for the patient and the surgeon. Additionally, renal function may be more affected by simultaneous procedure because of surgical blood loss and contrast load. In contrast, rupture of the aneurysm may occur after the extra-anatomical hybrid bypass, whilst the patients are waiting for staged endovascular treatment.

With the development of endovascular technology, supra-aortic hybrid procedures will continue to play a large role in the treatment of aortic arch pathology. Such procedures are less invasive without the need of aortic cross clamping, extracorporeal cardiopulmonary bypass or deep hypothermic circulatory arrest. Additionally, with time, it
appears likely that pure endovascular procedures with branched and fenestrated stent grafts may become more commonplace.30 However, apart from durability, there are still many unanswered questions regarding supra-aortic hybrid procedures: we do not know whether it is safe to base the entire cerebrovascular blood supply from a single carotid artery, or what is the potential for stroke over time. Long-term follow-up of these patients is therefore crucial in order to answer these questions. Furthermore, there will still be a place for open surgical repair when the anatomy is not suitable for a hybrid or endovascular option, in young medically fit patients, or in patients with Marfan’s syndrome, where the role of endovascular repair is still undefined.

AUTHOR CONTRIBUTIONS
Conception and design: YC, SC
Analysis and interpretation: YC, SC, AC, PH
Data collection: YC, SC, AC, PH
Writing the article: YC, SC
Critical revision of the article: YC, SC
Final approval of the article: YC, SC
Statistical analysis: Not applicable
Obtained funding: Not applicable
Overall responsibility: SC

REFERENCES

RECOUP THE LOUPES

Despite extremely limited resources, surgeons in developing countries work to provide their patients with the best possible care. For many of these surgeons, technology such as loupes, which facilitate delicate procedures, is simply out of reach.

One year ago, Loupes Around The World distributed its first pair of loupes to a plastic surgeon in Phnom Penh, Cambodia. Before Loupes Around The World, this surgeon commonly repaired cleft lips and palates, and treated trauma patients with maxillofacial injuries without the benefit of surgical magnification. Since then, this not-for-profit organization has provided loupes to surgeons from Panama to India and continues to receive requests from surgeons around the world.

Loupes Around The World is now recycling donated loupes via a program called “Recoup the Loupes.” Surgeons with unused loupes are asked to send them to the foundation; there, repairs can be made to adjustable loupes, and the telescopes from fixed loupes can be installed into new lenses and frames. For fixed loupes, optical measurements are taken to ensure that the loupes will meet the needs of each individual surgeon.

Please send your unused loupes to:

David C. Knight, M.D., F.A.C.S.
Loupes Around The World
c/o Surgical Associates of Waterbury
1211 West Main St.
Waterbury, CT 06708

Loupes Around The World accepts loupes made by any manufacturer. For more information about Loupes Around The World, as well as information about how to contribute, please visit: www.loupesaroundtheworld.org. Upon receiving loupes, a letter of acknowledgment will be sent to the donor for tax purposes. Loupes Around The World is a 501(c)3 tax-exempt organization.