Hybrid and endovascular therapy for extensive thoracoabdominal aortic disease

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The past 4 decades have witnessed tremendous strides in the evolution of endovascular technology with increased operator experience, greater availability of more sophisticated and versatile endovascular devices, and advances in imaging modalities. In an attempt to limit the physiologic derangements associated with aortic crossclamping and extensive tissue dissection during traditional open surgical repair of extensive thoracoabdominal aortic aneurysms, less invasive strategies have been explored using endovascular technology: hybrid approaches and solely endovascular techniques. This article describes these techniques and their advantages, their current role in thoracoabdominal aortic aneurysm repair and potential future developments in this field. (*J Thorac Cardiovasc Surg* 2010;140:S168-70)

Despite significant advances in surgical techniques, perioperative adjuncts, and critical care, the traditional open repair of extensive disease of the thoracoabdominal aorta (TAA) remains a formidable challenge and is still associated with high morbidity and mortality rates. Several high-volume institutions have published results that are considered acceptable when compared with the risk of aneurysm rupture if left untreated; these figures, however, are not representative of surgical outcomes worldwide.¹ With evolution of endovascular techniques, less invasive strategies have been developed for treatment of TAA aneurysms in the hope of decreasing the extensive morbidity resulting from open aneurysm repair. Hybrid surgical/endovascular repair with surgical revascularization of aortic branches, stenting of the aneurysmal segment, and branched/fenestrated approaches to achieve a total endovascular approach are described herein.

HYBRID SURGERY

Hybrid surgery refers to procedures combining both open surgical and endovascular techniques. This strategy has been used in 2 particular areas: (1) the TAA segment and its branches and (2) aneurysms involving the aortic arch. As a general principle, extra-anatomic bypass of vital aortic side branches is followed by stent grafting of the diseased segment, thus achieving total aneurysm exclusion without the need for thoracotomy and complete aortic crossclamping.

The Visceral Hybrid Procedure

Our institution described one of the earliest visceral hybrid cases in 2002.² Since then, many have described their

experience along with modifications of the original technique. Our preferred technical approach for extensive aneurysms that extend into the TAA segment (types I, II, and III) involves retrograde revascularization of the visceral and renal arteries from the aorta, iliac vessels, or a previous aortic graft via a transperitoneal approach.

Our first published series of 29 cases showed exceptional results, with low mortality and no paraplegia.³ However, as our experience has grown and we have taken on greater numbers of patients with complex problems, the results are now more representative of a major surgical procedure in a high-risk population with atherosclerosis. Our unit has recently reported the largest published series of these repairs for TAA aneurysms and aortic dissections in 107 high-risk patients, as a collaborative approach with 2 other major European centers; we⁴ observed a 30-day mortality rate of 14.9% and a paraplegia rate of 8.4%. There was a 3.7% rate of long-term dialysis and a 2.8% rate of gut ischemia. Graft patency at 30 days was 86.9%. Endoleaks were detected in 29.9% of cases: 56% were type II, and the majority were managed conservatively.

One of the unanswered questions relating to these extensive aneurysm repairs using the hybrid strategy is whether to perform the operation as a simultaneous or a 2-stage approach. Our view is that a cold, hypotensive, and coagulopathic patient who has undergone extensive intra-abdominal dissection, and who has significant cardiovascular instability, should not immediately undergo stent grafting inasmuch as there is a potential for prolonged or recurrent hypotension and an increased risk of significant paraplegia. In this scenario, it is safer to stabilize the patient and then exclude the aneurysm during a subsequent procedure. Against this view are those who cite the risk of interval rupture (which we have experienced first hand) and the risk of embolic occlusion of visceral grafts when passing multiple stent grafts through the iliac segment at a later stage. There is a strong case for single-stage surgery in patients with large aneurysms who are stable during the hybrid procedure, especially in those with access difficulties. Each case needs to be judged on an individual basis. Stent-graft placement should not be undertaken at the same time as open surgery unless it is safe to do so.

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Abbreviation and Acronym

TAA = thoracoabdominal aorta

More than a quarter of our patient cohort had had a previous thoracotomy for either cardiac or thoracic aortic surgery, with 82% of patients in American Society of Anesthesiologists grade greater than 3 and significant comorbidity, rendering them unfit for an open repair. Taking these adverse factors into account, we believe this procedure represents a real advance in the treatment of patients with extensive TAA aneurysms in our center. Similar results have been reported by others,⁵ who share the view that in centers with suitable expertise, the visceral hybrid repair is a viable treatment option for a high-risk patient population with limited therapeutic alternatives.

The Arch Hybrid Procedure

Aortic disease that involves the most proximal descending thoracic aorta and/or aortic arch may require extra-anatomic bypasses of the subclavian, brachiocephalic, and carotid arteries with subsequent stenting. There are several graft configurations that may facilitate successful, safe stent grafting in this area. In patients with aneurysms that necessitate a proximal landing zone in the arch, complete supra-aortic revascularization can be performed from the ascending aorta. A variety of graft configurations may be used: we typically use a graft to the right carotid artery with a smaller side branch to the left carotid and a left carotid–subclavian bypass. When the aortic disease necessitates graft coverage of the left subclavian and/or left carotid vessels, a left carotid–subclavian bypass and/or right-to-left carotid cross-over is fashioned, respectively, before stenting.

A recently published systematic review of arch hybrid outcomes in 195 patients showed pooled perioperative mortality and morbidity rates of 9% and 21%, respectively (7% stroke rate), with a 9% endoleak rate.⁶ However, most of the series included in this review contained a small numbers of patients, increasing the possibility of publication bias. This is a varied group also in that there are significant differences between those requiring carotid–subclavian bypass alone and those requiring full supra-aortic revascularization to facilitate stent-graft placement. In our experience of 37 such cases in high-risk patients who require extensive intervention, mortality and morbidity remain significant, especially in those with concomitant distal aortic disease. We do believe that the arch hybrid repair provides a feasible alternative treatment in patients who are at high risk for conventional open surgical repair; however, careful patient selection and consideration of morphologic features are essential to achieve satisfactory results.

TOTAL ENDOVASCULAR APPROACH

Although the visceral hybrid repair eliminates the need for thoracotomy, the results of larger series still suggest a significant mortality and paraplegia risk. Advances in stent-graft technology in recent years have allowed the treatment of extensive aortic disease with custom-made fenestrated and branched devices, originally designed to extend the proximal sealing zone in infrarenal disease. Much effort is now expended in development of this strategy for treatment of aneurysms that involve the supra-aortic branches.

Once access has been gained through the groin or via an iliac conduit, the fenestrated or branched device is placed at the level of the target vessels under fluoroscopic control, aligning the fenestrations/branches with the target vessel ostium to allow cannulation of the target vessels, subsequent side-branch stenting, and overall exclusion of the aneurysm. The efficacy and safety of custom-made fenestrated stents for the treatment of short-necked infrarenal aneurysms has been widely described. We⁷ have demonstrated, with others,⁸ encouraging short- and intermediate-term results for treatment of more extensive aneurysms, with low perioperative mortality and morbidity rates and brief hospital stays in patients with uncomplicated pathologic conditions.

Despite a custom-made device design and extensive preoperative planning, graft rotation and misalignment of the fenestration/vessel ostium interface can still occur. Target vessel cannulation itself can be technically challenging and time-consuming even for experienced operators, especially in the presence of complex tortuous anatomy. Our research at Imperial College has shown definite advantages for cannulation of vessels using a remotely steerable robotic catheter system in complex endovascular interventions. Intuitive robotic technology has the potential to overcome some of the limitations of conventional selective catheters, demonstrating significant reductions in target vessel cannulation times, enhanced accuracy and catheter stability, and overall improvement in operator performance scores.⁹

Another primary concern with fenestrated and branched endografting is the inherent delay in manufacturing owing to its bespoke nature, which precludes use in ruptured and urgent cases, even if the anatomic configuration is suitable for endovascular repair. In situ fenestration may be a potential solution to this, and several authors have demonstrated its feasibility using an antegrade or a retrograde approach.¹⁰ We¹¹ have found that robotic technology can provide a stable platform for antegrade in situ fenestration and facilitate the technique. Further advances in stent-graft design and imaging modalities are essential to make this a viable therapeutic alternative. Off-the-shelf (non-custom made) branched and fenestrated devices have also been suggested by several authors, which may limit the cost of current devices and expedite treatment,¹² but may require significant further development.

CONCLUSIONS

As endovascular techniques and technology are constantly improving and evolving, the full impact of fenestrated stents and branched grafts on TAA aneurysm repair is yet to be realized in the context of clinical trials. We believe that this technology, along with other adjuncts such as endovascular robotics and dynamic imaging modalities, represent the future in the management of extensive TAA disease. However, in the meantime, and in high-risk patients in whom fenestrated or branched stent grafting is not an option and open surgery is hazardous, the visceral hybrid represents a viable, robust, and transferable alternative method of treating this complex and life-threatening disease process.

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