



The changing surgical approach to acute type A aortic dissection

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Contributions: (I) Conception and design: A Harky, M Bashir; (II) Administrative support: A Harky, M Bashir; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: A Harky, M Bashir; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: Acute type A aortic dissection (ATAAD) is a surgical emergency that requires immediate intervention once recognised, mortality rate from such condition can be as high as 75% if not managed on time. Currently, the gold standard method for management of such life-threatening condition is open repair. The extent of the aorta to be repaired is dependent on many factors, primarily the extent of the dissected aorta and patients haemodynamic status at the time of presentation. Nevertheless, the surgeon experience and availability of hybrid approach to treat it, have direct influence on the approach to treat ATAAD. With advancement in operative techniques and graft modalities, there is marked shift in managing such lethal condition from total open repair to open repair of the aortic root with frozen elephant trunk (FET) and lately the role of endovascular management of ATAAD. In this review article, we will focus on the current advancement and changing trend in surgical management of ATAAD.

Keywords: Aortic surgery; type A dissection; aorta; acute dissection

Received: 06 June 2018; Accepted: 05 July 2018; Published: 23 July 2018.

doi: 10.21037/jovs.2018.07.05

View this article at: <http://dx.doi.org/10.21037/jovs.2018.07.05>

Introduction

Type A aortic dissection, by definition is presence of a tear anywhere from the aortic root up to the, including, the origin of the left subclavian artery. In certain circumstances, this dissection involves the great vessels of the neck which indicates a poor neurologic prognosis (1). Repairing the dissected aortic tissue can be very challenging, the more aorta is dissected the more complex is the repair procedure, in cases of isolated dissection of the ascending aorta ± aortic root, open repair with an interposition graft or full aortic root replacement (ARR) is the preferred method of treatment (2), this procedure doesn't require the use of hypothermic circulatory arrest (HCA) or any other method for cerebral protection and therefore, it is associated with lower mortality rate when compared with extended procedures and the use of HCA. In majority of

the cases, the intimal tear extends to involve the aortic arch, either in partial or in full and this warrants surgical intervention either as single procedure with extended hemi-arch replacement or in selected cases to perform total arch replacement (3). However, the moment aortic arch is involved in surgical intervention, a brain protection mechanism is required to reduce the advent of neurological complications which serves a key postoperative indicator to recover from this complex repair (4). With no doubt, open aortic arch repair is the gold standard method of repair as of today (5,6), however with current advancement in clinical practice and technology, several other options have challenged this practice, initially it started with the use of elephant trunk technique and two stage procedure and lately, the use of frozen elephant trunk (FET) is gaining momentum in treatment of acute type A aortic dissection (ATAAD) along open repair of the dissected tissue (7,8).

However, despite presence of excellent brain protection mechanism with HCA, with or without the use of antegrade or retrograde cerebral perfusion, this complex operation has significant perioperative morbidity and mortality rates (9-11). Endovascular techniques have evolved dramatically to assist in repairing such dissected aorta, either as separate procedure at a later stage or combined with open repair as hybrid aortic surgery (12,13). Currently, the role of endovascular repair for aortic arch is evolving, while use of such technique in ATAAD remains challenging and obscure with very limited international data to support its application and yet the mid or long-term outcomes to be reported (12,14).

Isolated aortic root dissection—what is the prospect?

The most common form of TAAD is the tear starting from the ascending aorta involving the non-coronary cusp, however uncommonly it could also involve any of right or left coronary cusps, aortic valve cusp or the annulus itself (15), in such cases it is therefore considered as an “easy to approach” surgical emergency with good prognosis due to the limited dissected tissue that needs repair (11,16). The gold standard method in such isolated ATAAD is through open repair. Such repair technique ranges from isolated ascending aorta replacement to total aortic root repair and the key in such life-threatening case is to repair enough aortic tissue to provide safe recovery and stable health afterward (17). However, the choice of only ascending replacement over total ARR is depending on many factors such as status of the aortic valve, annulus, coronary sinus involvement and the origin of the tear itself (18,19). Cohen *et al.* (17) in their institutional experience, they emphasized the fact of minimal tissue intervention and recommends not to intervene with rest of aortic conduit unless extremely necessary, on the contrary, Leshnower *et al.* (15) is a strong supporter of conservative aortic root repair through preserving the aortic valve, this technique involves the preservation of the dissected sinus segments through resuspension of the native aortic valve commissural posts or replacing the native valve with a prosthetic one in contrary to less preferred method of total ARR which requires excision of the dissected sinus segments plus replacement of aortic root and reimplantation of the coronary buttons. The advantage of the conservative aortic root repair lies in keeping minimal native tissue disruption, avoiding introduction of anti-coagulation

when a mechanical prostheses is used and hence lower rate of thromboembolic events (20), additionally promoting thrombosis of the false lumen and occlusion thereafter (21,22) thus improved long term survival, finally, reduction in the re-intervention rate for the prosthetic aortic valve at later stage (23), although the later has been debated heavily and several other studies have reported higher re-operation rates following conservative aortic root repair *vs.* ARR. In a study by Halstead *et al.* (19), they reported a similar operative mortality between both techniques, however with a higher survival rate at ten years in ARR group (65% *vs.* 55%, $P=0.48$) and higher re-operation rate in the conservatively repaired group (4.5% *vs.* 0%, $P=0.08$), this was also supported by a similar study from Di Eusanio *et al.* (24) with a rate re-operation rate of 22% in the conservatively repaired while only 6.3% in the ARR group, $P=0.005$. Those re-intervention findings were not supported by the findings from the international registry of acute aortic dissection (IRAD) which reported no differences in reoperation rates between both groups at three years of follow up (1% *vs.* 1%, $P=0.77$), yet this lacks long term data support at 10 years (15).

Recently, several other reports have come into publication through a more conservative surgical management of valve sparing root repair (VSRR), this technique failed to show a good success rate in patients with ATAAD at early experience which has led to modification in its clinical practice techniques (25). Due to the complexity of the VSRR procedure and the data are being limited to small number of case series in relation to patients presenting with ATAAD, not to mention that is performed only in high volume centres with relevant expertise in this procedure, the evidences behind this technique is limited and should be carefully considered (26,27).

Regardless of how life saving open surgical repair can be, it is associated with significant perioperative complications, among the key ones are death and neurological complications which can be catastrophic. In the view of the recent advancement in clinical practice and understanding the pathophysiology of ATAAD, the practice is facing a newly born challenge to reduce such open repair related complication rates and this is through endovascular intervention (28). The very first reported case of successful endovascular repair of ATAAD was by Metcalfe *et al.* (29) in which a 68-year-old patient who presented with ATAAD was treated and discharged effectively. Thereafter, several studies have reported the use of endovascular stenting for ATAAD, however such data are limited to only case series

and small numbers of patients were involved and therefore can't be used as a strong literature evidence for use in emergency cases of ATAAD (30-32).

Hemi-arch or full arch?

Inspection of the aortic arch during open repair of ATAAD looking for intimal or re-entry tear is a key element to decide whether intervention to the aortic arch is required. Pre-operative imaging that determines localization of the dissection to the aortic root plays a key role whether application of aortic cross clamp can induce iatrogenic extension of the aortic dissection (33). When the tear is localized to the ascending aorta or the start of the aortic curvature, a hemi-arch replacement is the procedure of choice especially when it comes to elderly and haemodynamically unstable patients. However, when the dissection tear extends beyond that, then a total open aortic arch repair is warranted. Nevertheless, open aortic arch repair is a complex procedure that needs circulatory arrest and certainly some degree of neurological deficits may occur postoperatively (34); however, to minimize rate of such adverse outcomes, use of several methods to protect the brain is recommended, these could be in the form of HCA with or without adjuncts such as antegrade or retrograde cerebral perfusions. In addition to the location and extent of the intimal tear, there are other factors that significantly influence the decision to perform hemi or full aortic arch repair and it includes, but not limited to, presence of dissected tissue in the descending aorta, severity of compression of the true lumen, involvement of neck vessels, and presence or absence of connective tissue disorders (3,8).

In a study by Kim *et al.* (3) of 188 patients that underwent either total aortic arch replacement (n=44) or hemi-arch replacement (n=144) for ATAAD, all patients had ascending aorta replaced at the same time, they found that patients that had total arch replacement had lower 5 years survival when compared to hemi-arch group of patients (65.8% *vs.* 83.2%, $P=0.013$) and higher rate of neurological complications (56.9% *vs.* 24.8%, $P<0.001$ respectively), interestingly there were no significant difference in re-operation rate nor rate of aortic root dilatation in both groups ($P=0.14$), therefore they recommended a conservative management against aggressive surgical intervention when possible.

In a separate single centre study by Lio *et al.* (35) of 201 patients that underwent either full or hemi-arch replacement for ATAAD, they supported the findings by

Kim *et al.*, there was higher operative mortality rate in full arch group (33% *vs.* 15%, $P=0.04$), total arch replacement was independent risk factor of operative mortality ($P=0.021$), finally, the mean five year survival was 59% and freedom from distal reoperation was 95% ($P>0.05$) and therefore, they have also recommended the hemi-arch approach when appropriate and safe in patients with ATAAD. Similar data were reported by Rylski *et al.* from 534 patients, hemi-arch group of patients had lower operative mortality as well as higher 5 and 10 years survival and freedom from re-interventions when compared with full arch group of patients (36,37).

A prognostic factor in patients with ATAAD is the patency of the false lumen, which is a major risk factor for reintervention when it exists in the aortic arch or the descending aorta, this is supported by two large studies from Halestead *et al.* (38) and Fattori *et al.* (39), whom they identified a direct correlation between patent false lumen and increased rate of re-intervention rate, hence the recommendation for total arch replacement to minimize such risk in patients presenting with ATAAD comes into place (40-42).

Finally, the aggressive approach of replacing the arch has been supported by two large studies, the first one is from the German registry for ATAAD (GERAADA) which supporting total arch replacement in such group of patients than hemi-arch replacement, as there was no significant difference in the perioperative outcomes among both groups of patients (43). The second evidence is from a systematic review and meta-analysis by Poon *et al.* of 2,221 patients that presented with ATAAD and underwent either total or hemi-arch replacement, there reported no different in operative mortality among either group, no significant difference in the rate of aortic re-intervention at follow up period and similar rate of freedom from re-operation in between both groups (44), however their study was limited by many factors including publication and detection bias, as high volume centres with relevant surgical expertise have better perioperative surgical outcomes when compared to low volume centres and surgeons (45).

Is FET the solution?

With current advancement in technology and clinical practice, the outcomes and prognosis post repair of ATAAD has been dramatically improved, however, the long-term results are guarded by the residual dissection and the patent false lumen that extends into the descending aorta

which increases the risk of latent aortic re-intervention at later stage (46). Therefore, a new technique has evolved in the era of clinical practice and known as FET through hybrid technique, which is a combination of conventional open aortic arch repair and floating the stent down the descending thoracic aorta at the same time and as one stage procedure, however this procedure is technically demanding and more time consuming when compared to conventional open repair (33). With this technique, there is more than 90% chance of obliteration of the false lumen and hence improved survival rate and lower rate of re-intervention (47).

Uchida *et al.* (47) compared outcomes in 120 consecutive patients that underwent either hemi-arch or full arch replacement with FET in the setting of ATAAD, they have shown similar operative mortality in both groups, however a higher survival rate in the FET group at 5 years (95.3% *vs.* 69%, $P=0.03$) and total occlusion of the false lumen in all patients that underwent FET while 29% of the hemi-arch patient group had patent false lumen. The same group has published a different series of 120 patients that underwent FET repair for ATAAD (48), their mean follow up period was 104.6 ± 51.9 months. No patient had a patent false lumen at the time of final follow-up, 10 years survival was 75% and hence they concluded that FET should be performed in patients with ATAAD when there is evidence of involvement of other parts of thoracic aorta as it improves long term outcomes. Di Bartolomeo *et al.* have also reported and suggested the use of FET in the setting of acute thoracic aortic dissection, however with caution and in high volume centres with presence of experienced surgeons, as FET requires particular attention and adverse outcomes can be dramatic if duration of cerebral perfusion or surgery itself prolonged unnecessarily (49), and this was backed up as well earlier by Jakob (50).

Later the recommendations came into place of using FET in patients with ATAAD with a primary tear entry into distal aortic arch or proximal descending thoracic aorta (51).

Finally, in a meta-analysis by Takagi *et al.* (52) of 1,279 patients that underwent total aortic arch replacement with FET, they reported an early mortality of 9.2%, stroke rate of 4.8%, spinal cord injury of 3.5%, an overall mortality of 13% (>1 year), re-intervention rate of 9.6% and lumen thrombosis in 96.8% of the cases. Therefore, this technique of FET is considered as safe, effective and reliable approach during total aortic arch repair in comparison to conventional elephant trunk surgery.

In a later study by Matt *et al.* of 141 patients (53), they recommended the use of a different technique known as

modified FET in patients presenting with ATAAD that requires aortic arch intervention. They have performed a match analysis of 37 patients in hemi-arch and 37 patients in modified FET group of patients. Their results were far more detailed any the previously reported ones, the rate of stroke and paraplegia were higher in hemi-arch group, however this didn't reach statistical significance (24.3% *vs.* 8.1%, $P=0.1$ and 2.7% *vs.* 0%, $P=1.0$ respectively), 30-day mortality was higher in the hemi-arch group (13.5% *vs.* 0%, $P=0.05$) and survival rate in the modified FET was higher at 6 months of follow up (100% *vs.* 86.5%, $P=0.02$).

The endovascular and hybrid approach

Literature evidences supporting the use of endovascular stenting of isolated ATAAD that is limited to the aortic root is very scarce and in majority of published literature is limited to personal experience to limited cases and in limited centres (30-32); therefore, open surgical repair remains the gold standard method in such patients.

However, when the aortic dissection extends to the aortic arch and beyond, the role of endovascular repair gets more into attention. As open aortic surgery, particularly the arch and descending aorta, associated with significant mortality and morbidities, in particular neurological complications, aortic surgeons have prompted the use of such minimal invasive techniques to aid in improving patients perioperative outcomes (12). The combined use of open replacement of aortic arch with stent deployment into the rest of the thoracic aorta, known as hybrid procedure or FET, seems to be the perfect practice example now a day among the pioneers in aortic surgery (51,54). Due to nature of such procedures being complex and requires prolonged periods of circulatory arrest and use of adjuncts to protect the brain, its use is limited to specialized centres with practice of experienced surgeon in this particular field to minimize the adverse outcomes (53).

On the contrary to the aortic root dissection with arch involvement, endovascular repair of the extended dissection into the descending thoracic aorta has taken over open repair with or without open repair of the aortic arch.

Conclusions

Open repair of the dissected aortic root remains the optimum management option for patients with ATAAD, when the dissection extends beyond the aortic root, current literature supports equivocal outcomes between hemi or full

aortic arch replacement, hence the decision is surgeon and centre specific. A dissection that involves aortic arch and beyond is optimally managed with open aortic arch repair and FET, such technique provides safe, durable and reliable outcomes in such acutely unwell patient cohort.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Journal of Visualized Surgery* for the series “Innovations in Thoracic Aortic Aneurysm Surgery”. The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/jovs.2018.07.05>). The series “Innovations in Thoracic Aortic Aneurysm Surgery” was commissioned by the editorial office without any funding or sponsorship. MB served as the unpaid Guest Editor of the series. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/jovs.2018.07.05

Cite this article as: Harky A, Bashir M, Antoniou A, Bilal H. The changing surgical approach to acute type A aortic dissection. *J Vis Surg* 2018;4:151.