Perspectives from Bologna on the future directions of aortic surgery

The 10th Postgraduate Course on 'Surgery of the Thoracic Aorta' in Bologna in 2019 brought together renowned international leaders in the field of aortovascular and cardiac surgery, facilitating the exchange of expert opinions and the continuation of stimulating debate over some of modern surgery's most high-stakes and challenging procedures. The Series published following the Course comprises a wide range of topics, representing the areas of aortovascular surgery subject to the most debate, such as congenital aortic surgery, arch and thoracoabdominal dissection repair, and endovascular versus open abdominal aortic repair.

In their comprehensive and detailed review of the management of adults with aortic coarctation, Velayudhan *et al.* outlined and evaluated the gold-standard approaches for surgical repair of what continues to be a formidable entity to manage effectively (1). Coarctation of the aorta accounts for 5–8% of all congenital heart defects and is associated with a mean life expectance of 35 years if left untreated (2). Currently, open surgical and endovascular repair are the most commonly-taken routes to repair. Open resection of the lesion with subsequent end-to-end anastomosis, introduced in 1945 by Crafoord and Nylin, is a viable approach for paediatric cases however is a suboptimal strategy for repair of aortic coarctation in adults as a result of reduced aortic elasticity and extensive collateralisation (3). The subclavian flap repair technique, though more promising in older children, is similarly not as effective in adults owing to the high risk of claudication of the arm in the long term. Prosthetic interposition tube grafting, therefore, is the preferred approach for the repair of aortic coarctation in adults (1). The use of a vascular graft to bypass the lesion with end-to-end or side-to-side anastomosis is favoured in adults as it relies on aortic dimensions remaining more or less constant following implantation. therefore, it is unsuitable for children due to the risk of outgrowth. Velayudhan *et al.* also outline a hybrid approach to repair of aortic coarctation: percutaneous transaortic stenting, combined with open repair of intracardiac pathologies if needed, is reported to be associated with reduced trauma and relatively rapid recovery (1). It is worth highlighting that without national or international guidelines, patient-specific treatment plans are required—Velayudhan *et al.* emphasise a need for prospective randomised studies to identify the optimal strategy for the surgical management of adults with aortic coarctation.

Smith and Heijmen *et al.* favour a staged, hybrid approach to the repair of DeBakey type I aortic dissection (4). The classical technique of entry tear resection, aortic wall re-approximation, and aortic valve resuspension represents a viable approach to a complex pathology, and can be achieved with hemi-arch repair in the majority of cases. However, it is emphasised that this technique fails to address the downstream aortic dissection often seen in patients with DeBakey type I dissections, meaning late distal sequelae (e.g., disease progression) and the need for reintervention remain omnipresent risks (4). Whether a more comprehensive technique involving distal repair during the index procedure—essentially total arch repair with frozen elephant trunk (FET)—truly offers an improved cost-benefit profile remains unclear, most especially when one recalls that a large proportion of DeBakey type I dissections present acutely out-of-ours and are therefore often operated on by non-aortovascular specialists. It is unsurprising therefore that this formidably complex procedure to address a notoriously fatal disease is associated with has been associated with up to 12% 30-day mortality, 9% permanent neurological deficit rate, and an overall 13% rate of reintervention (5). Smith and Heijmen *et al.* hence consider the FET technique too complex, high-risk, and expensive to be applied to all acute DeBakey type I patients. Alternatively, a hybrid approach involving two-thirds arch repair with a liberal Zone 2 landing zone [thereby facilitating completion with elective thoracic endovascular aortic repair (TEVAR)] may be more feasible for non-aortovascular specialists in the acute setting (6). Such an option may be associated with improved neurological outcomes compared to full, acute FET, paving the way for a more efficacious management of acute DeBakey type I dissection.

The time-to-treatment element of managing acute Stanford type A aortic dissection (ATAAD) is no stranger to even the most novice surgeon, emergency physician, or paramedic. The propensity for ATAAD to mimic other more common and similarly serious syndromes (e.g., acute coronary syndromes) at initial presentation makes the timely identification, diagnosis, and treatment of ATAAD notoriously challenging. De Vos *et al.* conducted a single-centre retrospective analysis of 52 patients

with ATAAD over the course of 10 years to identify the sources of delays between onset-to-presentation, presentation-to-diagnosis, diagnosis-to-surgery, and onset-to-knife intervals, and evaluated the possible effect of these delays on clinical outcomes (7). The interval between diagnosis to surgery was found to be the most significant source of delay ($P<0.05$), while patient gender imaging was noted to exert considerable influence over onset-to-knife time. De Vos *et al.* note that though computed tomography (CT) is the gold-standard imaging modality for the diagnosis of ATAAD, it considerably delays the interval between presentation and surgery (7). Less time-consuming modalities such as transthoracic echocardiography or, better yet, transoesophageal echocardiography can accurately diagnose aortic dissection, and also be conducted with the patient in theatre (8). It is important to also account for structural factors often out of the hands of the attending care team; De Vos *et al.* report a 3.5-hour delay between diagnosis and surgery, while Harris *et al.* a corresponding interval of 4.3 hours (7,9). Improvements in staffing management and organisation, and operating theatre availability, though difficult to implement across-the-board, would undoubtedly improve the onset-to-treatment delay associated with this progressively lethal, time-sensitive entity.

Morshuis' review on the place of classical elephant trunk (cET) for aortic arch repair challenges the widely-held belief that FET represents modern surgery's best effort for open surgical total arch repair (10). Though the FET technique is an effective single-stage procedure for the definitive repair of aortic arch aneurysms or dissections, and most notably eliminates mortalities associated with the delay between cET and secondary endovascular stenting (estimated to be 3.2%), Morshuis argues that FET was associated with net higher rates of complications such as paraplegia and early mortality (10,11). Even with shortened stent-graft lengths, thought to decrease the risk of spinal ischaemia, recurrent laryngeal nerve palsy and stroke rates remained high (as high as 17% in degenerative aneurysm cases) (12). Several unanswered questions are highlighted—such as the effect of FET stent-graft stiffness on cardiac function, and reintervention risks, which remain high. It is key, therefore to balance the short-term risks against long-term benefits, and on this front Morshuis remains an advocate of the cET technique, which persists and remains far from obsolete. But do modern innovative alternatives truly provide an improved cost-benefit profile? Undoubtedly, debate on whether FET is truly superior for cET will continue, and for now perhaps a case-by-case, patient-specific approach is optimal.

Kalra *et al.* evaluated and analysed the TEVAR-first approach to ATAAD complicated with mesenteric malperfusion in their narrative review (13). ATAAD complicated by malperfusion syndrome is associated with prolonged intervals from onset to diagnosis, and from diagnosis to surgery. Traditionally, this phenomenon has been managed by urgent repair of the proximal aortic tear prior to exploratory laparotomy with bowel resection, depending on the extent of mesenteric ischaemia. Unsurprisingly, this approach is associated with myriad intraoperative risks, and involves two majorly invasive phases which undoubtedly increases mortality rates among higher-risk groups. Persistent false lumen patency, re-entry tears, and branch vessel involvement are likely, and play a significant role in intraoperative or early mortality. The Emory protocol, promulgated in 2019 and outlined by Kalra *et al.* as a more viable route to successfully manage ATAAD with malperfusion syndrome, utilises initial TEVAR to normalise perfusion in the thoracoabdominal aorta, before open proximal aortic repair in haemodynamically stable patients (13). Early reperfusion of visceral tissue is thought to mitigate the sequelae associated with profuse mesenteric ischaemia (e.g., persistent acidosis, bowel necrosis, and oxidative stress). Aggressive fluid resuscitation to maintain normotension and reverse acidosis is then carried out, before proximal aortic repair under cardiopulmonary bypass and hypothermic circulatory arrest (HCA) (13). Notably, such an interval would also allow for complex proximal aortic repair to take place outside of the out-of-hours setting, in the hands of experienced aortovascular specialists. In cases of haemodynamic instability (e.g., rupture), antegrade deployment of TEVAR is performed during the HCA interval. In either case, it should be kept in view that the risk of mesenteric ischaemia is substantial even normotension and acidosis are correct preoperatively. All things considered, the Emory protocol for TEVAR-first approach to ATAAD with mesenteric malperfusion syndrome is promising, and results on its long-term effectiveness are eagerly awaited.

Kothari *et al.* offered an insightful comparison between traditional open surgical repair of thoracoabdominal aortic aneurysm (TAAA) against emerging endovascular techniques, which offer less-invasive alternative options (14,15). It is unsurprising that the extreme invasiveness, high risks of mortality, and debilitating neurological and renal complications

has driven the search for less-invasive, endovascular alternatives for the repair of extensive TAAA. Yet, the durability and long-term stability of open repair, coupled with recent advancements in strategies to mitigate its associated surgical risks, mean that open repair of TAAA is likely here to stay for some time. Indeed, endovascular repair of TAAA with extensive branch involvement is challenging, even with the use of fenestrated or branched stent grafts. Interestingly, FDA approval for endovascular repair of TAAA has yet to materialise. Kothari *et al.* highlight that intraoperative mortality for the open repair of TAAA stands at 7.5%, permanent paraplegia at 2.9%, and renal failure at 5.7% (14). Emergent repair is thought to double the risk of intraoperative mortality. Yet, open repair has been associated with a freedom from reintervention rate of 94% over 15 years. This is contrasted by a 76.8% rate of freedom from reintervention (five years) associated with branched endovascular repair, which is also thought to carry a 4.8% early mortality rate and little real difference in long-term survival or freedom from complications (16). Aneurysmal expansion, infection, and fistula formation have been identified as the key reasons for endovascular-to-open reintervention. Perhaps, then, it may be argued that though endovascular repair of TAAA is presently less durable than that which can be achieved by open repair, it represents a viable option for lower-risk TAAA repair, or as an efficacious option for reintervention following open repair in certain groups. Yet, Kothari *et al.* emphasise that endovascular intervention for TAAA may better suit octogenarians or other groups deemed unfit for such an extensively invasive procedure.

Undoubtedly, the 10th Postgraduate Course on 'Surgery of the Thoracic Aorta' in Bologna has yielded intriguing results and has laid important groundwork for exciting future developments for the repair of congenital aortic defects, acute and chronic aortic dissection, and thoracoabdominal aortic repair. Though much further research is needed, we can be confident in the fact that the foundations laid in Bologna will serve as solid foundations for the advancement of personalised aortic care.

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Mohamad Bashir, MD, PhD, MRCS
Vascular and Endovascular Surgery, Health Education and Improvement Wales, Velindre University NHS Trust, Wales, UK.
(*Email: drmobashir@outlook.com*)
Davide Pacini
Cardiac Surgery Department, Policlinico di Sant'Orsola, Alma Mater Studiorum Università di Bologna, Italy.
(*Email: dav.pacini@gmail.com*)
Roberto di Bartolomeo
Cardiac Surgery Department, Policlinico di Sant'Orsola, Alma Mater Studiorum Università di Bologna, Italy.
(*Email: roberto.dibartolomeo@unibo.it*)
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