Aortic surgery – perspectives, challenges and future trend

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Aortic surgery as a specialty has developed in leaps and bounds from the platform laid by the likes of Dr. DeBakey, Dr. Cooley and Dr. Crawford. Days are gone when cardiovascular surgeons shied away from taking aortic surgery as their career, and many young surgeons are now pursuing it enthusiastically. The first international aortic summit organized by the Guest Editor in 2007 only had a handful of attendees. In 2018, the 7th International aortic summit witnessed more than 300 delegates and in 2020, the 8th International aortic summit (virtual), witnessed 650 plus delegates participating from over 40 countries. This shows the growing enthusiasm in aortic surgery among the younger generation. The reasons could be multi-fold:

1. Standardization of the surgical procedure by the pioneers, helping to reduce the mortality and morbidity
2. Improvement in imaging technology, helping to plan the surgery with precision and comfort.
3. The advancements in cardiopulmonary bypass with better organ protection.
4. Availability of better device technology. Earlier, the classical elephant trunk needed a cumbersome pull back technique, whereas, at present, the Sienna® grafts with collar help to perform the distal anastomosis at ease.
5. Knowledge about the dynamics of aortic dilation and the role of genetics.

Yet there are so many unanswered questions in the aortic speciality - ‘Why a few with bicuspid aortic valve (BAV) develop aortic dissection?’, ‘If the aortic wall of the BAV is inherently weak, the stronger aortic wall in the tricuspid aortic

valve should tolerate more aortic dilation. But is it true?’, ‘Given the fate of false lumen, is frozen elephant trunk a must for all aortic dissections?’, ‘Genetic dictionary - will it help in screening and identifying susceptible individuals?’ and a lot more.

This special issue attempts to bring a comprehensive review of the management of aortic diseases. With contributions from reputed surgeons across the globe, we hope that the information provided will help to understand the mechanisms behind disease patterns and pathologies and their application in current clinical practice.

Mechanisms and genetics

The aorta is very elastic, which is responsible for the compressive effect that converts the phasic flow from the left ventricle into a continuous flow to the peripheral artery. This is known as the ‘Windkessel effect’ - the elastic rebound of the arterial wall resulting in an additional force on the blood within the arteries [1]. Dr. Lars G. Svensson with his team from the Cleveland Clinic discusses the biomechanics of the aorta in the opening chapter of this special issue. The derangement in the structure of the aorta can ultimately lead to failure in the biomechanics resulting in aortic dissection or rupture. The authors have extensively studied the elastic properties of the aorta using the in-vitro biaxial tensile test, which mimics in-vivo behaviour. They believe that the understanding of these biomechanics will help guide for therapy, surveillance and intervention in aortic disorders. The aortic size as an individual risk factor for aortic dissection banks on the knowledge of the Law of Laplace. The authors question this fact, stating there are numerous assumptions by the law; most importantly that the vessels behave in a linear elastic, isotropic fashion. Further, the underlying tissue biology is not taken into consideration.

Close to one-fifth of the patients with thoracic aortic aneurysms or dissection exhibit a strong family history - an

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allusion to the genetic component as aetiology. Familial cases are more pernicious, occur earlier in life, and have a higher rate of aneurysm growth. More than 30 genes have been associated with syndromic and non-syndromic thoracic aortic aneurysms and dissection. These genes help predict the disease phenotype, risk of dissection even when the aortic diameter is small, and the age of presentation [2]. Dr. John Alex Elefteriades, Yale University School of Medicine, introduced the concept of “genetic dictionary” and is working on the same. Though this is far from completion, he and his team keep adding several genes and providing an annual update. They believe this can help personalize the aortic care, based on the specific causative mutations for a substantial proportion of these patients. They define that the ideal ‘genetic dictionary’ would ‘include variants that confer a high risk of the aortic aneurysm, as well as other variants that confer medium or low risk of aortic aneurysm, or confer risk only in combination with other genetic variants or environmental factors’. Whole Exome Sequencing, on the other hand, maps only the 2.5% of the human genome known to be involved in directing the manufacture of proteins. The authors routinely perform Whole Exome Sequencing, when covered by their insurance companies. Though this looks interesting, Dr. Giovanni Mariscalco, on the other hand, apart from talking about the importance of genetic screening, also highlights the pitfalls and controversies involved in genetic screening. Given the incidence of these genetic disorders (Marfans Syndrome: 1:5000, Ehlers-Danlos syndrome: 1:90,000, Loeys-Dietz syndrome < 1:100,000), genetic testing does not represent a common clinical requirement within the general population [3]. There may be several mutations existing for a gene, all of which need careful screening. In the real world, these tests are not widely available for the patients and kins may need to approach tertiary or quaternary aortic centres or genetic clinics for counselling far from their station. This keeps the future open for more research in refinements of the sensitivity and specificity of genetic screening in these patients.

Reflection from pioneers - strategies in aortic arch surgery

Aortic arch surgeries are complex procedures even in the present era, the Achilles heel being the neurological complications. Open arch surgery has progressed significantly in the last few decades. The introduction of newer technologies to monitor cerebral perfusion, greater collaborations in research, and refinement of the surgical techniques have provided better patient outcomes. It is onerous to construe the results of the aortic arch surgeries across the various approaches involved, different disease patterns, nature of the aortic tissue, previous surgeries, techniques used and the specific environmental conditions of some centres and teams. The two important aspects

of protecting the brain during aortic arch surgeries include the optimum temperature and maintaining the perfusion to the brain. Given this, we have invited pioneers in this field to provide us with their techniques and approach for these surgical pathologies.

Dr. Edward Chen, Duke University, discuss the various options and strategies for cerebral protection. He has eloquently compared the different options including the deep hypothermic circulatory arrest (DHCA) with retrograde cerebral perfusion, and moderate hypothermic circulatory arrest with antegrade cerebral perfusion. Though robust data are still lacking, he has provided his insight with the available literature on the best possible options in real-world scenarios. Dr. Roberto di Bartolomeo enumerates the historical aspect of the development of aortic arch surgery in Bologna, while Dr. Yutaka Okita vividly explains the surgical steps/techniques of aortic arch surgery. The descriptive surgical images in the latter’s article are like an atlas for aortic arch surgery. Dr. George Matalanis, who popularized the ‘Branch-first total arch replacement’ technique, has provided an insight into the advantages of this approach in acute aortic dissection. He claims that this approach apart from reducing the risk of neurological complications and end-organ dysfunction will also aid in the reconstruction of the aortic arch in an unhurried manner.

Elephant trunk

The complex disease of the aortic arch extending proximally into the ascending aorta and/or extending distally into the descending thoracic aorta is a challenge for any surgeon. This was surmounted by Dr. Hans Borst and his colleagues in 1983 with an innovative procedure called classic elephant trunk (cET) [4]. This required a two-stage approach to address aortic arch and the proximal descending thoracic aorta. Thirteen years later, Suto and Kato introduced the concept of ‘Stented elephant trunk’ [5]. This was further modified in the next decade and the industry developed the hybrid prosthesis giving rise to the frozen elephant trunk (FET). The treatment goals for both cET and FET are the same - (i) address the combined aortic pathology of ascending aorta, aortic arch and descending thoracic aorta, and (ii) ease the future treatment of the descending thoracic/thoracoabdominal aorta. To date, there is no randomized controlled trial comparing both the procedures. Considering this fact, we have invited Dr. Marc Schepens, Belgium and Dr. Davide Pacini, Bologna to debate on cET versus FET. The former scripts on “*Is the classical elephant trunk better than the frozen elephant trunk?*”, while the latter talks on “*Why is Frozen Elephant Trunk better than classical Elephant Trunk?*”. cET will definitely need a second procedure for completion, on the other hand, FET can be a definite procedure in certain clinical conditions. The results from multiple centres show

enthusiastic results in favour of FET. Dr. Marc Schepens states that the answer to either of the questions - ‘Is cET better than FET?’ or ‘Is cET worse than the FET?’ is negative. FET has been a better alternative in acute aortic dissection, but in chronic dissection, the role is still unclear. Though the inter-stage mortality was higher with cET, FET has a different subset of complications including spinal cord ischemia. Adding more spice to this debate, we the Guest Editors have discussed the use of FET in acute aortic dissection, especially in Indian scenario. The challenges faced in using FET in acute aortic dissection in India have been dealt with in detail with regard to the financial burden, the wide difference in the health care system, delayed diagnosis and late presentation, the concept of ‘aortic supercenters’, and challenges in transport. Dr. Heinz, who has a vast experience in FET, has detailed the development of the Evita hybrid prosthesis and his clinical experience from Essen, Germany with the same.

The Grey zone

In the words of Sir William Osler: *“There is no disease more conducive to clinical humility than aneurysms of the aorta”*. Not all aortic diseases are the same and therefore should not be treated the same with a ubiquitous procedure. Many a time, we need to tailor the treatment plan according to the need of the patient, based on the age, associated comorbidities including the coronary artery disease and connective tissue disorders, malperfusion in case of acute aortic dissection, extent of the aortic disease, general condition of the patient and many more. In research, there always exists a point of controversy, which later, on accumulation of data, ends at a point of accuracy. Aortic surgery is no exception. We have invited a few experts in the field across the globe to discuss the grey zones in aortic surgery.

It is well known that Indian patients have a smaller stature as compared to the western world and so is the aortic annulus. This is more pronounced in Rheumatic aortic stenosis and small build females. Dr. Praveen K. Varma and his colleagues have elaborated on patient-prosthesis mismatch and measures to avoid the same during aortic valve replacement. In clinical situations, where it cannot be avoided, the surgeons need to widen the aortic annulus to implant a larger prosthetic aortic valve. The authors have eloquently provided various techniques with images for a better understanding of the readers. Infection of the aorta is a clinical challenge with incidence ranging from 0.6 and 2.6%, and carrying 30-day mortality of about 30%. Dr. Chandrasekar Padmanabhan has provided a comprehensive literature review of the aetiology and bacteriology. He has elaborated on the various options of management of these dreadful clinical conditions, including vascular reconstruction. Coronary artery disease along with aortic aneurysms are complex in their own way. Apart from connective

tissue disorders, the aetiology of aneurysms of the thoracic and abdominal aorta are mostly due to degeneration and atherosclerosis. Coronary artery disease shares a common aetiology with these aneurysms, hence the high prevalence ranging from 25 to 90%. It is relatively uncommon in ascending aortic aneurysms, where prevalence is less than 20%. Despite the lack of consensus, Dr. Kay-Hyun Park has provided a comprehensive manuscript for the management of these patients. The decision-making algorithm provided by the authors from Seoul National University Bundang Hospital is a handy guide for the practising surgeon. Penetrating Aortic Ulcer and Intramural Hematoma are both parts of a clinical spectrum of acute aortic syndromes. The exact mechanism of the pathology and ideal management for the disease still remains unclear. Dr. Cherrie Z Abraham and his colleagues have shed light on this aspect in their comprehensive literature review.

Malperfusion in acute aortic dissection is a lethal complication with high mortality and morbidity. There still exists uncertainty in the literature of when to operate a patient with cerebral or mesenteric malperfusion. Various options and management strategies have been advocated. Dr. Paneer Selvam illustrates the different malperfusion syndromes and comprehensively provides management strategies in his manuscript.

Aortic disease - strategies and management

“It’s not about making the right choice. It’s about making a choice and making it right.”— J.R. Rim.

Similarly in aortic surgery, it is very important to make the right choice for a ‘safe and optimal outcome’. The choice and decision has to be promptly made in regard to the cannulation strategy, extent of resection and reconstruction according to the pathology, etc. Dr. Shiv Choudhary in his article has provided all the options of cannulation strategies and the pros and cons of each, helping the surgeon to decide the best which suit him/her on that particular day. The thoracoabdominal aortic aneurysms (TAAA) extend from the thoracic aorta to the abdominal aorta, with an incidence of 10 new aneurysms per 100,000 person-year [6, 7]. Dr. Germano Melissano and colleagues have briefed upon the surgical strategy for TAAA with a special concentration on connective tissue disorders. In addition to circulatory support, multiple adjunctive measures are advocated to reduce the ischemic injury to the abdominal viscera and the spinal cord. Dr. Vijaya Shankar has provided an extensive literature review on visceral and renal protection during open TAAA repair. Redo aortic surgeries are challenging, with increased surgical risk as compared to primary aortic surgery. The hospital mortality can be as high as 16.4% in some reports. Dr. Worawong Slisatkorn has briefed upon the strategies for meticulous planning and execution, which would reduce mortality and morbidity.

Future directions

Minimally invasive surgery is gaining popularity over the last decade and it is becoming the first-choice approach to treat heart valve diseases in many experienced centres across the globe. The increasing popularity and patients' demand have prompted many surgeons to adopt the approach even in aortic surgery. Dr. Marco Di Eusanio has comprehensively described the surgical techniques of mini thoracic aortic surgery. Further, in the last 15 years, endovascular techniques and technologies have advanced, providing excellent results with acceptable complications. Type A aortic dissection continues to be a challenge for many surgeons, even in the present era. Nearly 10–30% of type A aortic dissections are not accepted for surgery due to various reasons [8]. Though endovascular has replaced open aortic repair for amenable lesions in distal aortic dissections, it is yet to find its place in type A aortic dissection due to the presence of key structures at the desired landing zone (coronary artery, aortic valve, supra-aortic arch vessels). A few small case series and case reports have shown that carefully selected patients with favourable anatomical characteristics can be offered endovascular stent-graft treatment. Dr. Christoph A. Nienaber and Dr. Vasudevan have dwelled on this topic with the available evidence. Though the technology for Type A aortic dissection is in its infancy, sooner or later it may replace open surgery with further research and development.

Conclusion

Though aortic surgery has grown tremendously in recent years, yet there remain a lot of areas of concern where evidence is still lacking. With further research and clinical data, the controversies will end at a point of veracity. It is heart-warming to see the growing enthusiasm among the younger generation in this relatively young sub-speciality of cardiac surgery. This special issue was initiated with the intent to provide readers with an update of the present status of aortic surgery for some of the pathological conditions. We are sure that the content of this special issue, contributed by eminent

surgeons will be of aid to the aortic surgeons in their clinical practise. We sincerely thank the Editor in Chief Dr. O P Yadava for giving this opportunity and all the authors for providing the manuscripts written exclusively for this issue.

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