Building a Complex Thoracic Aortic Program From the Ground Up: What Does It Take?

Outlining the key elements to a successful aortic service.

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Aortic services have enjoyed a new impetus in recent years, and the distribution of aortic services has evolved in the last few decades. Accepting that technology creates an environment where more care can be delivered to a larger volume of patients, the provision of care in a team setting is now recognized to improve outcomes and maximize resource use. The aortic team offers the ideal model for contemporary health care service provision. A strong, dedicated multidisciplinary team with a varied skill set and fidelity to the aortic service is essential to building an aortic program. This article outlines the benefits of centralizing services, assembling the correct multidisciplinary team, amassing essential resources, and building dedicated critical care facilities in the development of an aortic service.

CENTRALIZING SERVICES AND VOLUME-BASED OUTCOMES

Substantial, robust evidence has demonstrated that concentrating expertise and centralizing services are necessary for delivering high-quality aortic care, resulting in improved outcomes with higher-volume practice.[1,2] This relationship persists regardless of whether the aortic repair is abdominal or thoracic or when the pathology is an aneurysm or dissection.[2-4] Furthermore, outcomes continue to improve with time when services are centralized.[5]

Although infrarenal endovascular aneurysm repair (EVAR) is a reasonably straightforward procedure, examining the volume-outcome relationship is valuable when building an aortic team. This volume-outcome relationship was a major stimulus in reconfiguring vascular services in the United Kingdom (UK). A VASCUNET report from 1999 to 2006 showed worse EVAR-related outcomes in the UK compared with many other countries (7.9% vs 1.9%–4.5%),[6] which led to the establishment of the Abdominal Aortic Aneurysm (AAA) Quality Improvement Program. Restructuring services, with a move toward concentrating services into specialist centers, has proven to reduce mortality and advance technology, as reflected in the VASCUNET report from 2012, in which UK outcomes had improved with a reduction in elective AAA mortality to 2.4%.[7] Despite national improvements, the outcomes of AAA repair still considerably vary between different hospitals in the National Health Service,[8] analogous to the interprovider variation reported across a range of emergency medical and surgical conditions.[9] This suggests that underlying institutional structures and processes contribute independently to patient outcomes and that further concentration and specialization are necessary.

Developing clinical pathways within and between networks has been a major thrust of vascular centers around the UK. A UK study reported a clear

relationship between high-volume units and enhanced outcomes, with a 13% reduction in the mortality odds for each additional 20 cases performed.[10] This relationship also exists in the United States, with a Medicare study reporting that higher-volume units had better mortality outcomes after EVAR in a risk-adjusted analysis (odds ratio [OR], 1.68; 95% confidence interval [CI], 1.32–2.22).[11]

Such structures and processes are even more pertinent when considering complex aortic repair. Thoracic and thoracoabdominal aortic pathologies require a further concentration of expertise and more complex infrastructures. A comprehensive review of thoracic aortic services in the UK demonstrated that the wide variation in care relates not only to treatment outcomes but also to treatment thresholds.[12] Treatment rates for thoracic aortic disease within 6 months of index admission ranged from 7.6% to 31.5% between English counties; risk-adjusted 6-month mortality in untreated patients ranged from 19.4% to 36.3%. In essence, regional units with higher case volumes treat more complex patients, and they do so with significantly lower risk-adjusted mortality relative to low-volume units. However, as with most complex disease therapies, it is naive to presume that the link between good outcomes and high volumes is a straightforward or sustainable association, and allowances need to be made for learning curves and ongoing training within developmental environments. Weiss et al found no difference in mortality between low- and high-volume institutions in California; however, there was a decrease in mortality at high-volume hospitals when they were defined as each year after meeting the initial threshold case volume of nine cases per year.[13]

This association between case volume and mortality has also been demonstrated with endovascular repair, whereby after the threshold is met, morbidity and mortality reduce, despite increasing complexity.[14] This phenomenon can be explained by learning curves, not only in terms of intraoperative skill but also in terms of perioperative care and developing reproducible and consistent pathways of care. In other words, consistent high volumes help standardize outcomes and train surgeons and wider aortic teams.

Aortic repair services are an obvious example of how institutional structures influence outcomes. There is considerable evidence that with the implementation of necessary infrastructure and manpower, the outcomes of aortic repair improve even within different health care systems, across different institutions, and in both elective and emergency settings. Acknowledging this can help identify which factors are consistently associated with the best outcomes, informing efforts to better organize and deliver services for patients who require aortic surgery.[15-20]

Centralization is contingent on a streamlined emergent care pathway (24/7 availability without diversion), adequate transportation and transfer capabilities, and rapid activation of the multidisciplinary team. The team-based approach shines in aortic rupture. A well-rehearsed team with efficient algorithms for timely provision of care has demonstrated excellent outcomes. Team rehearsal can be enhanced with simulation, which uses virtual or enhanced reality environments to develop technical and communication skills.[21] These are further enhanced with technologic approaches to team mobilization, such as the app development under trial at Royal Free London.[22]

Improvement in outcome after rupture is especially pronounced in the case of complex aortic repair. A review of the Society for Vascular Surgery Vascular Quality Initiative database from 2003 to 2017 highlighted that when EVAR for infrarenal aortic rupture is performed by high-volume surgeons, improvement in survival is much less pronounced as compared with open repair.[23] This is partly because EVAR has become more ubiquitous across vascular units, and there has been a reduction both in the number of surgeons trained for open repair and the number of units performing open repairs. This trend underpins the importance of perioperative care because increasing institutional complex aortic repair volume means that intensivists are better equipped to manage postoperative complications, the subsequent management of which plays a critical role in survival at the highest-volume aortic centers. Although the threshold number needed to define *high volume* appears to be approximately 10 repairs per year for elective repair, this number has not been defined for ruptured AAA repair.[24]

THE MULTIDISCIPLINARY AORTIC TEAM

A recent expert consensus document of the European Association for Cardio-Thoracic Surgery (EACTS) and the European Society for Vascular Surgery (ESVS) recommends an aortic team-based approach to managing patients with complex thoracoabdominal aneurysms.[16] The Joint Committee sees this team-based approach as the best way to harness combined expertise and take advantage of innovations in both vascular and cardiac surgery. Patients with disease involving the aortic arch are particularly well catered for with this combined approach. Cross-linking between cardiac and vascular surgery has amplified knowledge, and it is now recognized

that high standards of care can only be provided by aortic teams.

The EACTS/ESVS defines the aortic team as one that is led by members from cardiac and vascular surgery in collaboration with anesthesiology, cardiology, radiology, and genetics. One could also argue that perfusionists and aortic clinical nurse specialists/advanced nurse practitioners also form integral components of this team-based approach. The consensus documents also recommend that aortic teams have surgical leadership; a major advantage of this is that surgeons have experience linking radiographic findings to tissue quality, which is a significant consideration when deciding between open surgery or endovascular treatment.

Currently, there is no clinical prediction model that can stratify risk for aortic patients and quantify fitness; thus, decision-making is based on pragmatism and expertise of experienced surgeons in consultation with specialized high-volume aortic anesthetists.[17] A critical contributor to improving patient outcome and reducing risk aversion is the inclusion of specialist anesthetists on aortic teams. Guidelines recommend that experienced anesthetists manage vascular patients.[25] For aortic patients in particular, a 2005 UK National Confidential Enquiry into Patient Outcome and Death report noted that for elective AAA repair, more deaths occurred within 30 days for anesthetists who had carried out less than the median number of vascular procedures, and this was particularly true in the emergency setting.[26]

Centralizing care of complex aortic pathologies in large centers also requires state-of-the-art imaging facilities and dedicated cardiovascular radiologists. Expertise in imaging is the only way to adequately appreciate the natural course of the disease, provides a timely diagnosis of acute pathologies and identification of complications, and facilitates treatment.[18]

A team-based approach, consisting of surgeons, anesthesiology, cardiology, and radiology, should involve structured surveillance of all patients, both before and after treatment. The reasons for this are multifactorial and include quality control and in case aortic pathology develops in nontreated upstream or downstream aortic segments. Ironically, the need for ongoing surveillance was cited by the National Institute for Health and Care Excellence (NICE) committee as an adverse association with EVAR. Although there is no doubt that research efforts should focus on ways to improve yields from nontoxic forms of imaging surveillance, surveillance is necessary for all forms of aortic repair. In addition to monitoring disease progression, it also contributes to a patient's sense of security and education.

CLINICAL EXPERTISE AND EXPERIENCE

Failure to rescue (*FTR*) is an interesting concept that underpins the need for centralized high-volume centers of excellence.[27] Many deaths after aortic repair are not related to the procedure itself but more directly to the failure to identify and treat the significant complications and morbidity that follow the procedure. FTR directly correlates with hospital volume and staffing levels and can act as a proxy for the quality of postoperative care provided. Aortic programs should ensure that there is adequate staff to diagnose and treat complications, and staff must be familiar with the usual postoperative course.

FTR is of even greater importance in patients with higher comorbidity. A study of 23,207 AAA repairs from the National Surgical Quality Improvement Program database (2005–2012) demonstrated higher mortality and morbidity in patients with a higher modified frailty index.[28] Specifically, in patients who had a postoperative complication, the frailest patients were almost twice as likely to die. This was the case for both EVAR (OR, 1.8; 95% CI, 1.1–3) and open repair (OR, 1.7; 95% CI, 1–2.8). In the UK, a similar study based on 19,638 patients also reported a strong positive correlation between FTR and in-hospital mortality for both open ($r = 0.68$) and endovascular repair ($r = 0.7$). Moreover, they found that patients with complications were more likely to die (OR, 12.22; 95% CI, 10.51–14.21) and had more extended hospital stays ($P < .001$).[27]

An essential factor in aortic patient management is the turndown rate, which is significantly affected by the availability of necessary expertise. There is no doubt that a significant portion of patients who are turned down for surgery in smaller risk-averse centers could benefit from treatment under the care of high-volume aortic teams. Approximately one in four patients with an aneurysm > 8 cm will rupture within 6 months if managed conservatively, and approximately one in three patients with an aneurysm > 7 cm will rupture within 1 year.[29] Evidence suggests that along with poorer outcomes, smaller-volume units are less likely to offer intervention in the first place. For example, in patients presenting with ruptured AAA in the UK, smaller-volume units are likely to offer palliation to 50% of patients compared with only 20% in the highest-volume centers.[8] The reverse can also compromise care when teams are not experienced enough to appreciate their limitations and take on cases that are inoperable or beyond their expertise. However, there is undoubtedly a cohort of high-risk patients who can benefit from treatment by the right team.

A study analyzed 11,799 patients from the UK and 23,838 from the United States who underwent surgery for ruptured AAA between 2005 and 2010.[30] In both countries, lower mortality and lower palliation were associated with increased use of EVAR, higher-volume case loads, higher hospital bed capacity, and teaching hospital status; but, the overall rate of palliative treatment in the UK was significantly higher than in the United States, even after matching for patient age and sex. This may be improved with more consistent expert assessment of patient fitness for intervention and less risk aversion and a simultaneous acute appreciation of when not to operate. This latter awareness is not always tangible and requires a pragmatism that can only be achieved through experience.

ESSENTIAL RESOURCES FOR AN AORTIC SERVICE

A considerable benefit of centralizing services for complex aortic care is cost-efficiency. There is no doubt that the provision of aortic care is an expensive business, not only due to the expense of the index aortic repair procedure but also because the patients require management of complex comorbidities and an economy of scale exists in the field. Subtle savings can be made when resources are used more efficiently and funds are more appropriately directed. The overuse of services can be as high as 40% to 50%, as in the case of preoperative cardiac testing in patients undergoing noncardiac surgery as reported Brownlee et al.[31] Expert teams more often have streamlined protocols that dictate when testing is necessary and when patients might benefit from intervention. In particular, experienced specialist teams are more likely to decipher who will benefit from intervention and will therefore be less likely to burn resources on patients who are technically not suitable for repair and may not live long enough to benefit from repair.[22]

Although the recent draft guidelines from NICE recommend against EVAR due to a lack of long-term benefit and reduced cost-effectiveness, there is support for the benefits of EVAR in published observational data and cohort studies. Some evidence used for the basis of the NICE draft guidance reflect outcomes when participating physicians were at the start of their learning curves and the technology was still in its infancy.[32-35] With greater experience, newer iterations of device design, and higher volumes of repair, EVAR outcomes dramatically improve, and this can be extrapolated to complex aortic repair if delivered in the appropriate environment. Although no trials directly compare endovascular repair of complex aortic aneurysms with open surgical repair, evidence suggests that the benefits are even more significant in these patients,[36,37] who are often older and have multiple comorbidities. The relationship between volume and outcome is even more pronounced in this patient cohort, and referral to high-volume units or networks that provide both open and endovascular options should be mandatory in these patients.[38,39] This patient group exemplifies the reality that endovascular and open surgical options are not competitive but, rather, patient-specific. Per European guidelines, the decision of which method to use in the most straightforward[15] to the most complex of anatomies[16] should be unbiased and based on a multidisciplinary approach.

A fundamental consideration when reviewing contributory factors to successful aortic treatment is the availability of dedicated wards and use of critical care facilities for complex surgery. Such infrastructure provides concentrated and consistent access to necessary expertise, facilitates rapid patient turnover, and ultimately reduces death and rupture rates. A 2005 UK National Confidential Enquiry Into Patient Outcome and Death report acknowledged a lack of intensive care beds as a significant contributor to delayed surgery and cancellations in patients scheduled for major vascular surgery.[26] The report identified that one in six elective AAA repairs were postponed due to a lack of critical care beds, which led to an inevitable underuse of theatre time, an increase in waiting lists, and the potential for ruptures to occur.

The benefit of seamless access to critical care is particularly explicit in the emergency setting, as demonstrated by a UK-based study that reviewed 9,877 patients with ruptured AAA who were admitted to 153 hospital trusts from 2005 to 2010.[40] Of note, the low-mortality trusts had double the number of doctors and consultants and approximately 30% more nurses, operating theatres, and fluoroscopies per bed. Specialist critical care facilities are of similar importance after complex aortic repair. Issues such as organ perfusion and spinal drainage require close monitoring and agile ability to respond to changes that often can be subtle and missed by the untrained eye but have devastating consequences if missed, including death, paraplegia, and organ failure.

THE FUTURE OF AORTIC CARE

The joint EACTS/ESVS guidelines on aortic arch repair identified unmet needs and gaps in evidence as topics for future clinical research in the field, which can equally apply to all forms of complex aortic repair.[16] These include consolidation of evidence, consensus on treatment pathways, and establishment of prospective databases, particularly in subgroups of patients who are most

vulnerable due to age, fragility, or genetic aortopathy (which reduces aortic tissue integrity). Improved imaging techniques for patient-specific risk prediction, reduced toxicity of surveillance, and individualized therapeutics and devices to prevent or stall disease progression are also factors to consider.

CONCLUSION

The development of a complex thoracic aortic service is team-based, and this dedicated multidisciplinary team should be led by vascular and cardiac surgeons with expertise and a dedication to aortic care. Essential full-time team members are specialist anesthetists, cardiovascular imaging experts, geneticists, aortic nurse specialists, and perfusionists. Expert input should be sought from cardiologists and neuroradiologists to manage comorbidities and potential perioperative complications. A complex aortic service needs to be centralized within a high-volume teaching hospital, ideally with productive research activity, and this center should be part of an international network of dedicated aortic centers. ■

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