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SPECIAL EDITION

Controversies in Surgery for Thoracic Aorta

Decoding the volume–outcome relationship in Type A aortic dissection

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Abstract
Over the past few decades, the advents in monitoring, imaging, diagnostics, and implementation of multidisciplinary team approach in Type A aortic dissection surgery resulted in improved surgical outcomes. One other factor that needed to be targeted and carefully analyzed was the volume–outcome relationship on hospital and surgeon level in the settings of Type A dissection. This surely sprung form reports which indicated that supercenters providing aortic services with concentrated expert and expertise were performing better than smaller centers. We dwell in this article on the body of evidence to support concentration of experts and the effect of this organization on volume, referral, and outcome in Type A aortic dissection.

Keywords Volume–outcome relationship · Aortic dissection · Aortic surgeon · Aortic center

Introduction

It is generally anticipated that in undertaking any activity the greater the level of experience/practice that any individual has access to then the better the performance and hence the outcome of the service being performed. In the clinical context, this volume–outcome relationship is a longitudinal process where an increase in the volume of a particular procedure performed by a surgeon is anticipated to lead to improved patient outcomes (mortality, hospital length of stay, and survival).

Acute aortic dissection (AAD) remains a life-treating clinical catastrophe that continues to present to the surgeon and patient a pertinent challenge. The incidence is 30–43 per million per year which is incrementally increasing [1–3]. It has been shown that of every 1000 emergency department patients presenting with acute back, chest, or abdominal pain, 3 patients with AAD are diagnosed [4]. In medically treated patients, mortality rates are 1–2% per hour after the initial event. On the contrary, emergency surgery can convert a 90% mortality rate at 30 days to a 75–90% long-term survival rate [5, 6]. Mortality rates vary. In the United States, an earlier report using the Nationwide Inpatient Sample (NIS) showed the mortality to be 26% between 1995 and 2003, 21.6% between 2003 and 2008, and finally 19.1% from 2005 to 2008 [7, 8]. The International Registry for AAD and the United Kingdom Society for Cardiothoracic Surgery (SCTS) "Blue Book" have published operative mortality rates of 25.1 and 22.8%, respectively [9, 10]. In contrast, the German registry GERAADA published their series with lower rates of 17% [11]. This variation in reported mortality might be due to the volume–outcome relationship that has been at the center of debate and discussion.

Obviously, these results have been improved over the last few years due to advances in diagnosis and surgical techniques, creating an inexorable trend toward subspecialisation. So the management of the patients with AAD, because of the severe patho-anatomical damages induced in the vascular network, and, often enough, in the main organs and because of the highly variable and unstable condition of the patients, represents one of the most, if not the most difficult challenge in cardiovascular surgery and should be operated on aortic centers and by high-volume surgeon.

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Where is the evidence?

Many recent studies have revealed an inverse relationship between institution and surgeon volume with the mortality. Chikwe et al. [8] analyzed the outcomes of 5184 patients diagnosed with AAD in USA, reported that patients operated on by surgeons within the lowest annual thoracic dissection volume categories (averaging less than one case annually) were almost twice as likely to die in the hospital than those operated on by surgeons who averaged five or more such procedures per year. This relationship between volume and hospital mortality remained true for institutions, with patients twice as likely to die in the hospital if they were operated on at a center performing three or fewer acute thoracic aortic dissection cases per year, compared with the highest volume institutions, which performed more than 13 cases a year. Chikwe et al. also reported that patients operated on by surgeons who performed 60 or fewer total cardiac surgery cases annually were approximately two to three times more likely to die in the hospital than those operated on by surgeons who performed more than 170 cardiac surgery procedures per year. One more interesting finding that deserves to be highlighted is that surgeon and institution volume appeared to have a greater impact on outcomes than preoperative morbidity such as chronic pulmonary disease, renal failure, ischaemic heart disease, and valvular disease.

Bashir et al. [5], reviewing the outcomes of 1632 patients diagnosed with ATAAD in UK, reported that significant improvements in hospital mortality can be observed beyond a surgeon with mean annual case volume (MAV) of 4.0–4.5. More specifically, the unadjusted in-hospital mortality rate decreased from 19.3% in the group of surgeons who had an MAV < 4 during the study period to 12.6% in the group who had an MAV ≥ 4. On the contrary, they did not find substantial differences in the relationship between surgeon MAV and in-hospital mortality as hospital MAV increases.

Knipp et al. [7] showed a strong correlation between institution volume and in-hospital mortality in an overlapping cohort of patients operated on between 1993 and 2003, but at that time the National Inpatient Sample (NIS) did not provide sufficient surgeon-specific data to analyze outcomes of an individual surgeon level [8].

Subsequent change in data collection and reporting enable to look at this in details reveals that individual surgeon annual experience in repair of AAD was one of the strongest predictors of patient survival to discharge. In more detail, the most significant improvement in outcomes occurred at a cutoff of roughly two repairs of aortic dissections a year: below that number, operative mortality was more than 23%, above that number, operative mortality dropped to 19%. This difference remained highly significant after adjusting for patient factors including age and comorbidity; institution size, annual case volume, and teaching status; and social factors such as payer status and location [8].

The effect of multidisciplinary approach was analyzed by Andersen et al. [12] at Duke. They compared the results of AAD repair before and after implementation of a multidisciplinary thoracic aortic surgery program (TASP) at their institution, with dedicated high-volume thoracic aortic surgeons, a multidisciplinary approach to thoracic aortic disease management, and a standardized protocol for AAD repair. They found that ATAAD repair can be performed with results approximating those of elective proximal aortic surgery when operations are performed by a high-volume multidisciplinary thoracic aortic surgery team.

The case load effect

The definition of aortic surgeon and aortic center, based on the volume of the cases, remains controversial. As it was mentioned earlier, Knipp et al. [7] placed that number on 2 cases per year, Bashir et al. [5] on 4 0.5 cases per year, and Chikwe et al. [8] consider as cutoff, 5 cases per year. Similarly, for aortic centers, Knipp et al. [7] named high-volume centers amongst those which perform more than 2.5 cases per year, and Chikwe et al. [8] and Andersen et al. [12] reported better results in centers which performed more than 13 cases per year. There is a correlation between the volume of cases and the mortality, however, decoding and decrypting this further reveals the effect of a general agreement among multidisciplinary team. However, how could an agreement be supported in Type A dissection which is an emergency and settings of presentations are almost at night and after hours. Surely, there is no presence of multidisciplinary opinion after hours and as such the individual surgeon experience and level of expertise plays a pivotal which determine outcomes.

Moreover, Andersen et al. [12] reported that prior to TASP, marked variability in operative technique and circulation management was observed with a reported rate of strokes of 12.5 and 8.9% mortality because of unrecoverable neurological injury. Essential additions to the operative strategy, included right axillary cannulation, root replacement for standardized indications, routine hemi-arch reconstruction, use of circulatory arrest with deep hypothermia, electroencephalographic monitoring when available, and antegrade cerebral perfusion as the preferred cerebral protection adjunct, reduced the rate of stroke to 5.6% and no deaths reported from neurological injury.

The second major area of improvement that Andersen et al. [12] reported and needs to be mentioned is that the

management of the AAD by an experienced team, reducing the morbidity and mortality from bleeding complications. More specific, prior to TASP, nearly a quarter of patients underwent reoperation for bleeding and/or delayed sternal closure and a significant number of patients (8.9%) succumbed to refractory hemorrhage. On the contrary, after the induction of TASP, rates of reoperation for bleeding and sternal closure were significantly reduced and no patients died of hemorrhage. These improvements are likely attributable to the advent of intraoperative low-dose rFVIIa protocols as well as standardization and optimization of transfusion maneuvers with deep hypothermia [13, 14].

The timing and the expediency of surgery, were also noted by Andersen et al. [12], to change significantly since TASP was introduced. The proportion of cases initiated at night decreased from 48 to 29% and the number of emergent cases decreased from 89 to 75%. In most of the aortic centers, the trend is to defer surgery until daylight hours in stable patients who present more than 48 h after symptom onset, given the low rate of rupture or acute decompression in these patients. This strategy is associated with many advantages, including performance of a thorough preoperative evaluation as well as embarking upon these challenging cases with the most qualified ancillary team members and without the undue effects of sleep deprivation on the members of the team.

Finally, its imperative to note is remarkable that the improvement in outcomes before and after TASP implementation occurred without a marked increase institutional ATAAD volume. This suggests that the more important component of the volume–outcome relationship may be surgeon volume.

Following the induction of the TASP, the aortic emergencies are performed not by the on-call surgeon but by the aortic surgeon. This subspecialisation may be the major contributor to the improved mortality and morbidity, leading to fewer technical errors, shorter cardiopulmonary bypass (CPB) and circulatory arrest times, more complex root and arch operations, and avoidance of intraoperative deaths [12].

The controversy

The magic number that defines a surgeon as an aortic surgeon in unknown. For example, do surgeons with 5 AAD repairs per year under their belt, according to the cutoff that introduced by Bashir et al. [5] and Chikwe et al. [8], and few or no elective aortic cases have better results than surgeons who have performed many elective cases but only 2 or 3 dissection repairs? Are outcomes the same among surgeons who have treated 4 dissections but whose cumulative experience in elective aortic surgery varies? Preventza [15], recently reported, that the minimum number of cases that individual cardiac surgeons need to perform to significantly reduce the mortality associated with emergency aortic operations probably depends on their cumulative aortic experience.

The debate regarding the volume becomes more complicated, if we add the parameter of hospital volume. For example, do low-volume surgeons at high-volume institutions have the benefit to treat more stable patients, who have been transferred from outside institutions, whereas low-volume surgeons at low-volume institutions treat sicker and less stable patients? Are high-volume surgeons' outcomes the same at high- and low-volume hospitals? Furthermore, is a high-volume hospital more likely than a low-volume hospital to have an aortic surgical team? [15].

In terms of resource utilization two contradictory influences affect total hospital costs. If subspecialisation reduces in-hospital mortality, the average length of stay could easily increase, since a patient who dies in hospital has their stay curtailed while a patient who is sent home does so only when they have a sufficient recovery in hospital. On the other hand, higher quality surgery and a reduction in adverse events could mean that patients recover more quickly and avoid the very long ICU and ward stays that result from complications.

The same is also true for the costs of the surgeries themselves; a successful surgery may take longer than one in which the patient dies before it is completed, but a more experienced surgeon may complete the surgery with fewer complications and in less time than one who is less skilled.

Future directions

There is a general agreement that management of patients with AAD, do not solely depend on the surgeon but is multifactorial. Achieving great results from a technically demanding operation needs team coordination from patient admission to discharge, in the base of acute aortic treatment center (AATC). The concept of an AATC is primarily an organisational issue which requires development of the process, operational, and education. The essential components of this pathway could be summarized on: robust referral system, highly experienced cardiovascular and endovascular surgeons, highly experienced anaesthesiologists, education of emergency medical technicians on recognition of acute aortic syndromes, emergency group with extensive experience in diagnosis and resuscitation of patients with acute aortic emergencies, dedicated cardiovascular operating rooms and hybrid suites, comprehensive operating room to cardiovascular intensive care unit care with 24-h-in-house intensivist care, and on-site 64-slice computed tomography scanner in emergency room for immediate, fast imaging to permit emergent case triage. Obviously, the AATC should

also provide availability of new technologies for endovascular therapy on acute aortic syndromes outcome data. The basic aim all of the above is that the time to treatment initiation should be < 1 h [16].

But, how easy is the establishment of a AATC? Taking in account all the parameters, it does not seem so feasible from the practical point of view. First of all, even in active departments the aortic surgeons are few (1–3 perhaps). From a practical standpoint, how can those few individuals share all the on calls for aortic emergencies and dissections, all year long, including weekends and holidays? Similar to this, in many departments, the "most" experienced surgeons are the oldest ones and/or the ones in the highest hierarchic position and, thus, the least prone to be on call. In addition, the time cutoff that was mentioned earlier (< 1 h) might be possible in large urban areas where several centers of cardiac surgery co-exist, and the transfers would be rapidly organized and fast.

But what about the countries or the isolated areas where the distances between centers are important and where the transfers would take hours? It would likely result in higher preoperative mortality instead of high surgical mortality.

An important factor that affects the results of the management of AAD and require to be changed is the time that symptomatic patient spends at home before hospital presentation. As with myocardial infraction, patients frequently do not recognize the symptoms of AAD as warranting emergency care, and 1 of 5 AAD patients does not present at a hospital until > 6 h after symptom onset. The release of an inaugural set of guidelines for the management of aortic disease will further increase visibility and education. Patient education is also crucial, as patients with a family or personal history of aortic aneurysmal disease often must rely on their own personal advocacy to obtain aorta-specific testing. A patient handout and a website with internationals links, which will give the opportunity to include more active forms of patient education will provide useful information. Finally, determination of the most significant sources of delay in terms of patient characteristics and diagnostic approaches will better equip physicians, and particularly the unacquainted physician, to promptly and accurately recognize these often-lethal events [17].

Conclusion

The volume and outcome relationship has not been supported by evidence extensively in thoracic aortic aneurysm repair. Hence, further research is required to define the correlation and existing nature of this relationship. There is no clear-cut evidence to suggest that certain volume of cases is required for subspecialisation to be attained. Many factors as demonstrated in the body of this review underlie the relationship between volume and outcome in a subspecialised unit. Such could be attributed to specialized anesthetists, along with advanced intensive care facilities, that would support the transformation of service not only around the surgeon but also to other disciplines. Although the increasing evidence regarding the strong correlation between the surgeon's volume cases and mortality, it seems that the key for better patient outcome in the setting of Type A dissection is multifactorial and patient referral to an aortic center where a multidisciplinary team of members focused in aortic surgery will take over the management.

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Compliance with ethical standards

Conflict of interest All the authors disclose no conflict of interests.

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