
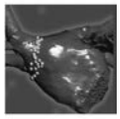
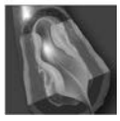

The link between volume and outcome in endovascular aneurysm repair

"A strong relationship exists between higher annual volume and lower mortality for elective and emergency endovascular aneurysm repair, mirroring similar robust relationships between volume and outcome in open AAA repair."

In many healthcare systems, vascular surgery remains an evolving specialty that has developed from the generality of surgery along a devolved model of care. This has meant that vascular services have been available in most hospitals with surgical capabilities, even when this has meant that the workload of individual units and surgeons was small. There is an increasing body of evidence that these vascular surgical procedures might be best placed within a centralized model of care to attain best outcomes.

The healthcare political landscape is evolving rapidly, with many countries now advocating specialization in surgical practice and regionalization of complex services, which would include arterial surgery. The change in delivery of specialized services has been driven by the increasing complexity of cases undertaken and the advent of new technology, in tandem with a focus on reporting health outcomes [1,2].

Elective abdominal aortic aneurysm (AAA) repair remains the key indicator procedure for vascular surgical practice and the mainstay of management for patients with large AAA is elective surgical repair. In more recent years, endovascular aneurysm repair (EVAR) has become commonplace and now exceeds the number of open repairs performed in the USA. Elective aneurysm surgery remains a procedure with significant morbidity and mortality as patients have comorbid risk factors, including significant cardio–respiratory disease and renal dysfunction. As such, the treatment of AAA by open aneurysm repair (OAR) or EVAR requires the effective working of a large multidisciplinary team [3].

The hypothesis that higher hospital operative caseload is associated with improved outcome from AAA repair has been reproducibly demonstrated in many healthcare systems. These data were subjected to meta-analysis, incorporating 421,229 elective AAA repairs. The result was significantly in favor of surgery delivered from high-volume institutions with a pooled effect estimate for mortality of 0.66 (range: 0.65–0.67) at a minimum volume threshold of 43 elective AAA repairs per annum [4].

> *"The hypothesis that higher hospital operative caseload is associated with improved outcome from AAA repair has been reproducibly demonstrated in many healthcare systems."*

These data were based on OAR, however, which might be considered to be an increasingly historical procedure. The advent of EVAR has changed the provision of vascular surgery by allowing AAA repair at a lower mortality compared with OAR. For example, the EVAR 1 trial reported a reduction in 30-day mortality from 4.7% after OAR to 1.7% after EVAR [5], and these findings were mirrored in both the Dutch Randomised Endovascular Aneurysm Management (DREAM) trial and USA Open Versus Endovascular Repair (OVER) trial [6,7]. However, there has been debate as to how EVAR is best delivered and as to whether the same volume–outcome relationships would be observed as with OAR.

Relationship between volume & outcome in EVAR

To date, two large population-based studies have examined the relationship between EVAR volume and outcome for elective AAA [8,9]. The findings from North America and the UK were concordant. In both studies, hospitals providing a higher annual caseload were more likely to operate on high-risk patients yet had lower in-hospital mortality, irrespective of the surgical modality used. The American study of 80,953 patients demonstrated significantly lower mortality for higher volume centers considering both OAR and EVAR together

Alan Karthikesalingam
St George's Vascular Institute, St George's Healthcare NHS Trust, London, UK

Matt M Thompson
St George's Vascular Institute, St George's Healthcare NHS Trust, London, UK

Peter JE Holt
Author for correspondence: Department of Outcomes Research, St George's Vascular Institute, Room 4.007, St George's Healthcare NHS Trust, London SW17 0QT, UK
Tel.: +44 208 725 3205
Fax: +44 208 725 3495
pholt@sgul.ac.uk

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(OR: 1.81; 95% CI: 1.62–2.04) [9]. The inverse relationship between total hospital operating volume and mortality remained significant in separate analysis of OAR (OR: 1.52; 95% CI: 1.33–1.73) and EVAR (OR: 1.68; 95% CI: 1.32–2.22). Although high-volume centers were more likely to employ EVAR techniques, an analysis employing statistical adjustment for this confounding factor nonetheless demonstrated significantly lower mortality in high-volume hospitals (OR: 1.52; 95% CI: 1.35–1.72).

> *"The advent of EVAR has changed the provision of vascular surgery by allowing AAA repair at a lower mortality compared with OAR."*

The UK study of 7313 patients had concordant results with the American study; it demonstrated significantly lower mortality for higher volume centers considering both OAR and EVAR together (OR: 0.993; 95% CI: 0.989–0.997) and this volume–outcome relationship remained significant in separate consideration of OAR (OR: 0.99; 95% CI: 0.989–0.999) and EVAR (OR: 0.993; 95% CI: 0.987–1.000) [8]. The scale of effect, including the finding of a higher magnitude of effect for EVAR than OAR, was notably consistent between the studies. This finding was perhaps unexpected owing to the lesser physiological stresses of EVAR, but the existence of this relationship would support a theory that it is the total aneurysm experience of a hospital that is of importance in deriving the best outcomes.

Many factors have been demonstrated to underlie the relationship between volume and outcome in vascular surgery, and it is likely that most apply in the endovascular era. High-volume surgeons with specialist vascular surgical training have been shown to deliver AAA repair with lower perioperative mortality than lower volume surgeons or those without a specialist vascular practice [10–13]. The provision of specialist anesthetic care by vascular anesthetists along with advanced intensive care facilities, where necessary, are likely to underlie the significant volume–outcome relationship for EVAR as well as OAR [14–16].

Volume–outcome relationship in EVAR for ruptured AAA

Any modern vascular service must have the capability to provide a 24-h emergency service, and this would include the routine availability of EVAR for ruptured AAA since there is mounting evidence that this reduces the mortality of ruptured aneurysms.

> *"...it is the total aneurysm experience of a hospital that is of importance in deriving the best outcomes."*

A recent study demonstrated a significantly reduced mortality associated with EVAR of ruptured AAA (eEVAR) compared with OAR of ruptured AAA (rAAA), with high-volume centers delivering rAAA repair at half the mortality of low-volume centers [17]. The use of eEVAR increased between 2000 and 2005 in this North American dataset, and mortality from eEVAR decreased over time in high-volume centers only, potentially due to a greater uptake of eEVAR. Although adjustment for case selection, morphology and the presenting hemodynamic condition of patients with rAAA was not possible, the finding of reduced mortality with eEVAR and the existence of a strong volume–outcome relationship are nonetheless of clear importance.

These key findings of reduced mortality with eEVAR and the robust volume–outcome relationship for rEVAR are mirrored in administrative data from the UK, and persisted after propensity-scored analysis [18]. One key finding was that the outcomes of ruptured AAA repairs were better when care was delivered from hospitals performing high volumes of elective aneurysm repairs. This was true whether the aneurysm repair was by EVAR or OAR.

The importance of concordance between existing large population studies of both EVAR and eEVAR in North America and the UK should not be underestimated and the robust volume–outcome relationship demonstrated has clear implications for service delivery.

Implications for delivery of AAA services

Given the magnitude of reduction in mortality at high-volume centers performing EVAR, a radical model of service reconfiguration for the centralized service delivery of aneurysm services in England was suggested. This model implied that significant reductions in perioperative deaths could be achieved through the centralized delivery of AAA repair [19]. This model was based around elective AAA repairs, but the subsequent evidence demonstrating improvements in outcome after the delivery of eEVAR from higher-volume institutions strengthen the claims of this model.

Conclusion

A strong relationship exists between higher annual volume and lower mortality for elective and emergency EVAR, mirroring similar robust relationships between volume and outcome in open AAA repair. In conjunction with the development of aneurysm screening programs these data highlight the need for regionalization of AAA service provision to high-volume centers offering a full range of vascular services, including advanced endovascular intervention.

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Bibliography

1 Department of Health: Measuring for Quality Improvement: the approach. London, UK (2009).

2 Darzi A: High quality care for all: NHS Next Stage Review final report. London, UK (2008).

3 National Confidential Enquiry into Patient Outcome and Death: The NCEPOD 2005 Report. Abdominal Aortic Aneurysm: a Service in Need of Surgery? London, UK (2005).

4 Holt PJ, Poloniecki JD, Gerrard D, Loftus IM, Thompson MM: Meta-analysis and systematic review of the relationship between volume and outcome in abdominal aortic aneurysm surgery. *Br. J. Surg.* 94(4), 395–403 (2007).

5 EVAR Trial Participants: Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysm (EVAR trial 1): randomised controlled trial. *The Lancet* 365, 2179–2186 (2005).

6 Blankensteijn JD, de Jong SE, Prinssen M *et al.*: Two-year outcomes after conventional or endovascular repair of abdominal aortic aneurysms. *N. Eng. J. Med.* 352(23), 2398–2405 (2005).

7 Lederle FA, Freischlag JA, Kyriakides TC *et al.*: Outcomes following endovascular vs open repair of abdominal aortic aneurysm: a randomized trial. *JAMA* 302(14), 1535–1542 (2009).

8 Holt PJ, Poloniecki JD, Khalid U, Hinchliffe R, Loftus IM, Thompson MM: Effect of endovascular aneurysm repair on the volume outcome relationship in aneurysm repair. *Circ. Cardiovasc. Qual. Outcomes* 2(6), 624–632 (2009).

9 Dimick JB, Upchurch GR Jr: Endovascular technology, hospital volume, and mortality with abdominal aortic aneurysm surgery. *J. Vasc. Surg.* 47(6), 1150–1154 (2008).

10 Dimick JB, Cowan JA Jr, Stanley JC *et al.*: Surgeon specialty and provider volumes are related to outcome of intact abdominal aortic aneurysm repair in the United States. *J. Vasc. Surg.* 38(4), 739–744 (2003).

11 Pearce WH, Parker MA, Feinglass J, Ujiki M, Manheim LM: The importance of surgeon volume and training in outcomes for vascular surgical procedures. *J. Vasc. Surg.* 29(5), 768–776; discussion 77–78 (1999).

12 Khuri SF, Daley J, Henderson W *et al.*: Relation of surgical volume to outcome in eight common operations: results from the VA National Surgical Quality Improvement Program. *Ann, Surg,* 230(3), 414–429; discussion 29–32 (1999).

13 Tu JV, Austin PC, Johnston KW: The influence of surgical specialty training on the outcomes of elective abdominal aortic aneurysm surgery. *J. Vasc. Surg.* 33(3), 447–452 (2001).

14 Cantlay KL, Baker S, Parry A, Danjoux G: The impact of a consultant anaesthetist led pre-operative assessment clinic on patients undergoing major vascular surgery. *Anaesthesia* 61(3), 234–239 (2006).

15 Urbach DR, Baxter NN: Does it matter what a hospital is 'high volume' for? Specificity of hospital volume-outcome associations for surgical procedures: analysis of administrative data. *BMJ* 328(7442), 737–740 (2004).

16 Bayly PJ, Matthews JN, Dobson PM, Price ML, Thomas DG: In-hospital mortality from abdominal aortic surgery in Great Britain and Ireland: Vascular Anaesthesia Society audit. *Br. J. Surg.* 88(5), 687–692 (2001).

17 Giles KA, Hamdan AD, Pomposelli FB, Wyers MC, Dahlberg SE, Schermerhorn ML: Population-based outcomes following endovascular and open repair of ruptured abdominal aortic aneurysms. *J. Endovasc. Ther.* 16(5), 554–564 (2009).

18 Holt PJ, Karthikesalingam A, Hinchliffe R, Poloniecki JD, Loftus IM, Thompson BG: Ruptured aneurysms in England: a propensity scored analysis of outcomes. *Brit. J. Surg.* (2010) (In Press).

19 Holt PJ, Poloniecki JD, Hinchliffe RJ, Loftus IM, Thompson MM: Model for the reconfiguration of specialized vascular services. *Br. J. Surg.* 95(12), 1469–1474 (2008).