In recent years, numerous studies have examined the inverse relation between hospital volume of surgical procedures and rates of operative mortality, which for selected surgical procedures was found to be higher at low-volume hospitals.1,2 As a result, a significant amount of surgical deaths in patients undergoing elective but high-risk surgery in hospitals with limited experience could be prevented each year.3

Differences between high- and low-volume hospital outcomes may be a reflection of several factors, either alone or in combination, including the skill and experience of the individual surgeon, better organised postoperative care, intensive care units staffed by intensivists, and greater resources for dealing with postoperative complications available at high-volume hospitals.1,4 These factors may also result in lower rates of failure to rescue, defined as death in a patient after a major complication, and ultimately influence postoperative mortality.5

Measures of surgical quality, such as hospital and surgeon volumes, have the potential to help patients select the best provider and hospital; to help payers to create incentives that direct patients to centres with the best outcomes; and to encourage providers to develop and implement quality improvement protocols.6,7

The authors discuss the inverse relationship between hospital volume of surgical procedures and rates of operative mortality, looking in particular at surgeons’ experience of performing radical prostatectomy and patient outcomes.

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Relationship between surgical volume and patient outcomes

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HOSPITAL VOLUME AND OUTCOMES

Birkmeyer et al.1 examined the mortality associated with 14 cardiovascular or cancer-related procedures between 1994 and 1999 (total number of procedures, 2.5 million) using data from the national Medicare claims database and the Nationwide Inpatient Sample. Hospital volume, defined as the average number of procedures per year, was first evaluated as a continuous variable, and then stratified into five categories of hospital volume (eg very low, low, medium, high, very high). After adjusting for patient characteristics, the relationship between hospital volume (total number of procedures/year) and mortality (in-hospital or within 30 days of surgery) was described.

Patient age and gender were similar among strata of hospital volume; however, Charlson score in patients managed at higher-volume hospitals was somewhat higher, and rates of non-elective admissions were higher at lower-volume hospitals.

Also, black patients were more likely to receive surgical treatment at lower-volume hospitals. For all 14 procedures, higher hospital volume was related to lower observed and adjusted mortality, although the relative importance of volume varied markedly according to the type of procedure. When comparing very-low-volume hospitals to very-high-volume hospitals, the absolute difference in adjusted mortality rates was over 12% for pancreatic resection (16.3 versus 3.8%, respectively); greater than 5% for oesophagectomy and pneumonectomy; 2–5% for gastrectomy, cystectomy, repair of a non-ruptured abdominal aneurysm, and replacement of an aortic or mitral valve; less than 2% for coronary-artery bypass grafting, lower-extremity bypass, colectomy, lobectomy and nephrectomy; and only 0.2% for carotid endarterectomy, 1.7 versus 1.5%, respectively.

SURGEON VOLUME AND OUTCOMES

Surgeon volume is a strong independent predictor of operative mortality. The impact of the surgeon’s experience on the observed effects of hospital volume and on the operative risk associated with eight cardiovascular procedures or cancer resections was evaluated by Birkmeyer et al. in 474 108 patients using information from the national Medicare claims database for 1998–99.6 Operative mortality was defined as death before hospital discharge or within 30 days after the index procedure. Surgeon volume was first evaluated as a continuous variable, and then stratified into three categories (low, medium and high).

After adjusting for patient and hospital characteristics, surgeon volume (Figure 1) was inversely related to operative mortality for all eight procedures (p<0.003 for lung resection; p<0.001 for all other procedures). For patients treated by a low-volume surgeon the adjusted odds ratio for increase in operative mortality ranged from 1.24 for lung resection to 3.61 for pancreatic resection higher than a high-volume surgeon. Surgeon volume accounted for 100% of the effect of the hospital volume for aortic-valve replacement; 57% for elective repair of an abdominal aortic aneurysm; 55% for pancreatic resection; 49% for coronary-artery bypass grafting; 46% for oesophagectomy; 39% for cystectomy; and 24% for lung resection.

For most procedures, mortality rate was higher among patients of low-volume surgeons, regardless of the surgical volume of the hospital in which they practised (Figure 2). Hospital volume was inversely related (p<0.001) to operative mortality for all procedures, with the exception (p>0.20) of carotid endarterectomy, when evaluated as a continuous variable. However, it remained a significant predictor of decreased mortality for only four procedures (repair of an abdominal aortic aneurysm, cystectomy, lung resection and pancreatic resection) after being adjusted for surgeon volume.

The authors concluded that surgeon volume mediates the associations between hospital volume and operative mortality and that patients of high-volume surgeons may have better chances of survival, even at high-volume hospitals. For some procedures, eg outpatient surgeries, the technical skill of the surgeon is the predominant determinant of operative outcomes. In contrast, complications such as multisystem failures and death resulting from major surgeries might not be directly related to the procedures themselves. In those cases, the quality of the perioperative care provided by better hospital-based services becomes the most important determinant of outcomes.4

HOSPITAL VOLUME AND COSTS

The body of evidence showing associations between hospital and surgeon volumes and outcomes has led to increased referral of high-risk procedures to high-volume centres and, in turn, to market concentration. This, however, raised the concern that better outcomes could have been achieved by high-volume hospitals at significantly increased costs secondary to an increased utilisation of resources.6 On the other hand, high-volume centres might have been able to reduce total costs through greater economies of scale and by preventing complications and readmissions.5

Using the Surveillance, Epidemiology, and End Results–Medicare database, Nathan et al.10 analysed the risk-adjusted 30-day episode Medicare payments for the index hospitalisation, readmissions, physician services, emergency room visits and post-discharge ancillary care for 31 191 colectomies, 2670 cystectomies, 1514 pancreatectomies, 2607 proctectomies, 12 228 prostatectomies and 10 151 pulmonary lobectomies performed in elderly patients with non-metastatic disease. The majority (67–78%) of the total episode payment for each procedure consisted of the payment for the index admission, followed by payment for physician services (8–22%), readmission (5–11%) and other services (2–10%).

No meaningful associations between total risk-adjusted payments and
Increased surgeon’s experience with radical prostatectomy (RP) was found to have a strong correlation with cancer control, as suggested by a risk of recurrence at 5 years of 11% in patients operated by surgeons who had completed their learning curve (250 prior RPs) compared to a risk of 18% for patients treated by surgeons who had performed only 10 prior RPs. A slower learning curve was noted for laparoscopic RPs. Using the Nationwide Inpatient Sample and the Healthcare Research and Quality databases, Savage et al. found that in the USA more than 25% of surgeons performed only one RP in year 2005 and more than 80% of surgeons had an annual volume of 10 or fewer procedures. Thus, the vast majority of surgeons appeared to be unable to complete within their career the learning curve required to provide optimum cancer control and likely provide patients with poorer oncologic outcomes than high-volume surgeons.

The relationship between hospital and surgeon volume and perioperative, oncologic and functional outcomes after RP has been examined in several studies that have been systematically reviewed by Trinh et al. Increasing hospital volume was found to be inversely associated with mortality; the risk of serious complications after RP (27 versus 32% complication rate in high- versus low-volume hospitals, respectively); mean length of hospital stay (10% lower in the highest than the lowest quartile of hospital volume); rates of late urinary complications (bladder neck obstruction, strictures, fistulas); and the need for salvage hormone- ablative or radiation therapy >6 months after surgery. It also improved recurrence-free survival.

Surgeon volume was inversely associated with perioperative adverse events and oncologic outcomes. A twofold decrease in overall complications (odds ratio: 0.53; range: 0.32–0.89) was observed in
Figure 2. Adjusted operative mortality among Medicare patients in 1998 and 1999, according to hospital–volume stratum and surgeon–volume stratum for a) four cardiovascular procedures and b) four cancer resections (reproduced with permission from Birkmeyer et al.4)
The effects of surgeon variability on oncologic and functional outcomes after RP were examined by Carlsson et al. in 1280 patients with prostate cancer treated with RP by one of nine surgeons practising in a Swedish academic centre between 2001 and 2008. Potency and continence outcomes were measured preoperatively and 18 months postoperatively by patient–administered questionnaires. Biochemical recurrence (BCR) was defined as a PSA value >0.2ng/ml with at least one confirmatory rise. After adjusting for age, PSA at diagnosis, pathologic stage, and surgical experience, a statistically significant (p<0.001) heterogeneity among surgeons was detected, with postoperative 18-month continence rates varying from 70 to 93%. No differences among surgeons were found in terms of potency outcomes, adjusted probabilities of functional recovery and 5-year probability of freedom from BCR. Based on their results, the authors suggested the need for quality-assurance measures involving performance feedback to help surgeons improving outcomes once aware of their own results.

Bianco et al. investigated the variations among experienced surgeons in cancer control after open RP. Types of variation included the surgeon volume (measured) and the surgeon’s technique (unmeasured). The study cohort consisted of 7725 patients with clinically localised prostate cancer treated with open RP at four major American academic medical centres from 1987 to 2003 by 1 of 54 surgeons. BCR was defined as PSA ≥0.4ng/ml followed by a higher level. After adjusting for case mix (baseline PSA, pathological stage and grade), surgery year and surgeon experience, the authors found a statistically significant heterogeneity in the prostate cancer recurrence rate independent of surgeon experience (p=0.002). Adjusted 5-year prostate cancer recurrence rate was less than 10% in seven and greater than 25% in another five surgeons, even though the surgeons had similar levels of experience. The authors concluded that both measured and unmeasured characteristics of the treating surgeon had an impact on the oncologic results of RP.

Vickers et al. examined heterogeneity for urinary and erectile outcomes in 1910 patients who underwent RP by one of 11 surgeons at Memorial Sloan Kettering Cancer Center between January 1999 and July 2007. After adjustment for case mix (baseline age and PSA, pathologic stage and grade, comorbidities) and year of surgery, significant heterogeneity in functional outcomes at 1 year after RP (p<0.001 for both urinary and erectile function) was detected. Adjusted rates of full continence were <75% for four surgeons and >85% for three surgeons. Adjusted rates of erectile function recovery were <20% for two surgeons and >45% for another two. Of note, better functional outcomes were associated with lower rates of BCR. The authors concluded that higher surgical quality resulted in better functional outcomes in the absence of poorer cancer control.

In an attempt to reduce heterogeneity among surgeons and uniformly offer patients high-quality care provided by urologic surgeons, a performance feedback system was piloted at Memorial Sloan Kettering Cancer Center in 2009. Surgeons who had performed a minimum of 30 procedures received their adjusted rates for recurrence, erectile dysfunction and continence obtained directly from the patient-filled electronic questionnaires using a previously validated interface. Surgeons were able to explore their oncologic and functional outcomes, both case-mix adjusted and in comparison to their peers, anonymously graphed on the report. Surgeons showed positive reactions to the feedback system, which prompted educational activities including refinements of the surgical technique. The monitoring of surgical outcomes and the development of strategies for their improvement after the implementation of the performance feedback system is ongoing at this institution.

CONTEMPORARY TRENDS

Reamess evaluated whether changes in the relationship between hospital volume and operative mortality could be detected in 3282 127 patients undergoing one of eight complex gastrointestinal, cardiac or vascular procedures at hospitals in the lowest and highest quintiles of operative volume in the recent decade (2000–9) as a result of new health policies and quality improvement initiatives developed to improve surgical quality and standards of care among poorly performing hospitals.

After adjusting for patient characteristics, the relationship between hospital volume and mortality, and changes over time were examined. A significant inverse relationship was observed in all procedures throughout the 10-year period in five of the eight procedures. Although only data from a subset of US hospitals in 1 year were included in the study, the strong inverse relationship between hospital volume and mortality appeared to have persisted despite all the changes stimulated by the body of evidence reported above. These recent data suggest that the efforts aimed at the identification and implementation of measures for the improvement of the quality of surgical care delivered by low-volume hospitals and surgeons should be re-evaluated, with continued efforts to decrease the quality gap between high- and low-volume centres.
Declaration of interests: none declared.

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