Review Article

The association between surgical volume, survival and quality of care

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Abstract: Improving surgical outcomes is important to the thoracic surgical community and operative mortality is often used as a benchmark to gauge the quality of lung resection. In lung cancer surgery, increasing hospital volume is associated with better survival although the categorisation of procedure volume is arbitrary. When US and UK data are scrutinised, the association holds true for increasingly higher volumes up to 150 resection per year and more. The reason may be due to better infrastructure, better-staffed units, more resources and wider specialist and technology-based services in higher volume centers. For individual surgeon volume, reports are not consistent. However, studies suggest that surgeon sub-specialty is an important consideration. The results of general thoracic surgeons and cardiac surgeons are reported to be better than general surgeons for lung resection surgery, and the effects of specialty training was also associated with an increase in the number of patients undergoing lung resection. We conclude that the current evidence strongly supports the association between increasing hospital volume with lower mortality and improved long-term survival following lung resection. Whilst the data presented supports centralization of lung cancer surgery in high volume hospitals, patient choice and the threshold of quality of improvement required to overcome travel and closure of local services need to be considered.

Keywords: Lung neoplasms/mortality; lung neoplasms/surgery; hospitals; high-volume; survival rate; non-small cell lung cancer (NSCLC)

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Lung cancer is a leading cause of cancer related deaths worldwide with up to 1.6 million deaths per year (1). Early stage disease accounts for 25-30% of all lung cancers. Surgical resection represents the primary treatment in this early stage group and a part in the multimodality management of advanced stages.

Efforts have been undertaken by the thoracic surgical community as a whole to continue to improve outcomes associated with surgical treatment, and whilst survival is only one measure, it is often used as a benchmark outcome to which quality is gauged.

It has been over three decades since Luft *et al*. suggested a link between hospital volume and surgical outcome by reporting hospitals that performed 200 times or more annually of selected complex procedures including open-heart surgery, vascular surgery, transurethral resection of the prostate, and coronary bypass had case adjusted death rates 25-41% lower than hospitals with low volume (2). The volume outcome relationship has also been documented in a number of cancer specific operations (3-7). In 1998 Begg *et al*. conducted a retrospective cohort study to determine whether hospital volume was inversely related to 30-day mortality for major cancer surgery. He concluded that when surgical teams in hospitals with specialty expertise provide complex surgical oncologic procedures, mortality rates are lower. He observed this for a number of cancer resections including pancreatectomy, oesophagectomy, liver resection, and pelvic exenteration (3).

Thoracic surgery survival outcomes

This interest in studying the volume outcome association in lung cancer resection has increased over the past two decades. Romano *et al*. reported approximately 40% lower

odds of death following either pneumonectomy or lesser resections performed at most active hospitals (25 or more resections per year) compared to those performed at least active hospitals (eight or fewer resections) (8).

In the United States, Bach *et al*. undertook a population-based study to estimate the extent to which the number of procedures performed at a hospital (hospital volume) is associated with survival after resection for lung cancer. They analyzed data on 2,118 patients in the Surveillance, Epidemiology, and End Results Program (SEER) database who received a diagnosis of lung cancer between 1985 and 1996 and who underwent resection for lung cancer at 1 of 76 hospitals included in the Nationwide Inpatient Sample (NIS) for 1997 and demonstrated that patients at highest-volume hospitals had lower rates of post-operative complications (20% *vs.* 44%), 30-day mortality (3% *vs.* 6%) and higher 5-year survival (44% *vs.* 33%) than those who underwent operations at the hospitals with the lowest volume defined as less than nine lung resections a year (9). They've concluded that patients who undergo resection for lung cancer at hospitals that perform large numbers of such procedures are likely to survive longer than patients who have such surgery at hospitals with a low volume of lung-resection procedures.

Birkmeyer *et al*. evaluated the relationship between hospital volume and in-hospital or 30-day mortality associated with six different types of cardiovascular procedures and eight types of major cancer resections (including lung cancer) between 1994 and 1999. They found mortality decreased as volume increased for all 14 types of procedures, but the relative importance of volume varied markedly according to the type of procedure and concluded (in the absence of other information about the quality of surgery at the hospitals near them) that patients undergoing selected cardiovascular or cancer procedures can significantly reduce their risk of operative death by selecting a high-volume hospital (10).

In general, most studies in the literature reviewing volume-outcome association use arbitrary limits for categorization of procedure volume. In US studies, an annual volume of 7 or 8 lung resections a year has been used to define the lowest volume group (9) with annual volume of 17 up to 100 used as reference of highest annual volume procedure (9,11). In the United Kingdom, this work was further explored with annual resection volumes between 70 to 150 per year (12).

Lüchtenborg *et al*. analyzed data on 134,293 patients with non-small cell lung cancer (NSCLC) diagnosed in England between 2004 and 2008, of whom 12,862 (9.6%) underwent surgical resection. They examined the association between hospital volume and survival at different intervals after surgery. Their results demonstrate increased survival in hospitals performing >150 surgical resections compared with those carrying out <70. The association between hospital volume and survival was present in all periods of follow-up, but the magnitude of this association was greatest in the early postoperative period. They also reported that patients who were older, have higher comorbidity or likely to be from more deprived areas were more likely to undergo surgery in high volume hospitals and concluded that high-volume hospitals have better outcomes despite more permissive surgical selection in higher risk patients (12).

Compared with USA data, the results from the UK suggest the inverse relationship between volume and mortality continues to hold past the 70 annual resection volumes per year.

What is the reason for the association between higher volume and better survival outcomes?

It is difficult to pinpoint the exact mechanism by which certain aspects of practice of high volume hospitals explain the observed association with survival. It is assumed that high volume hospitals have better infrastructure, better-staffed units, more resources and wider specialist and technology-based services. As a result, they are better equipped to deliver the complex care needed for higher-risk procedures.

However, there are other factors that may play a role in determining mortality after lung resection.

Individual surgeon volume

Higher surgeon volume has been reported to improve operative mortality in high-risk cancer resections such as gastrectomy, colectomy and lobectomy (13). Lien *et al*. performed a 4-year nationwide population-based study to examine the association between the volume of lung cancer resections (by both surgeon volume and hospitals) and in-hospital mortality. Surgeon volumes were divided into three groups, 46 cases or fewer referred to as low-volume, 47 to 131 cases as medium-volume and 132 cases or more as high-volume. They have demonstrated an inverse relationship between surgeon volume and the odds of in-hospital deaths whereby patients treated by low-volume surgeons had a significantly higher in hospital mortality rates than those treated by either medium-volume surgeons (2.3% *vs.* 1.0%; P=0.005) or high-volume surgeons (2.3%

vs. 0.6%; P<0.001) (14).

It is important however to note that the surgeon volume outcome has not been consistently agreed. In contrast to the above studies, a UK based study on individual surgeon volume did not demonstrate an association between individual surgeon volume and in-hospital mortality (15).

Surgeon sub-specialty

Internationally, lung resection is performed by general surgeons, general thoracic surgeons and cardiac surgeons. Schipper *et al*. examined the quality of care delivered by the three different groups of surgeons for four index non-cardiac, general thoracic surgical procedures. They assessed the effects of specialty on mortality and length of stay greater than 14 days as a surrogate for morbidity. They noted that general thoracic surgeons performed only 5% to 10% of four index thoracic operations, with more than 50% of these operations being performed by general surgeons and concluded that general thoracic surgeons and cardiac surgeons achieve better outcomes than general surgeons. These observations are supported by a number of studies reporting that American Board of Thoracic Surgery (ABTS) certified thoracic surgeons had a significantly lower mortality rate for lobectomy compared to surgeons who are board certified in general surgery (16,17). The advantage of specialty training was also extended to include better long-term survival rates for patients undergoing lung cancer surgery performed by a general thoracic surgeon compared to a general surgeon (18).

In the UK, it was observed that the addition of a specialized thoracic surgeon to the multi-disciplinary team resulted in a 3-fold increase in the number of patients undergoing lung resection without compromising outcome. It was proposed that specialized thoracic surgeons would further extend the boundaries of operability, increasing the number of patients undergoing lung resections (19).

Teaching hospitals and centralization of services

Patients undergoing surgery for lung cancer in teaching hospitals were found to have lower in-hospital mortality (20,21) and higher 5-year survival (21). Bach *et al*. suggested that improved survival was independent from procedure volume among patients who underwent surgery at teaching hospitals (9). In a more recent study, the type of teaching hospital designation has been demonstrated to influence surgical outcome. Bhamidipati *et al*. suggested lower morbidity and mortality following lung resection surgery performed at thoracic residency hospitals compared to general surgery residency hospitals, supporting specialist thoracic residency as an independent prognostic indicator (22).

At face value, the data presented seemingly supports centralization of lung cancer surgery in specialist teaching hospitals. However, one must not underestimate the reluctance of patients to travel for what is perceived to be "better" care, arbitrary comparison with different meaning to different patient populations. It is difficult to quantify the absolute difference in outcome that would persuade patients to travel away from the comforts of their local community and support system.

Quality indicators in lung cancer surgery

Defining the quality of the surgical care delivered to patients undergoing surgery for lung cancer is complex. Debate exists to define the best patient centered outcome measures that reflect surgical quality, as mortality is a relative rare outcome. Perhaps equally as important would be treatment satisfaction and quality of life measures, which are of paramount importance to patients and health care providers. Other measure could include surgical procedural quality such as pathologic staging, completeness of resection and follow up data.

It is unlikely that any single outcome would suffice as an overall marker of quality. Surgeons operate as part of a wider multidisciplinary team and different facilities can influence surgical outcome. Ultimately, "quality" is the result of the interplay of a spectrum of influencing factors that need to be taken into account to accurately compare differences in health care.

Whilst is may be difficult to quantify measures of quality, what is more pertinent and much more difficult is to define and identify unacceptable variation or results that are so poor that would necessitate the institution of formal measures. Future studies must aim to identify the process of care, which leads to improved outcome in high volume centers. It is also important to identify other indicators of quality, which may influence the overall outcome following lung resection.

Conclusions

We conclude that the current body of evidence strongly supports the association between increasing hospital volume with lower mortality and improved long-term survival following lung resection. This may in part be explained by

the association of high volume centers with thoracic surgery as a sub-specialty and a higher proportion of teaching hospital status.

Whilst it seems intuitive to suggest centralization of lung cancer surgical services, one must consider the difference in quality of care which would influence patient choice to travel away from local support and community to be able to achieve improved overall patient satisfaction with care.

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