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## A surgeon's case volume of oesophagectomy for cancer strongly influences the operative mortality rate<sup>☆</sup>

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### Abstract

**Objective:** To assess if individual case volume of oesophagectomy for cancer influences the risk of mortality and long-term survival. **Methods:** Between January 1994 and December 2005, 195 resections for oesophageal cancer were performed by nine surgeons in a single institution. Operative mortality, defined as in hospital death, was compared between the high-volume and low-volume surgeons. Multivariate logistic regression was used to analyze the risk factors for death between the two groups, also in the presence of covariates. **Results:** There were 140 males and 55 females with mean age of 63.4 (32–84). Two high-volume surgeons performed 61% (118) of the operations with a mean of 11 per year compared to 4 per year in the low-volume group. The patients in the two groups were matched for age (63 years vs 64;  $p = 0.53$ ), sex (67 vs 79% male;  $p = 0.07$ ). Ivor Lewis resections were performed more frequently by high-volume surgeons (95 vs 73%;  $p < 0.001$ ). The operative mortality rate was much lower when high case volume surgeons performed the procedure (4 vs 17%;  $p = 0.001$ ). The relative risk of death when low-volume surgeons performed the procedure was 4.59 (95% CI 1.57–13.46;  $p < 0.001$ ). In-hospital mortality was significantly associated with low-volume surgeon when controlling separately for age (OR 4.60; 95% CI 1.55, 13.60,  $p = 0.006$ ), tumor stage (OR 3.76; 95% CI 1.24, 11.45,  $p = 0.02$ ) and tumor type (OR 3.87; 95% CI 1.29, 11.60,  $p = 0.016$ ). Kaplan–Meier curves comparing the survival of high- and low-volume surgeons showed no statistical differences (Log rank  $p = 0.48$ ). **Conclusions:** Operative mortality rate for oesophagectomy for cancer is strongly influenced by case volume and was 4.6-fold higher when performed by surgeons with low case volume. Patients with oesophageal cancer in need of an oesophagectomy may benefit from referral to a high-volume thoracic surgeon.

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**Keywords:** Oesophagectomy; Mortality; Surgeon volume; Survival

### 1. Introduction

Oesophagectomy remains a challenging operation. Much effort has been undertaken to identify and minimize perioperative risk factors that adversely influence outcome following oesophagectomy for cancer. Despite this, mortality has remained high. A recent review of 70,756 oesophagectomies reported a mortality rate of 8.8% [1]. Other studies have reported a mortality figure that ranges between 0 and 25% depending on the size of the study, case mix, and hospital [2].

Hospitals performing a high volume of oesophagectomies (high-volume hospitals) have consistently reported better early clinical outcomes than low-volume counterparts [3–5]. More than 20 years ago, it had been proposed that

oesophagectomies should be limited to fewer centers (centralization) so as to increase the case volume each hospital undertook and to minimize surgical deaths [6]. This is however still difficult to put in practice in many countries.

The first publication suggesting a relationship between a surgeon's experience and operative mortality after oesophagectomy was published in 1986 by Matthews et al. [7]. Other studies have confirmed that mortality rates and complications after oesophagectomy for cancer vary widely among individual surgeons [8,9]. More recently, the surgeon has been indicated as a variable that may influence postoperative mortality and long-term survival [10].

There is still paucity in the general thoracic surgical literature assessing the relationship among individual surgeons, operative volume, and clinical outcome. Although there are many low-volume units presenting satisfactory outcomes [11], there is no agreement on off point for the volume associated with lower postoperative mortality.

We reviewed a cohort of patients who underwent oesophagectomy with the aim of determining the risks of in-hospital mortality, and to define the relationship between

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surgeon volume and outcome. The secondary aim was to establish the numerical difference in case volume between high-volume and low-volume surgeons.

## 2. Methods

The study population comprised of all patients with oesophageal cancer who were surgically treated at Papworth Hospital from January 1994 to December 2005. Since November 2004 all patient data were entered prospectively in a computer database. We included in the study only data from patients, who underwent oesophagectomy for malignant disease with palliative or curative intent. We excluded patients treated by endoscopic techniques.

The following variables were evaluated to determine their influence on postoperative mortality: age, sex, presence of co-morbidities, neoadjuvant chemo radiotherapy, type of oesophagectomy, postoperative complications, pathology, pre and postoperative TNM stage, 30-day and in-hospital mortality, and the surgeon. Neoadjuvant chemotherapy was initiated in 2000 at Papworth Hospital. Preoperative clinical staging consisted of upper gastrointestinal series, endoscopy with biopsy and computed tomography. Since 2002 other diagnostics modalities such as PET and endosonography have been utilized in the preoperative work up.

A surgeon was included in the study if he had performed any operations as the primary surgeon during the study period. The surgeons were categorized into high-volume and low-volume groups.

A consultant performed most of the operations. In the few circumstances where the senior trainee performed the operation under the direct supervision of the consultant, the operation was designated as having been done by the consultant. When two consultants (both thoracic or thoracic and general) surgeons were operating together, the operation was assigned to the surgeon who was first in the list.

## 3. Definitions

According to the definition of Matthews et al. [7], a surgeon was defined as a high-volume surgeon when he or she performed a mean of more than six cases per year.

Operative mortality was defined as in-hospital death.

## 4. Statistical analysis

Between groups comparisons were performed using *t*-tests for continuous variables and Fisher's exact test for categorical variables. Univariate logistic regression models were used to obtain unadjusted odds ratios (OR) (odds ratios from a model with a single variable) and these were used in addition to Wald test *p*-values of model parameters to assess significance of surgeon volume and other covariates of interest on in-hospital mortality. Survival curves were constructed using Kaplan–Meier methods. Survival in different groups was assessed using Wald test *p*-values for model parameters from Cox regression analysis.

Multiple logistic regression was used to further assess the effect of surgeon volume on in-hospital mortality in the presence of covariates. In these models, the ORs reflect the relative increase (if greater than 1) or decrease (if less than 1) in the odds of in-hospital death for operations done by low-volume surgeons while controlling for another variable.

Type of operation was not modeled with surgeon volume as they are strongly associated and probably provide similar information. Due to a small number of patients, models with more than one covariate in addition to surgeon volume were not explored in this study. Significance was taken as a *p*-value less than 0.05 in each analysis. Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) Version 14 (Chicago, Illinois, USA).

## 5. Results

### 5.1. Patients and surgeon characteristics

There were 140 males and 55 women, with a mean age of 64 years (range 48–80). Nine surgeons performed 195 oesophageal resections. There were two high-volume surgeons and seven low-volume surgeons. The two high-volume surgeons performed 118 (61%) of the operations. Low-volume surgeons performed 77 operations. The two patient groups were matched for age, and sex (Table 1).

### 5.2. Operative mortality and surgeon volume

The overall operative (in-hospital) mortality rate was 9.2%. The overall 30-day mortality was 7.6%. The operative mortality rate for the high-volume surgeon group was 4.2% compared with 16.9% for low-volume surgeons (Fig. 1). Low-volume surgeon was associated with significantly higher in-hospital mortality (OR 4.59; 95% CI 1.57, 13.46) (Table 2). Performing different types of operation other than Ivor Lewis resection was also associated with increased in-hospital mortality (OR 6.65; 95% CI 2.34, 18.91) (Table 2). In-hospital mortality was significantly associated with low-volume surgeon when controlling separately for age, tumor stage and tumor type (Table 3).

### 5.3. Long-term survival and surgeon volume

The overall 1-year and 5-year survival was 63.4 and 23.1%, respectively. Median survival in months (95% CI) was 16.8

Table 1  
Differences between high-volume and low-volume surgeons performing oesophagectomy

	High volume	Low volume	<i>p</i> -values
No. of patients	118	77	
Mean age, years (SD)	63 (10.6)	64 (9.5)	0.53
Males, <i>n</i> (%)	79 (67)	61 (79)	0.074
Squamous tumors, <i>n</i> (%)	79 (67)	62 (83)	0.029
Ivor Lewis procedure, <i>n</i> (%)	112 (95)	56 (73)	<0.001
Any comorbidity, <i>n</i> (%)	25 (21)	17 (22)	>0.99
In-hospital mortality, <i>n</i> (%)	5 (4.2)	13 (16.9)	0.004
Tumor stage III or IV, <i>n</i> (%)	55 (47)	47 (64)	0.037
Induction therapy, <i>n</i> = 60 patients, <i>n</i> (%)	39 (80)	21 (70)	0.42

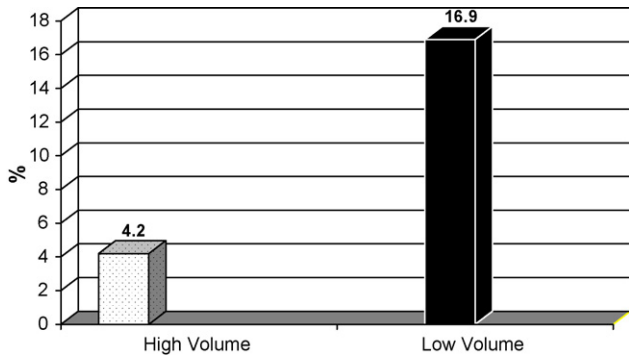


Fig. 1. Differences of mortality for oesophagectomies between high-volume and low-volume surgeons.

(13.8, 19.8) for the high-volume surgeons and 13.9 (11.0, 17.0) for the low-volume group. Surgeon volume was not significantly associated with overall survival after discharge ( $p = 0.48$ ) (Fig. 2). Advanced (stage III or IV) pathologic stage and the presence of preoperative co morbidities were associated with a decrease in post-discharge survival ( $p < 0.001$  and  $p = 0.021$ , respectively) (Table 4).

6. Discussion

The data in our study provide strong evidence that higher oesophagectomy volume surgeon for cancer achieves better operative mortality results as higher volume invariably translates to increased and better experience. For surgeons who had a low-volume practice, the patients had a 4.6 times increased in the odds of in-hospital death. The results held true despite controlling separately for age, postoperative tumor staging, and type of tumor.

With increased public scrutiny of surgical outcomes, it is important to attempt to understand the underlying reasons that may have given rise to these results.

6.1. Influence of low-volume surgeon on mortality and survival

Matthews et al. [7] reported that mortality was two times higher if the oesophageal resection was performed by a surgeon with less than six cases per year. Similar findings were also reported by Miller et al. [8]. Metzger et al. [5] showed that the minimum number of oesophageal resection performed in a unit per year to obtain mortality of 4.9% was

Table 3 Association of surgery volume with in-hospital mortality adjusted for covariates

Variables in model	Adjusted OR (95% CI)	Wald test p-value
Surgery volume, low versus high	4.60 (1.55, 13.60)	0.006
10-year changes in age	1.63 (0.93, 2.84)	0.087
Surgery volume, low versus high	3.76 (1.24, 11.45)	0.020
Tumor staging postoperative	1.21 (0.41, 3.59)	0.73
Surgery volume, low versus high	3.87 (1.29, 11.60)	0.016
Type of tumor	2.26 (0.48, 10.52)	0.30

OR: odds ratio. CI: confidence interval.

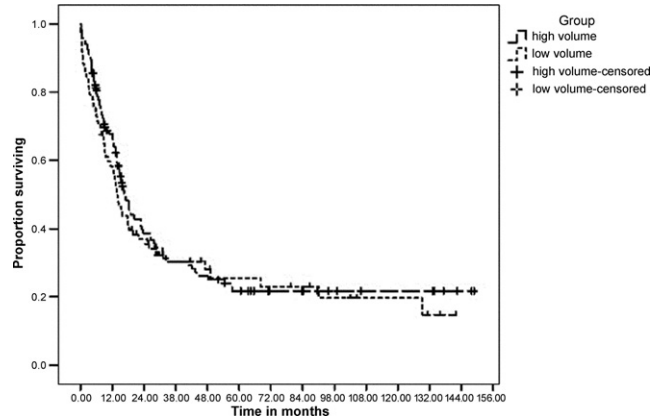


Fig. 2. Kaplan–Meier curves comparing the survival of high- and low-volume surgeons. No statistical differences are demonstrated. Log rank  $p$  value 0.476.

20. Andersen et al. [12] reported that the surgeon with fewer than five cases per year had a higher mortality rate than surgeon who performed more than 20 cases per year. Our experience shows that the minimum number of operations per year per surgeon to maintain a low rate of mortality should be at least 10. On the contrary, a surgeon performing five operations or less per year has had a higher rate of operative mortality.

The recent review by Jamieson et al. [1], which involves 70,756 patients, shows that, in the last decade, the 30 day mortality rate for oesophagectomy was 4.9% while the in hospital mortality rate was 8.8%. A majority of publications however did not report the in-hospital mortality, only 30-day mortality. In our experience, 30-day mortality is less than in hospital mortality. Reporting 30-day mortality for oesophagectomy instead of in hospital mortality may be misleading.

Table 2 Variables associated with in-hospital mortality after oesophagectomy for cancer

	Died in hospital, $n = 18$	Alive to discharge, $n = 177$	Unadjusted odds ratio (95% CI)	Wald test p-value from logistic regression
Surgery volume ( $n$ , % high)	5 (27.8)	113 (63.8)	4.59 (1.57, 13.46) (ref. = high)	0.006
10-year changes in age (mean, SD).	67.8 (10.2)	63.3 (10.1)	1.60 (0.95, 2.72)	0.080
Gender ( $n$ , % male)	15 (83.3)	125 (70.6)	2.08 (0.58, 7.49) (ref. = female)	0.26
Tumor staging postoperative ( $n$ , % III or IV)	10 (62.5)	92 (52.9)	1.49 (0.52, 4.27) (ref. = 0-IIb)	0.46
Preoperative comorbidities ( $n$ , % yes)	1 (5.6)	41 (23.2)	0.20 (0.03, 1.51) (ref. = none)	0.12
Type of tumor ( $n$ , % squamous)	15 (88.2)	126 (72.4)	2.86 (0.66, 12.97) (ref. = adeno)	0.17
Type of operation ( $n$ , % Ivor Lewis)	10 (55.6)	158 (89.3)	6.65 (2.34, 18.91) (ref. = Ivor Lewis)	<0.001
Induction therapy after 2000 $n = 60$ , ( $n$ , %)	3 (50.0)	57 (78.1)	0.28 (0.05, 1.53)	0.14

Table 4  
Variables associated with long-term survival in patients after oesophagectomy for cancer

Variable	Unadjusted OR (95% CI)	Wald test p-value
Surgeon volume group, low versus high	0.94 (0.65, 1.36)	0.73
Age per 10 years	1.04 (0.87, 1.25)	0.67
Gender male versus female	1.41 (0.93, 2.12)	0.10
Postoperative staging III and IV versus 0–II	3.63 (2.44, 5.40)	<0.001
Comorbidities, yes versus no	1.75 (1.08, 2.83)	0.023
Type of tumor adeno versus squamous	1.37 (0.91, 2.08)	0.13
Type of operation other versus Ivor Lewis	1.77 (0.86, 3.64)	0.12
Induction therapy, yes versus no	1.17 (0.49, 2.82)	0.72

OR: odds ratio. CI: confidence interval.

In our study, post-discharge survival showed no statistical differences between the low- and high-volume surgeon groups, and this is in agreement with the findings by Matthews et al. [7] and Stephen et al. [13]: but we have to consider that as much as half of the patients are dying within one year, the numbers are most likely too small to show a significance difference.

As expected, our data confirm previous results that tumor stage is the most important prognostic factor (post-discharge survival) after surgery for oesophageal cancer, and that patients with co morbidity had also a decrease in long-term survival [14].

It has been demonstrated that volume of oesophagectomies performed was an independent risk factor for operative mortality, while the number of non-oesophageal operations, hospital size, or cancer specialization did not seem to have a similar effect [9,15,16]. Low-volume surgeons working at low-volume hospitals had the worst outcomes. Increased volume appears to lead to an increase in expertise of the entire team, which may be inseparable from the surgeon's personal results. Teaching hospitals may need to take into consideration the additional burden of training specialist registrars, however we did not consider this in our study as the consultant was always present during the operation.

### 6.2. Why does low surgery volume influences mortality?

To answer this question three phases of paramount importance must be considered: patient selection; operative technique and intraoperative decisions; and postoperative care.

Patient's selection is important because the inexperienced low-volume surgeon may decide to operate on patients irrespective of age, stage, co morbidities and other characteristics. It has been shown that multidisciplinary team management and surgical sub specialization improves outcomes after surgery significantly for patients diagnosed with oesophageal cancer. The mortality of the control patients was 26% compared to 5.7% of the MDT patients [13]. In peripheral hospitals, the surgeon without the help of a multidisciplinary team generally makes the decision alone, and this can be one of the causes of preoperative evaluation errors.

Operative techniques, surgical skill and intraoperative decisions can certainly influence mortality. The inappropriate operative approach, the wrong choice of the conduit utilized to substitute the resected oesophagus and stomach, the inadequacy of the anastomosis, and lack of awareness to details during surgery can be common errors of the inexperienced surgeon.

Results of surgery depend not only on a surgeon's experience but also on the quality of postoperative care involving intensivists, anaesthesiologists and other medical personnel. Patients with adverse outcomes are kept alive for a median of 7.5 days longer in experienced high-volume hospitals due to better postoperative care [3].

Our data show that the type of operation was also associated with in-hospital mortality. In our study, the type of operation was not modeled with surgeon volume, as they were strongly associated with the surgeon, and would most likely provide similar information. Because the operation is surgeon specific the results cannot distinguish between the type of operation and the surgeon.

### 6.3. Implication of the results on training

The training received by a thoracic surgeon probably does not adequately prepare a new consultant to perform oesophagectomy independently and safely. It is common at the beginning of his career that a new consultant would usually start with only a few oesophagectomies per year. Super-specialist pre-consultant surgical training in oesophageal surgery should be mandatory because it may decrease patient risk attributable to surgeon inexperience.

Sutton et al. [17] reported that the 'learning curve' seems necessary, and it can take in some cases up to 7 years. Can a learning curve be justified for a surgeon who is going to perform oesophagectomy for oesophageal cancer? It seems wise that a new consultant willing to perform oesophagectomies should have performed several of those operations independently prior his appointment, in a high-volume training center with appropriate supervision. It is also to be recommended that a senior consultant with experience in oesophagectomy may act as a tutor to the new consultant when performing the first cases. It may then be possible to avoid the risk of higher mortality during the first years of independent practice, which can have a negative effect upon surgeon confidence, the hospital management and more importantly, the patients.

### 6.4. How can we decrease mortality for low-volume surgeons?

As suggested by others, centralization is the key point, keeping in mind that there are other clinical factors that can influence mortality and surgical results, such as ischemic heart disease, chronic obstructive pulmonary disease, and chronic renal failure [18,19]. Centralization should include the presence of a thoracic surgeon with special interest in



oesophageal diseases: he/she must provide leadership for multiple specialty teams (gastroenterologist, radiologist, oncologist, intensive care specialist) that can work together for the benefit of the patient [20]. These qualities have been recognized to be important for the cardiothoracic surgeon in the 21st century [21]. The surgeon could be the single most important variable to decrease hospital mortality. The presence of a high-volume surgeon in a high-volume hospital seems to be the best combination for achieving low mortality.

### 6.5. Potential limitation

There are several limitations of this study. The primary limitation was that this was a retrospective study. It is however not ethical to carry out a randomized controlled trial with regard to assigning patients to a low- or high-volume surgeon. Another limitation is the small number of patients with the potential risk of type II errors. Our study also did not differentiate between thoracic surgeons who focus in general thoracic surgery including the oesophagus and cardiothoracic surgeon who perform both heart and general thoracic surgery.

## 7. Conclusion

This study shows that low-volume surgery increased the odds of in-hospital mortality by more than four times, and in the multivariate analysis, individual surgeon's case volume was an independent risk factor for in-hospital mortality. In few words, the surgeon is a prognostic factor.

The results suggest that surgical skills must be maintained for the benefit of patients with oesophageal cancer and that quality and outcome are influenced by knowledge, skill, experience and interest.

In conclusion, our data demonstrate that patients with oesophageal cancer in need of an oesophagectomy may benefit from referral to a high-volume thoracic surgeon working in a high-volume center with experienced staff, facilities and equipment.

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## Appendix A. Conference discussion

**Dr M. Dusmet (London, United Kingdom):** Before opening the paper for discussion, I'm sure many people would like an answer to the same question. Far be it for me to suggest whether the consultant operates or the trainee makes a difference to outcome, because fortunately our society has shown many times that that is not the case, but I think everybody would like to know who is doing the most teaching of juniors, the high-volume or the low-volume surgeons.

**Dr Migliore:** We made this calculation in our study. Although there are a few trainees performing the operation as the first Surgeon, they are always assisted by a Consultant. The high-volume surgeons have more possibility to carry out the majority of teaching for juniors.

**Dr O. Kshivets (Siauliai, Lithuania):** I strongly agree with your first conclusion that more experienced surgeons have a lower mortality according to our database. It's probably twice below for those who perform high-volume esophagectomies. So low mortality and better 5-year survival for experienced surgeons according to Russian data and Lithuanian data. Is 5-year survival

better according to your report or is 5-year survival the same with high or low? With our data, 5-year survival is double higher with a high volume.

**Dr Migliore:** You are probably right, but we did not demonstrate a better survival at five years because our study did not show any significance between the two groups. This is probably due to the small number of patients. If the number of patients was increased, it would then be possible to demonstrate a better long-term survival for the patients operated by high-volume surgeons.

**Dr S. Mattioli (Bologna, Italy):** I agree that the more you do surgery, the better you do. I have two questions. First, were the two high-volume surgeons also, per se, more experienced surgeons, I mean not particularly experienced in esophageal surgery but just being old surgeons with overall experience in thoracic surgery? Second, how many cases of esophageal cancer resections per year are done in your hospital? It is not only a matter of the surgeon, but everybody knows that this is a problem of the team – anesthesiologists, ICU, nurses and so on. So I think that the full volume of cases per year should also be considered as a variable.

**Dr Migliore:** Regarding the second question 'the hospital volume'. We know that hospital volume is important; but different units can have different outcomes according to the number of operations and experience. We wanted to focus on Surgeons. In the same unit, it is possible to have two Surgeons who perform the operation in a different way, and one Surgeon can perform less operations per year than the other. So, our goal was to focus on who should perform the operation in the same unit for the benefit of the patient.

The first question; the overall experience is 200 cases in 12 years. The number of cases in the last few years was about 20 per year. Of course, the more patients we do, the better it is, because the team gains experience.

**Dr Dusmet:** The question was were the high-volume surgeons more experienced surgeons in your unit. That was the question.

**Dr Migliore:** More experienced surgeons and high-volume oesophagectomy surgeons are not synonymous. A new consultant thoracic surgeon can have more experience in oesophageal surgery than a senior thoracic surgeon, if the former has a background in oesophageal surgery, and the latter does not perform oesophagectomy.

**Dr A. Bilal (Peshawar, Pakistan):** Listening to your talk, I fully concur with your findings that high-volume surgeons in the high-volume centers have better results, but listening to the numbers of what you are calling high volumes, I feel we are living on a separate planet. You mentioned that anybody who was doing more than 6 cases a year was a high-volume surgeon. On the 5th of July 2007, on one list we did 6 oesophagectomies for esophageal cancer. We are flooded with esophageal cancer patients from Afghanistan, and the numbers have been going up in the last 4 or 5 years. In the year 2001 we did 7, in the year 2002 there were 17, in 2003 there were 20, in 2004 there were 55, and in 2006 there were 72, and the numbers are climbing every year. We have found that as our numbers have gone up, as the team has developed, as the postoperative care has developed, the results have definitely improved.

**Dr Migliore:** In the literature the cut-off number to define high-volume surgery is not the same for every center, and 6 is the number that we first found in the literature. We do not perform 6 oesophagectomies in one list. According to our data, a Surgeon who does more than 10 cases per year will have very good results. On the other end, a Surgeon who does less than 5 operations per year will put the patients at unacceptable risk of mortality.

**A surgeon's case volume of oesophagectomy for cancer strongly influences the operative mortality rate**

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