

# The Effect of Regionalization on Outcome in Esophagectomy: A Canadian National Study

Christian J. Finley, MD, Lindsay Jacks, MS, Shaf Keshavjee, MD, and Gail Darling, MD

Division of Thoracic Surgery, St. Joseph's Hospital, Hamilton; and the Departments of Surgery and Biostatistics, Toronto General Hospital, Toronto, Ontario, Canada

**Background.** Regionalization of specialized surgical services has been proposed to improve outcomes based on the reported association between volume and outcomes. The effect of regionalization of esophagectomy on in-hospital mortality (IHM) and length of stay (LOS) was examined.

**Methods.** Data from a Canadian database for 6985 patients (74% men; median age, 66 years) who underwent esophagectomy (1998 to 2007) were analyzed with a multivariable mixed model regression controlling for age, sex, Charlson comorbidity index, and year of esophagectomy to evaluate the effect of hospital volume. Volume changes were evaluated within and between hospitals.

**Results.** From 1998 to 2007, the number of hospitals performing esophagectomies decreased (101 to 85). The percentage of patients treated in large-volume (>20 cases/year) centers increased (29% to 61%) and IHM decreased (9.1% to 3.6%). The odds of IHM decreased

64% (95% confidence interval [CI], 51% to 74%), and LOS decreased 38% (95% CI, 34% to 43%). Comparing between hospitals, an increase of 10 cases was associated with a 15% decrease in IHM (95% CI, 6% to 23%,  $p = 0.001$ ) and a 10% increase in LOS (95% CI, 2% to 19%,  $p = 0.01$ ). Within an individual hospital, the relationship between increasing volume and LOS or IHM was not significant.

**Conclusions.** In-hospital mortality for esophagectomy has decreased in Canada but was not significantly reduced when volume was increased within a given hospital. Improved IHM may be related to selective referral of patients to high-volume hospitals. Although, decreased IHM is not solely attributable to volume changes, our results support regionalization policies for esophagectomy.

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The association between hospital volumes and surgical outcomes has been well documented for many high-risk surgical procedures, including operations for esophageal cancer [1–3]. A large body of evidence exists to suggest a consistent relationship between larger hospital volumes and improved short-term and long-term outcomes for esophagectomy [4–7]. There is also suggestion that institutional designation as a cancer center provides improved outcomes beyond that attributable to high volumes [8]. The evidence for this volume–outcome relationship is somewhat controversial, however, and some studies have failed to show any relationship between hospital volume and outcome for esophagectomy [9, 10]. Furthermore, many smaller institutions are considered to deliver high-quality care and report very favorable outcomes [11].

No volume standard for a large-volume center has been universally accepted, and many publications quote differing thresholds. The Society of Thoracic Surgeons database [10], a voluntary dedicated thoracic database, reports a yearly range of 1 to 83 per institution, with 29 of

44 participating institutions having a volume of less than 6. Hospital esophagectomy volumes of 6 to 19 per year have been considered large-volume [1, 6], and in Canada, Ontario has set the standard of 20 esophagectomies per year as the target for high-volume centers [12]. In searching for a volume threshold above which outcomes are improved, factors other than volume, particularly patient factors, are often have more influence on the variability in outcomes [13].

The evidence for a positive relationship between hospital volumes and surgical outcomes has led to the suggestion that care be regionalized primarily in large-volume centers [14]. In Canada, this resulted in formal regionalization of thoracic surgery services in British Columbia in 2001 and in Ontario in 2004, with funding and resources added to facilitate optimum care [12, 15]. In Ontario, the largest province, the regionalization occurred as part of an overall implementation of thoracic surgery standards [12]. Many other provinces have informally amalgamated existing smaller centers to effectively regionalize their services without explicit added resources.

Several authors have cautioned about potential untoward side effects of regionalization policies [11], such as limitations of emergency services, further limitations on rural facilities, and long travel distances for patients and families. The effect of manipulating hospital volumes by regionalization on surgical outcomes has not yet been

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Address correspondence to Dr Finley, Division of Thoracic Surgery, St. Joseph's Hospital, Rm T-2105H, 50 Charlton Ave E, Hamilton, ON L8N4A6, Canada; e-mail: christianfinley@shaw.ca.

established. Patient outcomes may be improved by increasing an institution's volume or by referring patients to existing high-volume centers.

To address the effect of regionalization on outcomes in thoracic surgery, esophagectomy was chosen because it is a commonly performed complex major thoracic oncologic surgical procedure, with a reported mortality rate of 2.7 to 22% [1, 4-6, 10] and a morbidity rate of 24% to 51% [10, 16].

The objective of this study was to examine changes in in-hospital mortality (IHM) and length of stay (LOS) after esophagectomy in Canada during a period in which regionalization of thoracic surgical services occurred and to describe relationships between short-term surgical outcomes and changes in hospital volumes, both between and within hospitals.

### Patients and Methods

All esophagectomies for patients aged 18 years and older recorded in the Canadian Institute for Health Information Discharge Abstract Database from 1998 to 2007 were included, specifying *International Classification of Diseases* 9th Revision (ICD-9) code 54.31, 54.32, 54.33, and 55.41, and 10th revision (ICD-10) code 1.NA.87 to 92. The Discharge Abstract Database contains all hospital discharges in Canada, with the exception of those performed in Quebec and in Manitoba outside Winnipeg. De-identified information were collected for age, sex, admission date, LOS, IHM, province of operation, institution number, surgeon, and patient disposition. To adjust for patient risk factors, the Charlson comorbidity index (CCI) was calculated using prehospitalization ICD-9 and ICD-10 diagnosis codes [17], a method that has been validated previously [18, 19]. The study was approved by the Institutional Research Ethics Board at the University Health Network.

Patient characteristics were summarized and procedural and outcome trends over time were assessed descriptively and graphically. To determine unadjusted changes in LOS and IHM during the study period, the models were fit by including only the year of procedure as a predictor. LOS stay was modeled using a log transformation due to its skewed distribution.

Hospital volume was decomposed into between-hospital and within-hospital effects [20]. Volume charges were evaluated within and between hospitals to examine if manipulating hospital volumes improved outcome. The average annual hospital volume was defined as the number of esophagectomy procedures performed at the hospital divided by the number of years of data for that hospital.

To assess within-hospital effects, the difference in a hospital's yearly volume from the average annual volume was determined. The effect of between-hospital and within-hospital components on the outcomes of LOS and IHM was estimated using multivariable random effects models [21] (linear and logistic, respectively), with a random intercept for hospital to adjust for the correlation of outcomes within hospitals.

The models were further adjusted for patient age, sex, CCI, and year of esophagectomy. Age, year of procedure, and hospital volume variables were modeled as continuous variables. CCI and sex were modeled as categorical variables. Results were unchanged when the linearity assumption between hospital volume variables and outcome were relaxed.

Volume was analyzed continuously, but for clinical relevance, hospitals volumes were grouped according to the number of esophageal cancer operations using the Cancer Care Ontario definitions and reported as low-volume ( $\leq 6$  procedures), medium-volume (7 to 9 procedures), and high-volume ( $\geq 20$  procedures) [12]. Changes in the percentage of cases being performed in each volume group over time were assessed. A value of  $p < 0.05$  was considered statistically significant, and all tests were two-sided. All statistical analyses were performed using SAS 9.2 software (SAS Institute, Cary, NC).

### Results

The study interval (1998 to 2007) included 6985 patients, of whom 5159 (74%) were men. The median age was 66 years (standard deviation [SD], 12.4; range, 18 to 101 years). The mean CCI was 2.12 (SD, 1.85; range, 0 [28%] to 10). The mean CCI increased from 1.63 to 2.14 during the study interval. The number of procedures performed per year increased from 569 to 807, as shown in Figure 1.

In-hospital mortality per year is shown in Figure 2. The unadjusted analysis showed a 64% decrease in the odds of IHM (95% confidence interval [CI], 51% to 74%;  $p < 0.0001$ ) and a 38% decrease in the expected LOS (95% CI, 34% to 43%;  $p < 0.0001$ ) during the study period. The IHM yearly rate decreased from 9.1% (95% CI, 6.9% to 11.8%) in 1998 to 3.6% (95% CI, 2.4% to 5.1%) in 2007. Similarly, LOS yearly rates decreased from a high of 24.2 (SD, 21.9) days in 1999 to 17.3 (SD, 21.9) days in 2007.

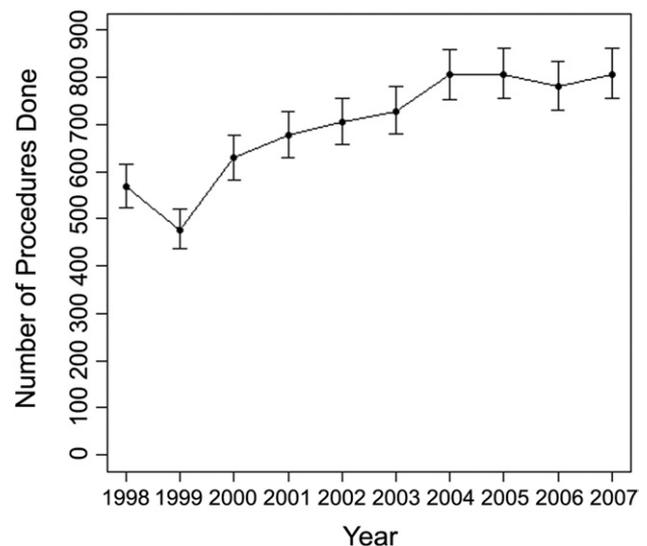


Fig 1. Number of esophagectomies performed in Canada per year. The bars show the 95% Confidence Intervals.

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