

## The Influence of Surgical Volume on Hospital Mortality and 5-Year Survival for Carcinoma of the Oesophagus and Gastric Cardia

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**Abstract.** *Objective:* To study the effects of hospital operation volume on hospital mortality and 5-year survival in patients treated with resection for carcinoma of the oesophagus and gastric cardia. *Introduction:* Surgery due to tumours of the oesophagus and gastric cardia is probably associated with the highest postoperative morbidity and mortality of all elective surgical procedures. Concentration to high-volume centres has been suggested to improve the outcome. *Materials and Methods:* Between 1987 and 1996, all patients with squamous cell carcinoma or adenocarcinoma of the oesophagus or gastric cardia were identified from the Swedish Cancer Registry and the Swedish Hospital Discharge Registry. The study population was assessed according to patients operated at hospitals with a low (L-V), intermediate (I-V) or high operation volume (H-V), defined as <5 resections/year, 5-15 resections/year and >15 resections/year, respectively. We analyzed hospital mortality and 5-year survival. *Results:* During the study period, 1429 patients were treated with resection for carcinoma of the oesophagus (n=665) or the gastric cardia (n=764). A total of 74 hospitals were registered with at least one surgical resection, of which 90% performed <5 resections/year. The distribution of gender and age was comparable in the three groups. Hospital mortality was 10.4, 6.3 and 3.5% in the L-V, I-V and H-V groups, respectively. Overall 5-year survival was 17% (L-V), 19% (I-V) and 22% (H-V). Multivariate analysis showed an improved long-term survival for patients operated at H-V compared to L-V hospitals ( $p=0.02$ ). *Conclusion:* This study supports an inverse relationship between hospital volume and hospital mortality after surgical tumour resection of the oesophagus or gastric

cardia. Overall 5-year survival was significantly higher at high-volume hospitals compared to low-volume centres. We believe that concentrating these patients in high-volume hospitals is necessary to achieve high quality surgical treatment and to facilitate research aiming to improve prognosis.

The influence of hospital volume and patient outcome has been under continuous debate since the beginning of the 1980's (1-3). Several studies report decreased postoperative mortality with a larger number of patients treated at the hospital. This is particularly true for pancreatic resection and oesophagectomy (4-7). Few studies have been performed studying the relationship between hospital volume and 5-year survival. For lung cancer, however, Bach and co-workers have shown survival benefits for patients operated at a high-volume hospital (8).

A tumour of the oesophagus or gastric cardia offers a challenge for every surgical team as it requires experience in surgery both above and below the diaphragm. Further, it requires experience in the construction of an oesophageal substitute by a gastric tube, a long Roux-en-Y limb or a colon interposition. The surgical team has also to be familiar with the method of extended lymph node dissection and to be able to cope with complications, since reconstruction of the oesophagus is known to be associated with the highest postoperative mortality rate of any elective surgery (4). Finally, quality training of junior doctors can only be achieved in specialized high-volume hospitals with sufficient numbers of patients in the catchment area (9).

The uniform, tax-funded Swedish health care system, with national registration numbers for each individual and nationwide registers, offers a unique opportunity for population-based studies. The aim of the study was to analyze the effect of hospital operative volume on hospital mortality and 5-year survival in patients treated with surgical resection for carcinoma of the oesophagus or gastric cardia during a ten-year period.

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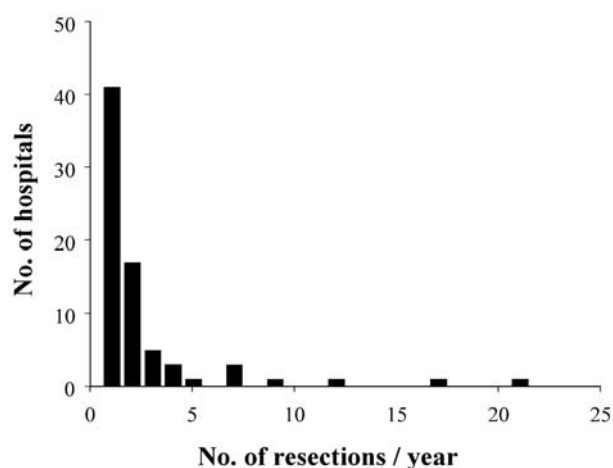


Figure 1. Distribution of mean number of tumour resections per hospital and year during the study period.

## Materials and Methods

**Register data.** In Sweden, all individuals have a unique personal identification number which makes it possible to trace an individual in different registers. All medical services providing oesophageal cancer surgery are tax-funded and the patients are primarily obliged to use a hospital in the catchment area in which they live. The Swedish Cancer Registry is a national data base to which all patients with a histologically confirmed cancer are reported. The register is regularly updated and claims to register more than 96% of all malignancies in Sweden (10). From the Swedish Cancer Registry, all individuals with squamous cell carcinoma of the oesophagus or adenocarcinoma of the oesophagus or gastric cardia during the period 1987-1996 were identified by their appropriate ICD-9 codes (International Classification of Disease: 150 and 151, and pathology codes: 096 and 146). Surgical resections, based on codes registered by the operating surgeon, linked to the cancer diagnosis were traced through the Swedish Hospital Discharge Register. We used the date of hospitalization as a replacement for the date of surgery, since the former is coded more reliably. Information about gender, age at surgery, operating hospital and county were also collected from the Swedish Hospital Discharge Registry and deaths before December 31, 2000 were collected from the Swedish Population Registers. The ethical committee of Lund approved the study (LU33-01).

**Statistical analyses.** For each of the hospitals, the mean number of tumour resections per year was determined. The patients were then grouped according to yearly hospital operative volume into three groups, low-volume <5, intermediate-volume 5-15 or high-volume >15 resections.

The hospital stay was calculated as the number of days between the registered date of admission and date of discharge, and hospital mortality was defined as the proportion dying in the hospital during the same hospitalization period as the surgical treatment. Differences in hospital mortality for the groups with different hospital operative volume were tested by Fisher's exact test.

Table I. Patient data and hospital stay per operative volume (n=1429).

	Low-volume	Intermediate-Volume	High-volume
No. of patients	662	399	368
No. of hospitals	67	5	2
Men%	76	77	75
Age, years*	67 (59-73)	66 (59-72)	67 (59-73)
> 70 years (%)	40	37	41
Hospital stay, (days*)	21 (16-32)	18 (13-26)	18 (15-23)

\*Median (25-75 percentile)

Survival was only analyzed for the first five years of follow-up, since the great majority of deaths due to this disease occur during these years. The effect of hospital operative volume on survival was analyzed by means of Kaplan-Meier survival curves and analyzed in models with adjustments for age, sex, calendar year and cancer type (11). Age was grouped in four categories: <60, 60-69, 70-79 and 80 years of age, and calendar year in two periods: 1987-1991 and 1992-1996.

Survival is generally known to be very different during the first year of follow-up compared to the following 2-5 years. Therefore, we fitted separate models for the postoperative periods; months 1-2, months 3-12 and years 2-5. Standard errors in the models were calculated with clustering at hospitals, allowing for inter-hospital variation (12-13).

As many of the deaths occurring in the first year of follow-up may be related to differences in hospital operation volume, the data were analyzed using a Cox-model, estimating relative risk of all deaths between different exposure groups (11). The covariates were evaluated by likelihood-ratio tests, and model goodness-of-fit were assessed by using the theory for Cox-models (12). Later in the follow-up the probability of other non-cancer-related causes contributing to deaths increases, and therefore we calculated excess mortality in a relative survival model, with the Swedish population as a comparison group (14). Since a relative survival model can be fitted by means of Poisson regression, evaluation of covariates and model goodness-of-fit were done by using the methods for generalized linear models (15-16).

All statistical analyses were performed using the software Stata version 7.0.

## Results

During the study period, 2356 squamous cell carcinomas of the oesophagus, 704 adenocarcinomas of the oesophagus and 1878 adenocarcinomas of the gastric cardia were identified. Of these, 1429 patients were treated with a tumour resection (22% of oesophageal carcinoma and 40%

Table II. Hospital mortality per hospital operative volume.

	Low-volume	Intermediate-Volume	High-volume
Hospital mortality (%) (dead)	10.4 (69)	6.3 (25)	3.5 (13)
Age < 70 years (%)	6.3	4.4	3.2
Age ≥ 70 years (%)	16.7	9.5	4.0

Table III. Hospital mortality per hospital volume and type of operative procedure.

	Low-volume	Intermediate-Volume	High-volume
Resection + - oesophago-gastrostomy, (n)	375	310	276
Hospital mortality, (%)	11.2	6.1	2.9
Total gastrectomy + oesophago-jejunostomy, (n)	275	75	66
Hospital mortality, (%)	9.1	4.0	3.0

of gastric cardia carcinoma). Less than 2% of the patients were surgically treated in a county other than where they lived. The resection rates varied between counties, between 14-30% for tumours of the oesophagus and 35-40% for tumours of the gastric cardia.

Seventy-four hospitals performed at least one tumour resection during the study period. The distribution of the number of hospitals and their mean yearly resection rate is shown in Figure 1. Low-volume hospitals, performing fewer than five resections annually, constituted 90% of all participating hospitals. Forty-six percent of all patients were operated at low-volume hospitals, 28% were operated at an intermediate-volume hospital and 26% at a high-volume hospital. There was no change over time in the number of hospitals performing resections during the study period. No difference in age or gender distribution was found between the study groups (Table I). The median hospital stay was 21 days in the low-volume group compared to 18 days in the intermediate- and high-volume groups.

Hospital mortality was significantly lower for patients operated at high-volume units compared to the low-volume

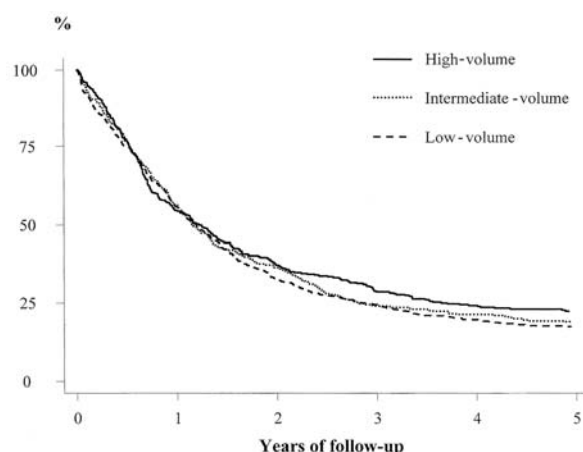


Figure 2. Kaplan-Meier curves of long-term cumulative survival after resection at high-, intermediate- and low-volume hospitals.

Table IV. Adjusted relative risks (ARR) during first 12 months of follow-up.

	months 1-2 (p-value)	months 3-12 (p-value)
High-volume *	1	1
Intermediate-volume	1.6 (0.06)	0.9 (0.4)
Low-volume	1.8 (0.02)	0.9 (0.1)

\* Reference group

hospitals, and there was a trend towards a significant difference between high- and intermediate-volume groups (Table II). The difference was even greater in patients older than 70 years, with a hospital mortality of 4.0% in high-volume units compared to 16.7% in low-volume ones.

Oesophagectomy and total gastrectomy with oesophageal resection were the two major types of surgical procedure performed in this study, even though the type of reconstruction of the alimentary tract is not given in the material. Table III shows the hospital mortality related to the type of surgical procedure.

A larger proportion of patients were operated with tumour resection and oesophagogastronomy in the high-volume than in the low-volume group (Table III). However, if hospital mortality was analyzed according to the two major types of resection performed, the relationship between high- and low-volume were almost the same.

Kaplan-Meier survival curves are shown in Figure 2. Five-year survival rates were 22%, 19% and 17% in the high-, intermediate- and low-volume groups, respectively. When analyzing the survival data, separate models were fitted for

Table V. *Adjusted relative excess risk (ARER) years 2-5 and estimated number of excess deaths compared to the Swedish population, per 100 persons and year of follow-up.*

	High- volume	Intermediate- volume	Low- volume
ARER ( <i>p</i> -value)	1.0	1.3 (0.08)	1.4 (0.02)
Excess deaths per 100 persons			
YEAR 2	34.8	43.8	46.7
YEAR 3	23.5	29.6	31.5
YEAR 4	11.6	14.6	15.5
YEAR 5	7.4	9.3	9.9

\* Reference group

months 1-2, months 3-12 and years 2-5. Table IV shows that the adjusted relative death risk during months 1-2 was significantly higher for low-volume hospitals compared to high-volume units (ARR=1.8,  $p=0.02$ ). There was a trend towards a significant difference when they were compared to the intermediate-volume group (ARR=1.6;  $p=0.06$ ).

Table V shows the adjusted relative excess risk (ARER) during years 2-5 and the number of excess deaths per year calculated from the relative survival model. ARER was significantly higher for low-volume hospitals (ARER=1.4;  $p=0.02$ ). In the intermediate-volume group the ARER was higher compared to the high-volume group (ARER=1.3;  $p=0.08$ ), but the difference did not reach statistical significance.

## Discussion

For oesophageal surgery there is now overwhelming evidence that increased hospital experience, expressed as number of operations, is associated with a significant decrease in hospital mortality. This fact is also supported by the results of this study. The majority of Swedish hospitals performed oesophageal surgery during the study period. Ninety percent of all hospitals performed fewer than five oesophageal resections per year. Hospital mortality was significantly lower if the surgical procedure was performed in a high-volume hospital (3.5%) compared to low-volume hospitals (10.4%).

Measuring surgical outcome is difficult. The criteria which are most often used are length of hospital stay, 30-days or hospital mortality, postoperative complication rate or 5-year survival. Until now the influence of case volume on 5-year survival in oesophageal cancer has only been studied by Gillison and co-workers in a case-note review

study from the the West Midlands (17). In their study, there was no difference in 5-year survival between inexperienced and experienced surgeons. In our study, five-year survival improved for patients operated at high-volume units. There are both differences and similarities between Gillison's study and our own. Surgeons who performed fewer than two resections annually had more than doubled 30-day mortality compared to high-volume surgeons (23.8% vs. 10.2%). In our material, hospital mortality was decreased by 66% when the operation was performed at a high-volume centre. These figures were even higher for patients above the age of 70 years.

The results from the Gillison study cover the same years which are included in our study. Their 30-day mortality for surgeons doing less than one operation annually was 21.7%, while the corresponding figure for those performing more than twenty operations annually was 10.2%. Postoperative mortality in Gillison's study is extremely high compared to the results in our material. This is probably explained by differences in the health care systems and the well known lack of resources in the UK healthcare system, where only 5.8% of the gross national product is spent on health care (18).

It is logical that the experience of the surgeon expressed as number of operations of a particular type performed regularly will be a major factor in patient outcome and it is well known that there is a learning curve for the surgeon in most surgical procedures (19). That the experience of the assisting surgeon will influence results is also obvious and is one possible explanation for the better results of the low volume surgeon practising in a high volume hospital (20). The number of operations at most hospitals in Sweden is too low to permit adequate evaluation of surgical outcome. With a mortality rate of 10% and a frequency of two oesophagectomies a year, a hospital will not experience death more than once in a five-year period.

However, the Swedish experience, when adding the results from all hospitals, shows that the outcome in low- and intermediate-volume centres is fairly good compared to other published results. The number of operations which define a "high-volume" hospital has been a point of discussion. The threshold we used in this regard is probably too low to describe a hospital with a sufficient number of patients to guarantee quality and the ability to improve and develop surgery. Most probably a high-volume hospital needs 100 operations or more annually.

Efforts to centralize oesophageal surgery have so far not been successful in most western countries. For example, in a review of surgery for oesophageal cancer in Denmark from 1985-88, patients were operated at 17 centres with a hospital mortality of 16.6%. These results were not considered satisfactory and, in 1996, the Danish National Board of Health and Welfare recommended centralization to seven

hospitals. Despite this recommendation, Jensen and coworkers in a follow-up study reported that, during the period 1997-2000, oesophageal resection was performed at 18 hospitals (21). In Sweden centralization has only been achieved by the National Board of Health and Welfare for pediatric heart surgery, where operations are restricted to only two hospitals. This has resulted in a decrease in hospital mortality from 9 to 1.9% (22).

The National Cancer Register in Sweden claims to register > 96% of all malignancies in the country. Diagnosis according to the International Classification of Disease (ICD) is based on data regarding tumour location reported by the local surgeon, histopathology and, in uncertain cases, re-evaluation of medical records at the Institution of National Health. However, for adenocarcinoma of the gastro-oesophageal junction, the distinction between adenocarcinoma in the distal oesophagus (Barrett cancer) and tumours of the gastric cardia is known to be difficult. Since the principles of surgical treatment are similar for tumours of the distal oesophagus and the gastrooesophageal junction, we chose to analyze the patients as one group. At low-volume hospitals, 57% of the patients were treated with resection and oesophagogastrostomy compared to 78% and 75% in the intermediate- and high-volume institutions, respectively. Several factors may contribute to these differences in surgical approach. The low-volume group patients were more frequently classified as having tumours of the gastric cardia. The location of oesophageal tumours was, in the majority of cases, not reported to the national register and, therefore, any differences in tumour location between the groups are unknown. The operating codes registered by the surgeon did not reveal whether the operation was performed through the abdominal or thoracoabdominal approach. Oesophagogastric anastomosis usually requires a thoracotomy, which may contribute to differences in the choice of surgical approach. However, the difference in hospital mortality between high- and low-volume hospitals in this study persisted when the two major procedures of resection and reconstruction were compared separately.

The cut-off points for hospital volume in this study were based mainly on previously published reports. Almost half (46%) of all patients were treated at 67 operating units that performed fewer than 5 resections per year, which accounted for 90% of the hospitals. This situation made division of the study population into equally large quartile or quintile groups unfeasible. High-volume is commonly defined as > 20 resection per year. In this study the cut-off point was set at >15 resections per year because only one hospital performed > 20 operations per year. We found no change over time in the number of hospitals performing resection during the study period.

This study showed a significant overall 5-year survival benefit for patients operated at high-volume compared to

low-volume hospitals. The national registers in Sweden lack data regarding tumour stage, known to be an important predictor for long-term survival. Even though there are national guidelines for Barrett surveillance and patients with high grade dysplasia were excluded in this study, differences in screening activity and technique may influence long-term survival. Previous studies have reported more advanced tumour stage in either high- or low-volume units. However, when the surgical technique including lymphadenectomy and histopathological examination is not strictly standardized, as is the case in most national studies, data regarding tumour stage are difficult to interpret.

Data on pre- or postoperative chemo- or radiotherapy are not registered on a national basis and there is no consensus on how to treat tumours of the oesophagus or gastric cardia in Sweden. Treatment is commonly uniform within geographic regions, but inter-regional differences existed during the study period. We consider potential differences in chemo- or radiotherapy treatment as unlikely to affect the results in this study.

There are concerns about the cost-effectiveness of health care in North America as well in Europe, irrespective of whether funding is from taxation or from the private sector. It can not be cost-effective to operate upon such a small number of patients as was done in the majority of hospitals in this study. As clearly shown in this study, with lower hospital mortality and improved 5-year survival in the high-volume group, low-volume hospitals will most likely give lower quality at a higher cost.

## Conclusion

We believe that national authorities must move to centralize the surgical treatment of tumours of the oesophagus and gastric cardia to high volume-hospitals. This is a prerequisite to achieving high quality surgical care and to facilitate research aimed at improving prognosis for these patients.

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