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Hospital volume and survival in oesophagectomy and gastrectomy for cancer

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ABSTRACT

Background: High volume upper gastrointestinal cancer hospitals demonstrate improved postoperative mortality rates, but the impact on survival is unclear. This population-based cohort study explores the effect of hospital volume on survival following upper gastrointestinal cancer surgery.

Patients and methods: This study used a population-based cohort of 3866 patients who underwent surgery for oesophageal or gastric cancer between 1998 and 2008 with follow-up until December 2008.

Results: Hospital volume ranged from 1 to 68 cases/year. Overall, 5-year survival was 27%. Increasing age and advanced stage of disease were independently correlated with shorter survival. High hospital volume was significantly and independently correlated with improved 30-day mortality postoperatively ($P < 0.001$), but not with survival beyond 30 days.

Conclusion: The correlation between hospital volume and improved 30-day mortality following oesophageal and gastric cancer surgery supports the centralisation of upper gastrointestinal cancer surgery services. The low survival in both high and low volume hospitals beyond 30 days highlights the need for increasing earlier diagnosis and optimising approaches to radical treatment.

1. Introduction

Centralisation of upper gastrointestinal cancer services aims to increase hospital volume and improve the outcome of oesophageal and gastric cancer surgery. In 2001, the Improving Outcomes Guidance for upper gastrointestinal cancers recommended that upper gastrointestinal cancer centres should perform at least 40 oesophagectomies and 60 gastrectomies for cancer each year.[1] The process of centralising upper gastrointestinal cancer services began in 2001 and was complete in the majority of networks by 2007.[2] Published reports in the United Kingdom (UK) have not shown that high hospital volume improved survival from upper gastrointestinal cancer surgery.[3,4] However, these studies used data from before 2000 and subsequent centralisation has not been assessed in relation to survival. Reports from the United States of America,[5,6] Japan,[7] Netherlands[8,9] and Sweden[10,11] have shown conflicting results. The aim of this

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study was to examine the relationship between hospital volume and survival from upper gastrointestinal cancer surgery using recent data from a population-based cancer registration.

2. Patients and methods

A population-based cohort of 3870 patients resident in South East England (London, Kent, Surrey and Sussex Counties; population approximately 10 million in 2001),[12] diagnosed with oesophageal or gastric cancer and treated operatively over an 11-year period (1998–2008) was identified by the Thames Cancer Registry using ICD-10 coded diagnoses (International Statistical Classification of Diseases and Related Health Problems 10th Revision) and OPCS-4 coded operations (Office of Population, Censuses and Surveys Classification of Surgical Operations and Procedures 4th Revision). In addition to demographic information, socio-economic deprivation, tumour stage, tumour topography, tumour morphology and chemotherapy treatment data were retrieved from the Thames Cancer Registry that obtains this information from the clinical records. The tumour was staged according to the World Health Organization classification system that is used in cancer registries worldwide (1 = local, 2 = extension to adjacent tissues, 3 = regional lymph nodes and 4 = metastases).[13] Information regarding neo-adjuvant therapy was derived from the recorded dates of chemotherapy and surgery. The Thames Cancer Registry receives death register data from the Office for National Statistics via the National Health Service Central Care Records Service. Survival was calculated from the date of operation to the date of death from any cause. Censoring of follow up occurred on 31st December 2008.

Hospital volume was calculated for each patient's record as the number of oesophagectomies and gastrectomies for cancer that were carried out in that patient's hospital in the same calendar year as their operation. Hospital volume was split into 10 cases/year groups; 1–10, 11–20, 21–30 and >30.

The data were prepared by the Thames Cancer Registry and anonymised before being analysed so that this exercise could be undertaken blind to the identity of the hospitals and the patients.

Table 1 – Demographic and clinical characteristics of patients undergoing oesophagectomy and gastrectomy for cancer, diagnosed 1998–2008, South East England.

Hospital volume (cases/year)	1–10	11–20	21–30	>30
n	1790	1211	588	277
Year of diagnosis (median)	2001	2001	2001	2005
Tumour topography				
Oesophageal	411 (23)	388 (32)	190 (32)	119 (43)
Gastric	1379 (77)	823 (68)	398 (68)	158 (57)
Median age (years)	69	69	68	64
Sex (Male:Female ratio)	7:3	7:3	7:3	7:3
Socio-economic deprivation				
1 (most affluent)	303 (17)	150 (12)	91 (15)	43 (16)
2	285 (16)	198 (16)	107 (18)	48 (17)
3	331 (18)	243 (20)	123 (21)	45 (16)
4	414 (23)	296 (24)	145 (25)	76 (27)
5 (least affluent)	457 (26)	324 (27)	122 (21)	65 (23)
Stage				
1 (local)	422 (24)	274 (23)	167 (28)	86 (31)
2 (extension to adjacent tissues)	130 (7)	108 (9)	43 (7)	14 (5)
3 (regional lymph nodes)	698 (39)	441 (36)	229 (39)	115 (42)
4 (metastases)	228 (13)	173 (14)	63 (11)	22 (8)
Unknown	312 (17)	215 (18)	86 (15)	40 (14)
Neo-adjuvant therapy				
No	1572 (88)	1007 (83)	464 (79)	150 (54)
Yes	218 (12)	204 (17)	124 (21)	127 (46)
Tumour morphology				
Adenocarcinoma	1521 (85)	1012 (84)	502 (85)	229 (83)
Squamous carcinoma	101 (6)	111 (9)	45 (8)	24 (9)
Other	166 (9)	88 (7)	41 (7)	24 (9)
Unknown	2 (0)	0	0	0
Operation				
Oesophagectomy	588 (33)	552 (46)	290 (49)	154 (56)
Gastrectomy	1202 (67)	659 (54)	298 (51)	123 (44)
Median survival (days)	668	703	730	1215

Numbers in table are frequencies, percentages in brackets.

2.1. Statistical analysis

All analyses were carried out using SPSS® (Version 18 SPSS, An IBM Company). The Pearson χ^2 was used to test if variables were significantly different between the hospital volume groups. Kaplan–Meier survival analysis was performed and the log-rank χ^2 test used to compare survival functions. Cox proportional hazards regression analysis was used to produce univariate and multivariate analyses. In order to study conditional survival, follow-up was stratified into three periods: 0–30 days, 31–365 days and >365 days. Only patients that survived a period were included in the analysis of the subsequent period. One-year survival does not represent cure and may be increased through earlier diagnosis. Therefore, long-term survival, conditional on surviving 1-year, was analysed.

3. Results

In total, data on 3870 patients were available. Four records were excluded because of time-sequence inconsistencies. There were differences between hospital volume groups in terms of the distribution of variables; tumour topography ($\chi^2 = 66.7$, 3 d.f., $P < 0.001$), age ($\chi^2 = 26.6$, 6 d.f., $P < 0.001$), socio-economic deprivation ($\chi^2 = 22.8$, 12 d.f., $P = 0.029$), stage ($\chi^2 = 31.2$, 12 d.f., $P = 0.002$), neo-adjuvant therapy ($\chi^2 = 195.7$, 3 d.f., $P < 0.001$), tumour morphology ($\chi^2 = 20.9$, 9 d.f., $P = 0.013$) and operation ($\chi^2 = 100.9$, 3 d.f., $P < 0.001$). There were greater proportions of oesophageal tumours, younger patients and neo-adjuvant therapy as hospital volume increased (Table 1).

Overall, 5-year survival was 27% (Table 2). Kaplan–Meier curves for the oesophagectomy and gastrectomy groups were not statistically significantly different (log-rank $\chi^2 = 0.8$, 1 d.f., $P = 0.372$) (Fig. 1). However, Kaplan–Meier curves for each hospital volume group showed significant variation in survival (log-rank $\chi^2 = 21.0$, 3 d.f., $P < 0.001$) (Fig. 2). Analysis of mortality and conditional survival, including 0–30 and 31–365 postoperative day periods also showed significant variation between hospital volume groups (log-rank $\chi^2 = 11.8$, 3 d.f., $P = 0.008$ and log-rank $\chi^2 = 25.6$, 3 d.f., $P < 0.001$, respectively) (Fig. 3a and Fig. 3b). There was no significant variation in conditional survival between hospital volume groups beyond one postoperative year (log-rank $\chi^2 = 0.9$, 3 d.f., $P = 0.824$) (Fig. 3c). Multivariate Cox regression analysis showed that hospital volume was independently and significantly correlated with 30-day mortality (Table 3).

Table 2 – Percentage survival of patients undergoing oesophagectomy and gastrectomy for cancer, diagnosed 1998–2008, South East England.

Time	Oesophagectomy	Gastrectomy	All
30 day	94	90	92
1 year	67	64	65
2 year	46	48	47
3 year	37	38	38
4 year	32	32	32
5 year	28	27	27

Numbers in table are percentages.

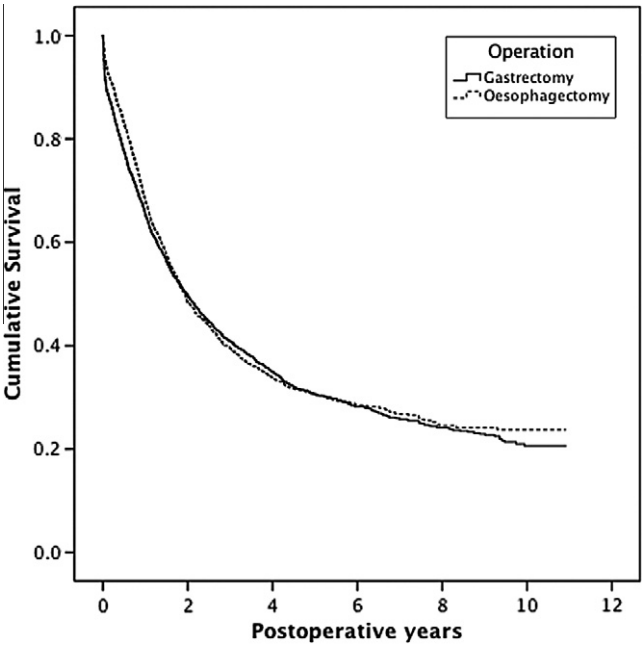

Fig. 1 – Kaplan–Meier survival estimates of patients undergoing oesophagectomy and gastrectomy for cancer, diagnosed 1998–2008, South East England.

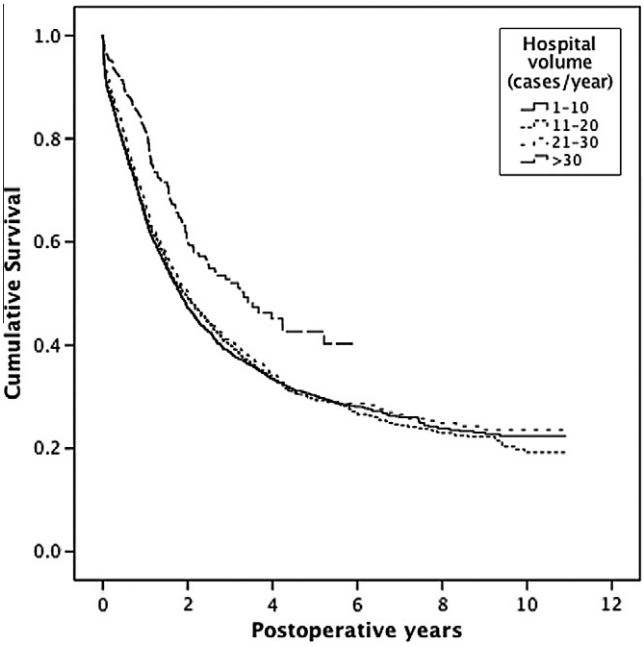

Fig. 2 – Kaplan–Meier survival estimates by hospital volume of patients undergoing oesophagectomy and gastrectomy for cancer, diagnosed 1998–2008, South East England.

4. Discussion

This population-based cohort of 3866 resected oesophageal and gastric cancer patients shows that hospital volume independently correlates with 30-day mortality postoperatively, but does not correlate with survival beyond 30 days.

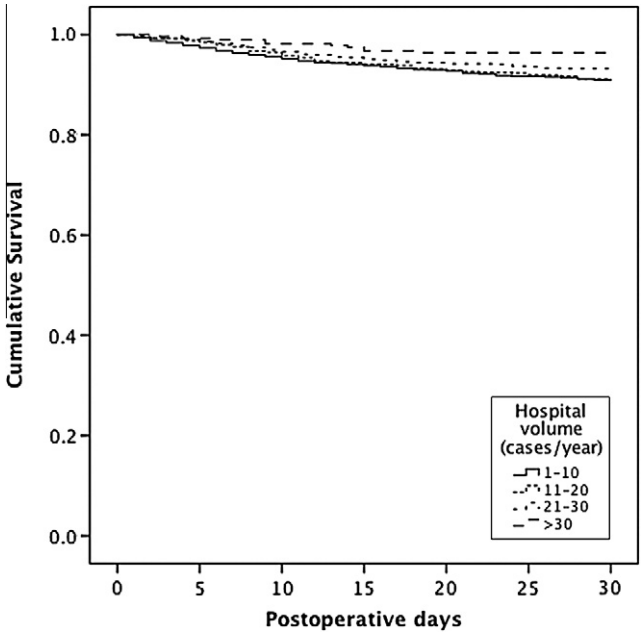

Fig. 3a – Kaplan–Meier survival estimates by hospital volume of patients undergoing oesophagectomy and gastrectomy for cancer, diagnosed 1998–2008, South East England – (a) 0–30 day survival.

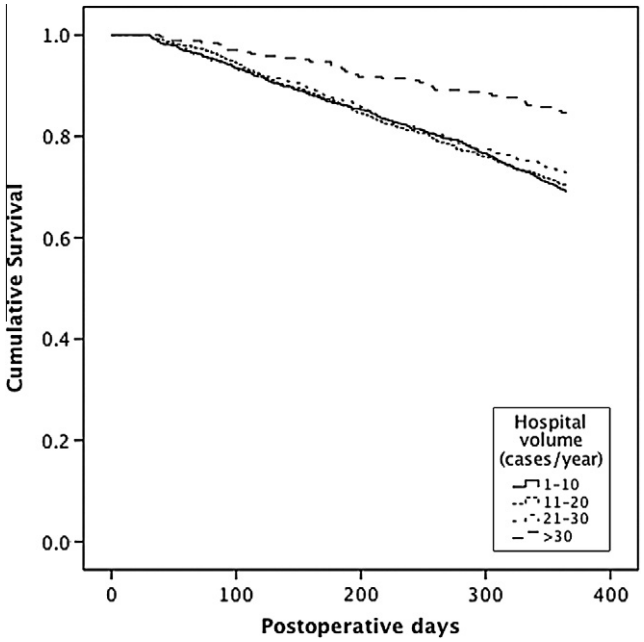

Fig. 3b – Kaplan–Meier survival estimates by hospital volume of patients undergoing oesophagectomy and gastrectomy for cancer, diagnosed 1998–2008, South East England – (b) 31–365 days survival.

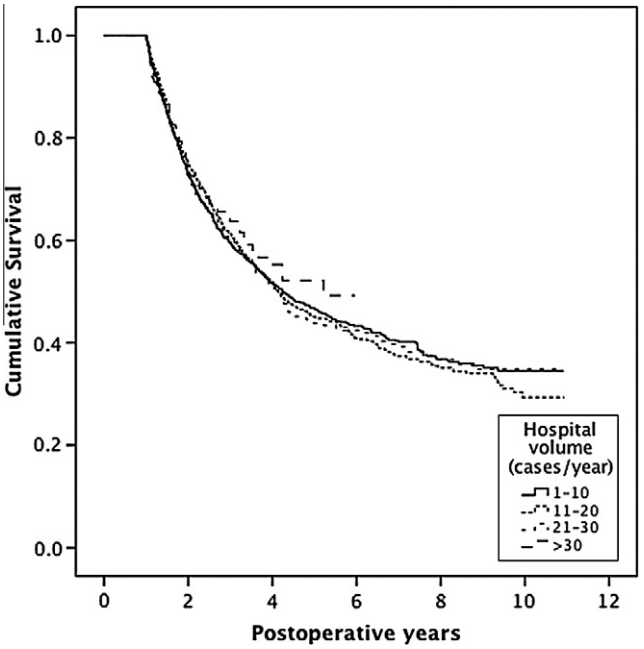

Fig. 3c – Kaplan–Meier survival estimates by hospital volume of patients undergoing oesophagectomy and gastrectomy for cancer, diagnosed 1998–2008, South East England – (c) >365 days survival.

The 5-year survival following oesophagectomy and gastrectomy for cancer was 28% and 27%, respectively.

The influence of hospital volume on 30-day mortality was independent of the year of diagnosis, tumour characteristics (tumour stage, morphology and topography), patient demographics (age, sex and socio-economic deprivation) and the use of neo-adjuvant chemotherapy. There are no data on the quality of care in this study. However, it is likely that the improvement in 30-day mortality in high volume hospitals is the direct result of multidisciplinary care. This ensures accurate cancer staging, better patient selection, improved patient preparation for surgery and appropriate experience in managing postoperative complications. The Improving Outcomes Guidance anticipated in 2001 that centralisation would improve perioperative and 1-year survival.[1] However, no hospital in this study achieved the 100 upper gastrointestinal cancer resections per year that is recommended.

Survival is determined mainly by earlier diagnosis, the use of multimodal oncological strategies, such as neo-adjuvant chemotherapy[14,15] and radicality of surgery.[16–18] Only 17.4% of patients received neo-adjuvant chemotherapy in this study. This may be because the time period of the study (1998–2008) partly preceded the publication of evidence on the effectiveness of neo-adjuvant chemotherapy on survival in gastric[14] and oesophageal cancer.[19] High volume centres adopted neo-adjuvant chemotherapy more quickly than low volume centres. This may be due to a higher recruitment rate in the trials by high volume centres. Radical surgery requires a different operative technique and it is unlikely that the process of centralisation alone would change the operating techniques of surgeons.

The level of hospital volume may account for the insignificant difference in survival in our study. The highest hospital volumes were 68, 49, 47 and 39 cases per year. Those hospital volumes may not be high enough to provide the individual surgeon with the caseload required to achieve proficiency in radical cancer resections that would result in a survival

Table 3 – Cox proportional hazards regression analysis.

Variable	Survival stratification					
	0–30 days		31–365 days		366 days–11 years	
	Univariate	Multivariate	Univariate	Multivariate	Univariate	Multivariate
Hospital volume (cases/year)						
1–10	1.000	1.000	1.000	1.000	1.000	1.000
11–20	0.983	0.974	0.979	0.947	1.024	1.016
21–30	0.737	0.865	0.951	1.002	1.012	1.020
>30	0.385**	0.660	0.493***	0.705	0.911	1.024
P trend	0.011	0.001	<0.001	0.215	0.824	1.130
Year of diagnosis	0.924***	0.934***	0.914***	0.917***	0.960***	0.954***
Tumour topography						
Gastric	1.000	1.000	1.000	1.000	1.000	1.000
Oesophageal	0.676**	1.188	0.953	1.004	1.021	1.130
P heterogeneity	0.004	0.420	0.499	0.972	0.736	0.165
Age (years)						
<60	1.000	1.000	1.000	1.000	1.000	1.000
60–70	2.431***	2.377***	1.276***	1.342***	1.061	1.098
>70	6.677***	6.012***	1.583**	1.832***	1.363***	1.559***
P trend	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sex						
Male	1.000	1.000	1.000	1.000	1.000	1.000
Female	1.153	0.986	0.892	0.910	0.827**	0.932
P heterogeneity	0.226	0.910	0.109	0.205	0.002	0.264
Socio-economic deprivation						
1 (most affluent)	1.000	1.000	1.000	1.000	1.000	1.000
2	1.294	1.403	0.940	1.042	1.208	1.249*
3	1.046	1.078	0.949	1.000	1.202	1.237*
4	1.380	1.406	1.040	1.095	1.193	1.263*
5 (least affluent)	1.127	1.145	0.974	0.962	1.007	1.024
P trend	0.308	0.223	0.856	0.695	0.043	0.010
Stage						
1 (local)	1.000	1.000	1.000	1.000	1.000	1.000
2 (extension to adjacent tissues)	1.039	1.034	1.904***	1.790***	1.780***	1.843***
3 (regional lymph nodes)	0.918	0.977	2.530***	2.584***	2.519***	2.576***
4 (metastases)	1.278	1.240	6.119***	6.303***	3.623***	4.052***
Unknown	1.979***	1.973***	2.663***	2.785***	1.439***	1.547***
P trend	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Neo-adjuvant chemotherapy						
No	1.000	1.000	1.000	1.000	1.000	1.000
Yes	0.353	0.660	0.864	1.206	1.075	1.251**
P heterogeneity	<0.001	0.076	0.092	0.060	0.340	0.009
Tumour morphology						
Adenocarcinoma	1.000	1.000	1.000	1.000	1.000	1.000
Squamous cell	0.783	1.082	1.077	1.275	0.678***	0.693**
Other	1.726***	1.533	1.294*	1.517***	0.612***	0.788
Unknown	0.000	0.000	1.823	2.222	0.001	0.001
P heterogeneity	0.005	0.098	0.125	0.001	<0.001	0.009
Operation						
Gastrectomy	1.000	1.000	1.000	1.000	1.000	1.000
Oesophagectomy	0.569***	0.818	1.001	1.166	1.059	1.124
P heterogeneity	<0.001	0.295	0.989	0.108	0.301	0.162

Numbers in table are hazard ratios.

* $P \leqslant 0.05$.

** $P \leqslant 0.01$.

*** $P \leqslant 0.001$.

advantage.[20,21] The process of centralisation in the South East of England resulted in less resections than expected, which may reflect more rigorous patient selection by multidisciplinary teams.[1]

The literature on the influence of hospital volume on survival after upper gastrointestinal cancer surgery contains conflicting results, some reports showed a positive effect,[5,7,9,10,22] others did not.[3,4,6,8,11,23,24] None of the studies, including our report, incorporate an analysis of the quality of care or radicality of surgery. Also, the definition of high volume varies between 10 and 44 cases per year for oesophagectomy and between 13 and 357 cases per year for gastrectomy. These issues constrain the analysis of factors that may account for the difference in the results between various reports.

A comparison of eastern with western publications shows that the Japanese outcome of upper gastrointestinal cancer surgery is superior.[25] The overall 5-year survival for gastrectomy in this series is approximately half the 5-year survival rate that has been achieved by UK specialist centres, which practise the Japanese style of radical resection.[26] Similarly, the survival rate following oesophagectomy is much lower than the western centres that adopt systematic radical resection.[27]

The strength of this study is the size of the recent data set that covers the period before, during and after the process of centralisation[2] and includes information on important variables that influence survival, such as stage of cancer and the use of neo-adjuvant chemotherapy. The analysis of conditional survival allows examination of long-term survival after excluding the effect of postoperative mortality. This effect was a major limitation of the MRC and Dutch D2 - D1 gastrectomy trials.[28,29] The recent Dutch report on 15-year survival showed a significant benefit of extended lymphadenectomy,[17] although the earlier publication did not.[29] On the other hand, the weaknesses of our study are the lack of information on co-morbidities, whether the resections were curative or palliative and the individual surgeon caseload. Variables that are known to influence survival were not equally distributed between the hospital volume groups and, therefore, our analysis incorporated multivariate regression in order to adjust for this.

In conclusion, this population-based study of 3866 patients demonstrates a significant correlation between hospital volume and 30-day mortality following oesophageal and gastric cancer surgery and lends support to the aim of centralisation to increase the hospital volume of upper gastrointestinal cancer services. The low 5-year survival in both high and low volume hospitals highlights the need to focus on earlier stage of diagnosis, appropriate patient selection for surgery, neo-adjuvant chemotherapy and increasing the radicality of surgery, because these are the key determinants of long-term survival. There is also a need for further research to determine the appropriate individual surgeon's caseload.

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Conflict of interest statement

None declared.

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