PART III

Surgical quality assurance

CHAPTER 15

The influence of hospital type on outcomes after esophageal and gastric cancer surgery

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ABSTRACT

BACKGROUND

Outcomes after esophagectomy and gastrectomy vary considerably between hospitals. Possible explanations include differences in case mix, hospital volume and hospital type. The present study examined the distribution of esophagectomies and gastrectomies between hospital types in the Netherlands, and the relationship between hospital type and outcome.

PATIENTS AND METHODS

Data were obtained from the nationwide Netherlands Cancer Registry. Hospitals were categorized as university hospitals (UH), teaching non-university hospitals (TNUH) and non-teaching hospitals (NTH). Hospital type-outcome relationships were analyzed by Cox regression, adjusting for case mix, hospital volume, year of diagnosis and use of multimodal therapies.

RESULTS

Between 1989 and 2009, 10,025 esophagectomies and 14,221 gastrectomies for cancer were performed in the Netherlands. The percentage of esophagectomies and gastrectomies performed in UH increased from 17.6% and 6.4% respectively in 1989 to 44.1% and 12.9% in 2009. After esophagectomy, the 3-month mortality rate was 2.5% in UH, 4.4% in TNUH and 4.1% in NTH ($P = 0.006$ for UH versus TNUH). After gastrectomy, the 3-month mortality rate was 4.9% in UH, 8.9% in TNUH and 8.7% in NTH ($P < 0.001$ for UH versus TNUH). Three-year survival was also higher in UH than in TNUH and NTH.

CONCLUSIONS

Esophagogastric resections performed in UH were associated with better outcomes but, owing to variation in outcomes within hospital types, centers of excellence cannot be designated solely on hospital type. Detailed information on case mix and outcomes is needed to identify centers of excellence.

INTRODUCTION

Long-term survival for patients with resectable esophageal and gastric cancer is low in the Western world. The 5-year overall survival rate is below 25% after esophagectomy and less than 40% after gastrectomy.[1,2] Both are high-risk operations with correspondingly high postoperative mortality rates.[3,4]

Both postoperative mortality and long-term survival after esophagogastric cancer surgery can be improved by performing these complex procedures in centers with sufficient experience and high annual volumes.[3,5] An exact cut-off value that defines high-volume surgery has not, however, been established. In a recent survey of all esophagectomies and gastrectomies performed in the Netherlands between 1989 and 2009, esophagectomies carried out in high-volume hospitals (more than 20 procedures per year) were associated with lower postoperative mortality and improved survival compared with those performed in low-volume hospitals. No such relationship was found after gastrectomy, but the number of high-volume hospitals was small.[6]

Although hospital volume can be used as a proxy for quality of care, another approach is to compare outcomes by type of hospital in which the surgery takes place.[7] University hospitals have been associated with better outcomes than non-university hospitals for a variety of procedures and diseases, including radical prostatectomy,[8] heart failure, myocardial infarction and stroke.[9,10] In a previous study, no difference was found in survival after gastrectomy between university teaching, non-university teaching and non-teaching hospitals, although the number of patients and hospitals was limited.[11] The effect of hospital type on outcomes after esophagogastric resections remains unclear.

The present study aimed to describe the distribution of esophagectomies and gastrectomies between hospital types in the Netherlands between 1989 and 2009, and to analyze the effect of hospital type on short- and long-term outcomes after these operations.

METHODS

NETHERLANDS CANCER REGISTRY

Data were obtained from the Netherlands Cancer Registry (NCR), in which information on all newly diagnosed malignancies in the Netherlands, a country of 16.5 million inhabitants, was collected. Patient, tumor and treatment characteristics were collected routinely by trained registrars from the hospital records 6-18 months after diagnosis. The quality and completeness of the data are known to be almost 100%.[12]

Topography and morphology were coded according to the International Classification of Diseases for Oncology (ICD-O).[13] ICD-O morphology codes were used to classify tumors as adenocarcinoma (8140-8145, 8190, 8201-8211, 8243, 8255-8401, 8453-8520, 8572, 8573, 8576), squamous cell carcinoma (8032, 8033, 8051-8074, 8076-8123) and other or unknown histology (8000-8022, 8041-8046, 8075, 8147, 8153, 8200, 8230-8242, 8244-8249, 8430, 8530, 8560, 8570, 8574, 8575). Tumors were staged according to the International Union Against Cancer tumor node metastasis (TNM) classification in use

in the year of diagnosis. Vital status was obtained initially from municipal registries, and from 1994 onwards from the nationwide population registries network. These registries provide complete coverage of all deceased Dutch citizens. Follow-up was complete for all patients until 31 December 2009. The study was approved by the NCR Review Board.
Esophagectomy and gastrectomy were analyzed separately. As the NCR is a topography-based registry, esophagectomies were defined as resections for cancers of the esophagus (C15.0-15.9) and gastric cardia (C16.0), whereas gastrectomies were defined as resections for non-cardia gastric cancer (C16.1-16.9).
If the hospital of surgery was not registered, the hospital of diagnosis was assumed to be the hospital of surgery. Annual hospital volumes were defined as the number of esophagectomies or gastrectomies per hospital per year. Volume categories were defined as very low (1-5 per year), low (6-10 per year), medium (11-20 per year) and high (at least 21 per year). Hospital types were defined as university hospitals, teaching non-university hospitals and non-teaching hospitals. University hospitals are attached to one of the eight universities in the Netherlands, and these hospitals collaborate closely with the corresponding medical faculty. A hospital was considered a teaching hospital if it offered (part of) a surgical residency programme.

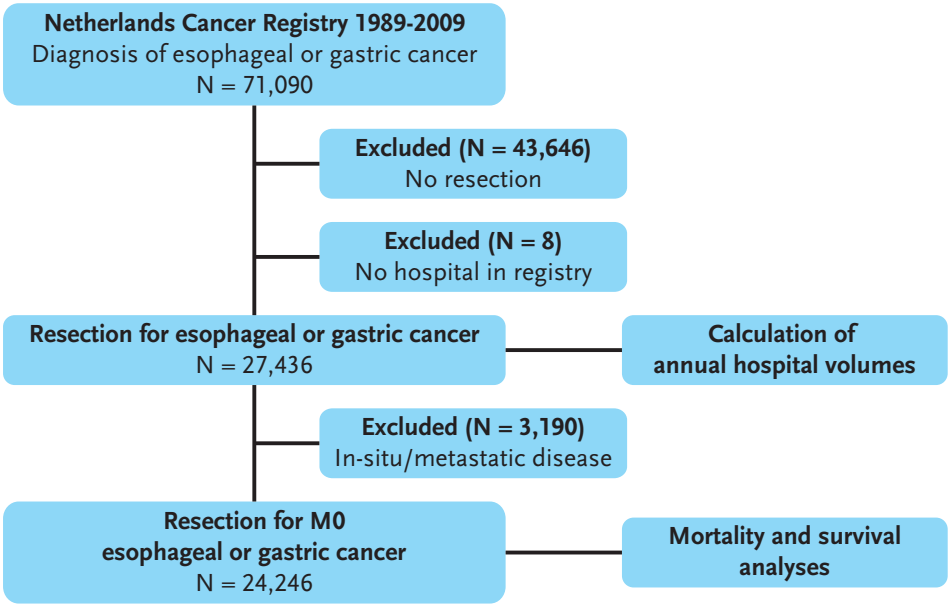
STATISTICAL ANALYSIS

Changes in the distribution of operations between hospital types over time and differences in patient characteristics between hospital types were analyzed by means of the χ^2 test. Overall survival was calculated from the day of the histological diagnosis until death, because the date of surgery was not available before 2005. Three-month overall survival was calculated unconditionally, whereas 3-year overall survival was calculated conditionally on surviving the first 3 months after diagnosis. Possible relationships between hospital type and outcomes were analyzed by stratified Cox regression, adjusted for annual hospital volume, year of diagnosis, sex, age, socioeconomic status,[14] tumor stage, morphology, preoperative therapy use, postoperative therapy use (only for 3-year survival) and for clustering of deaths within hospitals.[15] A separate analysis was performed including only patients diagnosed between 2005 and 2009. To assess potential referral bias, analyses were repeated for hospital of diagnosis instead of hospital of surgery. Analyses were performed with SPSS® version 17.0.2 (SPSS, Chicago, Illinois, USA) and R version 2.12.2 (R Project for Statistical Computing, Vienna, Austria).

RESULTS

Between January 1989 and December 2009, 71,090 patients with esophageal or gastric cancer were diagnosed (Figure 1). Some 43,646 patients who did not undergo surgical treatment and eight without information on the hospital of diagnosis or surgery were excluded, leaving 27,436 resections for analysis.
Before 2005, the hospital where the resection was performed was registered in 53.3%

Figure 1. Study flow chart



of cases, showing a match with the hospital of diagnosis in 79.8% of patients. For the remaining 46.7% of cases, the hospital of diagnosis was considered the hospital of surgery.

After analyzing hospital type distributions and their relation with annual hospital volume, 288 patients with carcinoma *in situ* and 2902 with distant metastases were excluded, leaving 24,246 patients with non-metastatic invasive carcinoma available for hospital type-outcome analyses.

HOSPITAL TYPES OVER TIME

There are eight university hospitals in the Netherlands and one specialized cancer center that was analyzed as a university hospital. The number of non-university hospitals where esophagectomies and gastrectomies were performed decreased, from 120 in 1989 to 82 in 2009.

The annual number of esophagectomies increased over the years, from 352 in 1989 to 723 in 2009 (Figure 2a). The percentage of esophagectomies performed in university hospitals increased from 17.6% (62/352) in 1989 to 44.1% (319/723) in 2009 ($P < 0.001$). The annual number of gastrectomies decreased from 1107 in 1989 to 495 in 2009 (Figure 2b). The percentage of gastrectomies performed in university hospitals increased from 6.4% (71/1107) in 1989 to 12.9% (64/495) in 2009 ($P < 0.001$). Most gastrectomies are currently performed in teaching non-university hospitals.

Table 1. Characteristics for all patients with resected non-metastatic esophageal cancer in the Netherlands between 1989 and 2009 (N = 10,025)

	University Hospital		Teaching Non-University Hospital		Non-Teaching Hospital		
	N	%	N	%	N	%	*P*
Total	3559	*100.0*	3905	*100.0*	2561	*100.0*	
Sex							
male	2694	*75.7*	3004	*76.9*	1952	*76.2*	0.454
female	865	*24.3*	901	*23.1*	609	*23.8*	
Age							
<60	1324	*37.2*	1330	*34.1*	785	*30.7*	<0.001
60-75	1947	*54.7*	2139	*54.8*	1446	*56.5*	
>75	288	*8.1*	436	*11.2*	330	*12.9*	
median age	63		64		65		
SES							
low	290	*8.1*	489	*12.5*	227	*8.9*	<0.001
medium	2633	*74.0*	3083	*79.0*	2162	*84.4*	
high	162	*4.6*	156	*4.0*	108	*4.2*	
unknown	474	*13.3*	177	*4.5*	64	*2.5*	
Morphology							
adenocarcinoma	2552	*71.7*	2997	*76.7*	1992	*77.8*	<0.001
SCC	928	*26.1*	818	*20.9*	509	*19.9*	
other	79	*2.2*	90	*2.3*	60	*2.3*	
TNM stage group							
I	624	*17.5*	810	*20.7*	507	*19.8*	<0.001
II	1305	*36.7*	1551	*39.7*	1042	*40.7*	
III	1388	*39.0*	1306	*33.4*	881	*34.4*	
IV	39	*1.1*	45	*1.2*	24	*0.9*	
unknown	203	*5.7*	193	*4.9*	107	*4.2*	
Preoperative therapy							
yes	907	*25.5*	634	*16.2*	163	*6.4*	<0.001
no	2652	*74.5*	3271	*83.8*	2398	*93.6*	
Postoperative therapy							
yes	194	*5.5*	233	*6.0*	104	*4.1*	0.003
no	3365	*94.5*	3672	*94.0*	2457	*95.9*	
Annual hospital volume							
1-5	144	*4.0*	1024	*26.2*	1746	*68.2*	<0.001
6-10	415	*11.7*	1623	*41.6*	657	*25.7*	
11-20	512	*14.4*	824	*21.1*	158	*6.2*	
≥21	2488	*69.9*	434	*11.1*	0	*0*	

SES: socio economic status, SCC: squamous cell carcinoma, preoperative/postoperative therapy: chemotherapy with/without radiotherapy

PATIENT, TUMOR AND TREATMENT CHARACTERISTICS

Between 1989 and 2009, 10,025 patients underwent esophagectomy and 14,221 underwent gastrectomy for cancer (Tables 1 and 2). The median age of patients who underwent esophagectomy in university hospitals was 63 years, compared with 64 and 65 in teaching non-university and non-teaching hospitals respectively. They were more likely to have a squamous cell carcinoma (26.1% in university hospitals *versus* 20.9% and 19.9% in teaching non-university and non-teaching hospitals respectively) and had higher tumor stages (stage III disease in 39.0% (1388/3559), 33.4% (1306/3905) and

Table 2. Characteristics for all patients with resected non-metastatic gastric cancer in the Netherlands between 1989 and 2009 (N = 14,221)

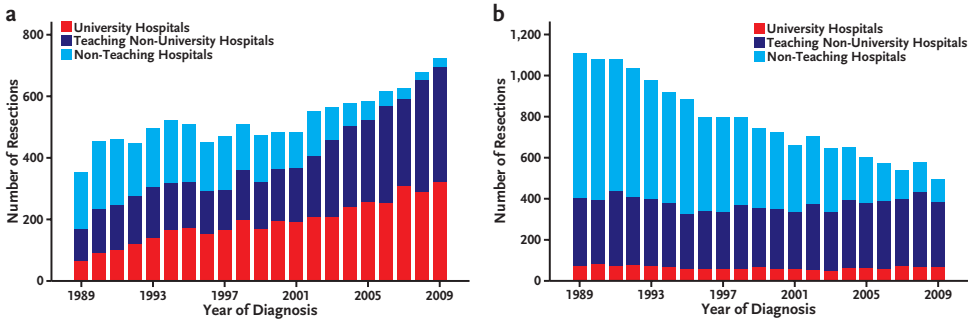
	University Hospital		Teaching Non-University Hospital		Non-Teaching Hospital		
	N	%	N	%	N	%	*P*
Total	1132	*100.0*	5702	*100.0*	7387	*100.0*	
Sex							
male	683	*60.3*	3458	*60.6*	4423	*59.9*	0.669
female	449	*39.7*	2244	*39.4*	2964	*40.1*	
Age							
<60	352	*31.1*	1151	*20.2*	1346	*18.2*	< 0.001
60-75	521	*46.0*	2711	*47.5*	3530	*47.8*	
>75	259	*22.9*	1840	*32.3*	2511	*34.0*	
median Age	67		71		71		
SES							
low	198	*17.5*	882	*15.5*	694	*9.4*	< 0.001
medium	789	*69.7*	4319	*75.5*	6256	*84.7*	
high	48	*4.2*	181	*3.2*	233	*3.2*	
unknown	97	*8.6*	320	*5.6*	204	*2.8*	
Morphology							
adenocarcinoma	1109	*98.0*	5602	*98.2*	7249	*98.1*	0.780
other	23	*2.0*	100	*1.8*	138	*1.9*	
TNM stage group							
I	436	*38.5*	2195	*38.5*	2781	*37.6*	<0.001
II	259	*22.9*	1569	*27.5*	2010	*27.2*	
III	329	*29.1*	1528	*26.8*	2112	*28.6*	
IV	72	*6.4*	258	*4.5*	264	*3.6*	
unknown	36	*3.2*	152	*2.7*	220	*3.0*	
Preoperative therapy							
yes	125	*11.0*	378	*6.6*	113	*1.5*	<0.001
no	1007	*89.0*	5324	*94.8*	7274	*98.5*	
Postoperative therapy							
yes	65	*5.7*	299	*5.2*	145	*2.0*	<0.001
no	1067	*94.3*	5403	*94.8*	7242	*98.0*	
Annual hospital volume							
1-5	235	*21.8*	893	*15.7*	2283	*30.9*	<0.001
6-10	511	*45.1*	2306	*40.4*	3282	*44.4*	
11-20	366	*32.3*	2284	*40.1*	1706	*23.1*	
≥21	20	*1.8*	219	*3.8*	116	*1.6*	
Type of resection[a]							
total gastrectomy	143	*51.1*	479	*32.6*	266	*37.7*	<0.001
subtotal gastrectomy	137	*48.9*	986	*67.3*	440	*62.3*	

SES: socio economic status, preoperative/postoperative therapy: chemotherapy with/without radiotherapy
[a]only available from 2005-2009

34.4% (881/2561) respectively). A higher proportion of patients in university hospitals received multimodal therapy. Annual hospital volumes were higher in university hospitals: 69.9% of esophagectomies (2488/3559) in such hospitals were performed in centers with an annual volume of at least 21, compared with 11.1% (434/3905) in teaching non-university hospitals and no esophagectomies in non-teaching hospitals.

Patients who underwent a gastrectomy in university hospitals had a median age of 67 years, compared with 71 years in both types of non-university hospital. Patients in university hospitals also received more preoperative and postoperative multimodal

Figure 2. Number of (a) esophagectomies and (b) gastrectomies performed in different hospital types, 1989-2009



therapy. Annual hospital volumes were highest in non-university teaching hospitals: 43.9% of gastrectomies (2503/5702) in teaching non-university hospitals were performed in centers with an annual volume of ≥11, compared with 34.1% (386/1132) in university hospitals and 24.7% (1822/7387) in non-teaching hospitals.

RELATIONSHIP BETWEEN HOSPITAL TYPE AND OUTCOMES

In multivariable regression analysis adjusting for case mix, annual hospital volume, year of diagnosis and use of multimodal therapy, both esophagectomies and gastrectomies in university hospitals were associated with lower 3-month mortality and higher 3-year survival (Table 3).

The adjusted 3-month mortality rate after esophagectomy was 2.5% (95% confidence interval 1.8-3.2%) in university hospitals, 4.4% (3.5-5.2%) in teaching non-university hospitals and 4.1% (3.2-5.0%) in non-teaching hospitals (Figure 3a). Corresponding 3-year survival rates were 46% (44-49%), 42% (40-44%) and 43% (40-59%) (Figure 3b). Adjusted 3-month mortality rates after gastrectomy were 4.9% (3.7-6.1%) in university hospitals, 8.9% (8.1-9.7%) in teaching non-university hospitals and 8.7% (8.0-9.4%) in non-teaching hospitals (Figure 3c). Respective 3-year survival rates were 58% (55-61%), 52% (51-54%) and 52% (51-54%) (Figure 3d).

Hospital type-outcome analyses including only patients diagnosed between 2005 and 2009 produced no major changes in the results, except that the difference in 3-year survival after gastrectomies between hospital types became non-significant (not shown). When analyses for 1989-2009 were repeated with the hospital of diagnosis instead of the hospital of surgery, again no major changes were found, although 3-month mortality after esophagectomy lost significance (not shown). When the analyses were repeated with university hospitals as the reference category, these hospitals were found to be associated with a significantly lower 3-month mortality rate after both esophagectomy and gastrectomy, and significantly better 3-year survival after gastrectomy, compared with non-teaching hospitals (not shown).

Figure 3. Relationship between hospital type and 3-month mortality and 3-year survival for (a, b) esophagectomy, and (c, d) gastrectomy

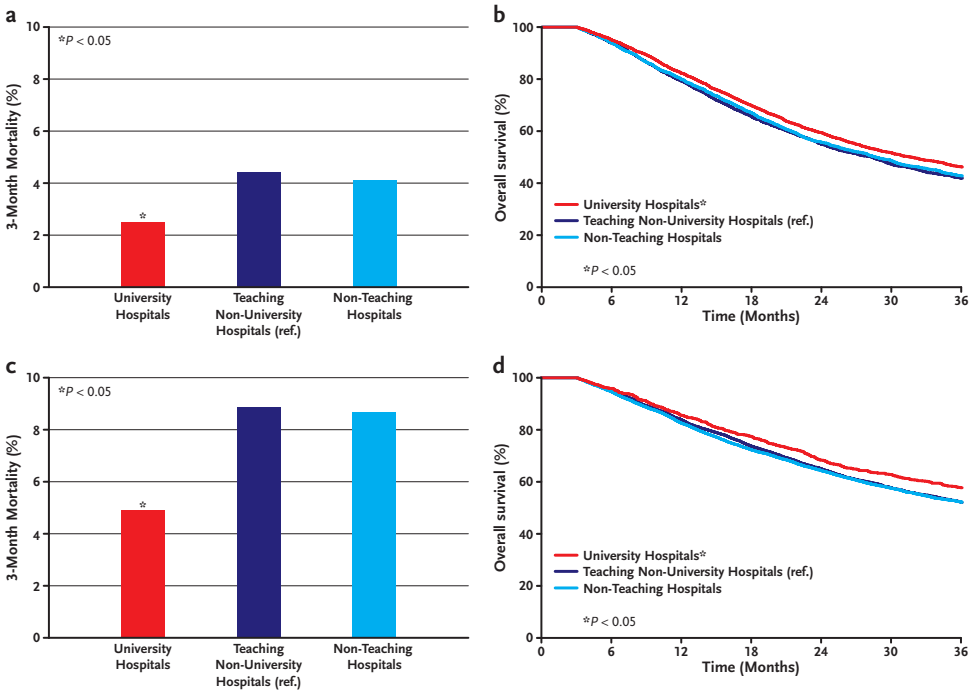
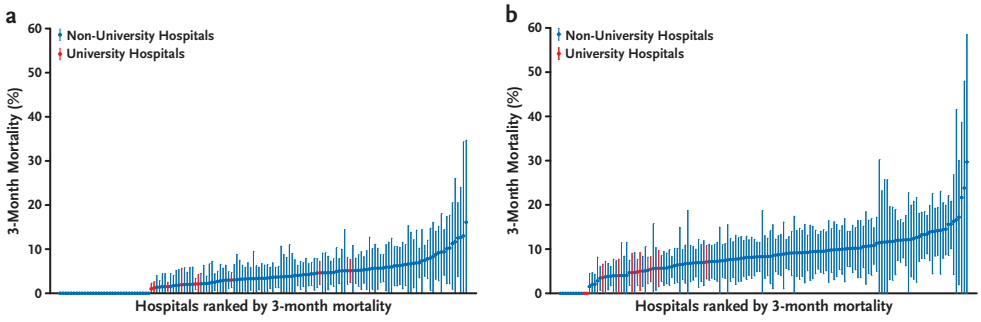


Figure 4. Three-month mortality rates after (a) esophagectomy and (b) gastrectomy analyzed at individual hospital level



PERFORMANCE OF INDIVIDUAL HOSPITALS

Analysis of 3-month mortality rates at the level of individual hospitals indicated that most university hospitals had good outcomes (Figure 4). There were, nevertheless, non-university hospitals with outcomes similar to, or better than those of all university hospitals. There were also university hospitals with average outcomes. The number of patients per hospital was too small for statistical assessment of differences in outcomes between hospitals.

DISCUSSION

The effect of hospital type on outcomes after esophagectomy or gastrectomy has been studied in a limited way before in the Netherlands.[11,16] In a large American study, postoperative mortality after esophagectomy and gastrectomy in National Cancer Institute (NCI)-designated hospitals was lower than in non-NCI hospitals, even after adjustment for hospital volume.[7] Most of these NCI centers are university hospitals.

In the present study, the increasing number of esophagectomies in the Netherlands reflects the increasing incidence of esophageal cancer. This increase has been taken up by university and teaching non-university hospitals. University hospitals have high annual volumes, whereas non-university hospitals operate in lower volumes.

In contrast, the incidence of gastric cancer is declining, leading to a smaller number of gastrectomies over the years.[17] Although the absolute number of gastrectomies in university hospitals (approximately 100 per year) and teaching non-university hospitals (about 300 per year) has remained stable, the number performed in non-teaching hospitals has decreased. Most centers, even university hospitals, performed fewer than 11 gastrectomies annually. In 2012, gastrectomy will be centralized in the Netherlands to hospitals with a minimum annual volume of 20 per year, mainly towards those centers currently performing esophagectomy.

In the present study, outcomes after esophagectomy and gastrectomy were better in university hospitals than in non-university hospitals, but there were no significant differences between teaching non-university hospitals and non-teaching hospitals. Despite differences of approximately 10% between university and non-university hospitals, 3-year survival rates after gastrectomy in the Netherlands remain low compared with Asian outcomes.[18] This difference might be explained by differences in tumor stage at presentation, stage migration owing to more extended lymph node retrieval, and intrinsic biological differences between Western and Asian patients with gastric cancer.[19]

Studies comparing outcomes between hospitals are vulnerable to various types of bias. The present methodology was chosen to limit some of these factors. Most esophagectomies performed in recent years were performed in university and teaching non-university hospitals. As quality of care in general is likely to have improved over the years, better outcomes for operations performed in university and teaching non-university hospitals might reflect improvements in perioperative care over the years, rather than a true difference between hospital types. Adjustment for year of diagnosis was used to eliminate this effect.

Adjustments were also made for annual hospital volume, reducing the effect of hospital volume on outcome when examining hospital types. Referral bias was assessed by repeating the analyses with the hospital of diagnosis instead of the hospital of surgery. No major differences in the results were found, indicating that the better outcomes in university hospitals were not the result of selective referral of healthier patients from non-university to university hospitals. A third of all esophagectomies were performed in

Table 3. Multivariate Cox regression analysis of the relationship between hospital type and outcomes after esophagectomy and gastrectomy, 1989-2009

	Esophagectomy				Gastrectomy			
	3-month mortality		3-year survival		3-month mortality		3-year survival	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Hospital type								
teaching non-university	1.00		1.00		1.00		1.00	
non-teaching	0.95	0.80-1.13	0.97	0.89-1.06	0.98	0.85-1.13	1.02	0.94-1.10
university	**0.56**	**0.37-0.85**	**0.87**	**0.78-0.99**	**0.53**	**0.42-0.66**	**0.85**	**0.78-0.93**
Annual hospital volume								
1-5	1.00		1.00		1.00		1.00	
6-10	0.88	0.74-1.05	1.02	0.94-1.10	0.95	0.83-1.09	0.99	0.92-1.06
11-20	0.83	0.63-1.09	0.94	0.84-1.05	0.95	0.82-1.10	1.00	0.91-1.09
≥21	**0.44**	**0.25-0.76**	0.86	0.73-1.01	1.08	0.81-1.44	1.01	0.91-1.13
Year of diagnosis								
1989-1993	1.00		1.00		1.00		1.00	
1994-1997	0.93	0.76-1.14	0.91	0.83-1.01	0.97	0.85-1.11	0.97	0.91-1.04
1998-2001	0.77	0.59-1.01	**0.88**	**0.80-0.96**	0.90	0.76-1.05	0.94	0.87-1.02
2002-2005	**0.58**	**0.43-0.80**	**0.69**	**0.63-0.76**	**0.76**	**0.64-0.91**	**0.86**	**0.79-0.94**
2006-2009	**0.42**	**0.29-0.63**	**0.74**	**0.66-0.83**	**0.64**	**0.51-0.81**	**0.80**	**0.73-0.87**
Sex								
male	1.00		1.00		1.00		1.00	
female	**0.68**	**0.57-0.81**	**0.84**	**0.78-0.89**	**0.67**	**0.61-0.74**	**0.92**	**0.87-0.98**
Age category								
<60	1.00		1.00		1.00		1.00	
60-75	**2.11**	**1.73-2.57**	**1.18**	**1.10-1.26**	**2.44**	**2.04-2.91**	**1.29**	**1.21-1.38**
>75	**3.66**	**2.82-4.74**	**1.52**	**1.36-1.70**	**5.65**	**4.70-6.79**	**1.61**	**1.49-1.74**
SES								
low	1.00		1.00		1.00		1.00	
medium	**0.77**	**0.62-0.97**	1.01	0.91-1.12	**0.85**	**0.73-0.98**	1.00	0.91-1.10
high	**0.44**	**0.26-0.73**	0.95	0.81-1.12	**0.56**	**0.39-0.81**	1.00	0.84-1.18
unknown	0.65	0.37-1.13	0.97	0.81-1.16	0.92	0.67-1.27	1.02	0.87-1.20
TNM stage group								
I	1.00		1.00		1.00		1.00	
II	1.12	0.90-1.40	**2.56**	**2.31-2.85**	**1.24**	**1.09-1.40**	**2.88**	**2.69-3.08**
III	**1.33**	**1.04-1.70**	**4.77**	**4.11-5.54**	**1.67**	**1.47-1.89**	**5.16**	**4.85-5.49**
IV	**2.74**	**1.43-5.24**	**9.31**	**7.24-11.97**	**2.65**	**2.17-3.23**	**8.24**	**7.36-9.21**
unknown	**1.51**	**1.01-2.27**	**2.45**	**2.08-2.87**	**1.96**	**1.42-2.71**	**2.28**	**1.92-2.70**
Morphology								
adenocarcinoma	1.00		1.00		1.00		1.00	
SCC	**1.37**	**1.15-1.64**	**1.10**	**1.01-1.21**				
other	0.82	0.46-1.45	1.17	0.96-1.44	1.17	0.79-1.74	**0.66**	**0.50-0.88**
Preoperative therapy								
No	1.00		1.00		1.00		1.00	
Yes	**0.06**	**0.02-0.15**	**0.80**	**0.74-0.88**	**0.08**	**0.03-0.25**	1.00	0.81-1.24
Postoperative therapy								
no			1.00				1.00	
yes			1.02	0.90-1.15			0.95	0.79-1.14

HR: hazard ratio, 95% CI: 95% confidence interval, SCC: squamous cell carcinoma, **Bold:** significant ($P < 0.05$)

university hospitals, but only 8.0% of gastrectomies. This tends to reduce the impact of the observation that university hospitals had better outcomes after gastrectomy.

The differences in outcomes between university and non-university hospitals may not be simply explained by type of hospital, regardless of any other factors. Rather, hospital

type might act as a proxy for differences in infrastructure and processes of care between different types of hospitals. In the Netherlands, university hospitals have higher staff-to-patient ratios, more financial resources per patient, more specialized treatments,[20] and have higher-level intensive care units than non-university hospitals.[21] Furthermore, individual hospitals may differ in quality of the diagnostic process, patient selection, administration of multimodal therapy, perioperative care, quality of surgery and ability to deal with complications. Excellent performance in all parts of this multidisciplinary care pathway contributes to a high standard of care and favorable outcome.[22] Identification of centers of excellence should be based on robust and case mix-adjusted data provided by high-quality clinical audits, where detailed information on the performance of individual hospitals is collected.

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