European Journal of Cancer (2012) 48, 1004–1013

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Effect of hospital volume on postoperative mortality and survival after oesophageal and gastric cancer surgery in the Netherlands between 1989 and 2009

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KEYWORDS
Oesophageal neoplasms
Stomach neoplasms
Gastrectomy
Oesophagectomy
Quality indicators – health care
Quality assurance – health care
Quality of health care
Hospital mortality
Survival

Abstract ***Background:*** High hospital volume is associated with better outcomes after oesophagectomy and gastrectomy. In the Netherlands, a minimal volume standard of 10 oesophagectomies per year was introduced in 2006. For gastrectomy, no minimal volume standard was set. Aims of this study were to describe changes in hospital volumes, mortality and survival and to explore if high hospital volume is associated with better outcomes after oesophagectomy and gastrectomy in the Netherlands.
Methods: From 1989 to 2009, 24,246 patients underwent oesophagectomy ($N = 10{,}025$) or gastrectomy ($N = 14{,}221$) in the Netherlands. Annual hospital volumes were defined as very low (1–5), low (6–10), medium (11–20), and high ($\geqslant 21$). Volume–outcome analyses were performed using Cox regression, adjusting for year of diagnosis, case-mix and the use of multimodality treatment.
Results: From 1989 to 2009, the percentage of patients treated in high-volume hospitals increased for oesophagectomy (from 7% to 64%), but decreased for gastrectomy (from 8% to 5%). Six-month mortality (from 15% to 7%) and 3-year survival (from 41% to 52%) improved after oesophagectomy, and to a lesser extent after gastrectomy (6-month mortality:

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0959-8049/$ - see front matter
http://dx.doi.org/10.1016/j.ejca.2012.02.064

15%-10%, three-year survival: 55–58%). High hospital volume was associated with lower 6-month mortality (hazard ratio (HR) 0.48, $P < 0.001$) and longer 3-year survival (HR 0.77, $P < 0.001$) after oesophagectomy, but not after gastrectomy.

Conclusions: Oesophagectomy was effectively centralised in the Netherlands, improving mortality and survival. Gastrectomies were mainly performed in low volumes, and outcomes after gastrectomy improved to a lesser extent, indicating an urgent need for improvement in quality of surgery and perioperative care for gastric cancer in the Netherlands.

1. Introduction

Oesophageal and gastric cancers are highly lethal malignancies.[1] Despite surgery, which is the cornerstone of curative treatment for these diseases, survival is low, and compared to other surgical procedures, postoperative mortality is high. In the Western world, 5-year survival rates are below 25% for oesophageal cancer,[2,3] and do not exceed 40% for gastric cancer.[2,4] Reported postoperative mortality after oesophagectomy varies from 2% for specialised centres[5] to 10% for certain nationwide registries.[6] After gastrectomy, postoperative mortality varies between 3% to well above 10%.[7,8] To reduce mortality and improve survival, it has been suggested that these high-risk operations should be performed in specialised centres with adequate annual volumes. Many studies have investigated volume–outcome relations after oesophagectomy and gastrectomy, but the relative importance of volume after gastrectomy in particular is disputed.[9,10]

In the Netherlands, a relation between high hospital volume and low postoperative mortality was demonstrated for oesophagectomy in 2000.[11] Despite extensive discussions within the Dutch Society of Surgery, this study did not lead to significant changes in referral patterns for oesophagectomies on a national level. Therefore, as of 2006 a minimum volume of 10 oesophagectomies per year was enforced by the Dutch Healthcare Inspectorate, and as of 2011 the Dutch Society of Surgery recommends a minimal volume of 20 oesophagectomies per year. For gastrectomy, no minimum volume standard has been established in the Netherlands.

Aims of the present study were to describe changes in annual hospital volumes, postoperative mortality, survival and lymph node yields for oesophagectomy and gastrectomy in the Netherlands between 1989 and 2009, and to explore whether there is any association between annual hospital volume for oesophagectomy and gastrectomy and postoperative mortality, survival and lymph node yield.

2. Patients and methods

2.1. The Netherlands Cancer Registry

Data were obtained from the Netherlands Cancer Registry (NCR), which covers all hospitals in the Netherlands, a country of 16.5 million inhabitants. Information on all newly diagnosed malignancies is routinely collected by trained registrars from the hospital records 6–18 months after diagnosis. Quality and completeness of the data are high.[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 tumours as adenocarcinoma (8140-8145, 8190, 8201-8211, 8243, 8255-8401, 8453-8520, 8572, 8573, 8576), squamous cell carcinoma (SCC) (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). Tumours were staged according to the International Union Against Cancer (UICC) Tumour Node Metastases (TNM) classification in use in the year of diagnosis. Vital status was initially obtained 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 31st December 2009. The study was approved by the NCR Review Board.

2.2. Patients

Between January 1989 and December 2009, 71,090 patients with oesophageal or gastric cancer were diagnosed in the Netherlands (Fig. 1). Patients who did not undergo surgical treatment ($N = 43,646$) and patients without information on the hospital where the diagnosis was established, or where surgery was performed ($N = 8$), were excluded, leaving 27,436 resections available to calculate annual hospital volumes. After establishing annual hospital volumes, patients with in-situ carcinoma ($N = 288$), and patients with distant metastases ($N = 2902$) were excluded, leaving 24,246 patients with non-metastatic invasive carcinoma available for volume–outcome analyses.

2.3. Surgery

Since the NCR is a topography-based registry, and the type of surgery was not specified for every patient, the distinction between oesophageal and gastric cancer surgery was based on tumour location. Oesophagectomies were defined as resections for cancers of the

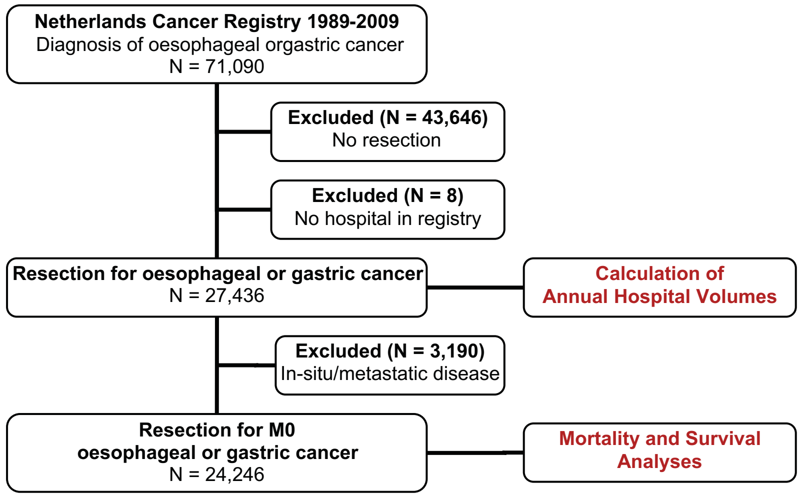

Fig. 1. Study profile.

oesophagus (C15.0-15.9) and gastric cardia (C16.0), whereas gastrectomies were defined as resections for non-cardia gastric cancer (C16.1-16.9). To ensure this distinction did not influence the results, volume–outcome analyses were repeated with cardia cancer coded as gastric cancer. Yearly resection rates were calculated as the number of resections relative to the number of cancers diagnosed in a year.

2.4. Hospital volumes

Annual hospital volumes were defined as the number of oesophagectomies or gastrectomies per hospital per year. Clinically relevant volume categories were defined as very low (1–5/year), low (6–10/year), medium (11–20/year), and high ($\geqslant$21/year). From 2005 to 2009, the hospital where the surgery was performed was registered for all patients. Before 2005, the hospital where the surgery was performed was only registered in 53% of the cases, and showed an 80% overlap with the hospital of diagnosis. For the remaining 47%, with an unknown surgical hospital, the hospital of diagnosis was used to calculate hospital volume.

2.5. Statistical analysis

Oesophagectomy and gastrectomy were analysed separately. Resection rates and hospital volumes over time were analysed with the Chi-square test. Changes in 6-month mortality and 3-year survival were analysed with stratified Cox regression, adjusted for sex, age, socio-economic status,[14] stage, morphology, preoperative therapy use and postoperative therapy use (only for 3-year survival). Overall survival (OS) was calculated from the day of diagnosis until death, because the date of surgery was not available before 2005. Six-month OS was calculated unconditionally, while 3-year OS was calculated conditionally on surviving the first 6 months after diagnosis. Lymph node yields over time were adjusted for sex, age, stage and morphology.

For volume–outcome analyses, the patient was considered the unit of analysis, with hospital volume as the exposure factor. Differences in survival estimates were calculated with Cox regression, stratified for hospital volume and adjusted for the factors used to analyse changes over time and for clustering of deaths within hospitals.[15] Differences in lymph node yields were analysed with generalised estimated equations, adjusted for the factors used to analyse changes over time and for clustering within hospitals.

Besides analysing hospital volume in categories, annual volume was analysed as a linear variable. Analyses were performed with SPSS (version 17.0.2) and R (version 2.12.2).

3. Results

3.1. Patient characteristics

Between 1989 and 2009, 24,246 patients with resectable, non-metastatic oesophageal ($N = 10{,}025$) or gastric cancer ($N = 14{,}221$) underwent a resection in the Netherlands. Patient characteristics (Tables 1 and 2) varied between the different volume categories. For oesophageal cancer, high-volume hospitals treated more patients with squamous cell carcinoma and more advanced tumour stages. For gastric cancer, patients treated in high-volume hospitals were older and had more advanced tumours.

3.2. Hospital volumes over time

From 1989 to 2009, the annual number of oesophagectomies doubled (from 352 to 723), and the annual number of gastrectomies steadily decreased (from 1107 to 495) (Fig. 2).

Table 1
Patient characteristics for all surgically treated patients with non-metastatic invasive oesophageal cancer in the Netherlands between 1989 and 2009 ($N = 10{,}025$).

	VLV (1–5)		LV (6–10)		MV (11–20)		HV (⩾21)		P
	N	%	N	%	N	%	N	%	
Total	2914	100	2695	100	1494	100	2922	100	
Sex									
Male	2213	76	2058	76	1130	76	2249	77	0.73
Female	701	24	637	24	364	24	673	23	
Age category									
<60	936	32	956	35	515	34	1032	35	0.002
60–75	1630	56	1456	54	814	54	1632	56	
>75	348	12	283	11	165	11	258	9	
SES									
Low	274	9	308	11	165	11	259	9	<0.001
Medium	2415	83	2124	79	1208	81	2131	73	
High	135	5	123	5	53	4	115	4	
Unknown	90	3	140	5	68	5	417	14	
Morphology									
Adenocarcinoma	2288	79	2006	74	1113	74	2134	73	<0.001
SCC	554	19	628	23	341	23	732	25	
Other	72	2	61	2	40	3	56	2	
TNM stage									
I	622	21	512	19	285	19	522	18	<0.001
II	1161	40	1093	41	576	39	1068	37	
III	988	34	940	35	535	36	1112	38	
IV[a]	30	1	30	1	23	2	25	1	
Unknown	113	4	120	4	75	5	195	7	
Preoperative therapy									
Yes	165	6	244	9	357	24	938	32	<0.001
No	2749	94	2451	91	1137	76	1984	68	
Postoperative therapy									
Yes	144	5	145	5	91	6	151	5	0.43
No	2770	95	2550	95	1403	94	2771	95	

VLV: Very Low Volume (1–5 resections/year) LV: Low Volume (6–10 resections/year), MV: Medium Volume (11–20 resections/year), HV: High Volume (⩾21 resections/year), SES: Socio Economic Status, SCC: squamous cell carcinoma, preoperative/postoperative therapy: chemotherapy with/without radiotherapy.
[a] T4N1-3M0 and T1-4N3M0 gastric cancers were assigned stage IV in the 6th edition TNM-classification

The percentage of oesophagectomies performed in high-volume hospitals increased from 7% to 64%, while the number of gastrectomies performed in high-volume hospitals decreased from 8% to 5%.

In 2009, 44 of the 92 hospitals (48%) in the Netherlands performed oesophagectomies, and 91 of the 92 hospitals performed gastrectomies.

3.3. Resection rates, mortality, survival and lymph node yields over the years

Resection rates slightly decreased for oesophageal cancer (from 1989 to 2009: 31–29%, $P < 0.01$), and strongly decreased for gastric cancer (56–37%, $P < 0.01$). Adjusted 6-month mortality after oesophagectomy decreased from 14.8% in 1989 to 7.1% in 2009 ($P < 0.001$), while adjusted 6-month mortality after gastrectomy decreased to a lesser extent: from 15.2% in 1989 to 9.9% in 2009 ($P < 0.001$) (Fig. 3a). Adjusted 3-year conditional survival significantly increased after oesophagectomy: from 41.0% in 1989 to 52.2% in 2009 ($P < 0.001$). Adjusted 3-year conditional survival after gastrectomy increased to a lesser extent: from 55.0% in 1989 to 58.4% in 2009 ($P < 0.01$) (Fig. 3b). The improvement in 6-month mortality and 3-year survival over time was significantly stronger after oesophagectomy, when compared to gastrectomy (both $P < 0.01$).

Mean lymph node yield after oesophagectomy increased from 10.1 in 1999 to 16.2 in 2009 ($P < 0.001$), and mean lymph node yield after gastrectomy increased from 8.1 in 1999 to 12.4 in 2009 ($P < 0.001$).

3.4. Volume–outcome relations

Results from the multivariable analyses on volume–outcome relations are shown in Table 3. After oesophagectomy, medium and high volume hospitals were associated with lower six-month mortality and longer three-year conditional survival when compared to very-low volume hospitals (Fig. 4). After gastrectomy, neither six-month mortality or three-year conditional survival were associated with hospital volume category (Fig. 5). High hospital volume was associated with high

Table 2
Patient characteristics for all surgically treated patients with non-metastatic invasive gastric cancer in the Netherlands between 1989 and 2009 ($N = 14{,}221$).

	VLV (1-5)		LV (6-10)		MV (11-20)		HV (⩾21)		P
	N	%	*N*	%	*N*	%	*N*	%	
Total	3411	100	6099	100	4356	100	355	100	
Sex									
Male	1987	58	3707	61	2646	61	224	63	0.045
Female	1424	42	2392	39	1710	39	131	37	
Age category									
<60	689	20	1270	21	837	19	53	15	0.016
60–75	1606	47	2917	48	2074	48	165	46	
>75	1116	33	1912	31	1445	33	137	39	
SES									
Low	378	11	783	13	560	13	53	15	<0.001
Medium	2665	78	4846	79	3559	82	294	83	
High	118	3	230	4	106	2	8	2	
Unknown	250	7	240	4	131	3	0	0	
Morphology									
Adenocarcinoma	3336	98	5985	98	4287	98	352	99	0.11
Other	75	2	114	2	69	2	3	1	
TNM stage									
I	1299	38	2279	37	1687	39	147	41	0.014
II	898	26	1675	27	1187	27	78	22	
III	936	27	1718	28	1204	28	111	31	
IV[a]	181	5	248	4	154	4	11	3	
Unknown	97	3	179	3	124	3	8	2	
Preoperative therapy									
Yes	167	5	303	5	138	3	8	2	<0.001
No	3244	95	5796	95	4218	97	347	98	
Postoperative therapy									
Yes	139	4	236	4	122	3	12	3	0.009
No	3272	96	5863	96	4234	97	343	97	

VLV: Very Low Volume (1–5 resections/year) LV: Low Volume (6–10 resections/year), MV: Medium Volume (11–20 resections/year), HV: High Volume (⩾21 resections/year), SES: Socio Economic Status, preoperative/postoperative therapy: chemotherapy with/without radiotherapy.
[a] T4N1-3M0 and T1-4N3M0 gastric cancers were assigned stage IV in the 6th edition TNM-classification

lymph node yield both after oesophagectomy and gastrectomy.

When analysing hospital volume as a linear covariate, volume–survival results remained the same. No changes in the results were found when volume–outcome relations were analysed with surgery for cardia cancer coded as gastrectomy (data not shown).

4. Discussion

Over the study period, the number of oesophagectomies performed in high volume hospitals considerably increased, while in 2009 most gastrectomies were performed in low volume hospitals. Both 6-month mortality and 3-year survival improved after oesophagectomy, but to a lesser extent after gastrectomy. In the current dataset, a volume–survival relation was revealed for oesophagectomy, but not for gastrectomy.

Since Luft et al. published the first study on volume–outcome relations for surgery,[16] many studies have emerged investigating the effect of hospital and surgeons volume on short term and long term outcomes for a variety of diseases, including resections for oesophageal and gastric cancers. Several large studies have shown an association between high hospital volume and low postoperative mortality both for oesophagectomy, [17–20] and gastrectomy[17,20–22], but other studies did not find an association.[23–25] In a meta-analysis exploring volume–outcome relations, high volume surgery was associated with lower postoperative mortality after both oesophagectomy and gastrectomy.[9] A limited number of studies investigate the relation between hospital volume and *long*-term survival after oesophagectomy and gastrectomy, with conflicting results.[7,24,26,27]

Over the past two decades, the number of oesophagectomies in the Netherlands has increased, corresponding with an increasing incidence of oesophageal cancer.[42] The decreasing incidence of gastric cancer explains the low number of gastrectomies currently performed in the Netherlands.[28] Furthermore, the resection rate for gastric cancer dropped significantly, most likely the result of improved preoperative staging. Combined with the almost complete disappearance of surgery for reflux disease and ulcers, surgeons are decreasingly exposed to gastrectomies. This might partly be compensated by

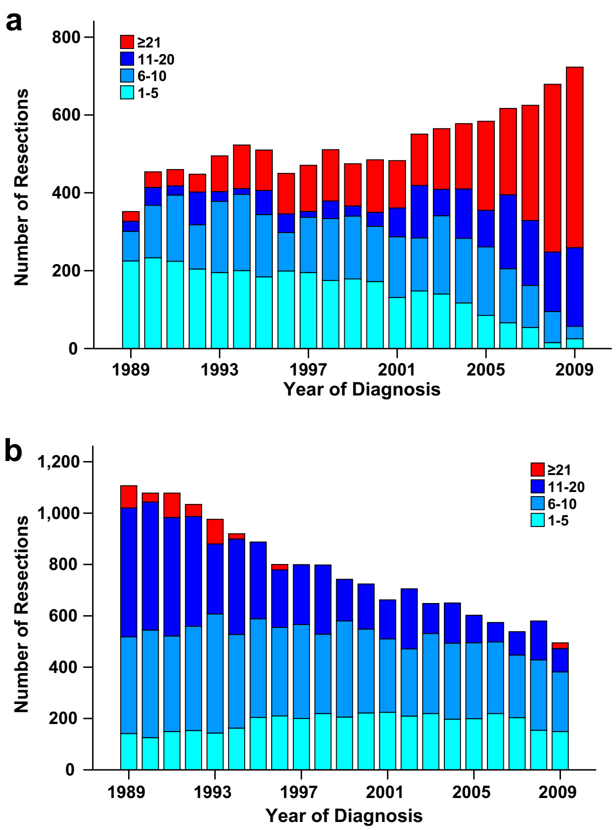

Fig. 2. (a) Number of oesophagectomies per hospital volume category. (b) Number of gastrectomies per hospital volume category.

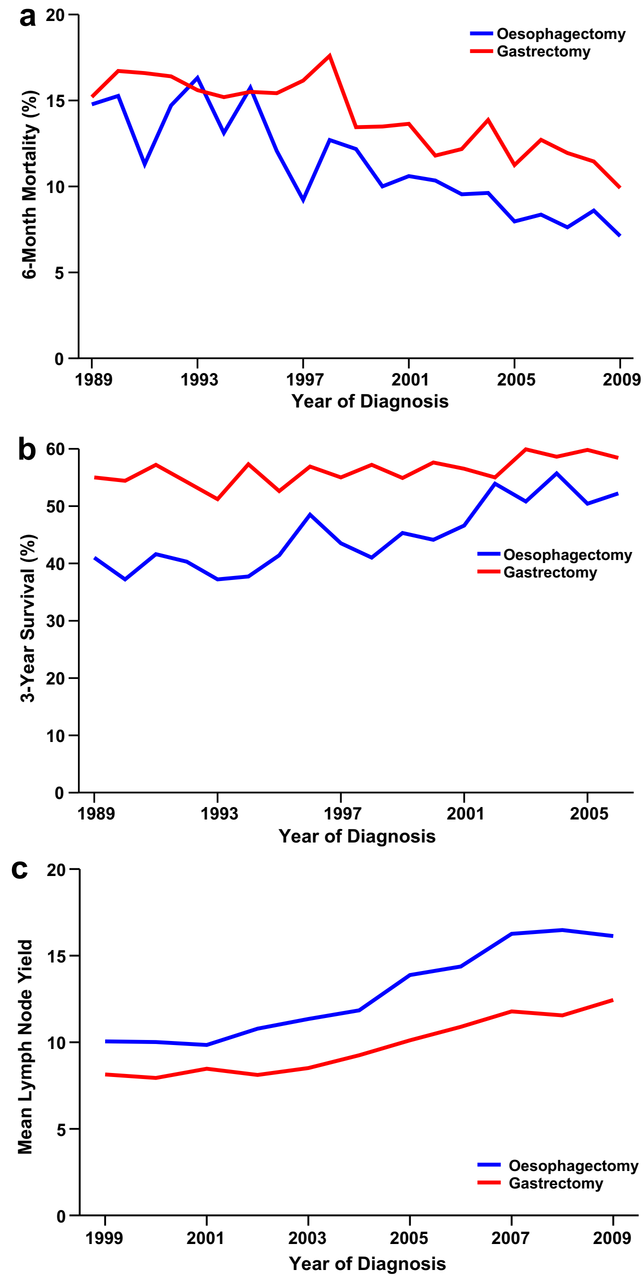

Fig. 3. (a) Six-month mortality for oesophagectomy and gastrectomy, adjusted for sex, age, socio-economic status, stage, morphology and use of preoperative therapy (1989–2009). Oesophagectomy, hazard ratio (HR) 0.96 for each year, $P < 0.001$. Gastrectomy, HR 0.98 for each year, $P < 0.001$. Difference between oesophagectomy and gastrectomy: $P = 0.003$. (b) Three-year survival rate conditional on surviving the first 6 months for oesophagectomy and gastrectomy, adjusted for sex, age, socio-economic status, stage, morphology and use of preoperative and postoperative therapy (1989–2006). Oesophagectomy, HR 0.97 for each year, $P < 0.001$. Gastrectomy, HR 0.99 for each year, $P < 0.001$. Difference between oesophagectomy and gastrectomy: $P < 0.001$. (c) Median lymph node yield for oesophagectomy and gastrectomy, adjusted for sex, age, stage and morphology (1999–2009). Oesophagectomy: $P < 0.001$. Gastrectomy: $P < 0.001$.

increasing volumes of bariatric surgery for obesity, but the surgical techniques used differ significantly.

In the current study, increasing hospital volume was associated with lower mortality and increased long-term survival after oesophagectomy, but not after gastrectomy. This observation for gastrectomies might be explained by the low number of high-volume gastrectomies (2.5% of all gastrectomies in the current dataset), and the low threshold for what was considered high-volume surgery. In other studies that did find an association between gastrectomy in high volumes and good outcomes, the lower limit of high volume surgery varied from 20/year up to 264/year.[17,27]

The current study covers an extensive period of two decades of oesophago-gastric cancer surgery in the Netherlands, and analyses a significant population of about 25,000 patients. Unlike many of the large volume–outcome studies, the current study uses a clinical database with highly reliable data, providing complete coverage of all diagnosed cancers in the Netherlands. Furthermore, outcomes are case-mix adjusted, increasing reliability of the results.[29] The absence of comorbidity in the current dataset was partly compensated by the use of SES, which can be considered a proxy for comorbidity.[30]

A potential bias when analysing outcomes over a long period is that preoperative staging and (perioperative) care generally improve over time. For example, endoscopic ultrasound, multislice high resolution

Table 3
Volume–outcome relations for oesophagectomy and gastrectomy (1989–2009). Mortality and survival were calculated with multivariable Cox regression, nodal yield was calculated with generalised estimated equations.

	Oesophagectomy						Gastrectomy					
	Six-month mortality		Three-year survival[a]		LN yield[b]		Six-month mortality		Three-year survival[a]		LN yield[b]	
	HR	95% CI	HR	95% CI	OR	95% CI	HR	95% CI	HR	95% CI	OR	95% CI
Hospital volume												
Very low (1–5/yr)	1.00		1.00		1.00		1.00		1.00		1.00	
Low (6–10/yr)	0.90	0.78–1.03	1.01	0.94–1.10	1.00	0.91–1.09	0.95	0.84–1.07	0.99	0.91–1.07	1.02	0.96–1.08
Medium (11–20/yr)	**0.78**	**0.62–0.97**	**0.90**	**0.81–0.99**	1.10	1.00–1.22	0. 95	0.83–1.08	0.99	0.90–1.08	0.99	0.90–1.10
High (⩾21/yr)	**0.48**	**0.38–0.61**	**0.77**	**0.70–0.85**	1.50	**1.25–1.80**	1. 10	0.82–1.49	0.98	0.86–1.12	**1.93**	**1.81–2.04**
Year of diagnosis												
1989–1993	1.00		1.00				1.00		1.00			
1994–1997	0.91	0.78–1.07	0.92	0.83–1.01			0.96	0.86–1.07	0.98	0.90–1.05		
1998–2001	**0.82**	**0.68–0.98**	**0.88**	**0.79–0.97**	1.00		0.89	0.79–1.01	0.94	0.87–1.02	1.00	
2002–2005	**0.69**	**0.55–0.86**	**0.69**	**0.63–0.75**	1.18	**1.10–1.25**	**0.74**	**0.65–0.85**	**0.88**	**0.81–0.96**	**1.08**	**1.02–1.16**
2006–2009	**0.67**	**0.52–0.85**	**0.75**	**0.63–0.75**	1.42	**1.27–1.60**	**0.70**	**0.60–0.81**	**0.78**	**0.72–0.86**	**1.42**	**1.32–1.52**
Sex												
Male	1.00		1.00		1.00		1.00		1.00			
Female	**0.75**	**0.66–0.86**	**0.83**	**0.78–0.89**	1.04	1.00–1.08	**0.79**	**0.73–0.85**	**0.91**	**0.85–0.97**	**1.10**	**1.05–1.14**
Age category												
<60	1.00		1.00		1.00		1.00		1.00		1.00	
60–75	**1.83**	**1.56–2.14**	**1.14**	**1.07–1.21**	0.97	0.94–1.00	**2.03**	**1.78–2.30**	**1.27**	**1.18–1.37**	**0.88**	**0.82–0.93**
>75	**3.10**	**2.54–3.79**	**1.41**	**1.25–1.59**	**0.87**	**0.82–0.92**	**3.94**	**3.47–4.49**	**1.57**	**1.44–1.71**	**0.75**	**0.69–0.81**
SES												
Low	1.00		1.00				1.00		1.00			
Medium	**0.76**	**0.64–0.90**	1.05	0.96–1.16			0.92	0.81–1.04	1.01	0.92–1.12		
High	**0.54**	**0.38–0.78**	1.00	0.85–1.17			**0.70**	**0.55–0.91**	1.00	0.84–1.20		
Unknown	**0.53**	**0.38–0.74**	1.04	0.86–1.26			0.94	0.73–1.21	1.03	0.85–1.24		
TNM stage												
I	1.00		1.00		1.00		1.00		1.00		1.00	
II	**1.28**	**1.08–1.52**	**2.74**	**2.46–3.04**	**1.15**	**1.09–1.21**	**1.46**	**1.31–1.63**	**2.99**	**2.78–3.22**	**1.23**	**1.16–1.31**
III	**1.73**	**1.41–2.13**	**5.20**	**4.46–6.05**	**1.39**	**1.31–1.47**	**2.15**	**1.93–2.38**	**5.37**	**5.01–5.75**	**1.55**	**1.46–1.66**
IV	**3.85**	**2.55–5.81**	**9.76**	**7.43–12.81**	**1.93**	**1.70–2.20**	**3.50**	**3.00–4.08**	**8.45**	**7.43–9.61**	**2.23**	**2.05–2.42**
Unknown	**1.92**	**1.41–2.62**	**2.37**	**2.00–2.81**	1.04	0.92–1.17	**1.91**	**1.40–2.60**	**2.36**	**1.96–2.84**	1.01	0.82–1.24
Morphology												
Adenocarcinoma	1.00		1.00		1.00		1.00				1.00	
SCC	**1.26**	**1.11–1.43**	1.09	0.98–1.21	1.05	0.99–1.11						
Other	1.28	0.94–1.75	1.05	0.84–1.33	1.00	0.88–1.12	1.18	0.86–1.64	**0.58**	**0.44–0.78**	0.94	0.71–1.25
Preoperative therapy												
No	1.00		1.00				1.00		1.00			
Yes	**0.32**	**0.23–0.43**	**0.84**	**0.76–0.93**			**0.27**	**0.17–0.43**	1.05	0.84–1.31		
Postoperative therapy												
No	1.00		1.00						1.00			
Yes			1.07	0.94–1.21					1.01	0.85–1.21		

HR: hazard ratio, OR: odds ratio, SES: Socio Economic Status, SCC: squamous cell carcinoma, CI: confidence interval, Bold: significant ($P < 0.05$).
[a] Conditional on surviving the first six months.
[b] 1999–2009.

computed tomography and PET computed tomography were introduced resulting in improvement of staging. Hospital volumes for oesophagectomy significantly change during the study period, with most high-volume resections performed in the more recent years. Therefore, high volume resections are intrinsically associated with better outcomes. However, adjusting for year of diagnosis offsets this effect. Another potential weakness is the unavailability of the surgery hospital for part of the patients treated before 2005. Instead, the hospital of diagnosis was used. However, this only happened in the first years of the study, when hospitals less frequently referred patients to another hospital for surgery.

A point of discussion might be that volumes are analysed on hospital level, rather than surgeon level.[27,31,32] Quality of care, however, consists of more than an individual surgeon's performance. Perioperative care, anaesthesia, ICU staffing, experience of the nursery staff and collaboration between different disciplines all contribute to outcomes associated with the performed procedure.[33] The role of the surgeon is only one, yet important, factor contributing to outcome.

Initiatives to improve medical and especially surgical care are legion. Randomised trials improve care by selecting appropriate treatments for certain indications,[3,34] and by educating surgeons participating in

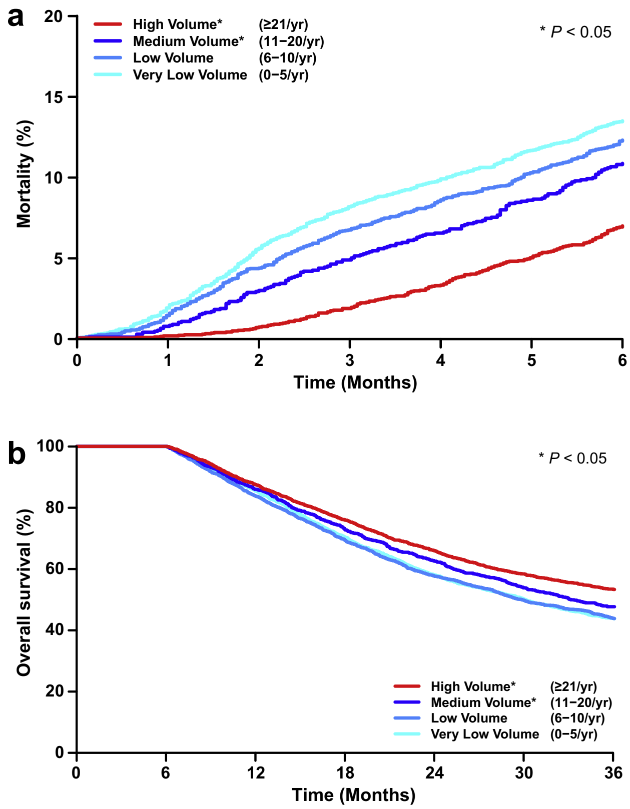

Fig. 4. Volume–outcome relations for oesophagectomy. (a) Relation between volume and 6-month survival, adjusted for year of diagnosis, sex, age, socio-economic status, stage, morphology and preoperative therapy use. *$^*P < 0.05$ compared to Very Low Volume.* (b) Relation between volume and 3-year survival, conditional on surviving the first 6 months, adjusted for year of diagnosis, sex, age, socio-economic status, stage, morphology and preoperative and postoperative therapy use. *$^*P < 0.05$ compared to Very Low Volume.*

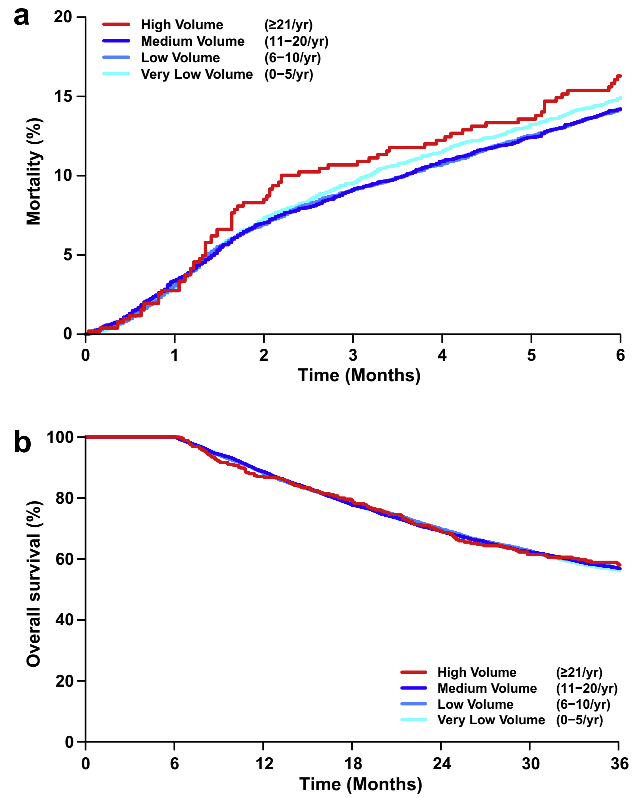

Fig. 5. Volume–outcome relations for gastrectomy. (a) Relation between volume and 6-month survival, adjusted for year of diagnosis, sex, age, socio-economic status, stage, morphology and preoperative therapy use. *$^*P < 0.05$ compared to Very Low Volume.* (b) Relation between volume and 3-year survival, conditional on surviving the first 6 months, adjusted for year of diagnosis, sex, age, socio-economic status, stage, morphology and preoperative and postoperative therapy use. *$^*P < 0.05$ compared to Very Low Volume.*

the trial.[35,36] However, the majority of cancer patients are treated outside trials, and especially improvements in the process and structure of care on a nation-wide level will bring benefit to this group of patients. Many studies have advocated the centralisation of low-volume, high-risk operations, thereby improving nationwide quality of care.[11,27] Centralisation of oesophageal and gastric cancer is currently performed in several European countries, whereas referral to high-volume centres is also advocated in the United States by the Leapfrog group.[37] In Denmark, centralisation of gastric cancer surgery from 37 to 5 hospitals leaded to a drop in post-operative mortality from 8.4% to 2.1% over a period of 5 years.[38]

Unlike the Netherlands, which is a relatively small country with good infrastructure, centralisation of care in countries with large rural areas might lead to unreasonable travel burdens and problems with continuity of care after surgery. Therefore, others have advocated implementing processes that are related to excellent outcomes in low volume hospitals, but identification of these processes remains challenging.[39]

Meanwhile, using hospital volume as the sole basis for referral to improve outcomes is criticised.[17] Although hospital volume can reliably identify groups of hospitals with better results on average, individual low volume hospitals can have excellent outcomes and vice versa. In contrast to volume-based referral, outcome based-referral avoids this problem, and has proven its value for oesophagectomy in the Western part of the Netherlands. In this area, a prospective audit was conducted to identify hospitals with excellent performance in oesophagectomy. During the five-year audit, a gradual concentration towards centres with excellent performance occurred, leading to a drop in postoperative mortality (12–4%) and an improvement in survival.[40]

Combining centralisation with auditing substantially adds to improvement of care.[41] With auditing, providers of care are monitored and their performance is benchmarked against their peers. Auditing is performed on a national level for oesophagogastric cancer in Denmark,[38] Sweden and the United Kingdom. A nationwide audit for both oesophageal and gastric cancer surgeries has started in the Netherlands as of 2011 aiming for complete coverage of all oesophagectomies and gastrectomies.

In conclusion, enforcing centralisation for oesophagectomy in the Netherlands has resulted in a shift in annual hospital volumes: most resections are currently performed in high volume centres. For gastrectomy, no minimum number of resections was required, and the majority of gastric cancer resections were performed in low volume hospitals. However, as of 2012 gastrectomies in the Netherlands will be centralised to a minimum of 10/year, and as of 2013 to a minimum of 20/year. Oesophagectomy in high volume hospitals is associated with improved outcomes. No such relation for gastric cancer could be established in the current dataset, but only a minority of patients was treated in high volume hospitals. Over the past two decades, short-term mortality and long-term survival after oesophagectomy decreased significantly, while outcomes after gastrectomy improved to a lesser extent, indicating an urgent need for improvement in quality of surgery and perioperative care for gastric cancer in the Netherlands.

Role of funding source

This study was funded by the Signalling Committee on Cancer of the Dutch Cancer Society (KWF Kankerbestrijding). This funding source had no role in study design, collection, analysis, interpretation, writing of the manuscript or in the decision to submit the manuscript for publication.

Conflict of interest statement

None declared.

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