Chapter 5

Volume- or Outcome-based Referral to Improve Quality of Care for Esophageal Cancer Surgery in the Netherlands

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ABSTRACT

Recently, in the Netherlands esophageal resections for cancer are banned from hospitals with an annual volume less than ten. In this study we evaluate the validity of this specific volume cut-off, based on a review of the literature and an analysis of the available data on esophagectomies in our country. In addition, we compare the expected benefits of volume-based referral to the results of a regional centralization process based on differences in outcome (outcome-based referral).

INTRODUCTION

For high-risk surgical procedures, variation in outcome between hospitals and surgeons, has been the subject of a large number of studies performed in different countries[1]. Most studies are from the United States, but also in European countries outcomes research has become a subject of major interest. In the Netherlands differences in outcome for esophagectomies and pancreatectomies between high- and low volume hospitals have been the subject of a continuing debate in the last decade[2]. In 2001 van Lanschot et al. reported the effect of hospital volume on hospital mortality after esophagectomy in the Netherlands on data from the Dutch National Medical Registry[3]. In the 1993-1998 study period mortality rates varied from 5 to 12 percent between high- and low volume providers. Despite extensive discussions within the Association of Surgeons in the Netherlands about the consequences this volume-based variation should have, there were few changes in referral patterns. In 2006 this lead to a decision of the Netherlands Health Care Inspectorate to ban esophageal resections from hospitals with a mean annual volume less than ten.

In the mid-western part of the Netherlands eleven hospitals are affiliated with the Comprehensive Cancer Center West (CCCL), one of the nine regional comprehensive cancer centers in the country. Based on the volume-outcome literature the Professional Network of Surgical Oncologists (PNSO) in this region decided to start a surgical outcome registration (clinical audit) for esophageal cancer surgery in 2000. Detailed clinical data were retrieved retrospectively from the 1990 -1999 time-period. In this period no hospital performed more than six esophagectomies a year and the overall in-hospital mortality rate was 13 percent, much higher than the national average and the results of high-volume referral centers in our country[4].
Based on these results the PNSO decided that esophageal resections had to be concentrated in 2 to 3 hospitals in the region. Because concentration of services could not be based on historical differences in procedural volume, all surgeons agreed upon a prospective outcome-registration, with a scenario of having to refer patients to hospitals with better outcome if their own results proved to be unfavorable (outcome-based referral).

The primary purpose of our study is to evaluate variations in outcome for esophageal cancer surgery in a nation-wide cohort of hospitals, in a larger time-period. By reviewing the volume-outcome literature and analyzing hospital specific data on esophagectomies performed in the Netherlands, we investigate the proportion of hospital variation that can be attributed to differences in volume and the validity of a specific cut-off value of 10 resections a year.
In addition, we evaluate outcome-based referral as an instrument to concentrate esophageal cancer surgery in a situation where historical hospital volumes are insufficient for the selection of referral centers.

METHODS

Review of the Volume-outcome Literature

A search of the medical literature was performed in Medline for the period 1998-2008. The search was limited to publications in the English language and original articles. The medical subject headings (MeSH) 'esophagectomy' and 'hospitals' were combined with the key words 'volume' or 'mortality'. Also the related articles feature of PubMed was used. A manual search was performed for references mentioned in the first selection of articles, to identify all publications considerable for inclusion.

All original articles comparing mortality rates after esophagectomy between hospitals with a lower and higher procedural volume, were selected. Reports on data from less than 10 hospitals or less than 500 patients were excluded. Two authors (MW and GG) performed the search independently. Disagreements were resolved by discussion with a third author (RT). From the selected articles 'study period', 'country of origin', 'number of patients', 'number of hospitals', 'volume categories' and 'outcome measures' being 'hospital mortality' or '30-day mortality' were retrieved. The relation between the different hospital volume categories and the corresponding mortality rates was graphically displayed.

A meta-analysis of the data provided by these studies was not considered feasible because of the heterogeneity in study populations and volume categories. In addition, several sources of bias, like selection- and publication bias can not be controlled for without the availability of the primary data.

Esophagectomies in the Netherlands

Patients

Data of all esophageal resections for cancer that were performed in Dutch hospitals from January 1991 to January 2005 were retrieved from the Dutch National Medical Registry (DNMR) administered by Prismant, the Dutch Center for Health Care Information, Utrecht, the Netherlands. This register is a (near) complete database of hospital discharge data for all in-hospital and day-care treatments in Dutch hospitals (general and academic). The DNMR collects data on diagnosis and treatments performed during hospital admission. In addition, demographic (age and gender) and outcome data (length of stay, mortality) are available. Only esophageal resections that were followed by reconstruction with a gastric tube or colon interposition were included in our study. Though individual patients and hospitals could not be identified, the number of resections performed per calendar year could be calculated for each hospital code. Hospital volume was defined as the average number of resections performed in that hospital in the three preceding calendar years. Hospitals were divided in three volume categories according to an earlier publication of vLanschot et al [3]: low volume, less than 10 resections a year, medium volume, 10 to 20 resections a year, and high volume, more than 20 resections a year.

CCCLeiden: hospital identification

To identify the data from the hospitals affiliated with the CCCL we asked the representing surgeons for a written consent to break their hospital code. The region of the CCCL has 1.7 million inhabitants and is served by eleven hospitals (one university hospital, five teaching hospitals and five general hospitals). The results of these hospitals were analyzed separately to be able to compare their results historically and in relation to the national averages.

Statistics

Differences in patient and hospital characteristics as well as in outcome were assessed using the chi-square test for categorical variables and ANOVA and Kruskall-Wallis test for continuous variables.

To study the difference in performance between hospitals and the relation between volume and mortality, logistic regression models with a random hospital effect were used. To study the difference in performance in the CCCL region before and after 2000, a logistic regression model with the independent variables age, sex, region, time-period and a random hospital effect was used.

To visualise the relation between hospital volume and mortality and show the variation in outcome among hospitals, funnel plots were made[5]. Therefore the observed mortality rates were compared to expected numbers, based on gender, age and operation year of the patients within the hospital. The expected numbers were obtained by fitting a logistic regression model with mortality as dependent and sex, age and year of operation as independent variables. Then standardized mortality rates (SMR) were computed (SMR = observed/expected).The SMRs and the control limits were then multiplied by the average mortality rate in the population in the study period to obtain adjusted mortality rates. As target the average mortality in the high volume hospitals was used, with the 95 and 99 % limits from the Possoin distribution.

Analyses were conducted using SPSS software (version 14.0; SPSS inc., Chicago.IL), SAS PROC NLMIXED (SAS Institute Inc., Carey, North Carolina) for the random effect logistic regression or R for Funnelplots (www.r-project.org).

RESULTS

Review of the Volume-outcome Literature

The initial two search strategies yielded 96 articles, of which 75 did not meet the inclusion criteria: 58 had a different subject, 6 where not original studies (reviews or comments), 9 studies reported the results of less than ten hospitals, 1 study was published twice and 1 article was not in the English language. The other 21 articles where included in our review. On these articles the related articles feature of PubMed was used and a manual reference search was performed. Four additional articles were found that met the inclusion criteria. The assessment of the 25 candidate articles led to exclusion of one article, which reported only the results of the lowest volume decile and the top volume decile of hospitals performing

Table 1. Studies evaluating the volume-outcome relationship for esophagectomies 1998-2008.

Year	Author	Country	Study period	Patients	Hospitals	Volume cut-offs*	Outcome measures	Result
1998	Begg [7]	USA	1984-1993	503	190	<6-11>	Mortality	S
1998	Patti [8]	USA	1990-1994	1561	273	<30>	Mortality	S
1999	Gordon [9]	USA	1989-1997	518	51	<11-21-51>	Mortality	S
2000	Swisher [10]	USA	1994-1996	n.k.	101	<5>	Mortality	S
2001	Kuo [11]	USA	1992-2000	1193	64	<6>	Mortality	S
2001	Lanschot [3]	Netherlands	1993-1998	1792	n.k.	<10-20>	Mortality	S
2001	Dimick [12]	USA	1984-1999	1136	52	<4-16>	Mortality	S
2002	Birkmeyer [13]	USA	1994-1999	6337	1575	<2-5-8-19>	Mortality	S
2003	Finlayson [14]	USA	1995-1997	5282	603	<4-10>	Mortality	S
2003	Urbach [15]	Canada	1994-1999	613	47	<3-9-17-19>	Mortality	S
2003	McCulloch [16]	UK	1999-2002	955	23	<10-21>	Mortality	S
2003	Dimick [17,18]	USA	1995-1999	3023	200	<3-6-16>	Mortality	S
2004	Urbach [19]	Canada	1994-1999	613	47	<9>	Mortality	NS
2005	Wenner [20]	Sweden	1987-1996	1429	74	<5-16>	Mortality	S
2005	Dimick [21]	USA	1997-2000	3031	n.k.	<6>	Mortality	S
2006	Simunovic [22]	Canada	1990-2000	629	68	<8-20-44>	Mortality	NS
2006	Lin [23]	Taiwan	2000-2003	6674	111	<20-34-59-86>	Mortality	S
2007	Rodgers [24]	USA	1988-2000	8075	n.k.	<5-10>	Mortality	NS
2007	Rouvelas [25]	Sweden	1987-2000	1199	n.k.	<10>	Mortality Survival	S NS
2007	Al-Sarira [26]	UK	2002-2003	3229	111	<10-20-30-40>	Mortality	S
2007	Allareddy [27]	USA	2000-2003	2473	717	<13>	Mortality	S
2008	Ra [28]	USA	1997-2003	1172	361	<1-2>	Mortality	S
2008	Wouters [4]	Netherlands	1990-1999	903	12	<7>	Mortality Survival	S S
2008	Pal [29]	UK	1999-2005	8874	144	<11-21-39>	Mortality	S

S = Significant. NS = Not significant. n.k. = not known. * = Volume categories are represented by '<x-y>' meaning: lowest volume category with hospitals performing less than x resections a year, medium volume category with x to less than y resections a year, high volume category with y or more resections a year.

esophagectomies[6]. The remaining 24 articles are listed in Table 1 [3 4 7 8 9 10 11 12 13 14 15 16 17,18 19 20 21 22 23 24 25 26 27 28 29].

A total number of 61,214 esophagectomies performed between 1984 and 2005 were studied. Most studies are from the USA and Canada, but more recently several European studies have been published. The median number of patients per study was 1429 and the median number of hospitals 106. Volume cut-offs between (very) low volume, median and (very) high volume differed widely. Twenty-one studies reported a statistically significant difference in hospital mortality between low- and high volume providers, with a median difference in mortality between the lowest and highest volume category of 7.2 percent. Two studies also report a difference in long-term survival.

Figure 1 shows the mortality rate found for each volume category in these studies. Mortality rates are high and vary widely, especially for hospital volume categories beneath 20 resections a year.

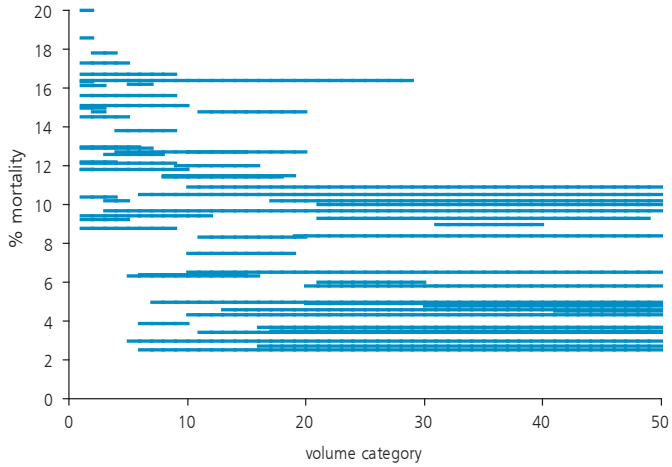

Figure 1. Mortality after esophageal resections for different hospital volume categories as reported in the literature

Esophagectomies in the Netherlands

In the period 1991-2004, a total of 4939 esophageal resections for cancer were performed in 104 Dutch hospitals. Patient, hospital and procedural characteristics of the resections are described in Table 2. Over time, no relevant differences were found in the distribution of age and gender. The hospital volume of esophageal resections increased since the mid 1990's and the length of hospital stay decreased during the study period (p<0.0001). In the most recent time-period (2000-2004) forty-seven percent of esophageal resections were performed in low volume hospitals, with a mean annual volume less than 10.

Nation-wide, the in-hospital mortality decreased from 9.7% in the period 1991-1994 to 7.3% in 2000-2004 (p=0.04). Figure 2 shows that in-hospital mortality decreased in high volume

Table 2. Patient, hospital and procedural characteristics of esophageal resections for cancer between 1991-2004 in the Netherlands by calendar period. (Data are presented as number (%), unless stated otherwise.)

	1991-1994 N=1377	1995-1999 N=1702	2000-2004 N=1860	P value
Patient age (yrs)				
mean ±SD	62.1 ±10.3	63.1 ±10.1	62.6 ±9.8	**0.02**
Gender				
male	1035 (75)	1290 (76)	1436 (77)	0.37
female	342 (25)	412 (24)	424 (23)	
Hospital volume *				
low (<10 /yr)	200 (54) **	802 (47)	884 (48)	**<0.0001**
medium (10-20 /yr)	0 (0)	150 (9)	265 (14)	
high (>20 /yr)	168 (46)	750 (44)	711 (38)	
Hospital stay (days)				
median (range)	18.4 (0.4-206)	17.6 (0-215)	16.4 (0.1-212)	**<0.0001**
In-hospital mortality	133 (9.7)	130 (7.6)	136 (7.3)	**0.04**

* Hospital volume was calculated as the average number of resections in a specific hospital in the three preceding calendar years. ** Available for calendar year 1994 (n=368). Hospital volume could not be calculated for 1991-1993, because the resection volume in the 3 preceding years was not (completely) known.

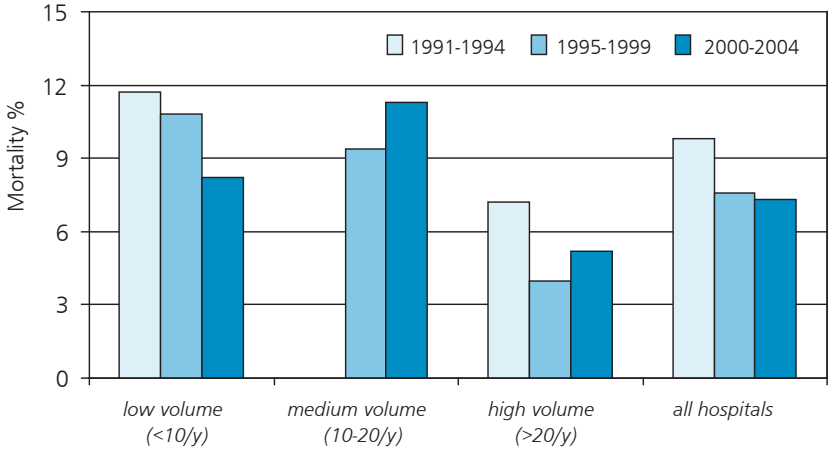

Figure 2. Mortality after esophageal resections in the Netherlands for low, medium and high volume hospitals in three time-periods: 1991-1994, 1995-1999, 2000-2004.

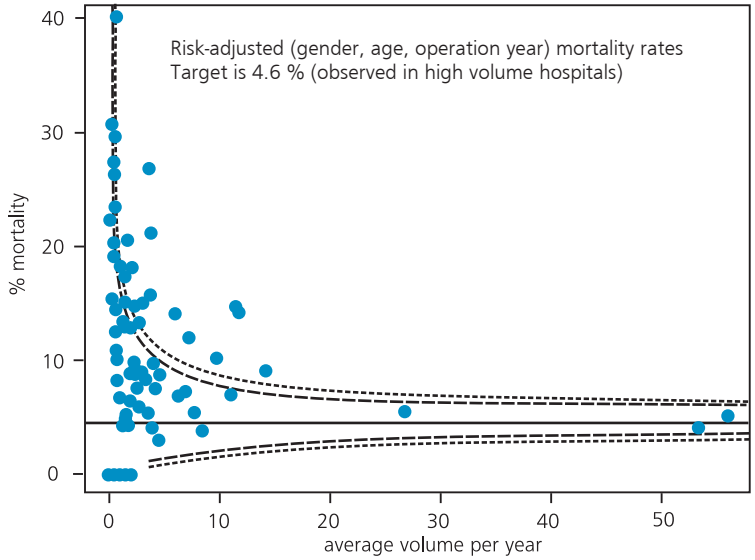

Figure 3. In-hospital mortality in relation to the average annual volume of esophageal resections, for each hospital in the Netherlands. (Mortality is adjusted for age, sex and year of operation. The straight line indicates the average mortality in the high volume hospitals, the dotted lines the 95 and 99 percent limits)

hospitals as well as in low-volume hospitals. A growing number of patients were treated in medium volume hospitals (10-20 resections / year) during the study period, from none during 1991-1994 period to 265 during the 2000-2004 time period. Mortality was high in these medium-volume hospitals; 11% during the most recent time period.

Figure 3 shows the mortality after esophageal resections for all hospitals performing esophagectomies in the Netherlands. Individual hospital volumes ranged from 1 to 682

esophagus resections in the 14 years study period. Targeting the outcome as was identified in the three high volume hospitals (>20 resections / year) mortality proved to be significantly worse in four out of five of the hospitals in the medium volume category (10-20 resections a year). Several low volume hospitals with a mean annual volume between five and ten, showed an in-hospital mortality similar to the mortality rate identified in the high volume hospitals. Logistic regression with mortality as dependent variable and a random hospital effect showed that after adjusting for age, gender and year of operation, there was a highly significant difference in performance between hospitals (hospital variation was

Table 3. Results of logistic regression for in-hospital mortality with random hospital effect

	Multivariate Analysis								
	for age, gender and operation year			for age, gender, operation year and volume			for age, gender, operation year, volume and region		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Age (years)	1.05	1.04-1.07	**<0.0001**	1.05	1.04-1.07	**<0.0001**	1.05	1.04-1.07	**0.0001**
Gender	0.78	0.58-1.04	0.09	0.78	0.58-1.04	0.09	0.78	0.58-1.04	0.09
Operation year	0.96	0.92-0.99	**0.02**	0.96	0.92-1.00	**0.03**	0.97	0.93-1.01	0.10
Hospital volume									
medium vs low				1.01	0.66-1.55	0.95	1.00	0.66-1.54	0.98
high vs low				0.49	0.30-0.79	0.004	0.48	0.30-0.77	**0.003**
CCCLeiden									
before 2000							1.35	0.75-2.43	0.31
after 2000							0.31	0.09-1.08	0.07
Hospital variation									
(on logit scale)		**0.27**			**0.14**			**0.13**	

OR = Odds ratio. 95% CI = 95 percent confidence interval. CCCL = region of Comprehensive Cancer Center West. Bold values indicate that p-values are statistically significant.

0.27). The hospital volume accounted for 50% of this variation; after adjusting for hospital volume, hospital variation reduced to 0.14 (Table 3). There was no difference in mortality risk between median volume and low volume hospitals (odds ratio median volume versus low volume was 1.01, 95%CI (0.66;1.55). The high volume hospitals performed significantly better (OR compared to low volume 0.49, 95%CI (0.30;.079).

Esophagectomies in the CCCL region

Of the 4939 esophageal resections, 312 (6.3%) were performed in the hospitals of the CCCL region. In this region, a centralization process for esophageal cancer surgery was started in the year 2000. The in-hospital mortality rates decreased from 11.6% before 2000 to 3.1% in the period afterwards (Figure 3). In a logistic model, adjusting for age, gender and between hospital variation, with a separate effect for the period before and after 2000 the odds of dying in the CCCL decreased 4.68 times (95% CI (1.26;17.3), p=0.02). In the other regions of the Netherlands, the in-hospital mortality rate was stable: 8.3% in the period 1991-1999 and 7.5% in 2000-2004, with a decrease in OR of 1.09 (95% CI (0.84; 1.41), p=0.50). This

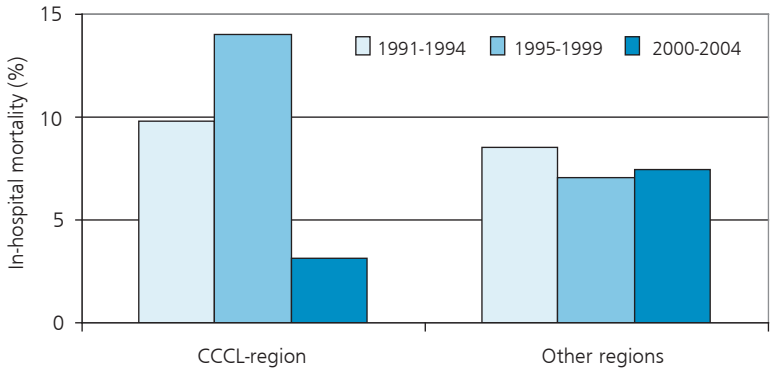

Figure 4. In-hospital mortality rates following esophageal resections in the CCCL region and in the other regions of the Netherlands by calendar period.

considerable decrease in the odds of dying in the CCCL region is not caused by an increase in hospital volumes; after adjustments for volume, the improvements in the CCCL region are still statistically significant: OR 4.76 (1.30;17.48).

DISCUSSION

In the last decade, esophagectomies for cancer have been the subject of many volume-outcome studies, addressing differences in mortality between high- and low volume providers. In the Netherlands, only recently esophagus resections were banned from hospitals with a mean annual volume below ten resections a year. In the literature there is little evidence for this specific volume-cut-off. In addition, our study based on the best available data on esophagectomies in our country, shows that hospitals with an annual volume between 10 and 20 resections a year, on average do not perform better than lower volume hospitals (less than 10 resections a year). Therefore, expectations about quality improvements as a result of this volume standard of 10 resections a year, have to be moderate. Procedural volume is not the only factor determining the variation in outcome between institutions. A strategy that directs patients to hospitals showing superior outcomes (outcome-based referral) could be more effective in improving quality of care than the current strategy of volume-based referral.

Volume standards for Esophageal Cancer Surgery

In 2004 a review by Metzger et al. showed 13 papers on the volume-outcome relationship for esophagectomies, showing a clear reduction in postoperative mortality with increasing case volumes[30]. The majority of these series originate from the United States, with several studies analyzing data from the same databases in overlapping time-periods. Nevertheless,

the authors concluded: "only with the experience of more than 20 procedures a year a significant reduction of mortality can be achieved".
In the present, more recent review of the literature we found 24 original articles concerning the inverse volume-mortality relationship for esophageal resections for cancer, on an institutional level. Some series describe procedures in more than 2000 hospitals (Table 1). Between studies, the choice of volume categories differs widely, with the lowest volume categories varying from less than 1 to less than 30 resections a year. In our study, we didn't perform a meta-analysis, because of heterogeneity in methodology and the choice of volume categories, with possible publication- and selection biases that can not be controlled for. Instead, a graphical representation of mortality rates found for the different volume categories in the literature is given in Figure 1. This figure also suggests that a volume cut-off for esophagectomies should at least be 20 resections a year. However, mortality rates found in several of these high volume categories exceed 10 percent, which in our opinion is still unacceptably high for non-emergency surgical procedures.

Our population-based study on patients that underwent an esophagus resection in the Netherlands in the period 1991-2004, shows an overall improvement in mortality rates over time. The introduction of relatively new anesthesiologic techniques, like the increasingly widespread use of thoracic epidurals, and better staffed ICU departments can be the cause of decreasing mortality rates. Some authors suggest that differences in quality of care between high and low volume hospitals could be based on the earlier adoption of new diagnostic tools and surgical or anesthesiologic techniques in high volume hospitals[31]. Nevertheless, differences in hospital mortality between high- and low volume providers proved to be persistent in the three consecutive time periods investigated in our study (Figure 2).
Since 2000, the evidence for these differences in mortality rates is available to the Dutch surgical community[3]. Despite, the remarkable variation in outcome, no changes in referral patterns were made in the most recent time-period. Only 38 percent of esophagectomies were performed in high volume hospitals, between 2000 and 2004 (Table 2). This information supports the decision of the Netherlands Health Care Inspectorate to ban esophageal resections from hospitals with low procedural volumes: the safety of patients surgically treated for esophageal cancer is at stake and quality improvements are certainly needed.
However, the present study does *not* support the cut-off value of ten resections a year that was chosen to concentrate esophagectomies in hospitals with historically higher procedural volumes. Our data show that only 3 centers have procedural volumes of more than 20 resections a year, with an in-hospital mortality of approximately 5%. On the other hand, the group of hospitals performing 10 to 20 resections a year, has significantly worse results than the outcome shown by these three high volume centers. On average they do not perform better than the low-volume group, but *are* selected as future referral centers for esophageal cancer surgery, under the current provision. Besides, there are several low volume hospitals, performing 5 to10 resections a year which do perform better, with similar results to those of the high volume centers (Figure 3). To our opinion, the effectivity of the current volume

standard (10 resections a year) as an instrument to improve quality of care for esophageal resections in the Netherlands is questionable, considering the presented data.

In addition, we found that volume accounted for only 50 percent of the variation in mortality between hospitals performing esophagectomies (Table 3). Probably, differences in infrastructure, patient selection, (surgical) expertise and dedication of multidisciplinary teams taking care of esophageal cancer patients are at least as important. Volume standards do not take these differences into account, bearing the risk of selecting the 'wrong' hospitals to become future referral centers for esophageal cancer surgery.
For example, recently the Netherlands Cancer Institute, a tertiary referral center for esophageal cancer patients with advanced stages of the disease, evaluated the outcome of patients treated in their hospital in the last thirteen years (1995-2007). The annual number of esophageal cancer patients referred to and treated in this hospital is high, more than 70 patients a year. However, the number of patients with an indication for surgical resection is below the volume standard of ten resections a year. Although most of these patients were downstaged with neoadjuvant therapies before surgery (65%), outcome in this patient group was remarkably good, with an in-hospital mortality of 1% and a five-year survival of 42% [unpublished data. Volume standards for operative procedures do not take in to account the experience with advanced tumor stages and multimodality treatments accumulated in the multidisciplinary setting of specialized cancer centres[32].
Moreover, few studies have been published that show an actual improvement in outcome after the introduction of minimal volume standards[29]. The leapfrog group, a large coalition of private and public purchasers of health insurance in the United States, is referring their patients to high volume providers of high-risk surgical procedures (esophagectomies, pancreatectomies etc.) since 2000[33]. Although expectations were high, no beneficial effects of this 'volume-based referral' initiative have been published yet[34].

Outcome-based Referral

In the region of the CCCL concentration of esophageal cancer surgery has started in 2000, with a scenario in which region-wide outcome registration was linked to a commitment to refer patients to hospitals with superior outcomes (outcome-based referral). In a recent article from our group we describe the results of this regional centralization project, in which detailed clinical data of the patients operated in the region were reported regularly to the participating surgeons. In a five years time period esophagus resections were concentrated in three of the original eleven hospitals. The data analyzed in the present study were retrieved from an independent data-source and validate the conclusions about quality improvements in the CCCL region. The dramatic fall in mortality after the intervention in this region differs significantly from the national trend (Figure 4). Moreover, this considerable decrease in the odds of dying in the CCCL region is not only caused by an increase in hospital volumes. After adjustments for differences in hospital volume between time-periods, the mortality rate in the CCCL region was still statistically significant (Table 3).

In the literature we find several examples of multi-institutional outcome registration programs, in which case-mix adjusted data are fed back to those personally involved in the clinical process of diagnosis, treatment planning, surgical intervention and peri-operative care[35 36]. In Europe, the Nordic countries like Norway and Sweden started a 'national audit' for the surgical treatment of rectal cancer more than 10 years ago. They focussed on the optimalization of the surgical technique for rectal cancer resections (Total Mesorectal Excisions). A nation-wide rectal cancer registry was established and results of rectal cancer resections were fed back to individual institutions and surgeons. In both countries the rate of local recurrence and overall survival improved within a few years[37]. Simultaneously, referral patterns changed with more patients treated in specialized surgical units which continued to show excellent results. Recently, national audit programs for colorectal cancer surgery have been started in the United Kingdom, the Netherlands and Belgium, to improve quality of care on a national level.

Transforming Outcomes into Health Care Policy

The present study is based on the best available data on esophageal cancer resections in the Netherlands. Unfortunately, these data have several limitations. First, few data were available on patient and tumor characteristics like co morbid diseases and stages of the disease. Adjustments for differences in case-mix can lead to considerable changes in results. Detailed clinical data of patients who underwent esophagectomy in the region of the CCCL were analyzed in a recently published study by Wouters et al[4]. Only minor differences in co morbid diseases and stages of the disease were identified between patients operated on in low and high volume hospitals in our country.
Second, in this study only in-hospital mortality and length of stay could be evaluated. In our opinion, more dimensions of outcome should be assessed to evaluate and compare the quality of care in different institutions. Unfortunately, few data collection systems that deliver comprehensive and reliable (case-mix adjusted) outcome data are available, at this moment.
Moreover, our analysis of differences in outcome between institutions is based on data from a 14 years time period. Presuming that concentration of esophageal cancer surgery in the Netherlands should ideally be based on differences in outcomes between providers (outcome-based referral), volumes of the hospitals performing esophageal resections should be sufficient to find statistical differences in quality of care in a more limited time-period [38]. Apparantly, outcome-based referral as an instrument to improve quality of care for esophageal resections for cancer is only feasible in a combination with minimal volume standards.

In conclusion, our study could not provide the evidence for a specific volume cut-off of ten resections a year as was established for esophageal cancer surgery by The Netherlands Health Care Inspectorate. Our data suggest that the use of 'volume' as a proxy for quality of care bears the risk of selecting hospitals with unfavorable outcomes as future referral centers for esophagectomies. Outcome-based referral could be a safer and more effective instrument for procedure-specific quality improvement, but the data needed to transform outcomes

in to policy are not available in most countries. In our opinion, (minimal) volume-standards should at least be accompanied by some sort of outcome registration (clinical audit), not only assessing hospital mortality, but a more extensive set of outcome parameters.

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