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ORIGINAL ARTICLE

Complex gastric surgery in Germany—is centralization beneficial? Observational study using national hospital discharge data

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Abstract

Purpose This observational study explored the association between hospital volume and short-term outcome following gastric resections for non-bariatric indication, aiming to contribute to the discussion on centralization of complex visceral surgery in Germany.

Methods Based on complete national hospital discharge data from 2010 to 2015, the association between hospital volume and in-hospital mortality was evaluated according to volume quintiles and volume deciles. Case-mix differences regarding surgical indication, age, sex, and comorbidities were considered for risk adjustment. In addition, rates of major complications and failure to rescue were analyzed across hospital volume categories.

Results Inpatient episodes (72,528) with gastric resection were analyzed. Risk-adjusted mortality in patients treated in very low volume hospitals (median volume of 5 surgeries per year) was higher (12.0% [95% CI 11.4 to 12.5]) compared to those treated in very high volume hospitals (50 surgeries per year; 10.6% [10.0 to 11.1]). Failure to rescue patients with complications was 28.1% [27.0 to 29.3] in very low volume hospitals and 22.7% [21.6 to 23.8] in very high volume hospitals. Differences were similar within the subgroup of patients operated for gastric cancer.

Conclusions Treatment in very high volume hospitals is associated with a lower in-hospital mortality compared to treatment in very low volume hospitals. This effect seems to be determined by the ability to rescue patients who experience complications. As the observed benefit is only related to very high volumes, the results do not clearly indicate that centralization may improve short-term results substantially, unless a very high degree of centralization would be achieved. Possibly, further research focusing on other outcome measures, such as clinical processes or long-term results, might lead to divergent conclusions.

Keywords Gastric surgery · Centralization · Failure to rescue · Hospital discharge data · Volume outcome relation

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Background

Mortality rates reported for gastric resections vary dramatically. In Asian series, mortality as low as 0.3% is reported for early gastric cancer surgery [1]. In the Netherlands, after implementation of minimum caseloads and cancer audits, mortality decreased significantly from 8.0% in 2011 to 4.0% in 2014 among patients with gastric cancer [2]. For gastric ulcer, postoperative mortality is still very high [3]. Gastric resection is regarded as high-risk surgery and there is some evidence that high volume hospitals have a lower mortality [4, 5] and a higher ability to rescue a patient once a serious complication occurs [6]. In Germany, national data regarding the volume–outcome relationship in complex gastric surgery is scarce. Therefore, it is not clear yet if centralization of gastric surgery might lead to improvements.

This observational study used complete national hospital discharge data to evaluate the association between hospital volume and in-hospital mortality following gastric resections for non-bariatric indication. In addition, rates of major complications and mortality among patients experiencing complications (failure to rescue) were analyzed across hospital volume categories.

Methods

Data

A controlled remote data analysis on inpatient data of the Diagnosis-Related Group Statistics (DRG Statistics) from 2010 to 2015 was performed. Data was provided by the Research Data Centre of the Federal Statistical Office [7]. The DRG Statistics comprise data records of all inpatient episodes in German acute care hospitals, with the exception of psychiatric and psychosomatic episodes.

The data contain principal and secondary diagnoses that are coded according to the German adaptation of the International Classification of Diseases (ICD-10-GM). Procedures are coded according to the German procedure coding system (OPS). Information on sex, age, source of admission, discharge disposition, and length of stay are also included in the data. Based on an anonymized hospital identifier, each inpatient episode can be assigned to the respective treating hospital.

Patient population

The units of analysis were adult patients who underwent partial, subtotal, or total gastric resection for non-bariatric indication from 2010 to 2015 (see Fig. 1.1, supporting information). Patients with bariatric indication were excluded from the analysis, because bariatric surgery represents a different specialty, characterized by rising case numbers (see Fig. 1.2, supporting information), and a very low risk of mortality [8].

For stratification, surgical indication groups, as well as types of gastric resection, were defined. For inclusion and exclusion criteria, see Table 1.1, supporting information.

Hospital volume

Volume of gastric resections performed by a hospital was calculated for each year of observation. After ranking hospitals according to increasing hospital volume, five volume categories were established that most closely sorted the patients into five groups of equal size (quintiles) within each year of observation. Patients were additionally categorized in 10 groups of equal size (deciles) aiming to explore the volume–outcome relation in a finer gradation.

Outcome measure, risk adjustment, and statistical analysis

Patient characteristics were analyzed descriptively according to year of observation, as well as according to volume quintiles, accumulated over the years.

In-hospital mortality was studied as primary outcome measure. Observed and risk-adjusted mortality was stratified by volume quintiles and deciles. Risk-adjusted mortality for each volume category was calculated by multiplying the ratio of observed to expected mortality by the overall mortality. Expected mortality was derived from generalized estimating equations with a logit link function, accounting for clustering of patients within institutions. The model included 5-year age groups, sex, calendar year of treatment, surgical indication, and comorbidities, which are likely to have been present on admission (see Table 1.2, supporting information).

The analysis of in-hospital mortality by volume was additionally performed separately for each surgical indication group.

As secondary outcome, failure to rescue patients with major complications, defined as mortality among patients with major complications, was analyzed within each volume quintile. Several types of severe complications that are associated with a high risk of death were defined [6, 9, 10]. Complications related to surgery were defined as endoscopic intervention (presumably for anastomotic leak), pleural drainage or pleurocentesis, relaparatomy or rethoracotomy, and transfusion of six or more units of whole blood or erythrocytes. Septic complications were defined as mediastinitis or pleural empyema, peritonitis, pneumonia, and septicaemia. Severe cardiovascular events were defined as stroke, acute myocardial infarction, or pulmonary embolism (for definitions of complications, see Table 1.3, supporting information). Because patients may experience more than one complication, different types of complications were combined within a composite complication measure.

Statistical significance of estimates was assessed by 95% confidence intervals (CI). The data analyses were conducted using SAS Version 9.3 (SAS Institute Inc., Cary, NC, USA).

Sensitivity analysis

The main analysis involved all gastric resections with a non-bariatric indication to determine hospital volume. However, the expertise of some hospitals might be rather related to specific indications, such as gastric cancer. Therefore, the analysis was repeated focusing only resections for gastric cancer, which resulted in a different determination of hospital volume (based on the number of gastric resections for cancer only) and a different ranking of hospitals.

Results

Patient characteristics by year

From 2010 to 2015, a total of 72,528 inpatient episodes with gastric resection for non-bariatric indication were identified. The annual number of gastric resections declined from 12,773 in 2010 to 11,281 in 2015 (Table 1).

Hospitals providing gastric surgery had a medium volume of nine resections per year. During the observation period, annual hospital volumes did not change substantially.

With a proportion of approximately 65% malign neoplasm of the stomach was the most frequent surgical indication for gastric resection. The number, as well as the proportion of gastric resections for gastric ulcer, declined from 2069 in 2010 (16%) to 1549 in 2015 (14%).

The distribution of types of surgery remained widely unchanged during the years of observation. Of patients, 34 to 35% underwent total gastric resection without esophageal resection, 54 to 55% underwent subtotal or partial resection, and about 11 to 12% of patients underwent gastric resection combined with esophageal resection.

Patient characteristics by hospital volume quintile

After patients were categorized according to the volume of gastric resections of their treating hospital within the year of treatment, more than 14,400 inpatient episodes were analyzed per quintile (Table 2).

Within the very low volume quintile, 508 hospitals had a median volume of five gastric resections per year, while in the very high volume quintile, 42 hospitals had a median volume of 50 resections per year.

Malign neoplasm of stomach was the most frequent surgical indication in all volume quintiles (64 to 66%). Diagnoses of malign neoplasm of nearby organs or secondary neoplasm were less frequent in hospitals with lower volume (very low 6%) compared to those with higher volume (very high 15%). In contrast, gastric ulcer was more frequent in lower volume hospitals (very low 19%) compared to higher volume hospitals (very high 10%).

Compared to lower volume hospitals, total gastrectomies were performed more often in high volume hospitals (34% vs. 38%), as well as gastric resections combined with esophageal resection (4% vs. 17%).

Table 1 Characteristics of patients undergoing gastric resection, by year

		2010	2011	2014	2015
Total number of patients undergoing non-bariatric gastric resection	*N*	12,773	12,609	11,533	11,281
Number of hospitals providing non-bariatric gastric resection	*N*	996	971	923	892
Annual volume per hospital	Median (IQR)	9 (4–17)	9 (4–17)	9 (4–17)	9 (4–16)
Demographics					
Age 65 years and older	*N* (%)	8291 (64.9)	8154 (64.7)	7259 (62.9)	7127 (63.2)
Female sex	*N* (%)	5620 (44.0)	5428 (43.0)	4892 (42.4)	4828 (42.8)
Surgical indication					
Malign neoplasm of stomach	*N* (%)	8261 (64.7)	8204 (65.1)	7606 (66.0)	7384 (65.5)
Malign neoplasm of nearby organs or secondary malign neoplasm	*N* (%)	1127 (8.8)	1178 (9.3)	1127 (9.8)	1129 (10.0)
Gastric ulcer	*N* (%)	2069 (16.2)	1924 (15.3)	1583 (13.7)	1549 (13.7)
Benign neoplasm of the upper gastrointestinal tract	*N* (%)	355 (2.8)	309 (2.5)	244 (2.1)	239 (2.1)
Other surgical indication	*N* (%)	961 (7.5)	994 (7.9)	973 (8.4)	980 (8.7)
Type of surgery					
Total gastric resection w/o esophageal resection	*N* (%)	4426 (34.7)	4501 (35.7)	4007 (34.7)	3831 (34.0)
Subtotal or partial gastric resection w/o esophageal resection	*N* (%)	6993 (54.7)	6768 (53.7)	6197 (53.7)	6164 (54.6)
Gastric resection with esophageal resection	*N* (%)	1354 (10.6)	1340 (10.6)	1329 (11.5)	1286 (11.4)
With splenectomy	*N* (%)	1290 (10.1)	1296 (10.3)	1018 (8.8)	989 (8.8)
With cholecystectomy	*N* (%)	2476 (19.4)	2642 (21.0)	2859 (24.8)	3046 (27.0)
With resection of other visceral organs[1]	*N* (%)	2642 (20.7)	2650 (21.0)	2449 (21.2)	2444 (21.7)
Length of stay	Median (IQR)	19 (14–29)	19 (14–29)	18 (13–29)	18 (13–28)
In-hospital death	*N* (%)	1555 (12.2)	1537 (12.2)	1212 (10.5)	1292 (11.5)
Surgical or septic or cardiovascular complication	*N* (%)	4973 (38.9)	5049 (40.0)	4585 (39.8)	4444 (39.4)

For the sake of brevity, results of the years 2012 and 2013 are not displayed

SD standard deviation, *IQR* interquartile range (25th–75th percentile)

[1] Small intestine, large intestine, liver, pancreas

Table 2 Characteristics of patients undergoing gastric resection from 2010 to 2015, by hospital volume quintiles

		Hospital volume quintile				
		Very low	Low	Medium	High	Very high
Total number of patients undergoing non-bariatric gastric resection	*N*	14,482	14,526	14,487	14,419	14,614
Number of hospitals providing non-bariatric gastric resection per year in quintile	Mean	508.2	188.3	121.5	82.3	41.8
Annual volume per hospital	Median (IQR)	5 (2–7)	13 (11–14)	20 (18–22)	28 (26–32)	50 (43–66)
Demographics						
Age 65 years and older	*N* (%)	10,072 (69.5)	9864 (67.9)	9334 (64.4)	8974 (62.2)	8056 (55.1)
Female sex	*N* (%)	6647 (45.9)	6456 (44.4)	6333 (43.7)	6035 (41.9)	5847 (40.0)
Surgical indication						
Malign neoplasm of stomach	*N* (%)	9311 (64.3)	9605 (66.1)	9595 (66.2)	9565 (66.3)	9345 (63.9)
Malign neoplasm of nearby organs or secondary malign neoplasm	*N* (%)	883 (6.1)	1103 (7.6)	1319 (9.1)	1466 (10.2)	2168 (14.8)
Gastric ulcer	*N* (%)	2727 (18.8)	2386 (16.4)	2098 (14.5)	1892 (13.1)	1491 (10.2)
Benign neoplasm of the upper gastrointestinal tract	*N* (%)	346 (2.4)	354 (2.4)	350 (2.4)	323 (2.2)	300 (2.1)
Other surgical indication	*N* (%)	1215 (8.4)	1078 (7.4)	1125 (7.8)	1173 (8.1)	1310 (9.0)
Type of surgery						
Total gastric resection w/o esophageal resection	*N* (%)	4865 (33.6)	4888 (33.7)	4892 (33.8)	5177 (35.9)	5499 (37.6)
Subtotal or partial gastric resection w/o esophageal resection	*N* (%)	9091 (62.8)	8328 (57.3)	7810 (53.9)	7255 (50.3)	6660 (45.6)
Gastric resection with esophageal resection	*N* (%)	526 (3.6)	1310 (9.0)	1785 (12.3)	1987 (13.8)	2455 (16.8)
With splenectomy	*N* (%)	1177 (8.1)	1257 (8.7)	1410 (9.7)	1425 (9.9)	1658 (11.3)
With cholecystectomy	*N* (%)	2216 (15.3)	2861 (19.7)	3231 (22.3)	3717 (25.8)	4609 (31.5)
With resection of other visceral organs[1]	*N* (%)	2635 (18.2)	2824 (19.4)	3140 (21.7)	3107 (21.5)	3637 (24.9)
Length of stay	Median (IQR)	20 (14–30)	19 (14–29)	19 (14–29)	18 (13–29)	17 (13–28)
In-hospital death	*N* (%)	1886 (13.0)	1698 (11.7)	1666 (11.5)	1643 (11.4)	1415 (9.7)
Surgical or septic or cardiovascular complication	*N* (%)	5804 (40.1)	5765 (39.7)	5644 (39.0)	5632 (39.1)	5863 (40.1)

SD standard deviation, *IQR* interquartile range (25th–75th percentile)

[1] Small intestine, large intestine, liver, pancreas

In-hospital mortality

Observed in-hospital mortality fell across hospital volume quintiles, ranging from 13.0% in the very low volume quintile to 9.7% in the very high volume quintile (Table 2). After risk adjustment, these differences were largely attenuated but the difference between the very low volume quintile and the very high volume quintile remained statistically significant (very low 12.0% [95% CI 11.4 to 12.5] vs. very high 10.6% [10.0 to 11.1]) (Fig. 1). The subsequent stratification by deciles of hospital volume showed that a visible decline of mortality appeared only in the group of patients who were treated by hospitals with the highest annual volumes (approximately 15 hospitals with a median volume of 72 gastric resections per year).

Figure 2 displays risk-adjusted in-hospital mortality across volume quintiles stratified by surgical indication. For single indication groups, no statistically significant differences were observed between hospital volume quintiles. However, mortality varied widely by indication group.

Complications and failure to rescue

The incidence of complications and failure to rescue are given in Fig. 3, stratified by volume quintiles. The composite complication measure showed that 39 to 40% of patients had at least one type of complication. No association between incidence and hospital volume was observed. However, failure to rescue, i.e., mortality of patients having at least one complication, was significantly lower in very high volume hospitals (22.7% [21.6 to 23.8]) compared to all other volume categories (high volume 26.2% [25.2 to 27.4]; very low volume 28.1% [27.0 to 29.3]).

For incidence and failure to rescue of single types of complications, see Table 1.5, supporting information.

Sensitivity analysis

From 2010 to 2015, 47,436 gastric resections with a principal diagnosis of gastric cancer were identified. After

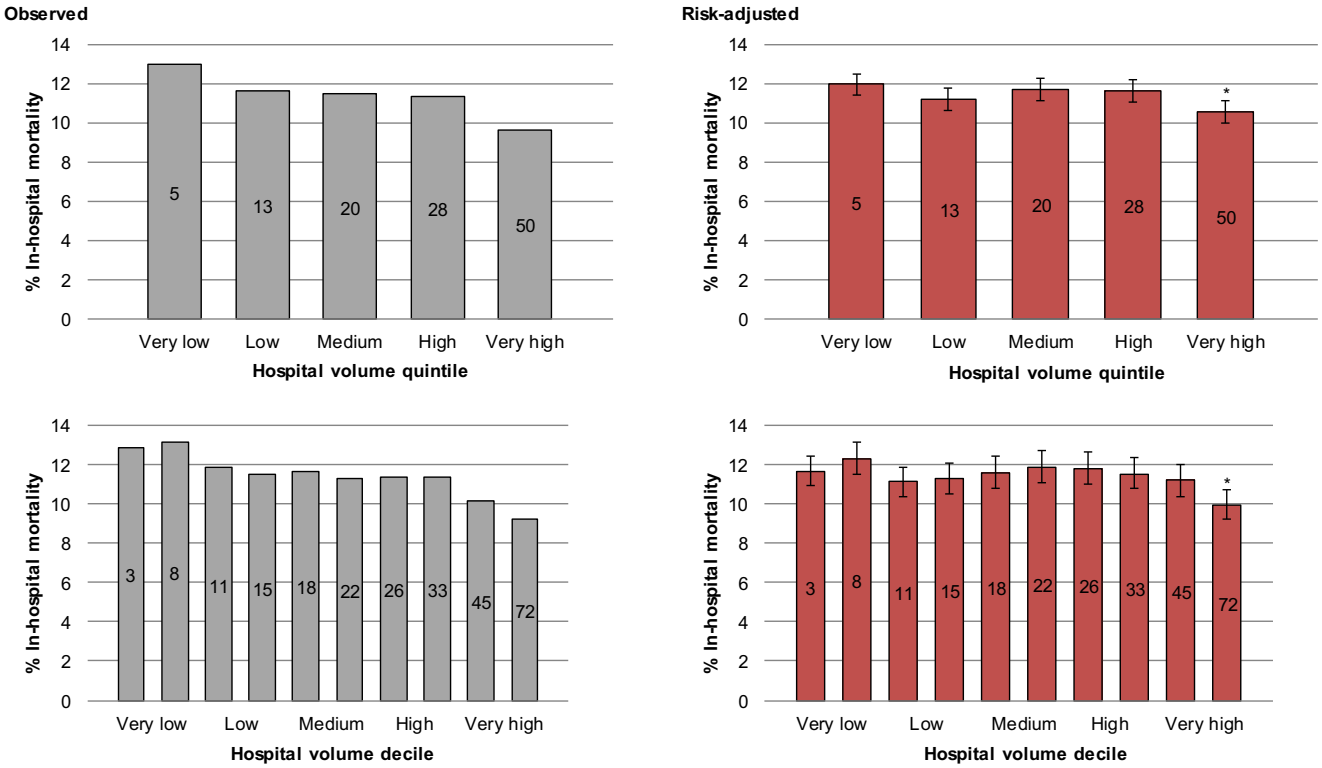

Fig. 1 In-hospital mortality of patients undergoing gastric resection (N = 72,528), by hospital volume quintiles and hospital volume deciles. The median annual no. of cases in quintile or decile is displayed in the bars. Whiskers indicate 95% confidence interval. Covariates for risk adjustment are listed in Table 1.2, supporting information. Area under the curve (c-statistic) of risk adjustment model 0.815, for model results see Table 1.4, supporting information. Statistically significant lower than lowest volume quintile or decile, respectively (asterisk)

determining hospital volume based on these cases only and ranking patients according to the gastric cancer resection volume of their treating hospital, approximately 9500 patients were analyzed in each quintile. Within the very low volume quintile, 476 hospitals had a median of three cancer resections per year, while in the very high volume quintile, 41 hospitals had a median of 34 cancer resections per year (see Table 2.1, supporting information). A statistically significant difference of risk-adjusted in-hospital mortality was observed between the very high volume quintile (6.3% [95% CI 5.8 to 6.9]) and the very low volume quintile (7.7% [7.2 to 8.2]) (see Fig. 2.1, supporting

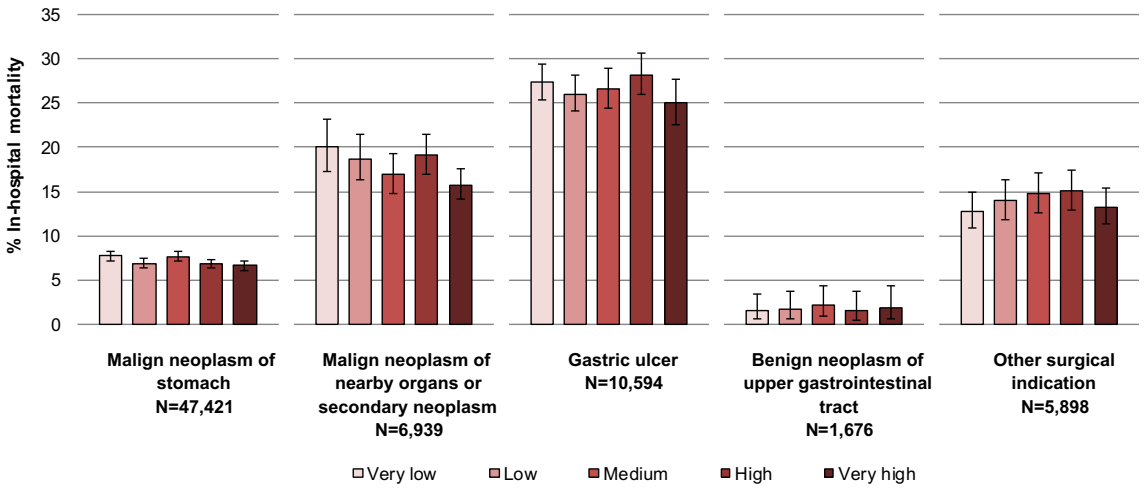

Fig. 2 Risk-adjusted in-hospital mortality of patients undergoing gastric resection, by hospital volume quintiles and stratified by surgical indication. Whiskers indicate 95% confidence interval. Covariates for risk adjustment are listed in Table 1.2, supporting information. For model results, see Table 1.4, supporting information

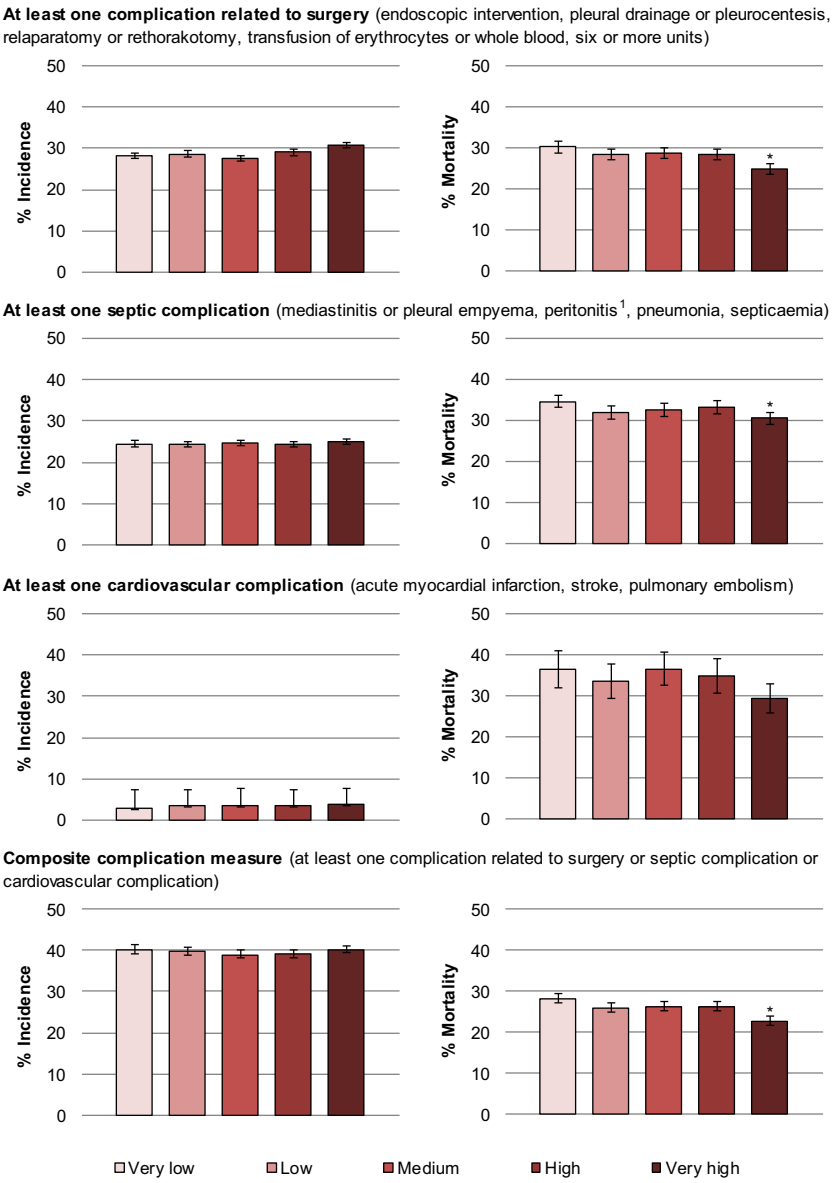

Fig. 3 Incidence of complications among patients undergoing gastric resection and failure to rescue, by hospital volume quintiles. [1]Excluding patients with perforated gastric ulcer. Statistically significant lower than very low volume quintile (asterisk)

information). The incidence of complications was 31.4% in the very low volume quintile and 29.8% in the very high volume quintile. Failure to rescue declined significantly with each higher volume quintile (very low volume quintile 22.1% [20.6 to 23.6]; very high volume 16.6% [15.3 to 18.1]; see Table 2.1, supporting information).

Discussion

The descriptive analysis showed a steady decline in the total number of non-bariatric gastric resections performed in German hospitals, which was driven by declining numbers of surgery for gastric cancer and gastric ulcer.

Hospital volumes of complex gastric surgery varied widely among German hospitals. After controlling for case-mix, the observed relationship between hospital volume and in-hospital mortality was markedly attenuated. However, a statistically significant lower mortality in patients treated in very high volume hospitals compared to those treated in very low volume hospitals remained after risk adjustment. This benefit within the very high volume group appeared predominantly in the decile of patients, who were treated in approximately 15 highest volume hospitals with a median annual volume of 72 gastric resections.

In contrast to esophageal resection for cancer, where there is strong evidence for benefits in short-term mortality from high volume surgery [11, 12], the volume–outcome relation

regarding gastric resection is not that clear. Most gastric surgery volume–outcome studies focused resections for cancer. While some of these studies, mainly with rather small patient numbers, showed no conclusive effects on postoperative mortality [13–15], other studies found better outcomes when surgery was performed in high volume hospitals [16–18]. Evidence syntheses of meta-analyses suggest that higher hospital volume is associated with better outcome in gastric cancer surgery [4, 5]. However, the relation observed in the present study was rather moderate, compared to other types of complex gastrointestinal surgery [19, 20].

Unlike most other studies, the present analysis included complex gastric surgery for all non-bariatric surgical indications and therefore included also gastric resections for gastric ulcer. This explains why the overall observed in-hospital mortality (11%) is higher compared to recent studies which included only cancer-related resections [17, 18]. The stratification of results by surgical indication revealed large differences in mortality, ranging from 2% for benign neoplasms up to 27% for gastric ulcer, on average. It is known that patients undergoing emergency resection for gastric ulcer have a high risk of mortality [3, 21]. In the present analysis, a higher percentage of resections for gastric ulcer were performed in low volume hospitals. Considering the high density of hospitals in Germany, it is unclear why this culmination of critical ill patients in low volume hospitals occurs. However, no significant mortality differences were observed across volume categories. This corresponds to a recent study from England which reported that management of perforated gastric ulcer in high volume esophagogastric cancer centers was not associated with reduced 30-day mortality [21].

Within the observation period, about 65% of all gastric resections were indicated by gastric cancer. The sensitivity analysis revealed that outcome of patients undergoing resection for gastric cancer is rather associated with cancer-specific procedure volume than with overall procedure volume. This finding suggests that centralization efforts might be more beneficial for cancer patients, if cancer-specific hospital volume would be addressed, as it has been applied in the Netherlands and Denmark. In the Netherlands, a voluntary minimum volume standard of 10 annual gastric cancer resections per hospital was implemented in 2012 and raised to 20 resections in 2013. An observational study reported a clear shift to higher volume hospitals for gastric cancer surgery while hospital mortality decreased significantly from 8% in 2011 to 4% in 2014 among patients with gastric cancer [2]. In Denmark, the provision of gastric cancer resections in university hospitals was centralized in 2003, from 37 departments before down to five departments after. After centralization, a decrease of hospital mortality from 8 to 2% was observed [22]. In comparison to these figures, mortality of gastric cancer surgery in Germany (7% on average) seems to be quite high. One should note that the present study included all adult patients receiving gastric surgery in German hospitals. In contrast, the cited studies applied several exclusion criteria, such as neoplasms of the cardia [2, 22], distant metastases [2], or concomitant esophageal resections [22]. Furthermore, outcomes reported from multi-institutional studies [22] might be affected by selection bias in favor of experienced hospitals [23].

The analysis of complications and failure to rescue showed that approximately 40% of all patients with gastric resection experienced a severe complication during their inpatient stay. While the incidence of complications was not related to hospital volume, failure to rescue was significantly lower in very high volume hospitals compared to all other volume quintiles. This finding is supported by other studies, reporting similar results [6, 10, 22, 24].

The results of the present analysis lead to the question, if outcomes of complex gastric surgery could be improved by centralization. In Germany, minimum caseload requirements are used as a policy tool for centralization of health services. Up to now, minimum caseloads were defined for complex esophageal and pancreatic surgery, among others, but not for gastric surgery. National data regarding the volume–outcome relationship is scarce. The latest results are coming from a prospective multicenter study, which analyzed 2897 gastric cancer patients who were operated in 140 surgical departments [24]. Observed hospital mortality was 6% in high volume hospitals (> 20 operations/year) and 8% in very low volume hospitals (< 5 operations/year). In a multivariate analysis, no significant differences in hospital mortality were observed. The present study, however, used complete national data. More than 14,400 inpatient episodes were analyzed per quintile, creating bigger differences in volume categories. The results indicate an effect of gastric surgery volume on outcome of gastric resections. However, the mortality effect seems to be related only to very high volumes, indicating that a minimum caseload requirement of 10 or 20 planned gastric resections per year might not be sufficient to improve short-term results. Substantial improvements might only be expected under a stronger degree of centralization. On the other hand, experiences from other countries suggest that there are more positive effects of centralization than lowering the hospital mortality rate. The Dutch group, for example, observed positive trends in various process measures, such as a significant increase of minimally invasive gastric resections during the process of centralization [2].

In the present study, more than half of all German hospitals performing gastric resections were found to have very low volumes. Although the investigated short-term results provide no conclusive support of a minimum caseload requirement in gastric surgery, other aspects of care, such as clinical processes, or long-term results in particular, might justify centralization efforts, nevertheless. For example, the Association of Upper Gastrointestinal Surgeons of Great Britain and Ireland recommend that one upper gastrointestinal surgery unit with 4

to 6 surgeons, each carrying out a minimum of 15–20 resections per year, serves a population of 1–2 million [25]. The German cancer society requires at least 20 gastric resections for cancer as a prerequisite for certification as a visceral cancer center with a specialty in gastric cancer treatment [26].

Strengths and limitations

The major strength of this study is the completeness of the data used. Limitations occur from the limited information available in administrative data including lack of information on appropriateness of patient selection for gastric resection. It is also possible that variables might be biased by different coding behaviors in different hospitals. Regarding the determination of hospital volume, a possible misclassification of multi-campus hospitals as high volume providers must be taken into account, resulting in a possible underestimation of the association between hospital volume and mortality [27]. Since the data do not contain information on surgeon volume, the analysis could focus hospital volume only. Finally, this study could only investigate short-term outcomes. Since there is mixed evidence for effects of hospital or surgeon volume on long-term survival of gastric cancer patients [24, 28–30], further research with long-term follow up is needed.

Conclusion

Non-bariatric gastric resections in Germany have a high risk of mortality, even when performed in high volume hospitals. Critically ill patients are often treated in hospitals with low volumes. Independent from case-mix differences, treatment in very high volume hospitals is associated with a significant lower mortality compared to treatment in very low volume hospitals. This effect seems to be largely determined by the ability to rescue patients who experience complications, indicating that, in particular, patients with a critical course might benefit from treatment in experienced hospitals. Therefore, the key to a reduction of mortality following gastric resections may lie in a centralization of complex gastric surgery procedures. However, as the observed effects on in-hospital mortality are related to very high volumes, the results do not clearly indicate that centralization may improve short-term results substantially, unless a very high degree of centralization would be achieved. Possibly, further research focusing on other outcome measures, such as clinical processes or long-term survival, might lead to divergent conclusions.

Author's contributions UN, TH, and DL designed the study. UN performed the data analysis. All authors interpreted the data. UN and TH performed literature search and drafted the manuscript. DL, IG, and TM edited the manuscript and provided intellectual input. TH and UN contributed equally to this article.

Compliance with ethical standards

Conflicts of interest All authors have completed the ICMJE uniform disclosure form and declare: The Department for Structural Advancement and Quality Management in Health Care at Technische Universität Berlin, for which UN and TM worked from 2010 to 2018, received ongoing funding from Helios Kliniken GmbH. TH, IG, and DL have nothing to disclose.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors. In accordance with the German guideline for conducting administrative data analyses "Good Practice in Secondary Data Analysis (GPS)," no ethical approval was required for this study.

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Informed consent This study used administrative data provided by the Research Data Centre of the German Federal Statistical Office. In accordance with the terms of use regarding microdata provided by the Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Federal States, no informed consent was required for this study. https://www.forschungsdatenzentrum.de/en/terms-use

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