Systematic review and/or Meta-analysis

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Association between hospital surgical case volume and postoperative mortality in patients undergoing gastrectomy for gastric cancer: a systematic review and meta-analysis

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Background: Postoperative mortality is an important indicator for evaluating surgical safety. Postoperative mortality is influenced by hospital volume; however, this association is not fully understood. This study aimed to investigate the volume–outcome association between the hospital surgical case volume for gastrectomies per year (hospital volume) and the risk of postoperative mortality in patients undergoing a gastrectomy for gastric cancer.

Methods: Studies assessing the association between hospital volume and the postoperative mortality in patients who underwent gastrectomy for gastric cancer were searched for eligibility. Odds ratios were pooled for the highest versus lowest categories of hospital volume using a random-effects model. The volume–outcome association between hospital volume and the risk of postoperative mortality was analyzed. The study protocol was registered with Prospective Register of Systematic Reviews (PROSPERO).

Results: Thirty studies including 586 993 participants were included. The risk of postgastrectomy mortality in patients with gastric cancer was 35% lower in hospitals with higher surgical case volumes than in their lower-volume counterparts (odds ratio: 0.65; 95% CI: 0.56–0.76; $P < 0.001$). This relationship was consistent and robust in most subgroup analyses. Volume–outcome analysis found that the postgastrectomy mortality rate remained stable or was reduced after the hospital volume reached a plateau of 100 gastrectomy cases per year.

Conclusions: The current findings suggest that a higher-volume hospital can reduce the risk of postgastrectomy mortality in patients with gastric cancer, and that greater than or equal to 100 gastrectomies for gastric cancer per year may be defined as a high hospital surgical case volume.

Keywords: gastric cancer, hospital surgical case volume, postoperative mortality, volume–outcome

HIGHLIGHTS

- Higher-volume hospitals reduced the risk of postgastrectomy mortality by 35%.
- Postgastrectomy mortality was stable or reduced after a plateau of 100 cases per year.
- At least 100 gastrectomies per year may be defined as a high hospital volume.

Introduction

Gastric cancer is a global health burden in terms of cancer mortality, especially in Eastern countries, and radical gastrectomy still plays a decisive role in the management of resectable cases[1]. Postoperative mortality is one of the most important indicators for evaluating the safety of surgery[2–4]. This varies greatly among different geographical locations, accounting for 0.1–13.0%, and even up to 17.7%, of patients undergoing radical gastrectomy for gastric cancer[5–10]. Cancer-related cachexia, emergency surgery, and older age may be associated with increased risks of postoperative mortality[11–14]. Recent advances in surgical procedures and equipment, together with revised guidelines, have contributed to improvements in the safety of gastrectomy for gastric cancer[1,15–18]. In addition, the development of

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prehabilitation, anesthesia, and ICUs have also improved surgical safety, and the risk of postoperative mortality has accordingly decreased worldwide[2,19–23]. Furthermore, the improvements in perioperative management and rescue treatments have contributed to this decline[2,24,25]. Hospital surgical case volume has been associated with postoperative mortality[26–31]; however, the association between hospital surgical case volume and the risk of postoperative mortality in gastric cancer patients undergoing gastrectomy remains unclear.

Recent studies investigating the association between hospital surgical case volume for gastrectomy and the postoperative mortality in gastric cancer patients undergoing gastrectomy have shown inconsistent results[5–7,32–42], and information on the volume–outcome association between hospital surgical volume and the risk of postoperative mortality is still lacking. Thus, the current study aimed to investigate the association between hospital surgical case volume and the risk of postoperative mortality in patients undergoing gastrectomy for gastric cancer, with the hypothesis that a higher hospital surgical case volume would lead to a lower risk of postoperative mortality. We also examined the volume–outcome effect of hospital surgical case volume on the risk of postoperative mortality in these patients with the aim of identifying a threshold volume above which there might be a lower risk of postoperative mortality.

Methods

This systematic review was conducted following the Meta-analysis of Observational Studies in Epidemiology (MOOSE) and Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA, Supplemental Digital Content 1, http://links.lww.com/JS9/A124, Supplemental Digital Content 2, http://links.lww.com/JS9/A125) guidelines[43–45]. Each quality assessment was based on AMSTAR 2, Supplemental Digital Content 3, http://links.lww.com/JS9/A126 [46], which is highly descriptive and consistent. The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) prior to conducting this systematic review.

Eligibility criteria

The inclusion criteria were relevant cohort studies assessing the association between hospital surgical case volume for gastrectomy and the postoperative mortality in patients undergoing gastric cancer surgery. In this study, postoperative mortality was defined as death during hospitalization, regardless of the length of hospital stay, and death after hospital discharge within 30 days from the operation date. The exclusion criteria were: case reports, reviews, and studies with insufficient data; studies with no short-term mortality data; studies with 60-day or 90-day mortality data only; studies in which data for benign disease and gastric cancer could not be separated; studies with a mixture of gastric and other cancer types; studies including nonsurgical patients; studies including endoscopic treatments; studies with surgeon-volume data only or hospital-type data only; studies with no or unclear reference groups; and studies with continuous data only.

Data sources and search strategy

Two authors systematically searched PubMed and Embase from their inception to 22 October 2022, without any restrictions. The search terms included those related to gastric cancer, gastrectomy, hospital volume, and their variants. The search strategies are presented in Supplemental Table 1, Supplemental Digital Content 4, http://links.lww.com/JS9/A127. The reference lists of relevant articles and reviews were also screened to identify eligible studies for inclusion. We also reviewed conference abstracts for potential unpublished studies.

Study selection

Duplicate studies were removed after a systematic search. Two authors assessed the remaining studies, and a third reviewer was consulted to resolve any discrepancies. Relevant studies were initially selected based on titles and abstracts, and the full texts were then read to confirm their relevance. If necessary, potentially relevant studies in languages other than English were translated using translation software or translators.

Data extraction

Two authors independently extracted data from the included studies according to a standardized procedure. The following information was extracted from each study in the adjusted model: first author, year of publication, study design, country, study period, number of gastric cancer patients who underwent gastrectomy, number of hospitals, hospital volume category (annual surgical cases per year), postoperative mortality, definition of postoperative mortality, and covariates. Two other reviewers reviewed the data. Any discrepancies were resolved through discussion and consensus.

Quality assessment

Two authors independently assessed the quality of the included studies using the Newcastle–Ottawa scale for cohort design[47]. All studies were evaluated regarding participant selection and measurement of exposure, comparability, assessment of outcomes, and adequacy of follow-up. The studies were then classified as high (7–9), moderate (4–6), or low quality (0–3).

Statistical analysis

Odds ratios (ORs) and the corresponding 95% CIs were pooled to compare the association between hospital surgical case volume (highest vs. lowest category) and the risk of postoperative mortality in gastric cancer patients undergoing gastrectomy. The lowest hospital volume was used as the reference group. We applied a random-effects model, considering the high possibility of clinical heterogeneity among the included studies. Heterogeneity across studies was assessed using the Q statistic (I^2 and P value), with I^2 values less than 25, 25–50, and greater than 50% indicating low, moderate, and high heterogeneity, respectively[48]. Publication bias was assessed using funnel plots with Begg's and Egger's tests[48,49]. $P < 0.05$ was considered statistically significant. All statistical analyses were performed using Stata software, Version 13.1 (StataCorp).

Subgroup analyses

We further confirmed the robustness of the findings by conducting subgroup analyses according to the study period (1982–1999 and 2000–2018), country (Eastern and Western), sample size (< 5000 and ≥ 5000), hospital number (< 100 and

≥100), study design (retrospective and prospective), study quality (high and moderate), volume grouping (dichotomies, tertiles, quartiles, and quintiles), and adjusted ORs (yes and no).

Volume–outcome analysis

We also conducted a volume–outcome analysis of the relationship between hospital surgical case volume and the risk of postoperative mortality in patients with gastric cancer undergoing gastrectomy[50,51]. This method required the following information: at least three quantitative categories of hospital volume, number of postoperative deaths, total number of patients, and ORs with 95% CIs. If no median (or mean) value was indicated, it was estimated from the midpoints between the upper and lower bounds: the lower boundary was assumed to be 0 when the lower boundary was open-ended; otherwise, the median value was assumed to be 1.5 times the lower boundary if the upper boundary was open-ended, as described previously[52]. The volume–outcome relationship was compared with a linear trend relationship, with P greater than or equal to 0.05 indicating a linear relationship and P less than 0.05 indicating a nonlinear trend. We produced a scatter plot to illustrate the distribution between hospital surgical case volume (x-axis) and the postoperative mortality (y-axis) in patients with gastric cancer undergoing gastrectomy.

Results

The initial search identified 4163 studies. After removing 1061 duplicates, 3102 studies remained, of which 112 were discarded after reviewing the titles and abstracts. Thirty cohort studies were finally included after reviewing the full texts[5–10,32–42,53–65]. Details of the literature search and study selection are shown in Figure 1.

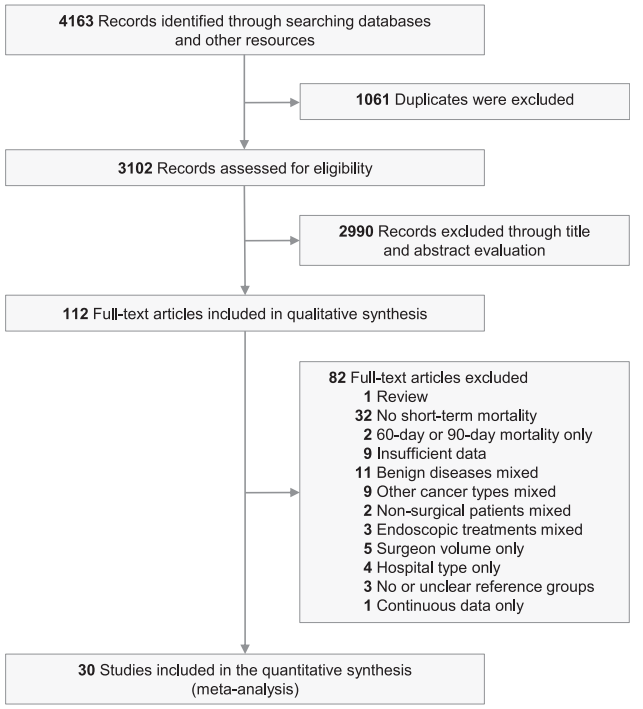

Figure 1. Flowchart of literature search and study selection.

Characteristics of included studies

The characteristics of the 30 included studies are summarized in Table 1. The number of patients in the included studies ranged from 188 to 145 523, with a total of 586 993 patients. Four studies were prospective[36,41,58,60], and 26 were retrospective cohort studies[5–10,32–35,37–40,42,53–57,59,61–65]. Nine studies were from Eastern countries[5,6,32,34,36,42,55,57,62], and 21 were from Western countries[7–10,33,35,37–41,53,54,56,58–61,63–65]. The postoperative mortality in the included studies ranged from 0.07 to 17.7% in different categories. The hospital volume categories, ORs, and adjusted factors are listed in Supplemental Table 2, Supplemental Digital Content 4, http://links.lww.com/JS9/A127. The Newcastle–Ottawa scale for the quality assessment of the included studies is presented in Supplemental Table 3, Supplemental Digital Content 4, http://links.lww.com/JS9/A127. The average total score was 7.6 (range: 5–9), indicating a high or moderate quality of all included studies.

Hospital volume and risk of postoperative mortality

Thirty studies with available data were included in the quantitative analysis[5–10,32–42,53–65]. A higher-volume hospital could reduce the risk of postoperative mortality among patients undergoing gastric cancer surgery by 35% compared with lower-volume hospitals (OR: 0.65; 95% CI: 0.56–0.76; $P<0.001$) (Fig. 2).

Subgroup analyses

Variations in hospital volume grouping strategies among the studies may be a potential source of heterogeneity. Compared with their lower-volume counterparts, higher-volume hospitals significantly reduced the risk of postoperative mortality in gastric cancer patients undergoing gastrectomy for dichotomies (OR: 0.65; 95% CI: 0.58–0.74; $P<0.001$), for tertiles (OR: 0.75; 95% CI: 0.57–0.98; $P=0.036$), for quartiles (OR: 0.54; 95% CI: 0.35–0.84; $P=0.006$), and for quintiles (OR: 0.57; 95% CI: 0.36–0.91; $P=0.019$), although heterogeneity could still be observed (Fig. 2, Table 2). The association between hospital surgical case volume and the postoperative mortality after gastric cancer surgery remained consistent in other subgroup analyses, except for prospective study design, moderate study quality, and unadjusted OR (Supplemental Figs 1–7, Supplemental Digital Content 4, http://links.lww.com/JS9/A127; Table 2).

Volume–outcome analysis

Fourteen studies were included in the volume–outcome analysis of hospital surgical case volume and the risk of postoperative mortality in gastric cancer patients undergoing gastrectomy[5–7,10,32–35,38,40,41,58,61,65]. The volume–outcome association was not a linear association (Fig. 3), and the risk of postgastrectomy mortality remained stable or decreased after the hospital volume reached a plateau of 100 gastrectomy cases per year. Twenty-seven studies were included in the scatter plot to assess the relationship between hospital surgical case volume and the postoperative mortality rates[5–10,32–41,53,54,56–58,60–65]. Similarly, the postoperative mortality rates showed a rapid decline from 17.7 to 0.3% until the hospital volume reached a plateau of 100 gastrectomies per year, and then remained at 0.07–0.51% (Fig. 4).

Table 1

Clinical characteristics of gastric cancer patients undergoing gastrectomy from 30 included studies.

References	Study design	Country	Period	Number of patients	Number of hospitals	Hospital volume (cases/year)	POM (death/total) (%)	Definition of POM
Wirth *et al.*[53]	Retrospective	Switzerland	2014–2018	188	62	≤10	1.9	In-hospital
						>10	1.3	
Narendra *et al.*[54]	Retrospective	Australia	2001–2015	796	49	<5	5.0	30-day
						≥5	3.0	
Iwatsuki *et al.*[34]	Retrospective	Japan	2011–2015	71 307	2051	0–11	3.1	In-hospital
						12–26	1.7	
						27–146	1.2	
Ji *et al.*[5]	Retrospective	China	2013–2018	125 683	515	1–83	0.44	In-hospital
						84–238	0.29	
						239–579	0.24	
						580–1193	0.15	
Diers *et al.*[35]	Retrospective	Germany	2009–2017	46 187	1084	≤10	6.9	In-hospital
						11–29	5.8	
						≥30	3.9	
Tian *et al.*[8]	Retrospective	Australia	2001–2015	1253	49	<5	6.4	In-hospital
						≥5	4.3	
Levy *et al.*[56]	Retrospective	Canada	2004–2015	1660	69	0–2	6.6	30 days
						2.5–5	NA	
						5.5–7.5	NA	
						8–11.5	NA	
						12–22	3.1	
Shibao *et al.*[55]	Retrospective	Japan	2012–2013	37 752	1074	1–35	NA	In-hospital
						36–61	NA	
						62–97	NA	
						98–458	NA	
Iwatsuki *et al.*[6]	Retrospective	Japan	2011–2015	145 523	2182	1–22	1.9	In-hospital
						23–51	1.0	
						52–404	0.5	
Wu *et al.*[57]	Retrospective	China	2000–2010	7905	185	<10	4.1	30 days
						≥10	1.9	
Claassen *et al.*[7]	Retrospective	Netherlands	2007–2015	494	NA	1–10	1.6	In-hospital/30 days
						11–20	4.3	
						21–30	2.0	
						≥31	0.63	
Haga *et al.*[36]	Retrospective	Japan	2000–2003	2045	NA	≤90	0.84	30 days
						>90	0.07	
Ptok *et al.*[58]	Prospective	Germany	2007–2009	2897	140	<5	7.8	In-hospital
						5–10	5.5	
						11–20	6.6	
						>20	5.8	
Busweiler *et al.*[61]	Retrospective	Netherlands	2007–2015	4837	NA	<15	7.4	30 days
						15–39	6.1	
						≥40	4.8	
Güller *et al.*[60]	Prospective	Switzerland	1999–2012	4404	NA	1–10	4.9	In-hospital
						>10	3.3	
Liu *et al.*[59]	Retrospective	United States	2010–2013	17 923	1297	≤4	NA	30 days
						>4	NA	
Murata *et al.*[62]	Retrospective	Japan	2009–2011	5941	741	<40	0.5	In-hospital
						≥40	0.3	
Altini *et al.*[37]	Retrospective	Italy	2004–2008	1314	16	<7	11.9	In-hospital/30 days
						7–21	NA	
						≥21	4.2	
Smith *et al.*[63]	Retrospective	Australia	2000–2009	1621	84	≤6	5.1	30 days
						>6	3.8	
Dikken *et al.*[39]	Retrospective	Netherlands, England, Sweden, Denmark,	2004–2009	9010	NA	1–10	4.4	30 days
						11–20	NA	
						≥21	6.7	

Table 1

(*Continued*)

References	Study design	Country	Period	Number of patients	Number of hospitals	Hospital volume (cases/year)	POM (death/total) (%)	Definition of POM
Ho *et al.*[38]	Retrospective	Netherlands	2008–2010	1024	88	1–6	6.1	30 days
						7–9	6.4	
						≥10	4.6	
Ghaferi *et al.*[9]	Retrospective	United States	2005–2007	8838	NA	1–4	17.7	In-hospital/30 days
						NA	NA	
						NA	NA	
						11–110	7.5	
Kim *et al.*[32]	Retrospective	South Korea	2002–2005	11 071	NA	<39	0.71	30 days
						39–126	0.86	
						>126	0.36	
Skipworth *et al.*[40]	Retrospective	Scotland	1982–2003	4589	61	1–3	8.9	In-hospital
						4–5	12.0	
						6–9	9.4	
						≥10	8.6	
Baré *et al.*[33]	Retrospective	Spain	2001–2002	3241	144	<18	7.9	In-hospital
						18–35	11.7	
						>35	11.6	
Thompson *et al.*[41]	Prospective	Scotland	1997–1999	639	39	<13	11.9	In-hospital/30 days
						13–19	9.1	
						20–34	10.3	
						≥35	10.0	
Lin *et al.*[42]	Retrospective	China	2000–2003	11 348	174	Q1	5.4	In-hospital
						Q2	3.4	
						Q3	3.1	
						Q4	1.6	
						Q5	1.4	
Wainess *et al.*[64]	Retrospective	United States	1988–2000	23,690	NA	1–4	8.3	In-hospital
						5–8	7.1	
						≥9	6.5	
Damhuis *et al.*[65]	Retrospective	Netherlands	1987–1997	1978	22	<7	8.0	30 days
						7–10	9.8	
						>10	6.8	
Birkmeyer *et al.*[10]	Retrospective	United States	1994–1999	31,944	3423	<5	13.0	In-hospital/30 days
						5–8	12.7	
						9–13	11.1	
						14–21	11.3	
						>21	8.7	

NA, not available; OR, odds ratio; POM, postoperative mortality; Q, quintiles.

Publication bias

Thirty studies were included in the quantitative meta-analysis[5–10,32–42,53–65], and there was no evidence of publication bias based on Begg's ($P = 0.412$) or Egger's tests ($P = 0.795$) (Fig. 5).

Discussion

This meta-analysis investigated the association between the hospital surgical case volume for gastrectomy and the risk of postoperative mortality in patients with gastric cancer undergoing the procedure. Compared with lower-volume hospitals, the risk of postoperative mortality was reduced by 35% in patients who underwent gastrectomy for gastric cancer in higher-volume hospitals. This volume effect on the risk of postoperative mortality remained robust and consistent in multiple subgroup analyses. Volume–outcome analysis further showed that the risk of postgastrectomy mortality remained stable or decreased after the hospital volume reached a plateau of 100 gastrectomy cases per year. Similarly, postoperative mortality rates decreased rapidly from 17.7 to 0.3% until the hospital surgical case volume reached a plateau of 100 gastrectomies per year and then remained below 0.51%.

A previous pioneering systematic review evaluated the potential relationships between hospital volume and survival outcomes for multiple cancers[66], while another recent meta-analysis further investigated the effect of surgical volume on surgical and oncological outcomes for gastric cancer[67]. However, these meta-analyses included several studies with heterogeneous patients with and without gastrectomy rather than only surgical

patients, limiting the analysis to postoperative mortality, which is one of the most important indicators for assessing surgical safety[2–4]. In contrast, we investigated the association between hospital surgical case volume and the risk of postoperative mortality exclusively in patients who underwent gastrectomy for gastric cancer. In addition, the current analysis included 12 further studies with a total of 213 792 patients, which were not included in previous systematic reviews[5,8,9,32,35,40,53,54,58,61–63]. We also excluded studies that included patients with benign disease in order to analyze a highly homogeneous patient population with curable gastrectomy. We further confirmed the robustness of our findings using multiple subgroup analyses. For the first time, we showed that greater than or equal to 100 gastrectomies per year for gastric cancer may be defined as a high hospital surgical case volume.

Although an association between hospital surgical volume and postoperative mortality has been proposed for several decades, the mechanism remains unclear[68]. Surgeons and anesthesia

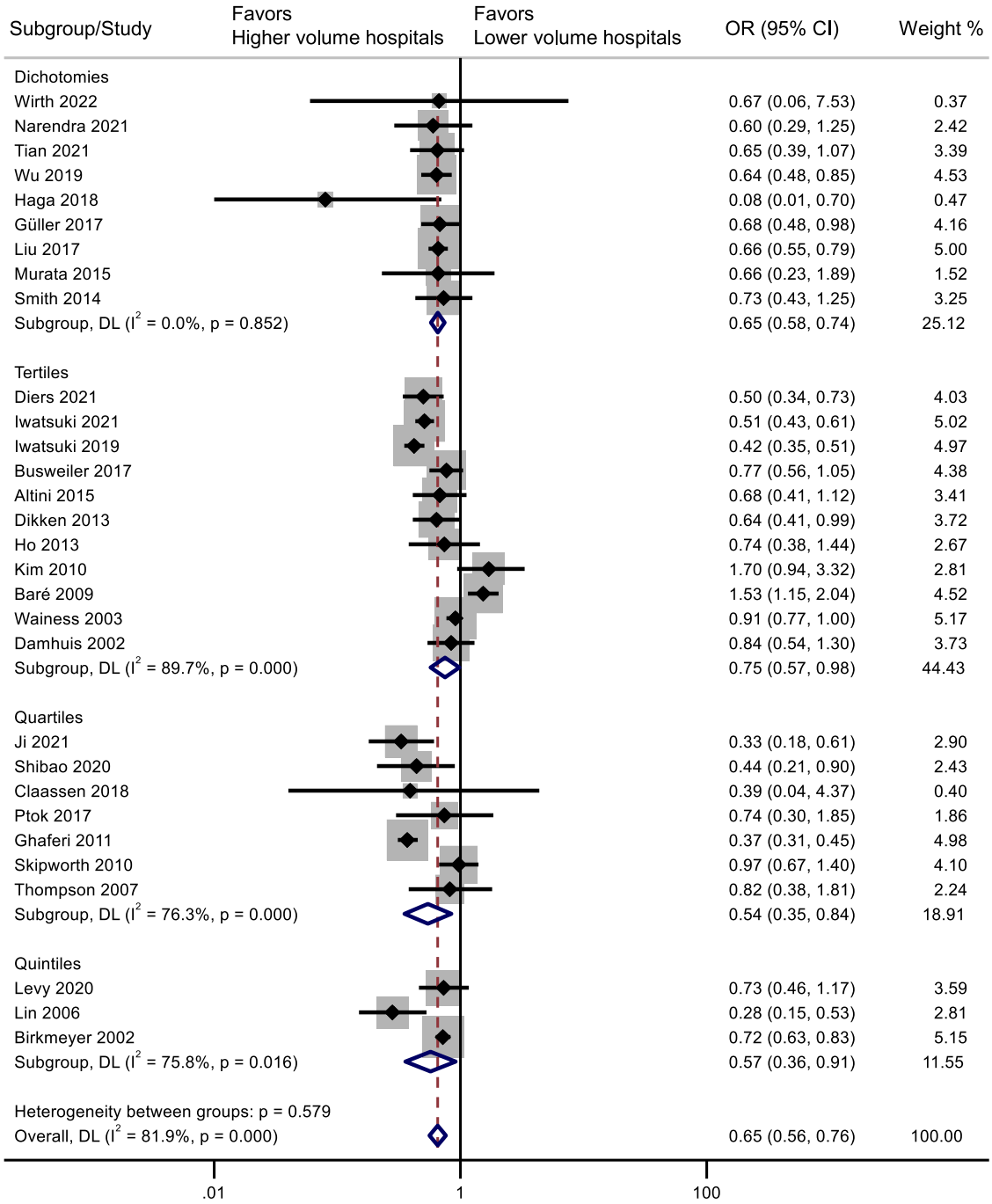

Figure 2. Forest plot of association between hospital surgical case volume per year and the risk of postoperative mortality among gastric cancer patients undergoing gastrectomy according to volume grouping. OR, odds ratio.

Table 2

Subgroup analyses of volume effect on postoperative mortality in gastric cancer patients undergoing gastrectomy.

Subgroup	Number of patients	Number of studies	Odds ratio (95% CI)	*P*	Test of heterogeneity	
					I^2 value (%)	*P*
Total	586 993	30	0.65 (0.56–0.76)	< 0.001	81.9	< 0.001
Study period						
1982–1999	34 561	3	0.73 (0.64–0.83)	< 0.001	0	0.774
2000–2018	519 749	24	0.61 (0.50–0.73)	< 0.001	79.5	< 0.001
Country						
Eastern	418 575	9	0.50 (0.38–0.66)	< 0.001	72.3	< 0.001
Western	168 418	21	0.72 (0.61–0.85)	< 0.001	79.3	< 0.001
Sample size						
< 5000	32 871	16	0.80 (0.66–0.96)	0.016	45.4	0.025
≥ 5000	554 122	14	0.57 (0.46–0.70)	< 0.001	88.3	< 0.001
Hospital number						
< 100	15 062	10	0.77 (0.65–0.92)	0.003	0	0.968
≥ 100	507 542	12	0.58 (0.46–0.73)	< 0.001	85.7	< 0.001
Study design						
Retrospective	577 117	26	0.65 (0.56–0.77)	< 0.001	84.0	< 0.001
Prospective	9876	4	0.66 (0.42–1.03)	0.066	27.7	0.246
Study quality						
High	559 670	23	0.66 (0.58–0.76)	< 0.001	72.0	< 0.001
Moderate	27 323	7	0.54 (0.27–1.11)	0.092	92.1	< 0.001
Volume grouping						
Dichotomies	42 076	9	0.65 (0.58–0.74)	< 0.001	0	0.852
Tertiles	319 182	11	0.75 (0.57–0.98)	0.036	89.7	< 0.001
Quartiles	180 783	7	0.54 (0.35–0.84)	0.006	76.3	< 0.001
Quintiles	44 952	3	0.57 (0.36–0.91)	0.019	75.8	< 0.001
Adjusted OR						
Yes	561 908	19	0.63 (0.54–0.73)	< 0.001	77.7	< 0.001
Unknown	25 085	11	0.69 (0.44–1.08)	0.102	87.4	0.001

OR, odds ratio.

teams in hospitals with higher surgical case volumes may have more experience and the chance of enhanced training, thus reducing postoperative mortality, that is, 'practice makes perfect'[2,69–73]. A higher rate of unplanned intensive care admissions in lower-volume hospitals also led to higher postoperative mortality[56]. High-volume hospitals were also reported to have higher rates of success of rescue treatments compared with low-volume hospitals[35,74], due to their structural differences such as the availability of specialized ICUs[35].

The current results may provide helpful information to guide patients' hospital choices, volume-based referrals, and hospital management. High-volume hospitals have been associated with improved patient outcomes, attributed to their subspecialty oncology expertise[30,75]. The current findings suggest that a higher-volume hospital can reduce the risk of postgastrectomy mortality in patients with gastric cancer, and that greater than or equal to 100 gastrectomies for gastric cancer per year may be defined as a high hospital surgical case volume. It is clinically important to make efforts to reduce postoperative mortality, especially in low-volume hospitals. First, self-training for surgical skills is important. For example, a LapMentor virtual reality laparoscopic simulator (Simbionix Corporation) was shown to help surgeons improve their surgical skills[76]. Surgeons are also encouraged to enhance their surgical skills through advanced training in high-volume cancer centers. Furthermore, it is critical to identify high-risk patients through an adequate preoperative evaluation. For instance, the surgical risks of most operations can be predicted by a decision-support tool, such as the American College of Surgeons National Surgical Quality Improvement Program surgical risk calculator[77]. Similarly, a machine-learning project trained on Pythia was built to predict the risks of postoperative complications, and high-risk patients could be identified[78]. These predictive models can help identify high-risk patients in low-volume hospitals, who can then be selectively transferred to high-volume hospitals[79–81] that have more surgical and anesthetic teams with better experience, a higher rate of rescue success, and a higher availability of specialized ICUs[2,35,69–74]. In addition, perioperative management plays a crucial role in surgical safety[2], which has been improved over time[25]. For example, a uniform perioperative management procedure can be applied to improve surgical safety, such as the clinical application of a surgical safety checklist[82] and the CLASSification of Intraoperative Complications (ClassIntra version 1.0, formerly known as CLASSIC)[2], which can effectively reduce postoperative mortality. Improved nurse staffing levels can also reduce postoperative mortality, and an increase in a nurse's workload by one patient was reported to increase the likelihood of 30-day mortality from admission by 7%, while every 10% increase in bachelor-degree nurses decreased this likelihood by 7%[83].

This study had several limitations. Most of the included studies were retrospective cohort studies with different populations. In addition, uniform adjustment factors for assessing the association between hospital volume and the risk of postoperative mortality were lacking; however, multiple subgroup analyses confirmed the robustness of the main findings. Furthermore, there was

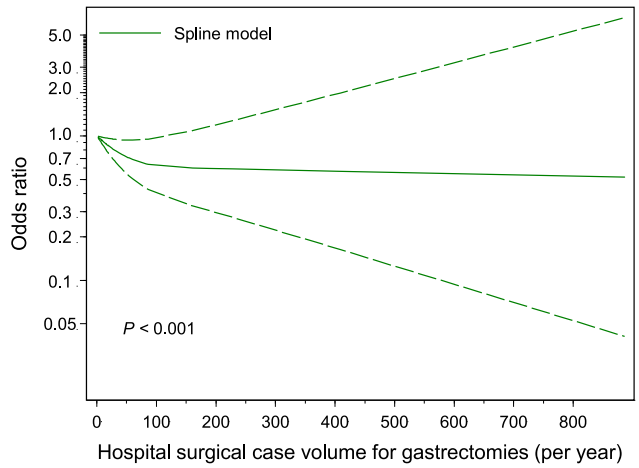

Figure 3. Volume–outcome analysis of association between hospital surgical case volume per year and the risk of postoperative mortality among gastric cancer patients undergoing gastrectomy. Middle green line is the fit curve of odds ratio; upper green line is the upper 95% CI; lower green line is the lower 95% CI.

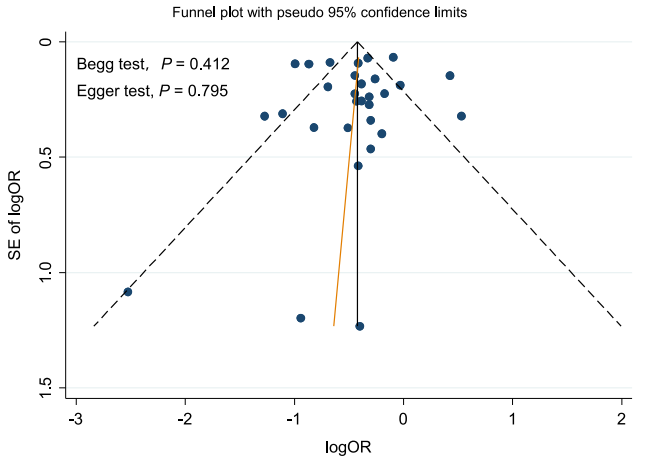

Figure 5. Funnel plot for publication bias of association between hospital surgical case volume per year and the risk of postoperative mortality among gastric cancer patients undergoing gastrectomy. OR, odds ratio.

heterogeneity among the cutoff values for categories of annual hospital surgical case volumes among the studies, and further investigations are needed to validate the main findings of the current study.

Conclusions

Treatment in hospitals with higher surgical case volumes could reduce the risk of postoperative mortality among gastric cancer patients undergoing gastrectomy by 35% compared with that in lower-volume hospitals. The current findings suggest that a higher-volume hospital can reduce the risk of postgastrectomy mortality in patients with gastric cancer, and that greater than or equal to 100 gastrectomies for gastric cancer per year may be defined as a high hospital surgical case volume. Patients with gastric cancer may benefit from a lower risk of postoperative mortality if radical gastrectomy procedures are centralized at high-volume hospitals above the threshold of 100 gastrectomies for gastric cancer per year.

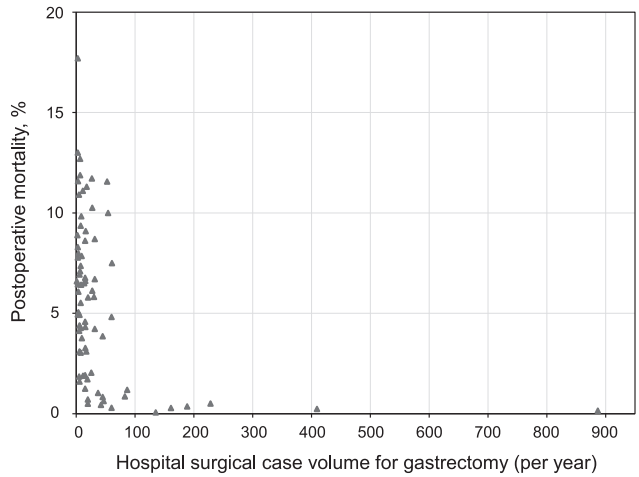

Figure 4. Scatter plot of distribution between median or mean hospital surgical case volume per year in each category from 27 studies and corresponding mortality rates among gastric cancer patients undergoing gastrectomy.

Ethical approval

Not applicable.

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This study received no funding.

Author contribution

F.-L.N., W.-J.G., Z.-M.Z., and C.-D.Z: conceived and designed the experiments. F.-L.N., Z.-M.Z., and C.-D.Z.: analyzed the data. F.-L.N., W.-J.G., Z.-M.Z., and C.-D.Z.: contributed reagents/materials/analysis. F.-L.N., W.-J.G., Z.-M.Z., W.-Y.D., M.S., S.-Y.C., Y.-J.Z., M.A., and C.-D.Z.: wrote the manuscript. All authors have read and approved the final manuscript.

Conflicts of interest disclosure

The authors declare no conflicts of interest.

Research registration unique identifying number (UIN)

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Guarantor

Chun-Dong Zhang.

Data availability statement

All the data generated and analyzed during this study are included in this article. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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