

Hospital Case Volume and Clinical Outcomes for Peptic Ulcer Treatment

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BACKGROUND: No study has explored the volume–outcome relationship for peptic ulcer treatment.

OBJECTIVE: To investigate the association between peptic ulcer case volume per hospital, on the one hand, and in-hospital mortality and 14-day readmission rates, on the other, using a nationwide population-based dataset.

DESIGN: A retrospective cross-sectional study, set in Taiwan.

PARTICIPANTS: There were 48,250 peptic ulcer patients included. Each patient was assigned to one of three hospital volume groups: low-volume (≤ 189 case), medium volume (190–410 cases), and high volume (≥ 411 cases).

MEASUREMENTS: Logistic regression analysis employing generalized estimating equations was used to examine the adjusted relationship of hospital volume with in-hospital mortality and 14-day readmission.

MAIN RESULTS: After adjusting for other factors, results showed that the likelihood of in-hospital mortality for peptic ulcer patients treated by low-volume hospitals (mortality rate = 0.68%) was 1.6 times ($p < 0.05$) that of those treated in high-volume hospitals (mortality rate = 0.72%) and 1.4 times ($p < 0.05$) that of those treated in medium-volume hospitals (mortality rate = 0.73%). The adjusted odds ratio of 14-day readmission likewise declined with increasing hospital volume, with the odds of 14-day readmission for those patients treated by low-volume hospitals being 1.5 times ($p < 0.001$) greater than for high-volume hospitals and 1.3 times ($p < 0.01$) greater than for medium-volume hospitals.

CONCLUSIONS: We found that, after adjusting for other factors, peptic ulcer patients treated in the low-volume hospitals had inferior clinical outcomes compared to those treated in medium-volume or high-volume ones.

KEY WORDS: ulcer; volume–outcome; mortality.

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INTRODUCTION

Bleeding or perforated peptic ulcers represent a life-threatening condition, accounting for 6500 hospital deaths in the US annually.¹ With the introduction of proton pump inhibitors and effective regimens for eradication of *Helicobacter pylori*, admissions for peptic ulcer-related complications have declined; however, there are still some subsets of patients suffering from bleeding or perforated peptic ulcers. Despite advances in medical care and endoscopic therapy, the morbidity and death rate from bleeding or perforated ulcers remains high. The management of bleeding or perforated ulcers requires teamwork, both medical and surgical, as well as experience. For this reason, hospital case volume might be related to outcomes for peptic ulcer disease, but we are not aware of any studies on this issue. As far as we know, there is no study at present dealing with this issue. One study by Freeman et al. reported that lower case volume has been associated with worse outcomes following endoscopic retrograde cholangiopancreatography (ERCP).² Other studies have also reported that high-volume providers are associated with decreased hospital deaths, shorter lengths of stay and lower hospital charges for complex gastrointestinal surgery.³

The aim of this study is to investigate the association between ulcer case volume per hospital on the one hand and in-hospital mortality and 14-day readmission rates on the other, using a Taiwan nationwide population-based dataset, to clarify the influence of case volume on clinical outcomes.

METHODS

Database

The study used 2004 hospitalization data from Taiwan's *National Health Insurance Research Database* (NHIRD), published by the National Health Research Institute, Taipei, Taiwan. The NHIRD covers all inpatient medical benefit claims for the Taiwanese population of over 21 million individuals (96% of Taiwan's population), and includes registries of contracted medical facilities and monthly summaries of inpatient claims.

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The NHIRD is one of the largest and most-comprehensive population-based data sources currently available in the world. This dataset provides a unique opportunity to examine the association of hospital ulcer case volume with clinical quality based upon a national database.

Since these were de-identified secondary data released for public access for research purposes, the study was exempt from full review by the Institutional Review Board.

Study Sample

All inpatient claims with a principal diagnosis of ICD-9-CM codes 531.XX to 533.XX from January 2004 to December 2004 were extracted ($n=56,610$). Of these, 3,354 hospitalizations were excluded because the patients were discharged against medical advice, transferred to another hospital, or had been transferred in from another hospital. In addition, we limited our study sample to the first-time hospitalizations for the treatment of ulcers (meaning no hospitalization for ulcer treatment within one year prior to the index hospitalization). Ultimately, there were 48,250 ulcer patients included in our study.

Hospital Ulcer Case Volume Groupings

Since unique hospital identifiers are in the claims data, we were able to identify the admitting hospital and classify patients by the hospital's total case volume for ulcer patients during the study period. Each of the 48,250 patients was assigned to one of three hospital volume groups: low volume (≤ 189 case volume of their admitting hospital), medium volume (190–410 cases), and high volume (≥ 411 cases). Based on the method used in a literature review by Rudley et al. that posited specific numbers of procedures would be associated with better outcomes,⁴ we selected a threshold for defining low-volume hospitals that included all low-volume hospitals showing no statistically significant differences in in-hospital mortality and 14-day readmission. This method allowed us to identify the minimum hospital volume threshold beyond which outcomes significantly improved. Furthermore, the volume thresholds for medium-volume and high-volume hospitals were determined by dividing the sampled patients into two approximately equal-sized groups. The respective volume groups had 13,227, 17,377, and 17,646 cases.

Statistical Analysis

The SAS package (Version 9.0) was used. Outcomes included in-hospital mortality and 14-day readmission for the treatment of peptic ulcer, with patient as the unit of analysis. The key independent variable was hospital volume, measured at hospital level. Chi-square and one-way ANOVA tests were performed to examine the sociodemographic distributions of the sampled patients among hospital case volume groups. A logistic regression analysis employing generalized estimating equations was used to examine the relationship of hospital volume with in-hospital mortality and 14-day readmission, adjusted for hospital and patient characteristics, including patient severity (clinical severity and co-morbidities), as well as clustering of patients within hospital panels (hospital-level random effect).

The hospitals' accreditation level, ownership (public, for-profit and not-for-profit) and geographic location, patient

demographics (age and gender) and patient severity were included in the regression model. Since there was a high co-linearity between hospitals' accreditation level and hospital volume group, hospitals' accreditation level was not included. However, we still analyzed the medium-volume and high-volume groups for medical centers and the medium-volume and low-volume groups for district hospitals, to see if there was a volume effect. Patient severity was comprised of ulcer severity (the presence or absence of hemorrhage or perforation) and the presence of co-morbidities. Clinical co-morbidities were measured using the Charlson comorbidity index (CCI). A two-sided p -value of 0.05 was used.

RESULTS

Table 1 describes the demographic characteristics and principal diagnosis types among the 48,250 inpatients admitted for the treatment of ulcers. Mean length of stay was 6.4 days, the mean cost per discharge was US \$950; 65.6% were male, 5.8% had Charlson scores ≥ 5 , and 33.4% had a principal diagnosis of ulcer without hemorrhage or perforation.

The characteristics of the hospitals and the patients, stratified by hospital volume, are presented in Table 2. The 385 hospitals admitted a mean of 412 ulcer patients per hospital in 2004. The vast majority of the hospitals (77.1%) fell into the low-volume group, with virtually none of the hospitals in this group being medical centers. In addition, all high-volume hospitals were teaching hospitals.

There were significant relationships between hospital volume groups and patient age, CCI, ulcer severity and the rate of endoscopic treatment (all $p < 0.001$), but not gender. Patients treated by high-volume hospitals were more likely to be younger, CCI ≥ 5 and had a principal diagnosis of ulcer with perforation.

The 14-day readmission rates decreased with increasing hospital volume; they were 2.66%, 2.15% and 1.80% for LVH, MVH and HVH, respectively. The in-hospital mortality rates

Table 1. Characteristics of Patients Admitted for Ulcer Treatments in Taiwan in 2004 (n=48,250)

Variables	Value
Patient gender, n (%)	
Male	31,631 (65.6)
Female	16,619 (34.4)
Patient age, n (%)	
<45	10,218 (21.2)
45–64	14,622 (30.3)
>64	23,410 (48.5)
Patient age (years), mean (SD)	60.4 (18.5)
Charlson comorbidity index score, n (%)	
1	25,030 (51.9)
2	13,560 (28.1)
3	4,724 (9.8)
4	2,117 (4.4)
5 or more	2,819 (5.8)
Principal diagnosis, n (%)	
Ulcer without hemorrhage or perforation	16,128 (33.4)
Ulcer with hemorrhage	29,362 (60.9)
Ulcer with perforation	2,506 (5.2)
Ulcer with hemorrhage and perforation	254 (0.5)
Length of stay (days), mean (SD)	6.4 (6.6)
Hospitalization costs (\$US), mean (SD)	950 (1,992)

Note: * Total patient sample = 48,250

Table 2. Hospital and Patient Characteristics by Hospital Ulcer Volume Groups in Taiwan in 2004

Variable	Low (1–189)		Medium (190–410)		High (≥411)		P-value
	No.	%	No.	%	No.	%	
Hospital ulcer volume group (n=385 hospitals)							
Hospital characteristics							
Total No. of hospitals	297	77.1	62	16.1	26	6.8	
Hospital ulcer volume mean, (SD)	44.5 (49.2)		280.3 (55.7)		678.7 (248.4)		<0.001
Hospital level							
Medical center	–	–	7	11.3	10	38.5	
Regional hospital	18	6.1	38	61.3	15	57.7	
District hospital	279	93.9	17	27.4	1	3.9	
Teaching status							
Yes	47	15.8	53	85.5	26	100	
No	250	84.2	9	14.5	–	–	
Hospital ownership							
Public	51	17.2	24	38.7	6	23.1	<0.001
Private not-for-profit	32	10.8	25	40.3	13	50.0	
Private for-profit	214	72.1	13	21.0	7	26.9	
Geographic location							
Northern	87	29.3	26	41.9	8	30.8	
Central	83	28.0	16	25.8	7	26.9	
Southern	115	38.7	16	25.8	11	42.3	
Eastern	12	4.0	4	6.5	–	–	
Patient characteristics							
Total No. of patients	13,227	27.4	17,377	36.0	17,646	36.6	
Age of patients, mean, SD	61.8 (17.9)		60.6 (18.3)		59.0 (19.0)		<0.001
Patient gender							
Male	8,638	65.3	11,448	65.9	11,545	65.4	0.520
Female	4,589	34.7	5,929	34.1	6,101	34.6	
Patient age							
<45	2,621	19.8	3,562	20.5	4,035	22.9	<0.001
45–64	3,908	29.6	5,259	30.3	5,455	30.9	
>64	6,698	50.6	8,556	49.2	8,156	46.2	
Hospital ulcer volume group (n=48,250 patients)							
Patient characteristics							
Charlson comorbidity index score							
1	7,009	53.0	9,010	51.9	9,011	51.1	<0.001
2	3,727	28.2	4,852	27.9	4,981	28.3	
3	1,335	10.1	1,702	9.8	1,687	9.6	
4	607	4.6	775	4.5	735	4.2	
5 or more	549	4.2	1,038	6.0	1,232	7.0	
Principal diagnosis							
Ulcer without hemorrhage or perforation	4,552	34.4	5,390	31.0	6,186	35.1	<0.001
Ulcer with hemorrhage	8,261	62.5	10,913	62.8	10,188	57.7	
Ulcer with perforation	333	2.5	990	5.7	1,183	6.7	
Ulcer with hemorrhage and perforation	81	0.6	84	0.5	89	0.5	
Endoscopic treatment							
Yes	6,502	49.2	9,826	56.6	9,947	56.4	<0.001
No	6,725	50.8	7,551	43.5	7,699	43.6	

SD: standard deviation

were 0.77%, 0.68% and 0.67% for low, medium, and high-volume hospitals, respectively. Mortality rates for patients with and without endoscopy were 0.39% and 1.09%, respectively, while 14-day readmission rates for patients with and without endoscopy were 1.59% and 2.84%, respectively.

The adjusted odds ratios for in-hospital mortality and 14-day readmission according to hospital ulcer volume groups are shown in Table 3. After adjusting for patients' demographic characteristics, clinical severity of the ulcer and presence of comorbidities, the likelihood of in-hospital mortality for ulcer patients treated by low-volume hospitals was 1.6 times ($p<0.05$) that of patients treated in high-volume hospitals and 1.5 times ($p<0.05$) that of patients treated in medium-volume hospitals. As expected, the odds of in-hospital mortality increased with patients' age and the Charlson score level. In hospital mortality for patients with both hemorrhage and perforation was markedly

higher relative to patients without these complications—a 25-fold difference.

The adjusted odds ratio of 14-day readmission also declined with increasing hospital volume, with odds of 14-day readmission being 1.4 times ($p<0.001$) greater at low-volume than high-volume hospitals, and 1.3 times ($p<0.01$) greater at low-volume than at medium-volume hospitals.

DISCUSSION

This is the first nationwide population-based study to explore the volume–outcome relationship for peptic ulcer treatment. In our study, we found that after adjusting for patients' demographic characteristics, severity of disease and clinical comorbidities, peptic ulcer patients treated in high-volume or

Table 3. Adjusted Odds Ratios for In-hospital Mortality and 14-day Readmission, by Hospital Ulcer Volume Groups and the Characteristics of the Hospital and Patient

Variables	In-hospital mortality	14-day readmission
	Adjusted OR ^a (95% CI)	Adjusted OR ^a (95% CI)
Hospital ulcer volume		
≤189	1.000	1.000
190–410	0.647*(0.451–0.927)	0.798**(0.682–0.935)
≥411	0.625*(0.410–0.952)	0.695**(0.589–0.821)
Hospital ownership		
Public	1.234 (0.887–1.718)	1.205* (1.027–1.414)
Private not-for-profit	0.590** (0.412–0.845)	0.898 (0.757–1.065)
Private for-profit	1.000	1.000
Geographic location		
Northern	1.000	1.000
Central	0.421*** (0.304–0.583)	1.195* (1.023–1.396)
Southern	0.624*** (0.481–0.811)	0.858 (0.731–1.007)
Eastern	0.920 (0.530–1.597)	0.708 (0.487–1.030)
Patient gender		
Male	1.000	1.000
Female	1.283* (1.006–1.635)	1.073 (0.940–1.226)
Charlson comorbidity index score		
1	1.000	1.000
2	1.127 (0.848–1.500)	0.947 (0.815–1.100)
3	1.673** (1.174–2.385)	1.094 (0.887–1.349)
4	2.297*** (1.521–3.467)	1.169 (0.881–1.551)
5 or more	3.836*** (2.722–5.406)	1.082 (0.823–1.422)
Patient age		
<45	1.000	1.000
45–64	2.624*** (1.508–4.568)	1.043 (0.860–1.265)
>64	6.573*** (3.912–11.042)	1.444*** (1.212–1.721)
Endoscopic treatment		
Yes	0.538*** (0.417–0.694)	0.624*** (0.547–0.712)
Principal diagnosis		
Ulcer without hemorrhage or perforation	1.000	1.000
Ulcer with hemorrhage	3.263*** (2.176–4.892)	1.177* (1.019–1.359)
Ulcer with perforation	17.538*** (11.037–27.868)	1.926*** (1.499–2.474)
Ulcer with hemorrhage and perforation	25.464*** (13.370–48.499)	2.555*** (1.464–4.460)

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Adjusted for patient's gender, age, Charlson Comorbidity Index score, endoscopic treatment, principal diagnosis, hospital ownership, geographic location and hospital random effect

medium-volume hospitals had lower in-hospital mortality than those treated in the low-volume hospitals. Similarly, the odds of 14-day readmission decreased with increasing hospital case volume. Our study results echo volume–outcome relationships reported by others, which consistently found inferior clinical outcomes associated with low provider volume for a variety of surgical procedures.^{5–9} This implies that if patients with peptic ulcers are treated at higher-volume hospitals, better outcomes would be obtained.

One potential explanation for our findings is the “practice makes perfect” hypothesis—that a larger volume of patients enables hospitals to attain more experience caring for certain types of patients, and this enhanced experience accounts for improved outcomes. According to this hypothesis, low-volume hospitals with poor outcomes can improve their clinical performance by increasing patient volume. How many patients

is enough? We found a significant decrease in in-hospital mortality rate and 14-day readmission rate when the annual volume of ulcer patients exceeded 190. Additional increases in volume were not associated with further improvement in outcomes. Unfortunately, simply recommending that hospitals increase their case volume may have adverse effects. To reach a higher volume target, low-volume hospitals may be tempted to artificially lower the entry criteria for ulcer hospitalization.

How might higher volumes translate into decreased mortality? In our study, we found that the use of endoscopic treatment was associated with decreased in-hospital mortality rate and 14-day readmission, but that this did not account for all the benefit of higher volume. The benefits of endoscopy to stabilize bleeding from peptic ulcers have been fully demonstrated.¹⁰ The success of endoscopic treatment also depends on the location of the ulcer, the clinical condition of the patient and the techniques that the endoscopist is most familiar with. It may be that higher-volume hospitals, which are generally better equipped, are more likely to meet most endoscopists' needs by making different endoscopic hemostasis tools available, thereby increasing the rate of achieving successful hemostasis. Moreover, endoscopists in higher-volume hospitals more frequently encounter “difficult” cases and thereby gain greater experience.

Furthermore, higher-volume hospitals usually employ more endoscopists, and are more likely to provide early endoscopy (i.e. within 24 hours of admission). Although the benefit of early endoscopy for upper gastrointestinal tract hemorrhage is not entirely established, patients may benefit from prompt diagnosis, severity stratification and most importantly, improved hemostasis, which profoundly reduces the chance of rebleeding and the need for surgery.^{11,12}

Differences in surgical expertise might also explain some of the benefit of volume. Perforated ulcers almost inevitably require surgical intervention. Delayed surgical treatment can result in sepsis and death. Previous investigations confirm the link between greater case volume and better surgical outcomes in a variety of procedures.³ Surgical treatment involving bleeding or perforated ulcers is usually carried out in emergency conditions, and it demands more critical care experience than other elective surgeries. Higher-volume hospitals may be more apt to possess specialized staff, equipment, and experienced surgeons.

A couple of limitations of this study arise mainly from the nature of the administrative data used. Firstly, although we adjusted for patient comorbidities and the presence of hemorrhage or perforation, we had limited ability to account for differences in ulcer severity. However, studies by Tu et al. and Jones et al. have demonstrated that a relatively small number of clinical variables are sufficient to enable a fair comparison of risk-adjusted mortality rates across hospitals.^{13,14} Secondly, peptic ulcer patients are only admitted for treatment in hospitals when their condition is severe enough, and the entry criteria may vary among hospitals. It is possible that hospitals that admit only the most severe cases are more likely to have greater numbers of in-hospital case mortalities vis-à-vis other hospitals admitting a greater proportion of patients with less severe conditions.

In summary, we found that after adjusting for patients' demographic characteristics, severity of disease and clinical comorbidities, ulcer patients treated in hospitals with fewer than 190 ulcer cases per year had inferior clinical outcomes compared to those at other hospitals. Although endoscopy may

play a role, the exact explanation for better outcomes could not be identified from our data. Further investigations should be undertaken to identify the clinical approaches and techniques among endoscopists and surgeons in high-volume hospitals that result in superior outcomes; the results of such studies could help lower-volume hospitals to improve the quality of their patient care.

Conflict of Interest: None disclosed.

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