Association between Hospital Volume and Outcomes of Elderly Patients with Hemorrhagic Peptic Ulcer in Japan: An Observational Study

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SUMMARY

Background: Little information is available on the relationship between case volume and the outcomes of elderly patients with bleeding peptic ulcers. This study investigated the effect of case volume on the outcomes of elderly patients with bleeding peptic ulcers, based on a national administrative database.

Methods: In total, 14,569 elderly patients (i.e., ≥ 80 years old) treated by endoscopic hemostasis for bleeding peptic ulcers were referred to 1073 hospitals from 2010 to 2012 in Japan. We compared in-hospital mortality (30-day and overall), length of hospital stay (LOS), and medical costs in relation to case volume. A hospital was categorized as a low-volume hospital (i.e., < 5 cases/y), a medium-volume hospital (i.e., 5−9 cases/y), or a high-volume hospital (HVH) (i.e., > 9 cases/y).

Results: Multiple logistic regression revealed that HVHS did not have lower in-hospital mortality rates, compared to low- or medium-volume hospitals [for 30-day mortality: the odds ratio (OR) was 0.97 with a 95% confidence interval (CI) of 0.76−1.24; p = 0.831; for overall mortality: OR, 0.86; 95% CI, 0.70−1.07; p = 0.197]. However, multiple linear regression showed that HVHS had significantly shorter LOS and lower medical costs. The coefficient for LOS was −5.02 days (95% CI, from −6.04 days to −4.01 days; p < 0.001), whereas the coefficient for LOS for medical costs was −1393.00 United States dollar (US$; 95% CI, from −1793.30 to −992.70 US$; p < 0.001).

Conclusion: This study demonstrated that a higher case volume was significantly associated with shorter LOS and lower medical costs among elderly patients with bleeding peptic ulcers. However, there was no significant effect of case volume on mortality in Japan.

1. Introduction

Hemorrhagic peptic ulcer is one of the most frequently encountered emergency conditions in daily practice. The overall incidence of hemorrhagic peptic ulcers has decreased worldwide, although the overall incidence in elderly patients remains high. Loperfido et al. reported that the mean age of patients with acute upper gastrointestinal bleeding had significantly increased from 1983−1985 to 2002−2004 in the United States. In a retrospective study in Norway, Bakkevold reported that the incidence of hemorrhagic peptic ulcers was significantly higher in elderly patients than in younger patients. Because of the high incidence of hemorrhagic peptic ulcers in elderly patients and the rapid acceleration in the growth of the aging population, it is expected that many gastroenterologists or endoscopists will encounter more elderly patients with hemorrhagic peptic ulcers.

Hospital volume is a major factor that influences the outcomes of various endoscopic treatments such as endoscopic retrograde cholangiopancreatography or endoscopic submucosal dissection. The presence of experienced endoscopists most strongly seems to influence this volume−outcome relationship. Some previous studies suggest that hospitals with large case volumes are more likely to have...
experienced endoscopists who are able to provide sufficient treat-
ment, which contributes significantly to fewer complications or a
shorter length of hospital stay (LOS). Therefore, it is reasonable to
presume that higher-volume hospitals significantly contribute to
the outcomes of patients who require endoscopic treatments.

However, little information is available on the relationship be-
tween hospital volume and the outcomes of hemorrhagic peptic
ulcer treatment. In particular, the focus of this study on elderly
patients clearly shows the effect of hospital volume because the
outcomes of elderly patients have remained significantly worse
than those of younger patients. In addition, the establishment of
the effect of hospital volume on the outcomes of elderly patients
with hemorrhagic peptic ulcers could contribute to future studies
and have implications for the quality of medical care of elderly
patients. Therefore, in this study, we investigated the effect of
hospital volume on the clinical and medical economic outcomes of
elderly patients with hemorrhagic peptic ulcers. We used the na-
tional administrative database developed in a Japanese case-mix
system project called the Diagnosis Procedure Combination (DPC).

2. Materials and methods

2.1. Administrative database associated with the DPC system

The DPC database has been described in detail elsewhere. This
database collects important information during a patient’s
hospitalization. It includes the patient’s financial data, claim in-
formation, and discharge summary (e.g., the principal diagnosis,
complications, and comorbidities). The data are coded using the
International Classification of Diseases and Injuries, 10th
revised (ICD-10) code. In addition, the DPC database contains com-
prehensive medical information such as all interventional or surgical
procedures, the amount of daily care delivered, and medications
that have been indexed in the original Japanese code. All codes
are assigned by the Ministry of Health, Labour and Welfare of Japan
(Tokyo, Japan).

2.2. Study setting

Information from 120,242 patients with peptic ulcers (i.e., ICD-
10 codes K25 and K26) was collected using the DPC administra-
tive database for 2010, 2011, and 2012. We excluded 60,497 patients
who did not undergo endoscopic hemostasis for hemorrhagic
peptic ulcers. We also excluded 45,176 patients younger than
80 years because this study aimed to investigate the effect of hos-
pital volume on the treatment outcomes of elderly patients with
hemorrhagic peptic ulcers. (Elderly patients have been defined as
individuals 80 years or older in previous studies.) Therefore,
14,569 elderly Japanese patients who had undergone endoscopic
hemostasis for hemorrhagic peptic ulcers were allocated for analy-
sis. The 14,569 patients were referred to 1073 DPC-participating
hospitals (83 academic hospitals and 990 community hospitals).
These hospitals are dispersed throughout Japan and have leading
roles in providing acute care medicine, advancing medical research,
and educating students and medical residents.

The use of DPC data was permitted by all institutions and hos-
pitals that provided detailed data. The research protocol of the
study was approved by the Ethics Committee of Medical Care and
Research of the University of Occupational and Environmental
Health, Kitakyushu, Japan.

2.3. Study variables

Study variables were the type of hemorrhagic peptic ulcer; age;
sex; chronic comorbid conditions; use of ambulance transportation
and the intensive care unit; other treatments for hemorrhagic
peptic ulcers such as transfusions or surgery; hospital type, size,
and region; proportion of hospitals with an emergency center; in-
hospital mortality; LOS; and medical costs during hospitalization.

Age was stratified as follows: 80–89 years and ≥ 90 years. The
severity of chronic comorbid conditions was assessed using the
Charlson Comorbidity Index (CCI), which is widely used to record
comorbidities and has been validated in various studies. The CCI
was calculated for each patient as in previous studies, which
showed an association between the CCI and the ICD-10 code. The
CCI was expressed as the score of all comorbid conditions and was
initially evaluated as a continuous variable. However, categorical
variables, which constituted four severity categories of chronic
comorbid conditions, were created to simplify the presentation of
the results: 0, “none”; 1, “mild”; 2, “moderate”; and ≥ 3, “severe.”
Hospital type was classified as “academic” or “community.” Hos-
pital size was categorized into three groups, according to the
number of hospital beds: small (i.e., < 200 beds), medium (i.e.,
200–600 beds), and large (i.e., > 600 beds). The analysis of medical
costs incurred during hospitalization was based on the exchange
rate (in December 2014) of approximately 100 yen to 1 United
States dollar (US$).

2.4. Main outcome measures and statistical analysis

The main measure of interest in this investigation was hospital
volume. Hospital volume was expressed as the number of cases
during the study period, and was initially evaluated as a continuous
variable. However, categorical variables that defined the three
hospital volume categories were created to simplify the presenta-
tion of the results: low-volume hospitals (LVHs) had fewer than five
cases per year (n = 4526), medium-volume hospitals (MVHs) had
from five to nine cases per year (n = 5062), and high-volume
hospitals (HVHs) had more than nine cases per year (n = 4981).
The range of the volume categories seems to be more closely set
than in previous reports because of the small sample size and the
numerous participating hospitals. However, the volume categories
were based on cutoffs that yielded roughly equal numbers of
patients in each volume category, as described in previous
studies. Therefore, the validity and reliability of this prospective
cohort study has been reasonably assured.

To evaluate statistical significance, we used the Chi-square test
for categorical data and one-way factorial analysis of variance for
continuous variables. We used multiple logistic regression models
to estimate the odds ratios (ORs) and their 95% confidence intervals
(CIs) for in-hospital mortality (i.e., 30-day and overall). The LVH
group was the reference group. To control for selection bias with
regard to the baseline characteristics of the patients among the
hospital volumes, we performed generalized propensity score
analysis to estimate the dose-response function for each hospital
volume. We used a multinomial logistic regression model with logit
as the link function to obtain generalized propensity scores using
the data of patient characteristics. We developed two propensity
score models between hospital volumes: LVHs versus MVHs and
LVHs versus HVHs. The propensity scores were categorized into
deciles, as reported previously in the literature. Multiple linear
regression models were also used to identify the impact of the ef-
fect of hospital volume on LOS and medical costs during hospital-
ization with regard to the hospital characteristics and propensity
scores.

All statistical analyses were performed using the STATA statis-
tical software package, version 11.0 (Stata Corporation, College
Station, TX, USA). A p value < 0.05 was considered statistically
significant.
3. Results

In total, 14,569 patients treated by endoscopic hemostasis for hemorrhagic peptic ulcers were identified for this study, and comprised 4526 patients at LVHs (684 hospitals), 5062 patients at MVHs (259 hospitals), and 4981 patients at HVHs (130 hospitals).

The clinical characteristics and presentations of the patients and hospitals are shown in Table 1. The frequency of the use of an ambulance was statistically higher in HVHs than in LVHs and MVHs (58.3% vs. 46.8% vs. 53.1%, respectively, \( p < 0.001 \)), whereas the frequency for patients who received transfusions was lower in HVHs than in LVHs and MVHs (21.6% vs. 22.1% vs. 18.7%, respectively, \( p < 0.001 \)). With regard to hospital characteristics, the ratios of large hospitals and hospitals with an emergency center were significantly higher in HVHs (\( p < 0.001 \)).

The comparisons of outcomes among hospital volumes are presented in Table 2. There were no significant differences in 30-day in-hospital mortality between LVHs, MVHs, and HVHs (4.2% vs. 3.8% vs. 3.9%, respectively, \( p = 0.678 \)). The HVHs had a lower overall in-hospital mortality than the LVHs and MVHs, but this difference was not significant (5.0% vs. 6.1% vs. 5.5%, respectively, \( p = 0.071 \)). However, significant differences in the mean LOS and medical costs during hospitalization were observed between the HVHs, MVHs, and LVHs (21.2 days vs. 18.3 days vs. 15.7 days, respectively, and US$10,038.50 vs. US$9467.80 vs. US$9003.70, respectively, \( p < 0.001 \)).

The results of logistic regression analysis for in-hospital mortality are shown in Table 2. After adjusting for patient and hospital characteristics, no significant association was observed for 30-day in-hospital mortality (for MVHs: OR, 0.90; 95% CI, 0.73–1.12; \( p = 0.368 \); and for HVHs: OR, 0.97; 95% CI, 0.76–1.24; \( p = 0.831 \)). Multiple logistic regression also showed no significant difference in the overall in-hospital mortality (for MVHs: OR, 0.91; 95% CI, 0.76–1.09; \( p = 0.330 \); and for HVHs: OR, 0.86; 95% CI, 0.70–1.07; \( p = 0.197 \)).

After adjusting for potentially confounding clinical variables, there was a consistently significant association between hospital

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Characteristics of the patients and hospitals.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LVH (n = 4526)</td>
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<tr>
<td>Patients' characteristics</td>
<td></td>
</tr>
<tr>
<td>Type of hemorrhagic ulcer (%)</td>
<td></td>
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<tr>
<td>Gastric ulcer</td>
<td>81.8</td>
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<tr>
<td>Duodenal ulcer</td>
<td>18.2</td>
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<tr>
<td>Age categories (%)</td>
<td></td>
</tr>
<tr>
<td>80–89 y</td>
<td>84.1</td>
</tr>
<tr>
<td>( \geq 90 \text{ y} )</td>
<td>15.9</td>
</tr>
<tr>
<td>Sex (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>48.3</td>
</tr>
<tr>
<td>Female</td>
<td>51.7</td>
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<tr>
<td>Chronic comorbid conditions (%)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>50.4</td>
</tr>
<tr>
<td>Mild</td>
<td>24.4</td>
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<tr>
<td>Moderate</td>
<td>16.0</td>
</tr>
<tr>
<td>Severe</td>
<td>9.2</td>
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<tr>
<td>Use of ambulance (%)</td>
<td></td>
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<tr>
<td>Transfusion</td>
<td>46.8</td>
</tr>
<tr>
<td>Use of intensive care unit (%)</td>
<td>3.1</td>
</tr>
<tr>
<td>Other treatments for peptic ulcer (%)</td>
<td></td>
</tr>
<tr>
<td>Surgery</td>
<td>21.6</td>
</tr>
<tr>
<td>Patient outcomes</td>
<td></td>
</tr>
<tr>
<td>Mortality within 30 days (%)</td>
<td></td>
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<tr>
<td>Overall mortality (%)</td>
<td></td>
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<tr>
<td>Mean length of stay (d)</td>
<td></td>
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<tr>
<td>Mean medical costs (US$)</td>
<td></td>
</tr>
</tbody>
</table>

HVH = high-volume hospitals; LVH = low-volume hospital; MVH = medium-volume hospital.
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volume and LOS. The coefficient for MVHs was \(-2.46\) days (95% CI, from \(-3.37\) days to \(-1.55\) days; \(p < 0.001\)), whereas the coefficient for HVHs was \(-5.02\) days (95% CI, from \(-6.04\) days to \(-4.01\) days; \(p < 0.001\)). Multiple regression analysis also showed that hospital volume was significantly associated with lower medical costs during hospitalization in elderly patients with hemorrhagic peptic ulcers. The coefficient for MVHs was \(-716.20\) US$ (95% CI, \(-1084.30\) to \(-348.20\) US$; \(p < 0.001\)), while that for HVHs was \(-1393.00\) US$ (95% CI, \(-1793.30\) to \(-992.70\) US$; \(p < 0.001\); Table 3).

4. Discussion

We conducted the present study to investigate the relationship between hospital volume and outcomes of elderly Japanese patients with hemorrhagic peptic ulcers using a Japanese administrative database. Our results showed that higher hospital volume was significantly associated with a shorter LOS and lower medical costs during hospitalization. However, there was no significant effect of hospital volume on mortality.

The World Health Report has highlighted the acceleration in the growth of the aging population worldwide, and dramatic increases in the number of elderly people have been noted in many countries. The increasing life expectancy and aging population will inevitably lead to a growing number of elderly patients in many countries. In addition, a recent report revealed that the main predictor for inhospital mortality in medical wards was an advanced age of more than 80 years. Therefore, we focused on elderly patients to investigate the effect of hospital volume on the outcomes of hemorrhagic peptic ulcers. In particular, the evaluation of medical economic factors such as LOS and medical costs is increasingly important because many countries expect a significant medical economic burden associated with the management of older patients.

Thus, determining the effect of hospital volume on outcomes of patients with disease will be essential for targeting future quality-improvement efforts for elderly patients.

The present study revealed no significant difference in mortality between different hospital volumes. Our results on the relationship between hospital volume and in-hospital mortality are inconsistent with those of previous studies in some developed countries. In a cohort study in the United States, Ananthakrishnan et al. reported that higher-volume hospitals had significantly lower inhospital mortality rates (OR, 0.85; 95% CI, 0.74–0.98). In a retrospective study from Hungary, Racz et al. similarly showed lower mortality rates among higher-volume hospitals than among lower-volume hospitals. The coefficient ratios were adjusted for the propensity score and hospital characteristics.

A recent study found no significant difference in the frequency of recurrent bleeding after endoscopic hemostasis for the treatment of hemorrhagic peptic ulcers. Furthermore, equivalent outcomes in parameters such as in-hospital mortality and LOS were observed in teaching hospitals and in nonteaching hospitals. Jairath et al. reported a much lower mortality rate among patients with nonvariceal upper gastrointestinal bleeding in Japan than in other developed countries. Therefore, the widespread distribution of experienced endoscopists or application of management protocols enables safe and effective treatment for hemorrhagic peptic ulcers in many hospitals, and may obscure any effect of hospital volume on in-hospital mortality in Japan.

However, in the present study, a higher hospital volume was significantly associated with a shorter LOS and lower medical costs during hospitalization in elderly patients with hemorrhagic peptic ulcers. Several factors may contribute to this association. Some previous studies have suggested that higher-volume hospitals have many experienced and specially trained physicians in various fields of medicine; specialized teams are generally present at hospitals with large case volumes and can provide multidisciplinary care that significantly contributes to improved clinical outcomes.

Several studies have also indicated that the presence of specialized physicians and teams is beneficial for favorable clinical outcomes of elderly patients with certain diseases. Nearly one-half of patients in the present study had a comorbid disease. Close coordination among physicians in various fields may be associated with effective management of comorbid conditions of patients. In addition, many previous reports have shown that hospitals with large case volumes have greater availability of resources or treatment facilities for patients.

Therefore, several factors such as the presence of specialized physicians and teams and available resources favorably influence the management of comorbid disease or complications in elderly patients with hemorrhagic peptic ulcers. This factor leads to a shorter LOS at higher-volume hospitals. In addition, the frequency of blood transfusion was higher in LVHs, whereas the frequency of salvage surgery was slightly higher in HVHs in this study. These results suggest that elderly patients in some LVHs may depend strongly on medical treatments instead of surgical or interventional treatments for the recurrence of refractory bleeding of peptic ulcers. Thus, differences in treatment plans among hospitals may also affect the LOS of elderly patients with hemorrhagic peptic ulcers. Furthermore, it is reasonable to suppose that medical costs decrease as the LOS decreases. It is therefore plausible that hospitals with larger case volumes have shorter LOS and lower medical costs during hospitalization than do lower-volume hospitals.

A major strength of the present study is that clinical data were used. A benefit of a national database is that it enables the evaluation of a large number of hospitals in an unbiased manner. Our investigation involved a nationally representative sample of elderly patients with hemorrhagic peptic ulcer disease at the population level. Detailed medical data such as all procedures, medications, and devices used in treatment are extensively coded with the original Japanese payment codes. These data are recorded on a daily basis for each patient. Therefore, this administrative database also enables interested parties to evaluate the outcomes of individual medical treatments.

Some potential limitations of this study also warrant mention. First, the data were obtained only from DPC-participating hospitals. This administrative database does not include data from all hospitals in Japan. Therefore, data from hospitals that do not participate in the DPC should be analyzed to confirm our findings. Second, this administrative database does not include endoscopic imaging data (e.g., lesion size or Forrest classification of endoscopic stigmata of hemorrhage) or laboratory test data (e.g., hemoglobin, creatinine, or blood urea nitrogen level). In addition, we have no data.

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**Table 3**

<table>
<thead>
<tr>
<th>Length of stay (d)</th>
<th>Coefficienta</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVH Reference</td>
<td>-2.46</td>
<td>-3.37 to -1.55</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MVH</td>
<td>-5.02</td>
<td>-6.04 to -4.01</td>
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<tr>
<td>HVH</td>
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<td>&lt;0.001</td>
</tr>
<tr>
<td>Medical costs (US$)</td>
<td>-1393.00</td>
<td>-1793.30 to -992.70</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

CI = confidence interval; HVH = high-volume hospitals; LVH = low-volume hospital; MVH = medium-volume hospital; US = United States.

a The coefficient ratios are adjusted for the propensity score and hospital characteristics.
regarding the time from admission to endoscopic treatment or the difference in the level of endoscopic equipment or modalities. These factors may have introduced bias into our evaluation of outcomes of patients with hemorrhagic peptic ulcers. Therefore, further clinical studies of the effect of hospital volume on the outcomes of patients with hemorrhagic peptic ulcers may be required and take into account more detailed data.

Despite these limitations, the current study has implications for healthcare policy decision-making and quality of patient care. The current study confirmed that hospital volume significantly influences LOS and medical costs during hospitalization of elderly patients with hemorrhagic peptic ulcers. Therefore, the centralization of elderly patients with hemorrhagic peptic ulcers—in particular, patients with comorbid conditions—could be a quality-improvement initiative in Japan. The current findings provide good evidence supporting the attempt to steer elderly patients with gastric cancer toward hospitals that have shorter LOS or lower medical costs during hospitalization. If these health policies can be implemented in Japan, the quality of care for elderly patients with hemorrhagic peptic ulcers will be maintained while the LOS or medical costs during hospitalization will be lowered. Therefore, consecutive monitoring of the outcomes of elderly patients in higher-volume hospitals may contribute to changes in patient referral policies in Japan. In addition, the relationship between hospital volume and the outcomes of patients with bleeding peptic ulcers may not necessarily be applicable to younger patients. Further research examining the association between hospital volume and outcomes of younger patients should also be conducted in the future.

5. Conclusion

This study demonstrated that a higher hospital volume is significantly associated with a shorter LOS and lower medical costs during hospitalization, while no significant difference in mortality was observed between hospital volumes. Consecutive monitoring of outcomes for elderly patients in HVHs may contribute to changes in patient referral policies in Japan.

Acknowledgments

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