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Relationship between hospital volume and outcomes in patients with traumatic brain injury: A retrospective observational study using a national inpatient database in Japan

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ABSTRACT

Background: The relationship between hospital volume and outcome after traumatic brain injury (TBI) is not completely understood in a real clinical setting. We investigated whether patients admitted with TBI achieved better outcomes in high-volume hospitals than in low-volume hospitals using a national inpatient database in Japan.
Methods: This retrospective cohort study used the Diagnosis Combination Procedure database in Japan. We included patients with TBI admitted to hospitals with a Japan Coma Scale (JCS) score ≥2 between April 1, 2013 and March 31, 2014. Hospital volume was defined as the annual number of all admissions with TBI in individual hospitals. The hospital volume was categorized into four volume groups: low (≤60 admissions per hospital), medium-low (61–120 admissions per hospital), medium-high (121–180 admissions per hospital) and high (≥181 admissions per hospital). The outcomes of interest included 28-day mortality and survival discharge with complete dependency defined as a Barthel Index score of 0 at discharge. We used multivariate logistic regression models fitted with generalized estimating equations to evaluate relationships between the hospital volume and the outcomes. The hospital volume was evaluated both as categorical variables defined above and as continuous variables.
Results: The analysis dataset consisted of 20,146 eligible patients. Of these, 2,784 died within 28 days (13.8%) and 3,409 were completely dependent among 16,996 patients discharged alive (20.1%). Multivariate analyses found that there was no significant difference between the high-volume and low-volume groups for 28-day mortality (adjusted odds ratio [OR] 0.79, 95% confidence interval [CI] 0.58–1.06 for the high-volume group) or complete dependency at discharge (adjusted OR 0.94, 95% CI 0.71–1.23 for the high-volume group). The results were the same when the hospital volume was evaluated as a continuous variable.
Conclusions: Hospital volume did not appear to influence outcomes in patients with TBI. High-volume hospitals may not be necessarily beneficial for patients with TBI exhibiting impaired consciousness as a whole.

Introduction

Traumatic brain injury (TBI) is the leading cause of death and disability among trauma patients. More than half of trauma death can be attributed to TBI [1]. Moreover, approximately 40% of TBI survivors develop long-term disability [2]. The incidence of TBI has reportedly increased in North America, particularly in elderly patients, over the last decade [3,4].

Many studies have investigated whether trauma patients achieved better outcomes in higher-volume hospitals [5]. Several previous studies have identified that superior outcomes after TBI are associated with admission to a high-volume hospital [6–8], but these studies' limitations mean that the precise nature of this relationship and its implications for clinical practice are not

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completely understood. For example, a study using an administrative claims database evaluated the volume-outcome relationship without adjustment for injury severity [7], while another study included only young patients admitted to one of seven level 1 trauma centres [8]. A secondary analysis examining the volume-outcome relationship in participants in a randomized controlled trial of out-of-hospital hypertonic saline in TBI [9] may have been influenced by the trial's inclusion criteria [6].

As the burden of TBI is a serious public health issue, there is a strong focus on identifying strategies for improving outcomes after TBI. A positive volume-outcome relationship implies that regionalization of health care for trauma patients would improve outcomes. It can, however, be argued that regionalization of health care would exacerbate overcrowding in high-volume hospitals, diminishing the quality of care in these hospitals [10]. Given the increase in emergency department visits for TBI [3,4], this effect might be amplified in patients with TBI. The aim of this study was to examine the relationship between hospital volume and outcome for patients with TBI in Japan using a national inpatient database.

Patients and methods

This retrospective observational study used the Diagnosis Procedure Combination (DPC) database. Conduct of the study was approved by the Institutional Review Board and Ethics Committee of The University of Tokyo. The requirement for informed consent was waived because of the anonymous nature of the data.

The DPC database has been described in detail elsewhere [11]. Briefly, the DPC database is an administrative claims and discharge abstract database in Japan. As of April 2013, 1,496 hospitals participated in data entry, which represented 20% of all hospitals in Japan. As participating hospitals were relatively large, the number of admissions recorded in the database during the 2013 fiscal year (April 1, 2013–March 31, 2014) represented approximately 50% of all hospital admissions in Japan.

Administrative and clinical data are recorded in the DPC database including demographic details, hospital identifiers, diagnoses, drugs administered, procedures undertaken, timing of treatments and status at discharge. Up to 12 diagnoses may be recorded: four main diagnoses including one primary diagnosis on admission, four concurrent diagnoses on admission including pre-existing comorbidities and concomitant injuries, and four post-admission complications. These diagnoses were recorded according to the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10), and using free text in Japanese. Japan Coma Scale (JCS) score [12] on admission and Barthel Index score [13] at discharge are also recorded. The attending physicians take responsibility for clinical data entry including diagnoses, JCS score on admission and Barthel Index score at discharge.

Patient selection

We included patients with an intracranial injury recorded as the main diagnosis or among the concurrent diagnoses on admission. Intracranial injuries were identified by the ICD-10 codes S06.x. Exclusion criteria were as follows: 1) age under 15 years, 2) a diagnosis of concussion recorded as the only intracranial injury (no positive findings in computed tomography), 3) chronic subdural hematoma, 3) a JCS score of 0 or 1 on admission, 4) survival discharge or transfer to another hospital on the day of hospital admission, 5) requirement for surgery or interventional radiology treatment of chest or abdominal injuries, 6) concurrent vascular injury in the neck or extremities, 7) concurrent diagnosis of including asphyxia, drowning, burns, hypothermia or hyperthermia, and 8) admission to hospitals where no neurosurgery was performed for patients with TBI in the study year.

The JCS score is a one-axis measurement of consciousness [12]. JCS scores of 0, 1–3, 10–30, and 100–300 represent alert, drowsy, somnolence and coma, respectively. JCS scores of 0–1 are equivalent to a Glasgow Coma Scale (GCS) score of 15, while a JCS score of 300 is equivalent to a GCS score of 3. JCS scores and GCS scores are well correlated [14]. We excluded patients with severe chest or abdominal injuries, and those with vascular injuries in the neck or extremities, as we judged that any associated hemodynamic shock would also have been likely to have influenced level of consciousness.

Variables

The primary variable of interest was hospital volume, defined as the annual number of all admissions with TBI in an individual hospital. Hospital volume was calculated from the study population with the ICD-10 codes of S06.x after excluding patients under 15 years, those with chronic subdural hematoma and those with the diagnosis of concussion recorded as the only TBI.

Patient characteristics were also used to adjust for the evaluation of the volume-outcome relationship. Patient characteristics included their demographic characteristics, pre-existing comorbidities, JCS score on admission, ICD-10–based injury severity scores (ICISS) [15], the type of TBI, and the requirement for one or more of the following procedures or treatments on admission: mechanical ventilation, blood transfusion, hyperosmolar therapy (glycerol or mannitol use), tranexamic acid use and neurosurgery (craniotomy or burr hole drainage). We also identified whether a patient had at least one of the following pre-existing comorbidities: cerebrovascular disease, congestive heart failure, myocardial infarction or peripheral vascular disease. We chose these diagnoses from the medical conditions needed to calculate the Charlson Comorbidity Index (CCI) score [16]. Patients with these comorbidities may use oral antithrombotic drugs, which would be a risk for mortality in trauma patients [17].

We used the multiplicative ICISS to measure injury severity in individual patients. The diagnosis-specific survival probability (DSP) for each injury-related ICD-10 code was used to calculate the multiplicative ICISS. The DSP for an ICD-10 code was defined as the proportion of patients discharged alive after a hospital admission during which the ICD-10 code was recorded [15,18]. The multiplicative ICISS was the product of the DSP for each ICD-10 code recorded in each patient [19]. Even though the Injury Severity Score (ISS) is widely used for the adjustment of injury severity in trauma studies, we judged that the ICISS would also accurately predict survival of trauma patients in a large-scale study [15].

Hospital characteristics other than hospital volume included tertiary emergency centre status and rural hospitals with catchment areas that included fewer than 500,000 people. We also identified whether patients were transferred from other hospitals. The Japanese government had certified 266 tertiary emergency centres as of February 2014. Requisites for tertiary emergency centre status include availability of designated operating rooms, intensive care units and availability of specialists including neurosurgeons. Patients with severe injuries were triaged by emergency medical personnel and transferred to tertiary emergency centres [20].

The main outcomes of interest were 28-day mortality and survival discharge with complete dependency (a Barthel Index score of 0). In-hospital mortality and length of hospital stay were also evaluated.