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Validation of the prognostic burn index: A nationwide retrospective study

Takashi Tagami [a,b,*], Hiroki Matsui [a], Kiyohide Fushimi [c], Hideo Yasunaga [a]

[a] Department of Clinical Epidemiology and Health Economics, School of Public Health, Graduate School of Medicine, The University of Tokyo, Tokyo 1130033, Japan

[b] Department of Emergency and Critical Care Medicine, Nippon Medical School, Tokyo 1138603, Japan

[c] Department of Health Informatics and Policy, Tokyo Medical and Dental University, Graduate School of Medicine, Tokyo 1138519, Japan

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ABSTRACT

Background: The burn index (BI = full thickness total burn surface area [TBSA] + 1/2 partial thickness TBSA) and prognostic burn index (PBI = BI + age) are clinically used particularly in Japan. However, few studies evaluated the validation of PBI with large sample size. We retrospectively investigated the relationships between PBI and mortality among burn patients using data from a nationwide database.

Methods: Data of all burn patients with burn index $\geq$1 were extracted from the Japanese Diagnosis Procedure Combination (DPC) inpatient database from 1 July 2010 to 31 March 2013 (17,185 patients in 1044 hospitals). The primary endpoint was all-cause in-hospital mortality.

Results: Overall in-hospital mortality was 5.9% (1011/17,185). Mortality increased significantly as the PBI increased (Mantel-Haenszel trend test, $P < 0.001$). The area under the receiver operating characteristic curve for PBI was 0.90 (95%CI, 0.90–0.91), and a PBI above a threshold of 85 showed the highest association with in-hospital mortality. Logistic regression analysis showed that PBI $\geq$ 85 (odds ratio (OR), 14.6; 95%CI, 12.1–17.6), inhalation injury with mechanical ventilation (OR, 13.0; 95%CI, 10.8–15.7), Charlson Comorbidity Index $\geq$ 2 (OR, 1.8; 95%CI, 1.5–2.3), and male gender (OR, 1.5; 95%CI, 1.3–1.8) were significant independent risk factors for death.

Conclusions: Our study suggested that a PBI above a threshold of 85 was significantly associated with mortality. The PBI and mechanical ventilation were the most significant factors predicting in-hospital mortality, after adjustment for inhalation injury, comorbidity, and gender.

1. Introduction

Determination of the factors which contribute to mortality has been an integral part of burns research. Several prognostic nomograms based on age and percentage area burned (total burn surface area, TBSA) were described more than half a century ago [1,2]. Baux [2] first described a prognostic score as follows: mortality rate = age + TBSA. The Baux score [2] gained wide international acceptance and was regarded as a landmark scoring system in the burn research field.

* *Corresponding author at*: Department of Clinical Epidemiology and Health Economics, School of Public Health, Graduate School of Medicine, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 1130033, Japan. Tel.: +81 358411887; fax: +81 358411888.

E-mail address: t-tagami@nms.ac.jp (T. Tagami).

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Cutaneous burns are classified according to the depth of tissue injury: epidermal (first degree), partial thickness (second degree, further divided into superficial and deep), or full thickness (third degree) [3]. Although epidermal and superficial partial-thickness burns heal spontaneously, deep partial thickness and full thickness burns usually undergo surgical treatment. Several studies indicated that prediction of mortality was more reliable when the full thickness burn area was taken into consideration [4–9]. Thus, the burn index (BI), which included both the surface area and the thickness of the burned area was proposed: BI = full thickness TBSA + 1/2 partial thickness TBSA [6]. Yasuda et al. [10] proposed the prognostic burn index (PBI) in 1986 as follows: PBI = BI + age. The PBI, which is simple to calculate and a more pathophysiologically adequate scoring system than the Baux score, gained popularity and is widely used in Asian countries [4–7,11–13], and is recommended to use in the current Japanese Society for Burn Injuries guidelines [14]. However, previous validation studies of PBI (Yasuda et al. [10] and Chen et al. [13]) were limited by a small sample size ($n = 30$ and $n = 141$, respectively), and manuscripts were written in Japanese and Chinese, respectively.

We hypothesized that the PBI had acceptable prognostic value for burn injury patients. We therefore investigated the relationships between PBI and mortality among burn patients using a large, nationwide dataset available through the Japanese Diagnosis Procedure Combination (DPC) inpatient database.

2. Methods

This study was approved by the Institutional Review Board of The University of Tokyo. Requirement for informed patient consent was waived because of the anonymous nature of the data.

2.1. Data source

The DPC database includes administrative claims and discharge abstract data for all inpatients discharged from more than 1000 participating hospitals, covering approximately 92% (244/266) of all tertiary-care emergency hospitals in Japan (http://www.jaam.jp/html/shisetsu/qq-center.htm) and 90% (90/100) of board certificated institutions for training burn specialists by *Japanese Society for Burn Injuries* (http://www.jsbi-burn.org/jsbi06-10.html). The database includes the following information for each patient: age, gender, primary diagnosis, comorbidities at admission, and after admission complications coded with International Classification of Diseases 10th Revision (ICD-10) codes and written in the Japanese language; medical procedures, including types of surgery, coded with original Japanese codes; daily records of drug administration and devices used; length of stay; and discharge status [15–18]. The dates of hospital admission, surgery, bedside procedures, drugs administered, and hospital discharge are recorded using a uniform data submission format. Several lists of scores are also available in the DPC database, including BI. To optimize the accuracy of the recorded diagnoses, the responsible physicians are obliged to record the diagnoses with reference to medical charts. Additionally, the diagnosis records are linked with the payment system, and the attending physicians are required to report objective evidence for the diagnosis of the disease for reimbursement of treatments. The dates of hospital admission, surgery, and discharge, in addition to medical procedures and drugs administered are recorded using a uniform data-submission format [15–18]. For the current study, each ICD-10 code for a comorbidity was converted to a score, and the sum was used to calculate the Charlson Comorbidity Index (CCI) [19,20]. CCI is a method of predicting mortality by classifying or weighting comorbidities, and has been widely utilized by health researchers to measure the burden of disease and the case mix [19]. The CCI was categorized into the three groups in the current study as follows: low, 0; medium, 1; and high, ≥ 2.

2.2. Patient selection and endpoint

We evaluated all burn patients with a BI ≥ 1 in the DPC database from 1 July 2010 to 31 March 2013. The exclusion criteria were: out-of-hospital cardiac arrest; death in the emergency room before admission; and readmission or planned admission for elective surgery.

The primary endpoint in the current study was all-cause in-hospital mortality.

2.3. Statistical analysis

We compared the background characteristics, PBI, and mortality between patients who survived and patients who died. Continuous variables were compared using a *t*-test or Mann–Whitney *U* test, as appropriate. Categorical variables were compared using the χ^2 test or Fisher's exact test. The trends in crude mortality and PBI (categorized per 10 PBI) were tested using the Mantel-Haenszel trend test. Receiver operating characteristic (ROC) curves were drawn and areas under the ROC curve (AUC) were calculated for age, BI, PBI and the full prediction model (including PBI, gender, CCI, and inhalation injury). The full model was also adjusted for institutional clustering, using a logistic regression fitted with a generalized estimating equation (GEE) [21]. The threshold for the each variable (i.e., age, BI, and PBI) that was best associated with in-hospital mortality was estimated by the Youden index [22]. We performed a logistic GEE regression model to examine the relationships between in-hospital survival and the PBI (dichotomous variable determined by ROC analysis), CCI, gender, and inhalation injury (with or without the use of mechanical ventilation) [6,23]. Finally, the patients were divided into four groups (low-PBI [dichotomous variable determined by ROC analysis] with/without mechanical ventilation and high-PBI with/without mechanical ventilation) and compared in-hospital mortality among the four groups using Kaplan–Meier curves and the log-rank test. $P < 0.05$ was considered statistically significant. All statistical analyses were performed using IBM SPSS version 22 (IBM Corp., Armonk, NY, USA).

3. Results

We identified 17,642 patients with a BI ≥ 1 from 1044 hospitals across Japan. After exclusions, data of 17,185 patients were