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## Original Article

# Defining polytrauma by abbreviated injury scale $\geq 3$ for a least two body regions is insufficient in terms of short-term outcome: A cross-sectional study at a level I trauma center

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## ABSTRACT

**Background:** Patients with polytrauma are expected to have a higher risk of mortality than the summation of expected mortality for their individual injuries. This study was designed to investigate the outcome of polytrauma patients, diagnosed by abbreviated injury scale (AIS)  $\geq 3$  for at least two body regions, at a level I trauma center.

**Methods:** Detailed data of 694 polytrauma patients and 2104 non-polytrauma patients with an overall Injury Severity Score (ISS)  $\geq 16$  and hospitalized between January 1, 2009, and December 31, 2014 for treatment of all traumatic injuries, were retrieved from the Trauma Registry System. Two-sided Fisher exact or Pearson chi-square tests were used to compare categorical data. The unpaired Student t-test was used to analyze normally distributed continuous data, and the Mann–Whitney U-test was used to compare non-normally distributed data. Propensity-score matching in a 1:1 ratio was performed using NCSS software with logistic regression to evaluate the effect of polytrauma on in-hospital mortality.

**Results:** There was no significant difference in short-term mortality between polytrauma and non-polytrauma patients, regardless of whether the comparison was made among the total patients (11.4% vs. 11.0%, respectively;  $p = 0.795$ ) or among the selected propensity score-matched groups of patients following controlled covariates including sex, age, systolic blood pressure, co-morbidities, Glasgow Coma Scale scores, injury region based on AIS.

**Conclusions:** Polytrauma defined by AIS  $\geq 3$  for at least two body regions failed to recognize a significant difference in short-term mortality among trauma patients.

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## At a glance commentary

### Scientific background on the subject

Although polytrauma is generally used to describe trauma patients whose injuries were severe and involved multiple body regions, the term 'polytrauma' lacks a universally accepted definition. This study was designed to validate the definition of polytrauma determined by abbreviated injury scale (AIS)  $\geq 3$  for at least two body regions.

### What this study adds to the field

This study revealed that patients with polytrauma defined by AIS  $\geq 3$  failed to recognize a significant difference in short-term mortality between the polytrauma and non-polytrauma patients. Additional criteria such as the relevant pathophysiologic change may be required for a better definition of polytrauma.

The monotrauma indicates an injury to one body region and multitrauma or multiple trauma depict those who had injuries to more than one body region, regardless of the injury severity. In addition, severely injured and major trauma had been used to indicate a patient with high injury severity [1,2]. Under the basic concept of a combination of injuries that causes a life-threatening condition, polytrauma is generally used to describe trauma patients whose injuries were severe and involved multiple body regions [3,4], compromise the patient's physiology and potentially cause dysfunction of uninjured organs [5]. These polytrauma patients are expected to have a higher risk of morbidity and mortality than the summation of expected morbidity and mortality of their individual injuries [1].

Some authors suggested that at least two anatomical regions have to be injured for a patient to be identified as having critically ill trauma [4–7]. Border et al. [4] and Osterwalder [8] defined polytrauma as presence of  $\geq 2$  significant injuries. However, the cut-off of abbreviated injury scale (AIS)  $\geq 2$  would enable identifying a patient with fairly low injury severity score (ISS) such as 8, 12, and 13 as having polytrauma, which would not make the score specific enough [5]. Furthermore, Butcher et al. define 'polytrauma' as an injured patient with AIS  $\geq 3$  points in at least two different body regions [8]. With associated higher mortality, more frequent ICU admissions, and longer hospital and ICU stays, this characteristic captured the greatest percentage of the worst outcomes and a significantly larger percent of the clinically diagnosed polytrauma patients than those who were diagnosed via the definition, ISS  $>15$  or ISS  $>17$  [7].

However, although a universally accepted definition for polytrauma is vital for comparing datasets, the term 'polytrauma' lacks a universally accepted and validated definition [1]. Before applying the definition of the term in the clinical setting, we designed this study to investigate the outcome of the polytrauma patients, diagnosed by AIS  $\geq 3$  for at least two body regions, admitted and treated for all trauma injuries at a level I trauma center. The primary hypothesis of this study was that

these polytrauma patients have a worse outcome than those patients with similar injury severity but without polytrauma.

## Methods

### Ethics statement

This study was pre-approved by the Institutional Review Board (IRB) of the Chang Gung Memorial Hospital (approval number 104-1783B). Informed consent was waived according to IRB regulations.

### Study design

This retrospective study reviewed data of all 20,106 hospitalized patients registered in the Trauma Registry System of a level I regional trauma center [9,10] from January 1, 2009, to December 31, 2014 (Fig. 1). The Trauma Registry System, which was established in our hospital since 2009, collected the data of patient characteristics, injury characteristics, injury mechanism, and outcome of patients hospitalized due to all trauma cause. All the registered data were input into hospital-based databank by two qualified nurses with specific responsibility for the integrity of the registered data. All patients with an overall ISS  $\geq 16$  and hospitalized for treatment of traumatic injuries were included in the study ( $n = 2798$ ). A patient with AIS  $\geq 3$  in two or more different body regions was considered to have polytrauma ( $n = 694$ ). Other patients who had an overall ISS  $\geq 16$  but did not fit into the above criteria of polytrauma were defined as non-polytrauma patients ( $n = 2104$ ). This group consisted of patients with (1) an AIS of 4 or 5 with injury at one body region and no additional or only minor (1 or 2 points) injury at a second ISS region, (2) an AIS of 3 with injury at one body region and two additional injuries (2 points) at a second and third ISS region. Patients with incomplete registered data would be excluded ( $n = 0$ ). Detailed patient information retrieved from the Trauma Registry System including: age; sex; trauma mechanism; initial Glasgow Coma Scale (GCS) score in the emergency department (ED); vital signs assessed by the physician upon arrival at the ED and procedures performed by the physician at the ED (cardiopulmonary resuscitation, intubation, chest tube insertion, and blood transfusion); AIS severity score for each body region; ISS; The Trauma and Injury Severity Score (TRISS); rates of associated injuries; revised trauma score (RTS); hospital length of stay (LOS); LOS in ICU; and in-hospital mortality. Pre-existing comorbidities and chronic diseases including diabetes mellitus (DM), hypertension (HTN), coronary artery diseases (CAD), congestive heart failure (CHF), cerebrovascular accident (CVA), and end-stage renal disease (ESRD) were also identified. The ISS is expressed as the median and interquartile range (IQR, Q1–Q3). Odds ratios (ORs) of the associated conditions and injuries of the patients were calculated with 95% confidence intervals (CIs). The data collected were compared using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). Two-sided Fisher exact or Pearson chi-square tests were used to compare categorical data. The unpaired Student t-test was used to analyze normally distributed continuous data, which

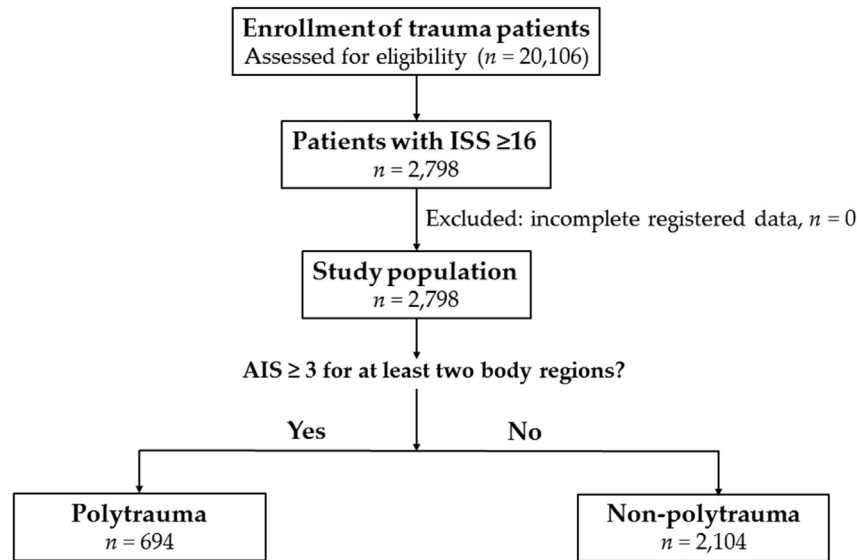


Fig. 1 Flow chart of the study population.

was reported as mean  $\pm$  standard deviation. The Mann–Whitney *U*-test was used to compare non-normally distributed data. To minimize confounding effects of baseline covariates that may be related to the outcome assessment, propensity scores were estimated by multiple logistic regression analysis with adjustments for patient age, sex, systolic blood pressure (SBP), GCS, injuries based on AIS, and ISS. After calculation of the propensity scores, a 1:1 matched study group was created by the Greedy method and a 0.2 caliper width using NCSS software (NCSS 10; NCSS Statistical software, Kaysville, Utah). A conditional logistic regression was used for evaluating the effect of polytrauma on mortality with crude OR being calculated with 95% CI as well as the adjusted odd ratio (AOR) for mortality adjusted by the ISS. All results are presented as the mean  $\pm$  standard error. A *p*-value less than 0.05 was considered statistically significant.

## Results

### Injury characteristics and severity of patients with polytrauma

As shown in Table 1, the mean age of patients with polytrauma was less than of those without polytrauma ( $46.2 \pm 19.9$  years and  $50.8 \pm 22.2$  years, respectively;  $p < 0.001$ ). No significant sex-specific predominance was noted among patients with polytrauma. Significantly lower rates of pre-existing comorbidities including DM, HTN, and CVA were found among patients with polytrauma than those without polytrauma. GCS scores were significantly lower for patients with polytrauma than for non-polytrauma patients ( $11.5 \pm 4.4$  vs.  $11.9 \pm 4.2$ , respectively;  $p = 0.028$ ); however, the difference in GCS scores was less than 1 point. Significantly more patients with polytrauma had a GCS  $\leq 8$  and significantly fewer patients with polytrauma had a GCS  $\geq 13$  compared to non-polytrauma patients. Analysis of AIS, regardless of the

criteria of AIS  $\geq 1$  or  $\geq 3$ , revealed that patients with polytrauma had sustained significantly higher rates of face, thoracic, abdomen, and extremity injuries than non-polytrauma patients, while non-polytrauma patients had sustained significantly higher rates of head and neck injury. In addition, a significantly higher ISS was found in patients with polytrauma than in non-polytrauma patients (median [IQR: Q1–Q3], 26 [22–34] vs. 17 [16–21], respectively;  $p < 0.001$ ). When stratified by ISS (16–24 or  $\geq 25$ ), among patients with polytrauma, more patients had an ISS  $\geq 25$  and fewer patients had an ISS of 16–24 as compared to non-polytrauma patients. The patients with polytrauma presented with a significantly lower RTS ( $6.8 \pm 1.5$  vs.  $7.0 \pm 1.3$ , respectively;  $p < 0.001$ ) and TRISS ( $0.803 \pm 0.246$  vs.  $0.872 \pm 0.200$ , respectively;  $p < 0.001$ ) than that in non-polytrauma patients.

### Associated management and injuries among patients with polytrauma

Patients with polytrauma exhibited higher ORs for presenting with worse hemodynamic measures than non-polytrauma patients. These measures included a systolic blood pressure (SBP) of  $<90$  mmHg, heart rate of  $>100$  beats/min, and respiratory rate of  $<10$  or  $>29$  times/min (Table 2). In addition, patients with polytrauma had higher odds for requiring procedures at the ED, including cardiopulmonary resuscitation, intubation, chest tube insertion, and blood transfusion. Regarding the associated injuries (Table 3), patients with polytrauma had statistically significantly lower ORs for sustaining epidural hematomas (OR 0.6, 95% CI 0.49–0.77;  $p < 0.001$ ), subdural hematomas (OR 0.4, 95% CI 0.37–0.53;  $p < 0.001$ ), and cerebral contusions (OR 0.6, 95% CI 0.48–0.75;  $p < 0.001$ ) than non-polytrauma patients. Notably, 297 (42.8%) of the 694 polytrauma patients and 1629 (77.4%) of the 2104 non-polytrauma patients have a head/neck AIS of  $\geq 4$  points. In contrast, patients with polytrauma had statistically significantly higher ORs for sustaining maxillofacial trauma,

**Table 1 Demographics and injury characteristics of patients with and without polytrauma.**

Variables	Polytrauma n = 694	Non-polytrauma n = 2104	Odds Ratio (95% CI)	p
Age	46.2 ± 19.9	50.8 ± 22.2	–	<0.001
Sex				
Male	479 (69.0)	1385 (65.8)	1.2 (0.96–1.39)	0.122
Female	215 (31.0)	719 (34.2)	0.9 (0.72–1.04)	0.122
Co-morbidity				
DM	72 (10.4)	299 (14.2)	0.7 (0.53–0.92)	0.010
HTN	141 (20.3)	551 (26.2)	0.7 (0.58–0.89)	0.002
CAD	19 (2.7)	75 (3.6)	0.8 (0.46–1.27)	0.294
CHF	1 (0.1)	15 (0.7)	0.2 (0.03–1.52)	0.141
CVA	7 (1.0)	102 (4.8)	0.2 (0.09–0.43)	<0.001
ESRD	0 (0.0)	3 (0.1)	–	1.000
GCS	11.5 ± 4.4	11.9 ± 4.2	–	0.028
≤8	195 (28.1)	493 (23.4)	1.3 (1.05–1.55)	0.013
9–12	86 (12.4)	267 (12.7)	1.0 (0.75–1.26)	0.837
≥13	413 (59.5)	1344 (63.9)	0.8 (0.70–0.99)	0.039
AIS, n (%)				
Head/Neck	521 (75.1)	1780 (84.6)	0.5 (0.45–0.68)	<0.001
Face	222 (32.0)	453 (21.5)	1.7 (1.42–2.07)	<0.001
Thorax	496 (71.5)	391 (18.6)	11.0 (9.00–13.38)	<0.001
Abdomen	265 (38.2)	184 (8.7)	6.4 (5.20–7.99)	<0.001
Extremity	510 (73.5)	595 (28.3)	7.0 (5.79–8.53)	<0.001
AIS ≥ 3, n (%)				
Head/Neck	467 (67.3)	1679 (79.8)	0.5 (0.43–0.63)	<0.001
Face	26 (3.7)	0 (0.0)	–	<0.001
Thorax	459 (66.1)	248 (11.8)	14.6 (11.90–17.95)	<0.001
Abdomen	179 (25.8)	60 (2.9)	11.8 (8.70–16.11)	<0.001
Extremity	347 (50.0)	54 (2.6)	38.0 (27.89–51.68)	<0.001
ISS, median (IQR)	26 (22–34)	17 (16–21)	–	<0.001
16–24	240 (34.6)	1701 (80.8)	0.1 (0.10–0.15)	<0.001
≥25	454 (65.4)	403 (19.2)	8.0 (6.60–9.66)	<0.001
RTS	6.8 ± 1.5	7.0 ± 1.3	–	<0.001
TRISS	0.8 ± 0.25	0.9 ± 0.2	–	<0.001
Mortality, n (%)	79 (11.4)	232 (11.0)	1.0 (0.79–1.36)	0.795
Hospital LOS (days)	20.2 ± 15.9	15.4 ± 15.9	–	<0.001
ICU, n (%)				
ISS 16–24	143 (20.6)	1161 (55.2)	0.2 (0.17–0.26)	<0.001
ISS ≥ 25	380 (54.8)	371 (17.6)	5.7 (4.69–6.81)	<0.001
LOS in ICU (days)	7.1 ± 9.8	6.9 ± 12.1	–	0.670

thoracic trauma, abdominal trauma, and extremity trauma than non-polytrauma patients.

### Outcome of patients with polytrauma

As shown in Table 1, mortality was found in 79 (11.4%) of 694 patients with polytrauma and 232 (11.0%) of 2104 patients without polytrauma. Patients with polytrauma did not present a significantly different lethality than non-polytrauma

patients (OR 1.0, 95% CI 0.79–1.36;  $p = 0.795$ ). Those fatal patients were significantly older, had a lower GCS scores, had a higher rate of head/neck injury, and had a significantly higher ISS than those patients who survived (Table 4). After propensity-score matching, mortality outcome was compared in 181 well-balanced pairs of patients (Table 4). In these propensity score-matched patients, there was no significant difference in sex, age, co-morbidities, SBP, GCS, injury region based on AIS, and ISS. Logistic regression analysis of these

**Table 2 Worse physiological response upon arrival and procedures performed at the emergency department for patients with and without polytrauma.**

Variables	Polytrauma n = 694	Non-polytrauma n = 2104	Odds Ratio (95% CI)	p
Physiology at ED, n (%)				
SBP < 90 mmHg	77 (11.1)	88 (4.2)	2.9 (2.08–3.93)	<0.001
HR > 100 beats/min	273 (39.3)	543 (25.8)	1.9 (1.56–2.23)	<0.001
RR < 10 or > 29 times/min	35 (5.0)	45 (2.1)	2.4 (1.55–3.81)	<0.001
Procedures at ED, n (%)				
Cardiopulmonary resuscitation	12 (1.7)	12 (0.6)	3.1 (1.37–6.86)	0.004
Intubation	114 (16.4)	261 (12.4)	1.4 (1.09–1.76)	0.007
Chest tube insertion	99 (14.3)	72 (3.4)	4.7 (3.42–6.45)	<0.001
Blood transfusion	180 (25.9)	154 (7.3)	4.4 (3.50–5.62)	<0.001

**Table 3 Significant associated injuries among patients with and without polytrauma.**

Variables	Polytrauma n = 694	Non-polytrauma n = 2104	Odds Ratio (95% CI)	P
<b>Head trauma, n (%)</b>				
Epidural hematoma (EDH)	112 (16.1)	500 (23.8)	0.6 (0.49–0.77)	<0.001
Subdural hematoma (SDH)	249 (35.9)	1178 (56.0)	0.4 (0.37–0.53)	<0.001
Cerebral contusion	106 (15.3)	487 (23.1)	0.6 (0.48–0.75)	<0.001
<b>Maxillofacial trauma, n (%)</b>				
Nasal fracture	17 (2.4)	18 (0.9)	2.9 (1.49–5.68)	0.001
Maxillary fracture	87 (12.5)	197 (9.4)	1.4 (1.06–1.81)	0.016
Mandibular fracture	31 (4.5)	42 (2.0)	2.3 (1.43–3.68)	<0.001
<b>Thoracic trauma, n (%)</b>				
Rib fracture	283 (40.8)	288 (13.7)	4.3 (3.57–5.28)	<0.001
Hemothorax	98 (14.1)	72 (3.4)	4.6 (3.38–6.38)	<0.001
Pneumothorax	114 (16.4)	63 (3.0)	6.4 (4.62–8.78)	<0.001
Hemopneumothorax	97 (14.0)	75 (3.6)	4.4 (3.21–6.02)	<0.001
Lung contusion	71 (10.2)	59 (2.8)	4.0 (2.77–5.64)	<0.001
Thoracic vertebral fracture	30 (4.3)	52 (2.5)	1.8 (1.13–2.82)	0.012
<b>Abdominal trauma, n (%)</b>				
Intra-abdominal injury	59 (8.5)	86 (4.1)	2.2 (1.55–3.07)	<0.001
Hepatic injury	117 (16.9)	62 (2.9)	6.7 (4.84–9.21)	<0.001
Splenic injury	64 (9.2)	37 (1.8)	5.7 (3.75–8.59)	<0.001
Retroperitoneal injury	10 (1.4)	5 (0.2)	6.1 (2.09–18.02)	0.001
Renal injury	23 (3.3)	20 (1.0)	3.6 (1.95–6.54)	<0.001
Lumbar vertebral fracture	48 (6.9)	32 (1.5)	4.8 (3.05–7.59)	<0.001
Sacral vertebral fracture	19 (2.7)	8 (0.4)	7.4 (3.21–16.92)	<0.001
<b>Extremity trauma, n (%)</b>				
Clavicle fracture	120 (17.3)	195 (9.3)	2.0 (1.60–2.62)	<0.001
Humeral fracture	51 (7.3)	31 (1.5)	5.3 (3.37–8.36)	<0.001
Radial fracture	80 (11.5)	52 (2.5)	5.1 (3.59–7.37)	<0.001
Ulnar fracture	52 (7.5)	41 (1.9)	4.1 (2.68–6.20)	<0.001
Pelvic fracture	93 (13.4)	56 (2.7)	5.7 (4.01–7.98)	<0.001
Femoral fracture	173 (24.9)	28 (1.3)	24.6 (16.33–37.12)	<0.001
Patella fracture	22 (3.2)	12 (0.6)	5.7 (2.81–11.59)	<0.001
Tibia fracture	94 (13.5)	30 (1.4)	10.8 (7.11–16.50)	<0.001
Fibular fracture	68 (9.8)	25 (1.2)	9.0 (5.66–14.41)	<0.001

**Table 4 Patient cohorts before and after the propensity-score matching.**

Variables	Before matching				After matching			
	Death n = 311	Survival n = 2487	OR (95%CI)	P	Death n = 181	Survival n = 181	OR (95%CI)	P
<b>Sex</b>								
Male	205 (65.9)	1659 (66.7)	1.0 (0.75–1.24)	0.780	133 (73.5)	133 (73.5)	1.0 (0.63–1.60)	1.000
Female	106 (34.1)	828 (33.3)	1.0 (0.81–1.33)	0.780	48 (26.5)	48 (26.5)	1.0 (0.63–1.60)	1.000
Age	56.2 ± 21.4	48.9 ± 21.6	–	<0.001	52.9 ± 21.5	52.9 ± 21.0	–	0.980
<b>Co-morbidity</b>								
DM	40 (12.9)	331 (13.3)	1.0 (0.68–1.37)	0.826	13 (7.2)	13 (7.2)	1.0 (0.45–2.22)	1.000
HTN	86 (27.7)	606 (24.4)	1.2 (0.91–1.55)	0.205	41 (22.7)	41 (22.7)	1.0 (0.61–1.64)	1.000
CAD	21 (6.8)	73 (2.9)	2.4 (1.45–3.95)	<0.001	6 (3.3)	6 (3.3)	1.0 (0.32–3.16)	1.000
CHF	3 (1.0)	13 (0.5)	1.9 (0.53–6.54)	0.410	0 (0.0)	0 (0.0)	–	–
CVA	15 (4.8)	94 (3.8)	1.3 (0.74–2.25)	0.370	3 (1.7)	3 (1.7)	1.0 (0.20–5.02)	1.000
ESRD	2 (0.6)	1 (0.0)	16.1 (1.46–177.97)	0.034	0 (0.0)	0 (0.0)	–	–
SBP mmHg	141.9 ± 60.1	146.6 ± 38.1	–	0.184	150.9 ± 49.5	149.2 ± 39.6	–	0.710
GCS	6.8 ± 4.4	12.5 ± 3.8	–	<0.001	8.1 ± 4.8	8.0 ± 4.8	–	0.710
<b>AIS, n (%)</b>								
Head/Neck	275 (88.4)	2026 (81.5)	1.7 (1.21–2.50)	0.002	161 (89.0)	161 (89.0)	1.0 (0.52–1.93)	1.000
Face	40 (12.9)	635 (25.5)	0.4 (0.31–0.61)	<0.001	20 (11.0)	20 (11.0)	1.0 (0.52–1.93)	1.000
Thorax	77 (24.8)	810 (32.6)	0.7 (0.52–0.89)	0.005	43 (23.8)	43 (23.8)	1.0 (0.62–1.62)	1.000
Extremity	85 (27.3)	1020 (41.0)	0.5 (0.42–0.70)	<0.001	51 (28.2)	51 (28.2)	1.0 (0.63–1.58)	1.000
ISS	25 (25–34)	19 (16–24)	–	<0.001	25 (20–29)	25 (18–29)	–	0.076
Polytrauma	79 (25.4)	615 (24.7)	1.0 (0.79–1.36)	0.795	45 (24.9)	51 (28.2)	0.5 (0.16–1.32)	0.147

well-balanced pairs of patients showed that the association of polytrauma did not significantly influence mortality (OR 0.5, 95% CI 0.16–1.32;  $p = 0.147$ ). In addition, compared to non-

polytrauma patients, patients with polytrauma had significantly longer hospital LOS (20.2 days vs. 15.4 days, respectively;  $p < 0.001$ ), and a higher proportion of patients had an

ISS  $\geq 25$  (54.8% vs. 17.6%, respectively;  $p < 0.001$ ) but a lower proportion of patients with an ISS of 16–24 (20.6% vs. 55.2%, respectively;  $p < 0.001$ ) were admitted to the ICU; however, the LOS in the ICU was not significantly different between patients with or without polytrauma (7.1 days vs. 6.9 days, respectively;  $p = 0.670$ ) (Table 1).

## Discussion

Many studies had defined polytrauma as an ISS  $> 15$  [11], an ISS  $> 16$  [12], an ISS  $> 18$  [13], an ISS  $\geq 18$  [14,15], or an ISS  $> 25$  [16]. If lower cut-offs are used ( $> 15$  or  $> 16$ ), a fairly low injury severity, e.g., AIS of 2 in two regions plus AIS of 3 ( $2^2 + 2^2 + 3^2 = 17$ ), may be included. If higher cut-offs are used ( $> 20$  or  $> 25$ ), the specificity would be increased at the expense of the exclusion of patients with AIS = 3 injuries in two body regions [1]. Different studies have pointed out the limited prognostic value of ISS in terms of mortality prediction [17–19]. Furthermore, ISS is hardly ever calculated on admission, which makes it difficult to be a useful tool for prognostic during initial resuscitation [20]. Whatever the definition of polytrauma presents a difference or not in term of mortality, ISS could be only more useful for secondary triage or ICU admission. In contrast, the ‘polytrauma’ definition of Butcher and colleagues with AIS  $\geq 3$  in at least two different body regions [2,6,8] seemed more reasonable and feasible in identifying the polytrauma patients. This definition was shown to be a better predictor of morbidity and mortality than the definition with an ISS  $> 15$  or ISS  $> 17$  [2,6,8]. However, in this study, we failed to demonstrate a significant difference in short-term mortality between the polytrauma and non-polytrauma patients. These results are in contrast to the basic assumption that polytrauma patients are expected to have a higher risk of mortality than the summation of expected mortality of their individual injuries [1]. Because the ISS score had been already calculated from three different injured body regions, if there was no worse outcome of these polytrauma patients, then we can just use multitrauma or multiple trauma to profile these patients and use ISS to depict the patient outcome, and there was no necessary of the use of polytrauma to describe the patient condition. Moreover, Paf-rath et al. had reported the mortality rate of the polytrauma patients with AIS  $\geq 3$  in at least two different body regions was even lower (18.7%) than in the whole group with an ISS  $\geq 16$  points (20.4%) [17]. The discrepancy of our results to those reported by Butcher and colleagues may be attributed to the exclusion of non-polytrauma patients with head injuries in their series. Because the head injury may have an inherently morbidity and mortality rate than the injury to other regions [21,22], the exclusion of the head injuries from the non-polytrauma patients can offer advantages for outcome comparison but would limit its feasibility in the clinical setting. In this study, 77.4% of non-polytrauma patients had a head/neck AIS  $\geq 4$  points. Polytrauma can indeed affect all body regions and all organs in an endless amount of combinations. The exclusion of the majority of patients from one specific group would result in a bias in the interpretation and limit the usefulness of conclusions in clinical application.

AIS/ISS does not reflect the physiological course after injury, which can be very dynamic in nature and may profoundly influence outcomes. Therefore, the definition of polytrauma by the number of injured body regions would make it difficult to be distinguished from the concept of “multiple trauma”. To improve the specificity of the polytrauma definition, some additional qualifying criteria for the body regions had been proposed, such as laparotomy involvement [23]; injuries leading to severe shock [24]; and involving at least one vital organ necessitating patient admission to a trauma ICU [25]. However, these additional criteria seemed to be limited and unverified. The levels of variation differ among trauma centers may be quite different. A combination of injury severity, relevant pathophysiological change, or physiologic changes in the clinical condition is useful [3]. Kondo et al. documented a good predictive power for GCS, age, and SBP in terms of mortality after an examination of the datasets from 35,732 patients of 115 hospitals from the Japan Trauma Data Bank [26]. An international consensus meeting in 2012 first tried to specify the term ‘polytrauma’ by combining the concept of injuries in different body regions and physiological risk factors [27]. With a minimum addition of one of five standardized physiological responses (hypotension [SBP  $\leq 90$  mmHg], unconsciousness [GCS score  $\leq 8$ ], acidosis [BE  $\leq -6.0$ ], coagulopathy [PTT  $\geq 40$  s or INR  $\geq 1.4$ ], and age [ $\geq 70$  years]) to the definition of ISS  $\geq 16$  and AIS  $\geq 3$  for at least two body regions, an improved definition of polytrauma was determined [5,28]. A sustained increase in coverage of mortality was noted, with the ancillary physiologic variables supplementary to the injury scoring [5].

Our study has some limitations that should be acknowledged. First, owing to the retrospective design of the study, there is inherent selection bias. Second, the patients declared dead on hospital arrival or at the accident scene were not included in the Trauma Registry Database, which may have led to a bias. Third, the study population, limited to a single urban trauma center in southern Taiwan, may not be representative of other populations and a prospective study conducted in multiple trauma centers may provide more validated information. Fourth, the descriptive study design with the lack of data regarding indication of hospitalization and admission into ICU, type of surgery, and the long-term mortality of patients prevents evaluation of the effects of any particular treatment intervention. This means that we could only rely on the assumption of uniform assessment and management of patients with or without polytrauma. For example, in this study, the patients of the polytrauma group present with worse hemodynamic measures and GCS compared to that of the non-polytrauma group, but the short-term mortality was similar between the groups. Although the results support the concept that the definition of polytrauma is insufficient, however, the results may be confounded by some un-explored factors, such as there was a possibility that the trauma team activation was more common for the polytrauma group and therefore this group of patients has been treated more aggressively in the resuscitation stage. Finally, the cost and resource used were not evaluated in this study.

## Conclusion

This study of hospitalized trauma patients based on the Trauma Registry System at a level I trauma center revealed that patients with polytrauma defined by AIS  $\geq 3$  failed to recognize a significant difference in short-term mortality among trauma patients.

## Conflicts of interest

The authors declare that they have no competing interests.

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