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ORIGINAL ARTICLE

Experienced trauma team leaders save the lives of multiple-trauma patients with severe head injuries

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Abstract

The trauma team leader is a professional who receives and treats trauma patients. We aimed to evaluate whether or not the seniority of a qualified trauma team leader was a prognostic factor for multiple-trauma patients managed by a trauma team. This was a retrospective cohort study conducted at a Level I Trauma Center in North Taiwan. From January 2009 to December 2013, 284 patients were randomly assigned to one of two trauma team leaders (junior and senior leaders) on duty, irrespective of the seniority of the qualified trauma team leader. All parameters were collected and compared between these two groups. In the subgroup of multiple-trauma patients with Glasgow Coma Scale (GCS) ≤ 8, there were significant differences in the injury severity score, revised trauma score, and seniority of the leader between the alive and dead groups. A multivariate logistic regression analysis showed that the seniority of the trauma team leader was an important mortality risk factor [odds ratio (OR): 14.529, 95% confidence interval (CI) 1.683–125.429, $p = 0.015$] in patients with GCS ≤ 8. However, in patients with GCS > 8, age was the only independent risk factor [OR: 1.055, 95% CI 1.023–1.087, $p = 0.001$]. The seniority of the qualified trauma leader is important for teamwork, organization, and efficiency, all of which play an important role in improving the survival outcome of patients with GCS ≤ 8.

Keywords Leadership · Seniority · Trauma team leader · Multiple-trauma

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Abbreviations

OHCA	Out-of-hospital cardiac arrest
ISS	Injury Severity Score
GCS	Glasgow Coma Scale
RTS	Revised Trauma Score
TSGHIRB	Tri-Service General Hospital Institutional Review Board
ED	Emergency department
ATLS	Advanced trauma life support
IQR	Interquartile range
OR	Odds ratio
CI	Confidence interval
EMT	Emergency medical technician
NOTSS	Non-technical skills for surgeons

Background

The trauma team is a multidisciplinary team that attempts to quickly diagnose and manage multiple-trauma patients [1]. The survival rate of patients depends on the team's comprehensive, effective performance [2]. Over half of patients die at the scene of the accident or within 24 h of hospitalization

after multiple major traumas, including blunt abdominal or thoracic trauma with massive bleeding and severe primary brain injury [3]. Therefore, the existence and composition of the trauma team in a Level I Trauma Center is an important determinant of the quality and outcome of the management of these patients.

The trauma leader is a key member of the trauma team, and experienced leadership determines the trauma team's organization and efficiency [4]. The most efficient team organizer can coordinate the simultaneous completion of each team member's individual tasks. In theory, the leadership of the team depends on the seniority and experience of the trauma team leader.

In a review of the literature, the clinical outcomes were similar for trainee and consultant trauma leaders, but consultant team leaders were able to improve the team's performance, leading to a shorter time for diagnostic imaging and hemorrhaging control when needed [5]. When comparing trauma patients treated by non-surgeon vs surgeon trauma team leaders, the background of the trauma team leader made no significant difference in the outcome [6]. Cummings et al. found that surgeons, on-call emergency physicians, and on-shift emergency physicians can all act as trauma team leaders with a similar impact on the patient survival or emergency department length-of-stay [7]. These findings support the notion that a more collaborative approach to resuscitative trauma management can be achieved by non-surgeon trauma team leaders than surgeons [6, 7].

However, leadership was also perceived as an essential component to trauma management. The ideal leader was viewed as an experienced surgeon who had extensive knowledge of trauma care, communicated clearly, and worked confidently. In contrast, the team leaders were reported to have little experience in managing trauma, and those interviewed requested more guidance and supervision. The need for better training of trauma teams, especially team leaders, requires increased attention and action [8]. Another retrospective study reported that as long as the senior in-house residents could perform the initial assessment and care for critically injured patients and the attending surgeon guided critical decision-making in a defined period of time (if not present on-site), the clinical outcome was similar to that performed by an in-house attending surgeon [9].

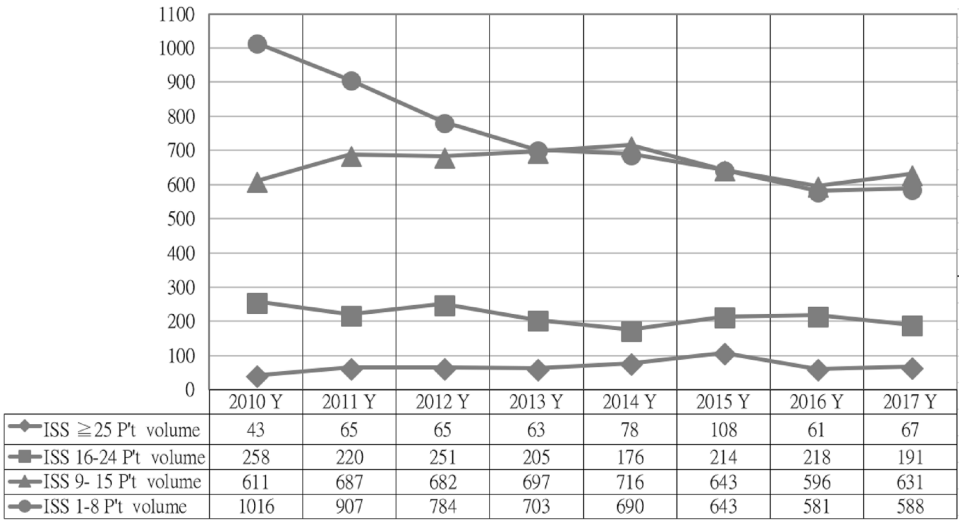
Another important determinant in the quality of care and outcome of major trauma patients is the trauma center patient volume. The trauma center volume reflects the total number of trauma patients with an injury severity score (ISS) exceeding 15, as these patients are considered to have experienced major multisystem trauma. Evidence suggests that a strong association exists between the trauma center volume and the patient outcomes, with significant improvements in the mortality and length of stay (LOS) when the volume exceeds 650 cases per year [10]. Accordingly, a trauma center volume of ≤ 650 cases could be defined as a hospital with a low trauma patient volume, which is associated with a poor outcome with regard to mortality and LOS. Another study also suggested that greater monthly trauma volumes were associated with a lower mortality [11], while another showed that a low total annual trauma center volume (< 2000) and a low volume of patients with ISS ≥ 16 (< 240) were significant predictors of a higher in-hospital mortality [adjusted odds ratio (OR) of mortality: 1.41; 95% confidence interval (CI) 1.17–1.69] [12].

However, no study has reported on the effect the seniority of the trauma team leader has on the outcome of multiple-trauma patients. Therefore, the aim of this study was to determine if the seniority of the qualified trauma team leader was a prognostic factor for multiple-trauma patients managed by a trauma team, especially in a hospital with a relatively lower trauma patient volume, such as our hospital (Fig. 1).

Methods

The Institutional Review Board of Tri-Service General Hospital, National Defense Medical Center. approved this retrospective cohort study without written informed consent. All patient records and information in the registered trauma database in our hospital had been anonymized and de-identified prior to the analysis. The approval number is TSGHIRB No. 1-106-05-129.

The trauma registry system established in our hospital in 2009 was used to analyze treatment strategies and factors that influenced the care of severely injured patients, and it served as a tool for monitoring the quality of care. At the time the present study commenced, the database contained records of 6232 trauma patients who had been admitted to the ED of the Level I Trauma Center in north Taiwan. There were 284 enrolled patients with multiple traumas managed by the trauma team from January 2009 to December 2013. In this study, there were five fixed senior attending surgeons and some rotating junior attending surgeons who served yearly as trauma team leaders (Fig. 2). We defined a senior attending surgeon as an experienced trauma team leader who had at least 2 years of full-time experience in clinical practice for trauma and was a certified trauma specialist by the Formosa Association for the Surgery of Trauma in our country. This means that the leader had extensive knowledge of trauma care, communicated clearly, and radiated confidence. However, the minimal requirement for being a trauma team leader in our institution is obtaining certification for Advanced Trauma Life Support (ATLS) after a series of training courses, so we also have junior attending surgeons on duty as trauma team leaders.



	2010 Y	2011 Y	2012 Y	2013 Y	2014 Y	2015 Y	2016 Y	2017 Y
ISS ≧25 P't volume	43	65	65	63	78	108	61	67
ISS 16-24 P't volume	258	220	251	205	176	214	218	191
ISS 9- 15 P't volume	611	687	682	697	716	643	596	631
ISS 1-8 P't volume	1016	907	784	703	690	643	581	588

Fig. 1 Yearly trauma patient volume of different ISS category in our Trauma Center. *P't volume* trauma patient volume, *ISS* injury severity score

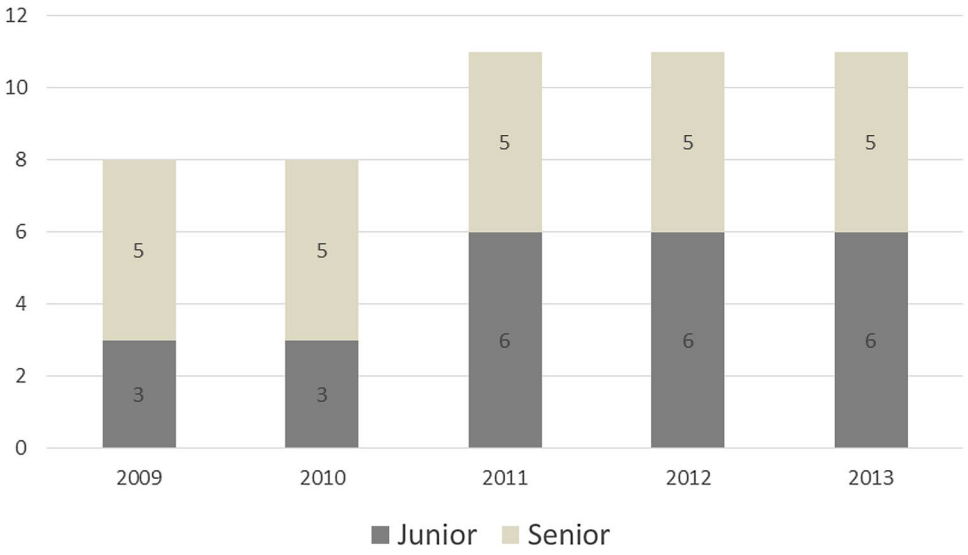


Fig. 2 The number of junior and senior attending surgeons as the trauma team leaders every year. Junior VS has less than 2 years of being trauma team leader; senior VS has more than 2 years of being trauma team leader

We enrolled patients who were at least 20 years of age with multiple traumas and had been managed by the trauma team from January 2009 to December 2013. In addition to the trauma team leader on duty, the trauma team comprised chief residents with primary expertise in the following surgical disciplines: general, thoracic, cardiovascular, genitourinary, neurological, and orthopedic surgery. The attending surgeons, as the trauma team leaders, were all qualified via ATLS training and testing. The trauma team treated patients meeting the following criteria: (1) unconscious or Glasgow Coma Scale (GCS) < 13 points; (2) initial hemodynamic instability, systolic blood pressure (SBP) < 90 mmHg; (3) fell from a height of 6 m (about 20 feet) or from a second floor; (4) gunshot to the head or trunk; (5) severe pelvic fracture; and (6) suspected multiple injuries to vital organs.

The exclusion criteria were out-of-hospital cardiac arrest (OHCA) due to multiple traumas, as the lower survival rates and severe brain damage in such patients would have caused a statistical bias when analyzing the contribution of the trauma team leader to the survival outcome of patients with multiple traumas and patients' revised trauma score (RTS), ISS, and time in the ED.

These data concerning patients suffering from multiple traumas were based on the work of the trauma team. The loss of some cases may have happened independent of the trauma team's work. This may be an inherent bias in our study design.

The results are expressed as the median [interquartile range (IQR)]. The Mann–Whitney *U* test of nonparametric statistics was used to analyze the confounding effects of age, gender, ISS, RTS, GCS, and time in the ED on the clinical outcomes of the alive group and compared the results with those of the dead group. Gender and leadership (senior vs junior staff) were compared using the Chi-square test. A

multivariate logistic regression analysis was used to adjust for all confounding factors to reduce the interactional bias. Statistical analyses were performed using the SPSS Version 16.0 software program for Windows. A p value ≤ 0.05 was considered statistically significant.

Results

The 284 enrolled patients were divided into alive ($n=208$) and dead ($n=76$) groups for the statistical analysis. The dead group included deaths occurring in the ED as well as all other in-hospital deaths. According to the trimodal mortality model, all deaths can be divided into three groups: immediate death, early death, and late death [13]. We defined immediate deaths as those occurring in the ED, early deaths as those occurring within 24 h of arrival at a trauma center (excluding immediate deaths), and late deaths as those occurring after the first 24 h and all other in-hospital deaths.

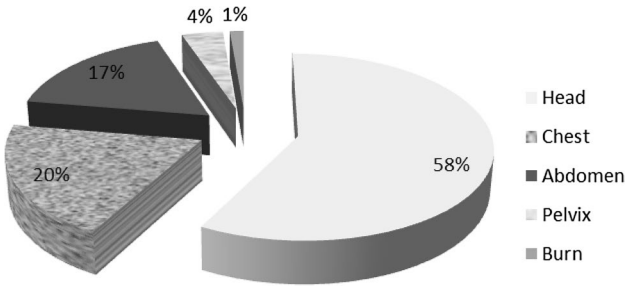


Fig. 3 The percentage of Major injury region in mortality

In the dead group, the major injuries were to the head (58%), chest (20%), and abdomen (17%) (Fig. 3). About 58% of deaths ($n=44$) were immediate and early deaths. The timing of death differed markedly depending on the cause. Hemorrhagic shock was the major cause of immediate ($n=17$, 81%) and early death ($n=12$, 52%), but in cases of late death, about 66% of patients ($n=21$) died of brain injury with cerebrovascular failure (including two organ donors) (Fig. 4).

The patients' characteristics and general findings of comparisons are presented in Table 1. There were significant differences in the age ($p=0.002$), ISS ($p<0.001$), GCS ($p<0.001$), and RTS ($p<0.001$) between the alive and dead groups. There were no significant differences in the gender, time in the ED, and leadership between these two groups (Table 1).

Given the above data, it is evident that head injuries were among the most common types of trauma encountered in the ED. Many patients with severe brain injuries die before

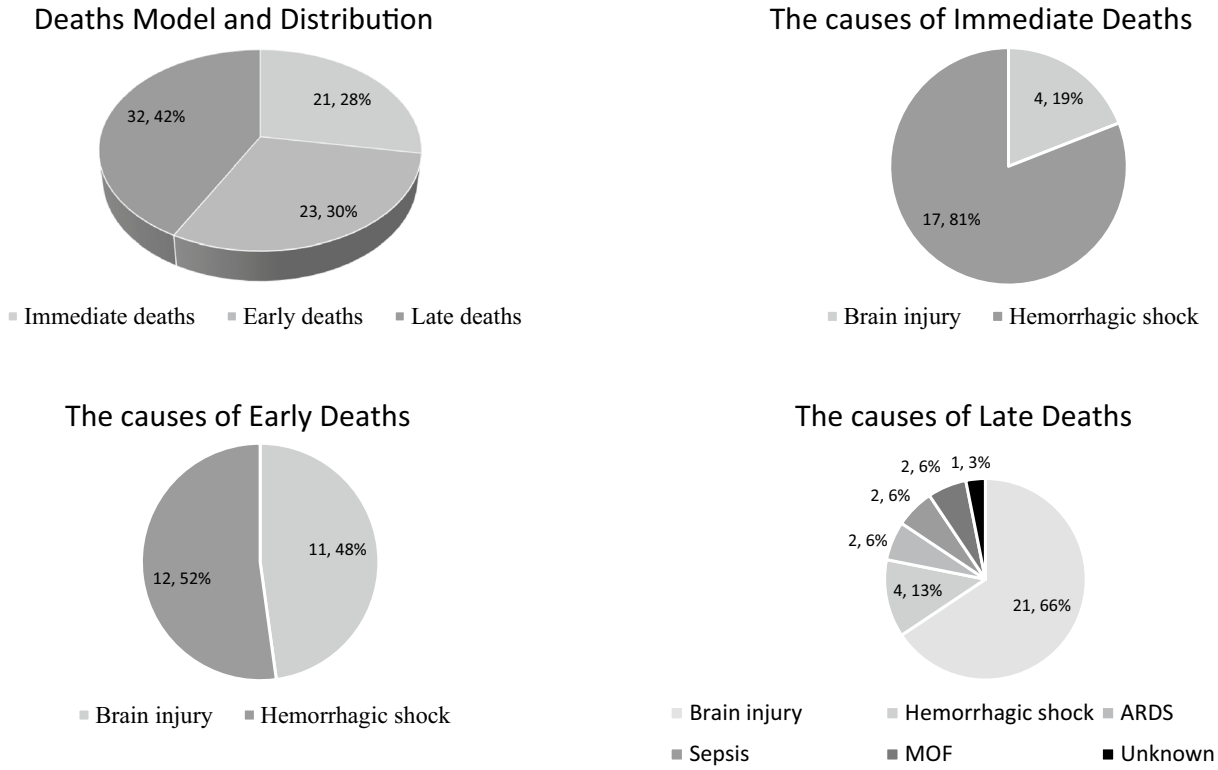


Fig. 4 Deaths model and distribution in the died group (patient number: $N=76$) and the causes of death in different death timing (patient number: $N=21$; 23; 32)

Table 1 A comparison of the characteristics of trauma patients ($n=284$ patients)

Parameter	Alive ($n=208$)	Dead ($n=76$)	p value
Age (years)[a]	38 (29.75)	49 (42)	**0.002
Gender			0.841
Male	148	55	
Female	60	21	
ISS[a]	20 (15.5)	34 (17)	**< 0.001
GCS[a]	15 (6)	6 (7.5)	**< 0.001
RTS[a]	7.8408 (1.47)	4.7396 (2.14)	**< 0.001
Time in ER[a]	183 (173.5)	152 (98.5)	0.116
Leadership			0.988
Senior	112	41	
Junior	96	35	

ISS Injury Severity Score, *GCS* Glasgow Coma Scale, *RTS* Revised Trauma Score, *ER* emergency room

**$p < 0.05$, statistically significant; Mann–Whitney test

[a]Median (interquartile range)

Table 2 A comparison of the characteristics of trauma patients with GCS ≤ 8 points ($n=89$ patients)

Parameter	Alive ($n=38$)	Dead ($n=51$)	p value
Age (years)[a]	31 (25.25)	51 (39)	0.140
Gender			0.845
Female	29	38	
Male	9	13	
ISS[a]	29 (15)	34 (18.5)	**0.006
GCS[a]	5.5 (4)	4 (3)	0.117
RTS[a]	5.67 (1.89)	4.09 (1.77)	**0.002
Time in ER[a]	166 (113)	156 (95)	0.684
Leadership			**0.012
Senior	35	36	
Junior	3	15	

ISS Injury Severity Score, *GCS* Glasgow Coma Scale, *RTS* Revised Trauma Score, *ER* emergency room

**$p < 0.05$, statistically significant; Mann–Whitney test

[a]Median (interquartile range)

reaching a hospital, with almost 90% of prehospital trauma-related deaths involving brain injury [14]. In our study, about 31% of patients with brain injuries were categorized as having severe injury (GCS ≤ 8). Managing these patients is a challenge for trauma team members and leaders. Therefore, we analyzed the effect of leadership on the clinical management of this subgroup of patients with severe brain damage (GCS ≤ 8). A total of 89 patients suffered from severe brain injury, and there were significant differences in the ISS ($p=0.006$), RTS ($p=0.002$), and leadership ($p=0.012$) between the alive and dead groups (Table 2). After a multivariate logistic regression analysis for prognostic factors in trauma patients with GCS ≤ 8, we found that the RTS (OR: 0.495, 95% CI 0.306–0.802, $p=0.004$) and leadership (junior, OR: 14.529, 95% CI 1.683–125.429, $p=0.015$) were independent prognostic factors (Table 3).

Among the patients with minor and moderate brain injuries (GCS > 8, total 195 patients), we found that the age, ISS, GCS, and RTS were significantly different between the alive and dead groups (Table 4). In a multivariate logistic regression analysis, we found that the age (OR: 1.055, 95% CI 1.023–1.087, $p=0.001$), ISS (OR: 1.097, 95% CI 1.049–1.147, $p<0.001$), and RTS (OR: 0.524, 95% CI 0.023–0.848, $p=0.009$) were independent prognostic factors (Table 5).

Table 3 Results of a multivariate logistic regression analysis of the mortality risk factors in trauma patients with GCS ≤ 8 points

Variable	Multivariate OR (95% CI)	p value
ISS	1.044 (0.997–1.092)	0.065
RTS	0.495 (0.306–0.802)	*0.004
Leadership (Junior)	14.529 (1.683–125.429)	*0.015

ISS Injury Severity Score, *RTS* Revised Trauma Score

*$p < 0.05$, statistically significant

Table 4 A comparison of the characteristics of trauma patients with GCS > 8 points ($n=195$ patients)

Parameter	Alive ($n=170$)	Dead ($n=25$)	p value
Age (years)[a]	38 (29)	49 (28.75)	**0.003
Gender			0.839
Female	119	17	
Male	51	8	
ISS[a]	17 (14.25)	34 (12)	**< 0.001
GCS[a]	15 (2)	12 (5)	**0.01
RTS[a]	7.84 (0.94)	6.90 (2.84)	**< 0.001
Time in ER[a]	187.5 (183.25)	143.5 (111.75)	0.323
Leadership			0.839
Senior	119	17	
Junior	51	8	

ISS Injury Severity Score, *GCS* Glasgow Coma Scale, *RTS* Revised Trauma Score, *ER* emergency room

**$p < 0.05$, statistically significant; Mann–Whitney test

[a]Median (interquartile range)

Discussion

According to the algorithm for the initial management of severe brain injury in ATLS [14], the primary survey and resuscitation and the secondary survey and AMPLE

Table 5 Results of a multivariate logistic regression analysis of the mortality risk factors of trauma patients with GCS > 8 points

Variable	Multivariate OR (95% CI)	*p* value
Age	1.055 (1.023–1.087)	*0.001
ISS	1.097 (1.049–1.147)	*< 0.001
GCS	0.937 (0.723–1.215)	0.625
RTS	0.524 (0.023–0.848)	*0.009

ISS Injury Severity Score, *GCS* Glasgow Coma Scale, *RTS* Revised Trauma Score

*$p < 0.05$, statistically significant

(Allergies, Medications currently used, Past illness/Pregnancy, Last meal, and Events/Environment related to the injury) history taking are the major principles of the initial assessment and management. These are all duties that must be carried out by the trauma team leader and members before the patients are admitted to a facility capable of definitive neurosurgical care. Patients with severe brain injuries or major trauma usually cannot supply detailed information on their trauma, so indeterminant information is typically obtained from an emergency medical technician or the patient's partner. In such a critical situation, a trauma team leader should manage these patients quickly and precisely, relying on the leader's training and experience.

In a literature review, consultant trauma team leaders were associated with improved care and trauma team performance in severely injured trauma patients compared with trainees, but the clinical outcomes were similar for trainees and consultants [5]. However, we obtained an interesting finding concerning the effect of the trauma team leader's seniority on the clinical outcomes. We found that the seniority of the team leader did not seem to be a prognostic factor among all trauma patients who were managed by trauma team members. However, in the subgroup of patients with GCS ≤ 8 points, the presence of a senior trauma leader was associated with better survival outcomes after univariate and multivariate logistic regression analyses. This finding suggests that, in a trauma center with a relatively low patient volume, the seniority of the trauma team leader may be associated with saving patients with severe brain trauma when that injury is combined with other major injuries. This means that the patient volume of the trauma center affects the experience of the team leader and subsequently determines the overall survival outcome and the quality of resuscitations in severe trauma patients. Experience gained in resuscitation team work over 1-year period did not enhance the leadership performance, but leaders who had up to 3 years' experience were more likely to be effective in the role of leader [15].

The type of trauma patient, team size, and seniority of the team leader can significantly affect the time required for a task [1]. Based on the above review and our present findings, we may reasonably infer that the seniority of the trauma team leader helps enhance their performance as a leader and possibly overcome the deficit of a reduced patient volume. Frequent clinical practice in a trauma team is very important for maintaining a good quality of major trauma management. However, the staff turnover in our trauma team results in an issue of medical manpower, as the work is difficult and the salary relatively low.

According to the non-technical skills for surgeons taxonomy used in the training of surgeons in non-technical skills by The Royal College of Surgeons of Edinburgh, a good surgeon leader needs to be skilled in situational awareness, decision-making, task management, leadership, communication, and teamwork [16]. We believe that this taxonomy can be applied to the evaluation of trauma team leader performance. A good trauma team leader should also have good situational awareness, fast decision-making, excellent task management, outstanding leadership, fluent communication, and commitment to teamwork when facing a critical patient suffering from major trauma. Reducing trauma mortality and improving the quality of trauma care requires an effectively performing trauma team. As such, a comprehensive performance improvement program is necessary, especially in hospitals with a low volume of major trauma patients [17].

Major questions are posed by this study. How can we improve the performance of less-experienced trauma team leaders? What can be done to reduce the time in the resuscitation room, the time to key diagnostic investigations, and the time to definitive care? How can the rate of missed injury and mortality be reduced? These questions may be answered by consistent, ongoing education and by the repeated introduction of processes designed to improve the functioning of the team. Based on our literature review, human patient simulators may be a useful tool for the education of trauma team leaders and members [18]. In a city with many medical centers, such as Taipei, the shortage of daily exposure to patients with major trauma is a critical issue that emphasizes the need for team training in various aspects of trauma care. Good teamwork, which is closely associated with patient safety during the dynamic flux of trauma care, is not only dependent on the leader being prepared with strong leadership skills but also on their being well-grounded in the principles of examination and prioritization [19]. However, Hoyer et al. found that inexperienced team leaders lacked the ability to assign tasks to other team members [20]. Trauma knowledge, experience, and training were all key factors associated with good leadership [8]. We believe that trauma team leaders with reduced practical experience and training in trauma surgery and team work are unlikely to perform optimally [15].

Conclusions

The experience and seniority of a qualified trauma leader has the potential to facilitate the functioning of an organized, efficient team; this in turn plays an important role in improving the survival outcome of patients with major trauma, especially those who are unconscious.

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Compliance with ethical standards

Conflict of interest All authors declare no conflict of interest.

Ethics approval and consent to participate The study methods were reviewed and approved by the Institutional Review Board II of the Tri-Service General Hospital, National Defense Medical Center (TSGHIRB No. 1-106-05-129).

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