



Construction and Operation of a Standardized Trauma Center in a Developing Country: A 6-Year Retrospective Study

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ABSTRACT

Background: International experiences have shown that trauma centers significantly reduce mortality for major trauma patients. During this 6-year study, the aim was to compare the outcomes before and after trauma center establishment and to identify the necessary components for a standardized trauma center.

Methods: ATLS® training was provided to doctors and a questionnaire was performed. A trauma team activation policy was established and trauma call-out system was installed. A multidisciplinary trauma team was organized, and a trauma resuscitation bay was set up. Trauma audit meetings were introduced as an approach to continuous trauma quality improvement. Data were collected before and after trauma center establishment, and guidelines for a standardized trauma center were explored.

Results: 221 doctors from mainland China received ATLS® training with positive feedback. A regional trauma center was established with a well-equipped trauma bay. Trauma admission was going up and trauma deaths were going down during 2016 to 2021. Trauma data from 2018 and 2019 showed that mortality of major trauma patients (ISS>15 or activated a multidisciplinary trauma team) has significantly decreased, with decreased in preventable trauma death as well. Trauma audit meeting has played an important role for trauma quality improvement. 12 Guidelines are recognized as components for a standardized trauma center.

Conclusion: Standardized trauma center decreases trauma mortality. The “12 Guidelines” have been proven to be successful examples. This practical approach can be replicated in other hospitals seeking to establish a trauma center. The effectiveness of this study has been demonstrated, and there is value in extending it to other parts of mainland China.

Keywords: ATLS®; Multidisciplinary trauma team; Trauma resuscitation bay; Trauma center

INTRODUCTION

According to the World Health Organization, injuries account for 9% of global mortality, and road traffic injuries alone will become the fifth leading cause of death in 2030 [1,2]. The trauma system has been widely reported to reduce trauma-related mortality, including preventable trauma deaths [3-7]. The trauma center is the core part of a trauma system. A famous study by MacKenzie et al. showed that the mortality rate of severely injured patients could be reduced by 25% if they were treated in a trauma center as opposed to a nontrauma center institution [4].

Since the late 1980s, trauma in China has been identified as a major public health challenge, and today, traffic-related fatalities account for 80% of accidental deaths. Since the mid-1990s, deaths caused by traffic accidents alone have been estimated to range from 200,000 to 400,000 persons per year [8]. China's National Health Commission released guidelines in June 2018 calling for the development of trauma centers and trauma systems across mainland China [9]. Shenzhen is located in South China, next to Hong Kong. In 2019, Shenzhen had a total population of approximately 20 million, with 10.8 million residents and an additional 9 million

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residents in the surrounding metropolitan area [10]. During the period of 2010–2017, both emergency medical services and the total number of trauma patients in Shenzhen increased, with trauma accounting for 47.0% and 38.4% of patients in 2010 and 2017, respectively [11]. During our 6-year study, the aim was to compare the outcomes before and after trauma center establishment and to identify the necessary components for a standardized trauma center.

METHODOLOGY

ATLS® course in mainland China has been organized in the University of Hong Kong-Shenzhen Hospital (HKU-SZH) since September 2016 and doctors attended ATLS® courses regularly from the related Departments. A computer-based trauma call-out system was installed and a multidisciplinary trauma team was established in October 2018. The first layer of the trauma team included one doctor from the emergency department, general surgery, orthopedic surgery, anesthesia department, ICU and one technician from the radiology department. Trauma team activation criteria were made as a chest card, and all the staff had a chance to take care of trauma patients carrying the card. Other specialists were called based on the patient's needs. A well-equipped trauma resuscitation bay was built with three beds and uncross matched red blood cell was stored inside. A trauma manual was developed with all the necessary information about the trauma center. The trauma audit meeting was introduced as a way to improve the quality of trauma care in HKU-SZH at the time of establishing the trauma center. Meetings were organized on a regular monthly or bimonthly basis. During the meetings, trauma management flow, decision-making, and trauma management skills were reviewed for each trauma death and for any major trauma patients who may experience errors or mistakes during the management process.

Trauma data were prospectively collected from January 1, 2016, to December 31, 2021, and were extracted from the hospital information system and trauma registry data-base for retrospective analysis. Data were collated and analyzed using Microsoft Excel for Mac 2011, Version 14.4.6 (Microsoft, Redmond, WA). Data were analyzed using SPSS® 24.0 for Windows® (SPSS Inc. IBM Corp.). The study was approved by HKU-SZH and Chinese PLA Medical School (Reference Lun (2016) 45).

RESULTS

Positive feedback from ATLS® course

As mentioned above, ATLS® provider course in mainland China has been held at HKU-SZH since September 2016. By December 2021, a total of 221 doctors from 11 provinces had received ATLS® training, and 106 doctors from HKU-SZH attended the ATLS® course. Students came from the departments of surgery, emergency department, ICU, anesthesia, orthopedic, and education. A questionnaire was sent to 121 students in October 2018, and 103 responses were received. The study showed that 96.1% of the respondents found the ATLS® course helpful in clinical work; 87.3% found the ATLS® course influential in deciding whether to intubate a patient; 86.4% found the ATLS® course influential in chest tube insertion, and 85.4% found the ATLS® course influential in resuscitating a traumatic shock patient (Table 1).

Table 1: A questionnaire survey* for ATLS® course in mainland China.

Results	respondents (103/121)
1.	96.1% of the respondents thought ATLS course helpful for clinical work
3.	3.9% of the respondents thought ATLS course was more helpful for ED
2.	51.4% thought ATLS was helpful to increase knowledge, to improve skills and confidence
3.	87.3% thought ATLS had an impact on deciding to intubate their patients
4.	86.4% thought ATLS had an impact on chest tube insertion
5.	85.4% thought ATLS had an impact on resuscitating a traumatic shock patient
6.	65% thought ATLS had an impact on uncross matched type "O" RBC used in their hospital
7.	80.6% thought ATLS had an impact on resuscitating a severe pelvic fracture with hemodynamic instability
8.	61.2% shared their ATLS knowledge and skills with their colleagues after their return to work

Note: * Questions attached as an attachment. ED: Emergency Department, RBC: Red Blood Cell

Establishment of a systematic approach for trauma reception and resuscitation

Once the patient meets the trauma call-out criteria, a group call will be sent out, either at prehospital or in A and E. Once trauma team members receive group trauma calls, six team members will gather in the trauma resuscitation bay. Personal protection equipment will be put on, and the team will be waiting for patient arrival if the patient has not yet arrived. Once the patient arrives, the anesthesia or the ED doctor will manage the patient's airway and protect the cervical spine (C-spine). The general surgeon will examine the patient's neck, chest, and abdomen, to determine any injury, fracture, or subcutaneous emphysema; to examine the abdomen; to perform a Focused Assessment Sonography in Trauma (FAST); and to take care of the pelvis. During this process, nurses will connect patients' to the vital sign monitor, and normally, 2 large IVs will be established. ICU doctors will help set up IVs, and orthopedic surgeons usually manage injuries to the limbs. During this process, chest and pelvic X-rays are usually taken by radiology technicians. Finally, rollover will be performed with C-spine protection. All of this process will follow ATLS® principles and ABCDE priority. The trauma resuscitation bay in HKU-SZH is shown in Figure 1.



Figure 1: Trauma resuscitation bay in HKU-SZH.

Decrease in trauma death and preventable trauma death

Trauma admission and trauma deaths from 2016 to 2021 are showed in Figure 2. Trauma deaths during 2019-2021 were obviously lower than those during 2016 to 2018 although trauma admission was increasing overall. The total trauma deaths within 7 days after admission (death on arrival excluded) from 2016 to 2021 were 8, 7, 8, 5, 3 and 3. Figure 3 shows the relationship between major trauma (ISS>15 or activated a multidisciplinary trauma team) and trauma death. It shows that major trauma patients during 2019 to 2021 are much higher than those during 2016 to 2018 but the trauma deaths are much lower. In

2018, a total of 1913 trauma patients were admitted to the author's hospital, including 82 major trauma patients. There were 8 trauma deaths, accounting for 9.8% of major trauma patients, and 1 patient with preventable trauma death was recognized based on regular trauma audit meetings. In 2019, 1919 trauma patients were admitted, of which 153 were major trauma patients. There were 5 trauma deaths, accounting for 3.3% of major trauma patients (P=0.00), and 1 potentially preventable trauma death was recognized (P=0.40) (Figure 2). There were no preventable or potentially preventable trauma deaths in 2020 and 2021 according to hospital regular trauma audit meetings in Table 2.

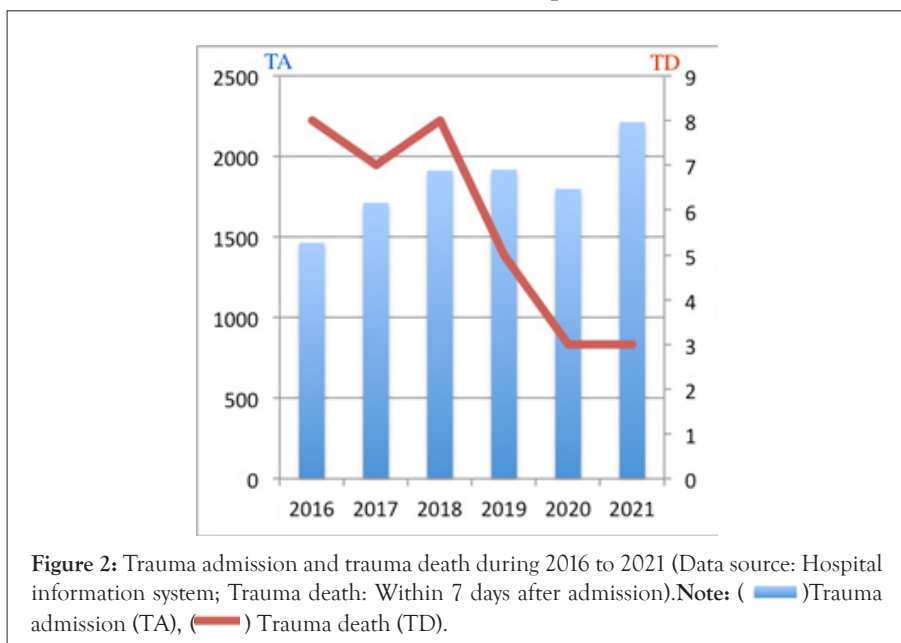
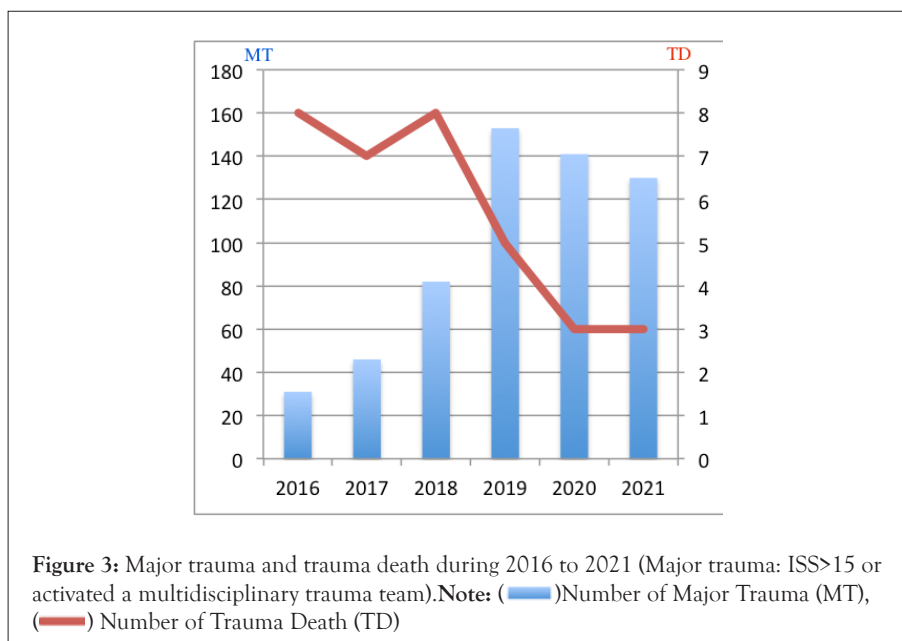


Table 2: Demographic data and outcomes of trauma services during January 2018-December 2019.

	January 2018–December 2018				January 2019–December 2019			P ₁	P ₂
	1913 patients	82 MTP (4.3%*)	8 Deaths (9.8%**)	1 PDP	1919 patients	153 MTP (8.0%*)	5 Deaths (3.3%**)	PPDP	0.000 0.401
Gender	Male 1157 (60.5%)	Male 58 (70.7%)	Male 7 (87.5%)	Male 1 (100%)	Male 1183 (61.6%)	Male 121 (70.7%)	Male 4 (80.0%)	Male 1 (100%)	0.152 0.641
	Female 756 (39.5%)	Female 24 (29.3%)	Female 1 (12.5%)		Female 736 (38.4%)	Female 32 (29.3%)	Female 1 (20.0%)		
Mean age (years)	38.48 (SD 22.86)	41.17 (SD 21.23)	41.63 (SD17.64)	32	39.58 (SD 22.13)	37.13 (SD 18.48)	29 (SD16.45)	50	0.000 0.000
Mechanism of Injury	1804 Blunt (94.3%)	56 Penetrating (2.9%)	53 Burn (2.8%)		1747 Blunt (91.0%)	99 Penetrating (5.2%)	73 Burn (3.8%)		0.580 0.046
MEDIAN ISS (IQR)		29 (IQR 20)	59 (IQR 25)	29		21 (IQR 17)	66 (IQR 10)	30	0.000 0.000
Cause of death									
Neurological			6 (75%)				2 (40%)		
Hypovolemic shock				1 (12.5%)			2 (40%)		
Multiorgan failure			0				0		0.293
Respiratory cardiac			1 (12.5%)				0		
Hypovolemic shock with Myocardial infarction								1 (20%)	

ISS: Injury Severity Score; MTP: Major Trauma Patient (ISS>15 or activated a multidisciplinary trauma team); PDP: Preventable Death Patient. * Proportion from the entire patient group, ** proportion from the MTP group, P1: MTP between January 2018-December 2018 and January 2019-December 2019, P2: Deaths between January 2018-December 2018 and January 2019-December 2019.



12 Guidelines for a standardized trauma center

During this study, 12 guidelines were identified in author's institution as necessary components to constitute a standardized trauma center, as stated in Table 3. These guidelines are to set up: pre-notification and trauma call-out system, trauma team activation criteria, multidisciplinary trauma team, trauma resuscitation bay, systematic resuscitation approach, trauma service manual, definitive trauma care capacity, trauma care in ICU, trauma ward organization, trauma audit meeting, hospital trauma committee, teaching and research.

Table 3: 12 Guidelines for a standardized trauma center.

12 Guidelines	How we do it
1. Prenotification and trauma call-out system	Continuous group calling computer-based information system
2. Trauma team activation criteria	Making it a chest card and carrying
3. Multidisciplinary trauma team	General surgery, AandE, Anaesthesia, ICU, orthopaedic, radiology
4. Trauma resuscitation bay	Ceiling X-ray, ultrasound, URBC, resuscitative operation capacity, etc.
5. Systematic resuscitation approach	Obtained training from the ATLS® course
6. Trauma service manual	Covering all the key information for the trauma center
7. Definitive trauma care capacity	Trauma team leader from the department of surgery
8. Trauma care in ICU	Two teams approach: Surgery+ICU
9 Trauma ward organization	Trauma surgery and acute care surgery
10. Trauma audit meeting	An effective method of trauma quality improvement
11. Hospital Trauma committee	Support trauma centre development
12. Teaching and research	Making a trauma centre stronger

Note: URBC: Uncross Matched Red Blood Cell

DISCUSSION

ATLS® has been developed by the ACS Committee on Trauma for over 40 years and has driven the development of trauma science worldwide. Many studies have shown that ATLS® has a positive impact on preventable and potentially preventable deaths [12-16]. In HKU-SZH, trauma admissions increased overall from 2016 to 2021, especially for major trauma patients. The trauma death decreased significantly from 2019 to 2021 compared to 2016 to 2018, which was mainly due to the organization of the multidisciplinary trauma team and the formal establishment of the trauma center in November 2018. All trauma team members received ATLS® training, and the ATLS® “common language” was adopted as the early management principle. The timely response of the trauma team and the well-organized trauma resuscitation and following definitive care play a major role in the improvement in 2019. Trauma resuscitation bays are the first place for trauma reception and resuscitation. It is a real patient-centered stage, and all life-saving diagnostic and treatment equipment needs to be around the patient, such as airway trolleys, ventilators, warm liquids, ultrasound machines, X-ray equipment, and uncrossmatched RBCs. Dr. Parlak and Dr. Enayati reported the application of radio frequency identification equipment in the resuscitation bay to better gather trauma teams and to facilitate the trauma resuscitation process [17,18]. In Denver Hospital and UC San Diego Hospital, both hospitals used operation room suites as unique trauma resuscitation bays according to the “Golden Hour” principle [19,20]. Two studies focused on CT scanners localized in the trauma resuscitation bay, with one study showing no reduction in time to CT scan compared to an earlier CT scanner next to the trauma room [21,22]. Another study suggested that if new emergency departments are planned or rebuilt, the CT scanner should be placed less than 50 m away from the trauma room or preferably in the trauma room. In Japan, two studies reported that CT scanners, Interventional Radiology (IVR) equipment, and surgical operation capacity were combined to establish a hybrid emergency room system with positive outcomes [23,24]. Doctors who work in the trauma resuscitation bay need to obtain the systematic resuscitation approach and skills from the ATLS® course, which propagates in more than 80 countries or regions [25]. It is recommended that ATLS® courses or other equivalent

courses be provided to local doctors.

During this study, “12 Guidelines” for a standardized trauma center were identified. The prenotification and trauma call-out system can pass patients’ key information to all trauma team members, even patients still in a prehospital environment or on the way to the hospital. It is crucial that the trauma team know the patient is coming and to organize necessary work beforehand. Carrying a chest card with trauma team activation criteria will facilitate the triage and trauma care process; furthermore, it will make people feel they are part of the trauma center and strengthen team cohesion. A multidisciplinary trauma team will maximize the resuscitation efficiency, shorten the management process, and lead to the best resuscitation outcome, especially for severely and critically injured patients. On the other hand, many human resources and physical resources are needed to organize this process, and strong support from the hospital level is absolutely necessary.

A standardized trauma center needs to develop its trauma service manual to provide guidelines for the staff to follow. It can help ensure that the whole team follows the same protocol and management procedure to maintain the expected quality. The trauma services manual can not only provide necessary information to new staff and visited scholars or guests but can also give people a positive and academic impression of the trauma center. The ACS “Resources for Optimal Care of the Injured Patient” is the ideal guideline for trauma center development [26]. The trauma team is usually led by a general surgeon who finished his training in general surgery plus 1–2 years in trauma surgery and surgical critical care.

In the ICU, the two-team approach is the standard care for trauma patients. Every day, the trauma team performs the ward round and meets with the ICU team and discusses the treatment plan for every individual trauma patient. This is the way many famous international trauma centers have been operating and is also the way we have been operating. In the 1990s, a new subspecialty started to appear in the United States: Trauma and Acute Care Surgery. Prof. Maier noted in his presidential address at the 61st Annual Meeting of the American Association for the Surgery of Trauma that “The number of Level I and Level II trauma centers should be based on the needs of patients; duplication of high-level trauma centers dilutes the patient volume and leads to unreasonable competition and resource allocation. It also limits the trauma science development capacity of the region” [27,28]. This may be the main reason why this new subspecialty appeared, because surgeons need reasonable operation practice to maintain their skills if the trauma patient volume is not large enough. Currently, many famous trauma centers worldwide have adopted and set up this sustainable subspecialty [25]. Trauma and acute care surgery are usually mixed together with surgical critical care.

Trauma audit meetings have been used around the world as an effective way to improve trauma quality. It is a way to determine what needs to be improved during trauma care for any trauma death or severe trauma patients and to develop further action for further quality improvement. A study performed recently in author’s institution also demonstrated that trauma audit meetings are helpful to improve trauma care and lead to a reduction in preventable death in multiple injured patients [29]. The running of the trauma center needs strong support and authorization from the hospital management committee. It is also essential to obtain support from different chiefs of service.

Limitation and strength

Although data collection is promising in this study, there is a lack of information in 2016 and 2017 due to inadequate documentation and non-dedicated trauma registry. The number of major trauma and trauma death in this study is relatively small, which may lead to possible bias in calculations and comparisons. However, this study shows how a newly trauma center has been developed with different necessary components in a developing country, which may bring value information for other similar settings where a trauma center is planned.

CONCLUSION

Although the construction and operation of a standardized trauma center may be different in a developing country versus a developed country due to resources allocation, many concepts and principles about running a trauma center should be very much the same. Standardized trauma center decreases trauma mortality. The guidelines for a standardized trauma center in this study have been proven to be successful examples. This practical approach can be replicated in other hospitals seeking to establish a trauma center. The effectiveness of this study has been demonstrated, and there is value in extending it to other parts of mainland China.

DECLARATIONS

Compliance with ethical standards

Ethical approval

This study was approved by the Ethics Committee of HKU-SZH, as well as the Chinese PLA Medical School (Reference Lun (2016) 45).

Competing interests

The authors declare that there are no competing interests.

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