



Contents lists available at ScienceDirect

Chinese Journal of Traumatology

journal homepage: <http://www.elsevier.com/locate/CJTEE>

Original Article

Application of trauma time axis management in the treatment of severe trauma patients

Liang Wang, Xiong-Hui Chen^{*}, Wei-Hua Ling, Long-Gang Wang, Heng-Feng Chen, Zheng-Jie Sun, Peng Yang, Feng Xu

Department of Emergency Surgery, First Affiliated Hospital of Soochow University, Suzhou, 215000, Jiangsu Province, China

ARTICLE INFO

Article history:

Received 18 August 2020
 Received in revised form
 17 November 2020
 Accepted 29 November 2020
 Available online 5 December 2020

Keywords:

Trauma centers
 Quality control
 Emergency treatment
 Medicalsystem trauma system

ABSTRACT

Purpose: This study aimed at exploring the application of trauma time axis management in the treatment of severe trauma patients by using the Medicalsystem trauma system.

Methods: We performed a retrospective cohort study involving patients with severe trauma. Patients who were admitted before the application of the Medicalsystem trauma system were divided into before system group; patients who were admitted after the application of the system were divided into after system group. Comparison was made between the two groups. For normally distributed data, means were reported along with standard deviation, and comparisons were made using the independent samples *t* test. Categorical data were compared using the Chi-square test. The Mann-Whitney *U* test was used to compare nonparametric variables.

Results: There were 528 patients admitted to the study during the study period. There was no significant statistical difference in the time from the start of trauma team to arrive at the resuscitation room between the two groups. The time from arrival at hospital to endotracheal intubation, to ventilator therapy, to blood transfusion, to completion of CT scan, to completion of closed thoracic drainage, to the start of operation, as well as the length of stay in resuscitation room and hospital were significantly lower after the application of the Medicalsystem trauma system. The mortality was decreased by 8.6% in the after system group compared with that in the before system group, but there was no statistical difference.

Conclusion: The Medicalsystem trauma system can optimize diagnosis and treatment process for trauma patients, and accordingly improve the treatment efficiency and shorten the treatment time. Therefore, the Medicalsystem trauma system deserves further popularization and promotion.

© 2020 Chinese Medical Association. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

With the rapid development of modern society, high-energy injuries caused by traffic accidents, falling, crushing, collapsing and natural disasters occur frequently. Trauma has been the third leading cause of death, the number one cause of death for people aged 1–44 years, and also an important factor for disability.¹ Severe trauma is often the injury of multiple anatomical parts and organs caused by high energy. This kind of trauma has a great influence on the patients' whole body physiological condition, which is easy to

miss diagnosis and difficult to treat. If the wounded can not be treated promptly and effectively, it may endanger life.² At present, most hospitals in China still adopt the mode of specialist consultation. In the treatment process, each specialist only focuses on the injured part of his own specialty. There are some disadvantages such as poor treatment timeliness and patients stranded in the emergency room.³

In recent years, various regions in China have been exploring new ideas and methods for the treatment of severe trauma, and the construction of trauma care center is one of the major measures.⁴ Since our hospital became the provincial trauma center in December 2016, the treatment effect of severe trauma patients has been significantly improved. The emergency treatment of severe trauma involves the coordination and cooperation of multiple disciplines and specialties. The principle of "fast, accurate, correct

^{*} Corresponding author.

E-mail addresses: docxhchen@163.com, xhchen2020@163.com (X.-H. Chen).

Peer review under responsibility of Chinese Medical Association.

and effective” must be followed in emergency treatment, among which “fast and effective” is the embodiment of the timeliness of emergency treatment.⁵ At present, most general hospitals in China cannot share the information of patients effectively and timely among pre-hospital first aid, in-hospital emergency, and surgical specialties. This is not conducive to the treatment of trauma patients, the quality control of trauma care center and continuous improvement of medical quality.⁶ In order to further improve the treatment efficiency and shorten the treatment time of severe trauma patients, our hospital introduced the Medicalsystem trauma system. The Medicalsystem trauma system provides the time records of the whole process including pre-hospital first aid, emergency room, operating room, ICU and trauma ward treatments. It forms a time axis and records the whole treatment process of patients. More importantly, it can provide data for the quality control of trauma care center and support for the improvement of diagnosis and treatment process.

Methods

Trauma center model and treatment process in our hospital

The trauma care center of our hospital is the first batch of trauma treatment centers certified by China Trauma Treatment Alliance and the Provincial Trauma Care Center of Jiangsu Province. Our trauma care center has established a multidisciplinary collaborative treatment platform with the emergency department as the core. We have realized the seamless connection of all treatment stages from pre-hospital to in-hospital by standardizing the treatment process settings. Therefore, severe trauma patients can receive the best integrated and team-oriented treatment so as to improve the outcome of patients in the shortest possible time.

The trauma center team consists of pre-hospital first aid team, emergency surgery team and specialist team. The trauma care center team strictly implements the duty team leader responsibility system, and the duty team leader must be a doctor with the title of associate chief physician or above and rich experience in emergency. Members include specialists in emergency surgery, neurosurgery, general surgery, cardiothoracic surgery, orthopedics and ICU.

When receiving severe trauma patients, the pre-hospital rescuers will transmit the patients’ information to the hospital through the vehicle-mounted information linkage system so that in-hospital emergency department can have a certain understanding of the patients’ conditions and make appropriate preparations. After receiving the pre-hospital warning signal, the emergency surgeons learned about the patient’s injury in advance, and determined the next emergency measures to be taken according to the patient’s injury information. While the relevant personnel, equipment and materials get ready, the emergency surgeons call the corresponding trauma treatment team members

to arrive at the emergency room in advance and wait for the arrival of patients through the hospital call system. After severe trauma patients are delivered to the hospital, the emergency surgeon promptly judge patients’ condition and commence managing life-threatening injuries according to the principle of “ABCDE”.^{7,8} If there are serious fatal conditions such as severe shock, active bleeding, brain hernia, pericardial tamponade, big blood vessel rupture, etc., the specialists of the trauma treatment team will carry out life-saving operation in the operating room. The examination, diagnosis and treatment should be carried out simultaneously as fast as possible so that the patients can be actively and effectively treated in the shortest time, and the patients can enter the operating room, ICU or special ward as soon as possible.⁹

Medicalsystem trauma system

The Medicalsystem trauma system can realize the digital upgrade of rescue links including emergency vehicle, emergency department, CT room, operating room, ICU and specialized ward, and achieve the purpose of automatic real-time recording diagnosis and treatment data in the treatment process; moreover, it can reduce the trouble of manual supplementary recording after medical treatment. The system completes the collection and transmission of the patient’s vital signs on the vehicle side, and uses the wireless network and the audio and video technology to complete a joint consultation with the doctors in hospital. By setting up timers for medical devices and installing unified clock for client terminals, the time at all sites of the trauma diagnosis and treatment link can be unified. When the patient enters the resuscitation room or trauma recovery room, radio frequency identification devices (RFID) (Fig. 1) on the wristband is bound to automatically record each key time point. The system will extract the holographic data of patients’ treatment, including pre-hospital emergency, emergency disposal, emergency surgery, hospitalization and rehabilitation, which can form a trauma data analysis center and provide the basis for continuous improvement of the trauma care center.

Quality control index of trauma axis

The Medicalsystem trauma system shares data with HaiTai system in the inpatient department, so the following 25 quality control indexes can be extracted and recorded in real time. The quality control indexes can provide data for the quality control of trauma care center and support for improvement of diagnosis and treatment process.

Quality control indexes recorded by the Medicalsystem trauma system included:

- (1) Number of severe trauma (ISS ≥16)
- (2) Average time of pre-hospital emergency treatment



Fig. 1. Radio frequency identification devices (RFID) wristband is automatically record each key time point. (A) The RFID wristband is bound to the patient’s ID card information. (B) There is a QR code on the RFID wristband for quick identification by scanning the code. (C) In each link of the patient’s treatment, the RFID wristband automatically records the time and summarizes it into the Medicalsystem trauma system.

- (3) Pre-hospital arrival time (alarm time - arrival time)
- (4) Time of pre-hospital information transmitted to a target hospital
- (5) Time from pre-hospital alarm time to arrival time of a target hospital
- (6) Time from the start of trauma team to arrive at the resuscitation room
- (7) Time from arrival at hospital to endotracheal intubation
- (8) Time from arrival at hospital to ventilator therapy
- (9) Time from arrival at hospital to blood transfusion
- (10) Time from arrival at hospital to completion of CT scan
- (11) Time from arrival at hospital to completion of closed thoracic drainage
- (12) Time from arrival at hospital to determine the diagnosis of fatal injury
- (13) Time from arrival at hospital to the start of operation
- (14) Length of stay in resuscitation room
- (15) Rehabilitation treatment time
- (16) Number and proportion of severe trauma patients infected (wounds, lungs)
- (17) Length of stay in ICU, length of stay in hospital
- (18) Hospitalization expenses
- (19) Operation frequency during hospitalization
- (20) Duration of ventilator use and incidence of ventilator-associated pneumonia
- (21) Success rate of rescue and mortality
- (22) Coincidence rate between admission diagnosis and discharge diagnosis
- (23) Annual number of trauma patients admitted
- (24) Proportion of patients referred from other hospitals
- (25) Proportion of trauma patients requiring referral

During the construction of provincial trauma care centers, we attached great importance to trauma time axis management. All members of the trauma care center have a meeting to analyze and summarize the quality control indexes every two months. The quality control indexes we focus on include: time from the start of trauma team to arrive at the resuscitation room, time from arrival at hospital to endotracheal intubation, time from arrival at hospital to ventilator therapy, time from arrival at hospital to blood transfusion, time from arrival at hospital to completion of CT scan, time from arrival at hospital to completion of closed thoracic drainage, time from arrival at hospital to the start of operation, and the stay time in resuscitation room. Through the research and summary of the quality control indicators, we find the problems in the treatment process and solutions so that we can constantly optimize the process and shorten the treatment time.

Problems and solutions in the treatment of severe trauma patients

- (1) There are often many patients in the emergency room. Doctors and nurses are easily affected by the surrounding conditions during the rescue process. Therefore, trauma care center has established a trauma resuscitation room with specialized nurses and the necessary bedside examination equipment.
- (2) Some surgeons are unskilled and non-standard in the trauma treatment, so the trauma care center continuously strengthens the standardized training for team members, and some members have become trauma treatment training in-structors.
- (3) It takes a long time for severe trauma patients to transfuse blood in accordance with the routine transfusion procedure, so an emergency non-homogenous transfusion system has been established. The emergency room should routinely prepare a certain unit of whole blood of type O to meet the needs of emergency transfusion for severe trauma patients. In this way, the transfusion time was significantly shortened.
- (4) Some bedside skills require specialist consultation and operation, which increases the time for trauma treatment. Therefore, every doctor in trauma care center must be proficient in endotracheal intubation, focused assessment of trauma by sonography, closed thoracic drainage, and deep vein catheterization.

Trauma time axis management

We used the Medicalsystem trauma system to implement full-process time axis management for patients with severe trauma. The system will record each diagnosis and treatment time nodes of severe trauma patients from pre-hospital to discharge in real time, and establish trauma database to complete the quality control. Fig. 2 shows the treatment time axis of a severe trauma patient, from which the patient's treatment process from pre-hospital to discharge can be clearly seen.

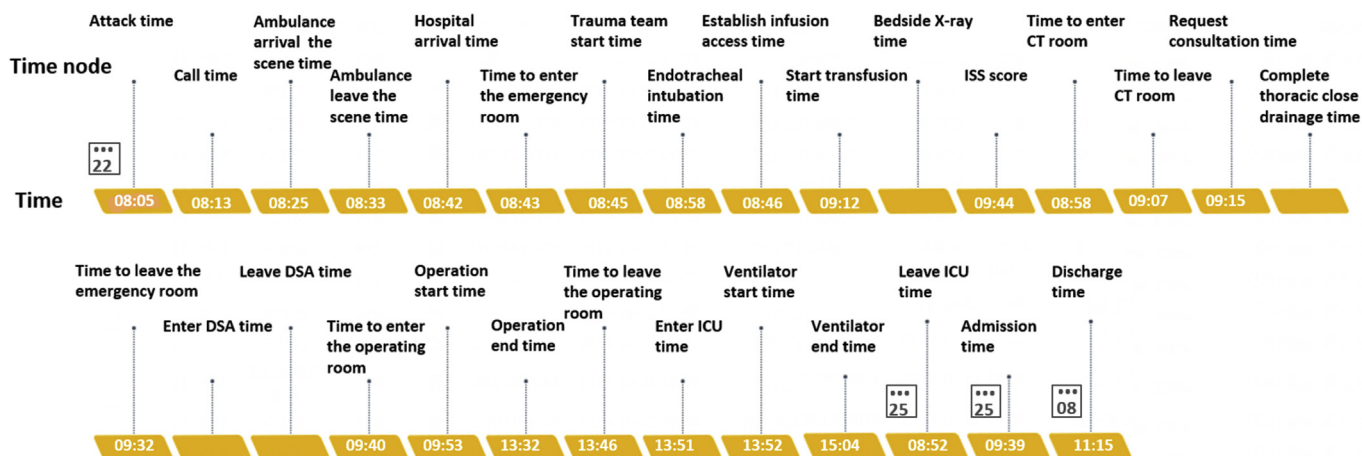


Fig. 2. Treatment time axis of a severe trauma patient.

- (5) Many emergency operations require the consultation and treatment by corresponding specialists. In order to further shorten the treatment time, emergency surgeons can carry out emergency operations by themselves such as brain hernia, liver rupture, spleen rupture, intestinal rupture, etc.
- (6) Since patients with severe trauma often have to wait for surgery, a green channel was opened for these patients, which significantly shortened the waiting time for surgery.
- (7) Trauma patients could not be admitted to the ward in time because of the shortage of beds in our hospital, so the trauma care center stipulated that the trauma ward and trauma ICU must vacate 4 beds for trauma patients every day.

Comparing the quality control indexes of severe trauma patients before and after 6 months' application of the Medimalsystem trauma system

We performed a retrospective cohort study involving patients with severe trauma who were admitted to the First Affiliated Hospital of Soochow University from November 2018 to October 2019. Patients who were admitted before the application of the Medimalsystem trauma system (from November 2018 to April 2019) were divided into before system group. Patients who were admitted after the application of the system (from May 2019 to October 2019) were divided into after system group. The data was obtained from the Medimalsystem trauma system.

Inclusion criteria for the patients in this study were as follows: (1) Injury Severity Score (ISS) ≥ 16, age ≥ 16 years; (2) time from the trauma to arrive at the resuscitation room ≤ 24h; (3) first diagnosis made in our hospital after trauma. Exclusion criteria for the patients in this study were as follows: (1) ISS < 16, age < 16 years; (2) the first visit in another hospital after trauma, then transferred to our hospital; (3) pregnancy women.

Statistical analysis

Statistical analysis was performed by using SPSS 25.0 (IBM, Armonk, NY). For normally distributed data, means were reported along with standard deviation (SD), and comparisons were made using the independent samples *t*-test. Categorical data were compared using the chi-square test. The Mann-Whitney U test was used to compare nonparametric variables. A *p*-value of less than 0.05 was considered statistically significant.

Results

There were 528 patients admitted to the study during the study period. There were no significant statistical differences between the two groups in age, gender, mechanism of injury, ISS (Table 1). There was no significant statistical difference in the time from the

Table 1
Comparison of the demographic and clinical characteristics of patients between the two groups.

Variables	Before system (n = 257)	After system (n = 271)	<i>p</i> value
Age (mean ± SD) (years)	45.2 ± 14.5	46.5 ± 15.1	0.37
Gender (male/female)	168/89	171/100	0.59
Mechanism of injury (%)			0.86
Traffic related injuries	65.0	67.2	
Fall from height	21.7	20.3	
Fall of heavy object	1.9	2.2	
Blow or assault	5.8	6.6	
Others	5.5	3.7	
ISS	27.5 ± 8.6	28.1 ± 9.2	0.49

start of trauma team to arrive at the resuscitation room between the two groups. The time from arrival at hospital to endotracheal intubation, to ventilator therapy, to blood transfusion, to completion of CT scan, to completion of closed thoracic drainage, to the start of operation, as well as the length of stay in resuscitation room and hospital were significantly lower after the application of the Medimalsystem trauma system than before. The mortality was decreased by 8.6% in the group after application of the Medimalsystem trauma system compared with that in the group before the system application, but there was no statistical difference (Table 2).

Discussion

Studies have shown that 50% of traumatic deaths occur within 1 h after accident, indicating that traumatic rescue is significantly time-dependent.^{10,11} How to evaluate trauma objectively and accurately in the shortest time and perform effective treatment has become an eternal topic in the field of traumatology.^{12,13} In recent decades, Chinese medical personnel have made unremitting exploration and efforts to achieve this goal. Although they have made gratifying achievements, there is still a certain gap compared with developed countries, especially the timeliness of emergency care.^{14,15} The timeliness of severe trauma means that severe trauma patients can achieve the best results through corresponding measures within the “time window”. Once the time is delayed or exceeds the “time window”, patients may lose the best treatment opportunity, and mortality and the incidence of complications will greatly be increase.¹⁶

The idea that trauma is a time-dependent disease is widely accepted by trauma medical workers. In the emergency treatment of patients with severe trauma, Physicians must recognize the relationship between the effect of first aid and time. “Time is life, time is speed” explains the general requirements of traumatology.^{17,18} It consist of a correct and effective treatment in the shortest time, especially the first aid, injury assessment, preoperative examination and preparation in the shortest time.^{19,20}

The Medimalsystem trauma system is a solution to achieve the purpose of automatic real-time recording of diagnosis and treatment data in the treatment process, and reduce the trouble of manual supplementary recording after medical treatment. The most important thing is to establish trauma database and complete the quality control and management of each data. We analyze the trauma database and strengthen the management of the trauma time axis to find problems in the treatment process and find solutions to continuously optimize the process. Through the analysis of quality control indexes, it is found that after strengthening the time axis management, time from arrival at hospital to endotracheal intubation, time from arrival at hospital to ventilator therapy, time from arrival at hospital to blood transfusion, time from arrival at hospital to completion of CT scan, time from arrival at hospital to completion of closed thoracic drainage, time from arrival at hospital to the start of operation, and the length of stay in resuscitation room were significantly lower than those before the application of the Medimalsystem trauma system. By doing so we can see that the treatment effect of patients with severe trauma has been significantly improved.

The Medimalsystem trauma system shares data with HaiTai system in the inpatient department, so 25 quality control indexes can be extracted and recorded in real time. The quality control indexes can provide data for the quality control of trauma care center and support for the improvement of diagnosis and treatment process. The time concept of emergency treatment for severe trauma can be developed from a faster and better qualitative process to a precise quantitative process through the Medimalsystem trauma system. With the application of Medimalsystem trauma system, the

Table 2
Comparison of quality control indexes before and after applying the Medicalsystem trauma system.

Quality control indexes	Before system	After system	Decreasing amplitude (%)	p value
Time from the start of trauma team to arrive at the resuscitation room (min)	4.5 ± 2.1 (n = 257)	4.2 ± 2.7 (n = 271)	6.7	0.16
Time from arrival at hospital to endotracheal intubation (min)	22.8 ± 8.4 (n = 121)	16.1 ± 6.2 (n = 147)	29.4	<0.001
Time from arrival at hospital to ventilator therapy (min)	24.1 ± 9.7 (n = 103)	17.8 ± 9.1 (n = 129)	26.1	<0.001
Time from arrival at hospital to blood transfusion (min)	39.5 ± 17.4 (n = 166)	28.2 ± 14.8 (n = 184)	26.3	<0.001
Time from arrival at hospital to completion of CT scan (min)	39.6 ± 23.2 (n = 241)	30.8 ± 17.8 (n = 263)	22.2	<0.001
Time from arrival at hospital to completion of closed thoracic drainage (min)	51.3 ± 27.1 (n = 89)	37.4 ± 22.5 (n = 95)	27.1	<0.001
Time from arrival at hospital to start of operation (min)	85.8 ± 39.2 (n = 187)	59.4 ± 31.5 (n = 219)	30.1	<0.001
Length of stay in resuscitation room (h)	4.5 ± 1.8 (n = 257)	2.8 ± 1.2 (n = 271)	37.8	<0.001
Length of stay in hospital (d)	15.6 ± 4.2 (n = 257)	13.3 ± 3.7 (n = 271)	14.7	<0.001
Mortality (%)	9.3 (n = 257)	8.5 (n = 271)	8.6	0.76

treatment effect of patients with severe trauma has been improved. The length of stay in hospital was significantly lower than those before the application of the system. The mortality decreased by 8.6%, but there was no statistical difference. With the further increase of the sample size in the follow-up study and the further improvement of trauma treatment, the mortality rate will be further reduced.

Although the treatment effect of patients with severe trauma has been improved, there is still a big gap compared with developed countries in Europe and the United States, especially the pre-operative preparation time and the length of stay in resuscitation room, which is related to China's national conditions.^{21,22} There are more elective operations in many tertiary medical centers in China, and less operating rooms are reserved for emergency patients with severe trauma, which eventually leads to the result that these patients can not be operated at the first time. The trauma wards and trauma ICU beds in many tertiary medical centers can not meet the needs of more and more trauma patients, resulting in more time for patients staying in the emergency room.²³ We believe that with administrative support and government funding stimulation, more operating rooms and ICU beds in trauma centers will be set up for amelioration of these patients' treatment.

Both government departments and medical institutions in China have realized the importance of severe trauma treatment and trauma care center construction, and increased economic input to provide stronger guarantee for the treatment of severe trauma patients.²⁴ On December 7, 2019, the National Health Commission set up the national trauma care center with Peking University People's Hospital as the main body, which was the first time to set up a medical center in the field of trauma. The national trauma care center began to promote the establishment of regional trauma care system so as to further improve the ability of trauma treatment, and reduce the mortality and disability rate of trauma patients.²⁵

In conclusion, the Medicalsystem trauma system provides the time records of the whole process from rescue, observation, ICU to the ward, which forms a time axis and records the whole treatment process. Moreover, the system can provide data for the quality control of trauma care center and support for the improvement of diagnosis and treatment process. The system can optimize diagnosis and treatment process for trauma patients, and accordingly improve the treatment efficiency and shorten the treatment time. Therefore, the Medicalsystem trauma system deserves further popularization and promotion.

Funding

This work was supported by China Scholarship Council(CSC NO. 202006920081); Jiangsu Provincial Medical Youth Talent, China (QNR2016724); Natural Science Research of Jiangsu Higher Education Institutions of China (18KJB320016); Basic Research on Medical and Health Application of the People's Livelihood Science

and Technology Project of Suzhou Science and Technology Bureau (SYS2020102).

Ethical statement

The ethical committee of hospital approved this study.

Declaration of competing interest

The authors declare that they have no competing interests.

References

- Su D, Chen Y, Gao H, et al. Does county-level medical centre policy influence the health outcomes of patients with trauma transported by the emergency medical service system? an integrated emergency model in rural China. *Int J Environ Res Publ Health*. 2019;16(1):133. <https://doi.org/10.3390/ijerph16010133>.
- Jiang B. The challenges faced in the field of trauma care in China. *Zhonghua Wai Ke Za Zhi*. 2015;53:401–404. <https://doi.org/10.3760/cma.j.issn.0529-5815.2015.06.001>.
- Zhang LY, Zhang XZ, Bai XJ, et al. Current trauma care system and trauma care training in China. *Chin J Traumatol*. 2018;21:73–76. <https://doi.org/10.1016/j.cjtee.2017.07.005>.
- Liu T, Bai XJ. Trauma care system in China. *Chin J Traumatol*. 2018;21:80–83. <https://doi.org/10.1016/j.cjtee.2017.06.004>.
- Yin XF, Wang TB, Zhang PX, et al. Evaluation of the effects of standard rescue procedure on severe trauma treatment in China. *Chin Med J*. 2015;128:1301–1305. <https://doi.org/10.4103/0366-6999.156768>.
- Ford K, Menchine M, Burner E, et al. Leadership and teamwork in trauma and resuscitation. *West J Emerg Med*. 2016;17:549–556. <https://doi.org/10.5811/westjem.2016.7.29812>.
- Dehli T, Monsen SA, Fredriksen K, et al. Evaluation of a trauma team activation protocol revision: a prospective cohort study. *Scand J Trauma Resuscitation Emerg Med*. 2016;24:105. <https://doi.org/10.1186/s13049-016-0295-3>.
- Waterford SD, Williams M, Siegert CJ, et al. Trauma education in a state of emergency: a curriculum-based analysis. *J Surg Res*. 2015;197:236–239. <https://doi.org/10.1016/j.jss.2015.03.002>.
- Zong ZW, Li N, Cheng TM, et al. Current state and future perspectives of trauma care system in mainland China. *Injury*. 2011;42:874–878. <https://doi.org/10.1016/j.injury.2010.09.034>.
- Bosson N, Kaji AH, Gausche-Hill M, et al. Evaluation of trauma triage criteria performance in a regional trauma system. *Prehosp Emerg Care*. 2019;23:828–837. <https://doi.org/10.1080/10903127.2019.1588444>.
- Garwe T, Cowan LD, Neas B, et al. Survival benefit of transfer to tertiary trauma centers for major trauma patients initially presenting to nontertiary trauma centers. *Acad Emerg Med*. 2010;17:1223–1232. <https://doi.org/10.1111/j.1553-2712.2010.00918>.
- Kotwal RS, Howard JT, Orman JA, et al. The effect of a golden hour policy on the morbidity and mortality of combat casualties. *JAMA Surg*. 2016;151:15–24. <https://doi.org/10.1001/jamasurg.2015.3104>.
- Jochems D, Leenen LPH, Hietbrink F, et al. Increased reduction in exsanguination rates leaves brain injury as the only major cause of death in blunt trauma. *Injury*. 2018;49:1661–1667. <https://doi.org/10.1016/j.injury.2018.05.012>.
- Hietbrink F, Houwert RM, van Wessel KJP, et al. The evolution of trauma care in The Netherlands over 20 years. *Eur J Trauma Emerg Surg*. 2019;46:329–335. <https://doi.org/10.1007/s00068-019-01273-4>.
- Moore L, Evans D, Hameed SM, et al. Mortality in Canadian trauma systems: a multicenter cohort study. *Ann Surg*. 2017;265:212–217. <https://doi.org/10.1097/SLA.0000000000001614>.
- Murdoch D. Trauma: when there's no time to count. *AORN J*. 2008;87:322–328. <https://doi.org/10.1016/j.aorn.2007.07.008>.

17. Russo A. Negative and positive prognostic factors in polytrauma, especially referring to "golden hour". *Ann Ital Chir.* 2009;80:337–349.
18. Linder F, Holmberg L, Eklof H, et al. Better compliance with triage criteria in trauma would reduce costs with maintained patient safety. *Eur J Emerg Med.* 2019;26:283–288. <https://doi.org/10.1097/MEJ.0000000000000544>.
19. Mutschler W, Mutschler M, Graw M, et al. Long-term survival after severe trauma. *Unfallchirurg.* 2016;119:546–553. <https://doi.org/10.1007/s00113-016-0185-1>.
20. Vallier HA, Moore TA, Como JJ, et al. Teamwork in trauma: system adjustment to a protocol for the management of multiply injured patients. *J Orthop Trauma.* 2015;29:e446–e450. <https://doi.org/10.1097/BOT.0000000000000383>.
21. Caputo LM, Salottolo KM, Slone DS, et al. The relationship between patient volume and mortality in American trauma centres: a systematic review of the evidence. *Injury.* 2014;45:478–486. <https://doi.org/10.1016/j.injury.2013.09.038>.
22. van der Vliet QMJ, van Maarseveen OEC, Dpj Smeeing, et al. Severely injured patients benefit from in-house attending trauma surgeons. *Injury.* 2019;50:20–26. <https://doi.org/10.1016/j.injury.2018.08.006>.
23. Wang Y, Liu HX, Wang YH, et al. Establishment of trauma treatment teams within a regional severe trauma treatment system in China: study protocol for a national cluster-randomised trial. *BMJ Open.* 2018;8, e023347. <https://doi.org/10.1136/bmjopen-2018-023347>.
24. Cole E, Lecky F, West A, et al. The impact of a pan-regional inclusive trauma system on quality of care. *Ann Surg.* 2016;264:188–194. <https://doi.org/10.1097/SLA.0000000000001393>.
25. Consensus on the establishment of urban trauma rescue system in China. *Zhonghua Wai Ke Za Zhi.* 2017;55:830–833. <https://doi.org/10.3760/cma-j.issn.0529-5815.2017.11.002>.