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Review Article

Trauma care construction under the guidance of county-level trauma centers

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ABSTRACT

Severe trauma has the characteristics of complicated condition, multiple organs involved, limited auxiliary examinations, and difficulty in treatment. Most of the trauma patients were sent to primary hospitals to receive treatments. But the traditional mode of separate discipline management can easily lead to delayed treatment, missed or wrong diagnosis and high disability, which causes a high mortality in severe trauma patients. Therefore, if the primary hospitals, especially county-level hospitals (usually the top general hospital within the administrative region of a county), can establish a scientific and comprehensive trauma care system, the success rate of trauma rescue in this region can be greatly improved. On March 1st, 2013, Tiantai People's Hospital of Zhejiang Province, China set up a trauma care center, which integrated the pre-hospital and in-hospital trauma treatment procedures, and has achieved good economic and social benefits. Till March 1st, 2017, 1265 severe trauma patients (injury severity score >16) have been treated in this trauma center. The rescue success rate reached 95% and the delayed and/or missed diagnosis rate was less than 5%. Totally 86 severe cases of pelvic fractures with unstable hemodynamics were treated, and the success rate was 92%. The in-hospital emergency rescue response time is less than 3 min, and the time from definite diagnosis to surgery is within 35 min.

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Introduction

With the rapid development of modern society, high-energy injuries caused by traffic accidents, falling, collapsing, crushing and natural disasters occur frequently, and the incidence of severe trauma remains high.^{1,2} Epidemiological data indicate that the number of traumatic injury patients worldwide is over 10 million each year, and most of them die of severe trauma. Even in the United States, which has well-developed medical and emergency care systems, trauma remains the leading cause of death in the population under the age of 45 years. In China, the number of traumatic deaths caused by various factors is more than 800,000 per year, which accounts for 10% of all death cases in the whole year and trauma ranks the fifth in the cause of death. The average death rate of severe trauma in China is 2 times higher than that in the developed countries in Europe and the United States.³ The practice

and evidence-based medicine in the developed countries in Europe and the United States have confirmed that the establishment of an integrated trauma center can significantly improve the success rate of trauma treatment.^{4,5} Primary hospitals, especially county-level hospitals, take the major responsibilities for trauma treatment in the early stage. The early treatment of trauma patients and the treatment process are directly related to the success of severe trauma rescue. At present, the departments in county-level hospitals are not capable for treatment of serious trauma alone, and the modes such as sub-section consultation and sub-section treatment easily result in delayed treatment, thus missing the best opportunities for trauma rescue, hence, it is essential to establish a scientific and effective trauma treatment system to improve the success rate of treatment. Tiantai county is a developing mountainous county, with the population of nearly 600,000 and a prefectural area of 1440 square kilometers and. The crowded Changtai Expressway runs through this county and Tiantai People's Hospital is a public tertiary level B hospital, and is most comprehensive in Taizhou county. Since March 1st, 2013, our hospital has set up a special trauma center and made an integrated reform toward the pre-hospital and in-hospital trauma treatment procedures, and has

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achieved good economic and social benefits. From March 1st, 2013 to March 1st, 2017, 1265 severe trauma patients with an ISS score higher than 16 were treated in our trauma center, with a success rate of 95% and a delayed and missed diagnosis rate less than 5%. Totally 86 cases of severe injury associated with hemodynamically unstable pelvic fractures were treated successfully, with a success rate of 92%. The in-hospital emergency treatment response time is less than 3 min, and the emergency definitive surgery is within 35 min.

Key issues for severe trauma treatment

It is well-known that the first peak of death rate in disasters, local wars or accidents occurs within 1 h after traumatic injury. At this time, the death toll accounts for 50% of the total trauma-related deaths. The lethal factors are mostly severe craniocerebral injury, high-level spinal cord injury, ruptures of heart, aortic or other large vessel, airway obstruction and so on. The second peak of death occurs in 2–4 h after injury, and the number of deaths accounts for 30% of trauma-related deaths. Causes of death are mostly massive blood loss resulted from brain, chest or abdominal blood vessels or solid organ rupture, severe multiple injuries, and severe fractures. The third peak of post-traumatic death occurs within 1–4 weeks after trauma, accounting for 20% of traumatic deaths, mostly due to severe infection, septic shock, multiple organ dysfunction syndrome and multiple organ failure.^{6–8} Since March 1st, 2013, the hospital has implemented the integrated treatment during pre-hospital and in-hospital period, and the three death peaks have obviously flattened. After the second peak (about 3–6 days after the injury), a small death peak appears, which may be related to the simplified pre-hospital and in-hospital treatment process, and the improved treatment. Therefore, for emergency trauma, the immediately effective treatment is the key to reduce the mortality of trauma patients.

Status of trauma care at home and abroad

At present, the development of trauma care system at home and abroad is not balanced. The developed countries in Europe have established consummate treatment systems, trauma centers and interdisciplinary cooperation, leading to successful establishment of three level trauma centers in rural community hospitals.⁹ The treatment model is relatively mature and the success rate of treatment is extremely high, so it has been widely recognized and promoted by international counterparts. Domestic emergency trauma patients are mostly treated in the emergency department, and the trauma treatment mode is roughly classified into three types: (1) independent type: medical staff are fixed, but most of them are the doctors majoring in internal medicine, not in traumatology; (2) alternative type: the specialists from the different department take turns in charge of emergency surgery, but most of them lack systematic knowledge of trauma care; (3) trauma-oriented type: two methods are used to direct the emergency trauma care. On one hand, nearly half of emergency doctors are trauma surgeons. On the other hand, trauma surgeons will be immediately informed to visit severe trauma patients in the emergency room (Chongqing Emergency Center). Clinical practice shows that the first two modes can take effect in triage and simple treatment, and emergency trauma care still relies on the specialist consultation, which easily leads to delayed treatment.¹⁰ The third mode is close to the trauma center construction mode, but is rare in the county-level hospitals. The problems in trauma rescue in China are as follows: (1) first-aid doctors and pre-hospital emergency doctors in primary hospitals are lack of rescue skills and knowledge about severe trauma treatment; (2) in the early emergency trauma

care period, they are prone to send severe trauma patients to higher-level hospitals, just “saving but not treating”, which extends the time for definitive treatment; (3) At present, the emergency medical network in China is still not perfect, and the information communication between pre-hospital units and emergency department is not adequate yet, leading to difficulty in timely discussion about their injury condition; (4) The emergency department of most general hospitals in China lags behind and the treatment of severe trauma is in the sub-branch treatment status from prehospital, emergency department, in-hospital separation, and simple triage^{11–15}; (5) severe trauma treatment often involves multiple sites and multidisciplinary cooperation, which has contradictions with the specialized diagnosis and treatment trend of modern hospitals. Most doctors in modern hospitals are specialists, lack of a holistic view on the diagnosis and treatment of multiple trauma.^{16–19} This often leads to repeated examination of severe trauma patients in the emergency department, delayed diagnosis and treatment, or even refusing to receive patients; (6) After admission, due to lack of trauma care knowledge and damage control concept, it may result in missed diagnosis, misdiagnosis and mistreatment, causing disability or death, which leads to medical disputes and medical accidents.^{20–22}

Despite of relatively late development of the overall domestic trauma care, the trauma care mode is also being explored and improved. Currently, some hospitals which imitate the European and American model have successfully implemented, such as Shanghai Oriental Hospital, the Southwest Hospital, the Second Hospital Affiliated to Zhejiang University. They successfully set up emergency trauma centers integrating the processes of first aid - emergency room - operating room-EICU or trauma ward for efficient treatment of severe trauma patients, which attracts much attention from trauma emergency professionals at home and abroad. Compared with the traditional model of in-hospital triage, the integrated pre-hospital and in-hospital trauma care mode greatly shortens the emergency response time, ensures effective treatment of severe trauma patients within “golden 1 h” after injury, significantly shortens the time from trauma to surgery or ICU and has achieved “early and definitive treatment”.²³ It greatly improves the quality of trauma care, and has been recognized by the domestic counterparts. A small number of grade III hospitals in China also set up specialized trauma hospitals, such as Trauma Hospital of Daping Hospital of Army Military Medical University, which greatly improves the success rate of treatment for patients with severe trauma. However, the treatment of severe trauma in the vast majority of hospitals is still in the traditional sub-branch treatment mode, especially at the county level.

At present, the emergency medical system of severe multiple trauma has been developed in China, but the link between pre-hospital and intra-hospital is still hard to be integrated. Some hospitals set up a special department to treat severe trauma, but it is still difficult to implement integrated pre-hospital and in-hospital treatment for severe trauma due to various reasons. However, it has made great progress compared to the hospital without professional trauma care.

Development direction of severe trauma treatment in county-level hospitals

The Trauma Branch of Chinese Medical Association make the following recommendations for the regional trauma treatment system in China: (1) Establishing a treatment system with large-scale general hospitals as trauma centers; (2) Establishing effective pre-hospital and in-hospital information links; (3) Building a normalized trauma team in trauma hospitals. Large-scale general hospitals with convenient transportation, relatively complete

disciplines, and strong trauma rescue ability is recommended to build regional trauma centers, which provides trauma care service for one million people in a relatively densely populated area and for two million people in relatively decentralized populated area.⁹ That is, it is hoped that trauma centers provide medical service for 1–2 million people, which seems to be the size of a prefecture-level city. However, this population data is not verified. There are many county-level hospitals with over one million people in China. Moreover, the finance, health care and social security are relatively independent in a county, which is more in line with the planning of the modern trauma center. However, compared to municipal hospitals, county-level hospitals have a great gap in hardware and software construction. In general, the overall strength of municipal hospitals is more advantageous for the treatment of severe trauma. Severe trauma patients need to be timely treated and are not suitable to be transferred. Moreover, most county-level hospitals and higher-level hospitals are far away from each other and patient transportation is inconvenient. In addition, the response time before the hospital is generally over an hour (the time from calling, sending a distress signal to treatment for the wounded), even longer in some rural areas,²⁴ greatly delaying the rescue time. According to the State Health Planning Commission and the hospital grade assessment requirements, the county-level hospitals can basically provide the early treatment of severe trauma, and higher-level hospitals without specialized traumatology department is not superior to county hospitals in this field. Therefore, it is possible for county-level hospitals to set up their own trauma center for integrated treatment, and it is also an urgent need for severe trauma patients at the county-level hospitals. In 2011, the Ministry of Health's Scientific Research Project "Research and Promotion of Severe Trauma Treatment Regulations" has been conducted in nearly 60 hospitals throughout the country. Most of them are large-scale general hospitals, which make improvements in the medical treatment mode. Our hospital is one participant as a county-level hospital. However, the treatment efficiency is hard to be greatly improved due to different circumstances of trauma care in each hospital and low-requirement of the project. Therefore, in county-level hospitals, it is still necessary to formulate an effective first aid strategy according to the existing conditions in line with its own hardware, software and medical staff and to explore an integrated approach for the treatment of severe traumatic injuries, which has great chance for improvement.

Construction of trauma center in a county-level hospital

With the call of trauma workers and the hospital's emphasis on trauma treatment, a few county-level hospitals began to treat multiple trauma patients through the combination of emergency surgery department and general surgery department, such as Emergency Trauma Department of Xiangshan People's Hospital of Zhejiang Province, Trauma Center of Yuyao People's Hospital of Zhejiang Province, and Trauma Center of the First People's Hospital of Changzho. They carry out multiple trauma treatment, but most of them receive multiple trauma patients with a major abdominal trauma, not severe trauma patients.²⁵ Some trauma centers only perform surgery, followed by resuscitation at ICU and then retransferring back to trauma centers, which cannot ensure the integrated treatment and the full implementation of trauma care concept. Tiantai People's Hospital is the largest hospital in Tiantai county, which is a grade III B hospital in the Tiantai county, receives more than 14,500 trauma patients in emergency clinic annually, and more than 300 severe trauma patients. Now it is the only general hospital with a trauma center in Zhejiang Province, and aims to strengthen the trauma care ability.

The trauma center of our hospital was a trauma critical care unit at the beginning of 2010 (equivalent to the "Comprehensive Team for Severe Trauma" mentioned by Professor Jiang of Peking University People's Hospital.²⁵ At that time, it was established to avoid medical disputes due to treatment in multiple departments or refusing admitting patients in primary hospitals. This team consisted of senior physicians from the departments of emergency surgery, orthopedics, general surgery, neurosurgery and critical care unit, and emergency surgery or ICU, which is responsible for admitting severe trauma patients. After the establishment of the trauma care group, the treatment outcome was obviously improved. In 2011, it was rated as a key support subject by Taizhou City of Zhejiang Province. In 2012, a trauma subject leader was specially introduced and the group was integrated with the department of orthopedic surgery to set up a trauma surgery department to treat trauma patients on October 15th, 2011. The department of trauma surgery is a general department involving general surgery, orthopedics, hand and foot surgery, microsurgery, maxillofacial surgery, critical care and emergency care. The success rate of treatment was about 92.5% in 305 severe trauma patients with ISS over 16. However, critically ill patients who needed respiratory support were still treated in ICU, which was different from the concept of trauma care of ICU doctors. On March 1st, 2013, a trauma care unit with 6 beds was established in our hospital and the doctors who had surgical work experience were selected for traumatic ICU. At that time, the trauma center was officially established, including emergency surgery, trauma clinics, trauma ward and trauma ICU. Trauma wards were divided into three treatment groups: multiple trauma, maxillofacial trauma and extremity trauma. The team leader focused on his discipline and other physicians routinely took turns in different groups every 6 months. There are 21 doctors in our trauma centers, with 8 professors and 10 attending physicians. The trauma center is equipped with 2 heating blankets, 1 heating high-speed infusion pump, 1 LOGE ultrasound machine, 8 ventilators (including 2 transport ventilators, 1 CRRT, 1 transaction CPR, 2 defibrillators, 2 bronchoscopes, 1 non-invasive intracranial pressure monitor, and 1 recovery unit). Severe trauma patients were firstly admitted in the emergency room and treated under the guidance of trauma center doctors, and then performed bedside emergency surgery according to the disease condition, or sent to trauma ICU or trauma ward. The doctors in the emergency surgery, traumatic surgery ward and trauma ICU are on duty in trauma center, which is supervised by a senior physician. The three on-duty team leaders are able to independently perform deep vein indwelling, endotracheal intubation, tracheostomy, closed thoracic drainage, ventilator applications, bedside FAST, pelvic external fixation, external fixation of the fracture, and bone traction. The team leader is also capable of rib fixation surgery, laparotomy, emergency thoracotomy and other life-saving surgeries, and needs to master the indications of intracranial surgery, chest and urological surgery, and timely consult relevant specialists before surgery. From March 1st, 2013 to March 1st, 2017, 1026 cases of chest trauma (8637 trauma patients) were admitted into our center, including 283 cases treated by closed drainage, 40 by rib fixation, and 4 by lobectomy with the participation of thoracic surgeons. Cardiac surgery is also mainly cardiac tamponade, which can be independently done by the trauma centers, and only 3 heart rupture patients were successfully performed cardiac repair by cardiothoracic surgeons without support of cardiopulmonary bypass. Neurosurgical and urological doctors are on duty within 24 h and can be called at any time. During the four years of related professional treatment, no delayed surgery occurred. If expanding the practice scope of trauma surgeons, the trauma center may not be routinely configured with

cardiothoracic surgeons. 88% of US physicians believe that the discipline of traumatology needs to be redefined. The scope of practice should include a wider range of general surgery, limited orthopedics, and some trauma-related neurosurgery.²⁶ We agree with this view, but believe that it is necessary to include DSA skills. DSA has obvious advantages in trauma treatment. Mastering vascular intervention can improve the emergency treatment and hemostasis skills. The center applied DSA technology in 2017 and has independently completed embolization hemostasis for dozens of patients with liver, spleen and kidney ruptures or internal iliac hemorrhage and endovascular stent-graft surgery for 1 case of pseudoaneurysm. This technique is minimally invasive for trauma treatment.

After more than four years of practice, our trauma center has achieved integrated in-hospital care for patients with severe multiple trauma. Up to March 1st, 2017, the success rate of treatment was about 95% in 1265 severe trauma patients with ISS over 16, 92% in 86 patients with severe hemodynamically unstable pelvic injury. Earlier in China, the concepts of early analgesia, early psychological intervention and early rehabilitation involved were well accepted by domestic counterparts.²⁷ In 2016, it was awarded as a key discipline in Taizhou, Zhejiang Province.

The integrated pre-hospital and in-hospital emergency care system in county-level hospitals

Most 120 Command Centers in domestic counties are affiliated to County People's Hospital (county hospital), but can rarely achieve a seamless connection between prehospital and in-hospital. Zhejiang Changxing County government invested 11 million to establish a pre-hospital emergency system, which received 5 years of support from the former chairman of the Chinese Medical Association Wound Branch president Jiang Baoguo, and can basically achieve a seamless connection between prehospital and in-hospital. Our hospital is also the affiliated unit of 120 emergency command center of our county. In early 2013, our hospital team began to carry out integrated emergency system construction, assigned to director of trauma center as director of Tiantai 120 emergency command center, and cooperate with Shanghai Qionglai First Aid Equipment Co., Ltd, so as to carry out integrated information platform between pre-hospital and in-hospital treatment. By the beginning of June 2014, nine ambulances at 120 command centers were equipped with GPS systems, car camera system, call system, information platform and electronic medical record system. Three client terminals were installed in the emergency department, the trauma ward and the office trauma center director, respectively. All nine ambulances already have seamless connectivity and transmission of information and images to patients in the command center, emergency department, trauma ward and center director's office. When emergency physicians arrive at the scene, they make a quick initial diagnosis and perform PHI scoring for the wounded. The indication of carrying out integrated pre-hospital and in-hospital system are as follows: (1) prehospital index PHI ≥ 4 points; (2) sudden respiratory cessation; (3) severe or extreme difficulty breathing; (4) severe trauma with uncontrollable movement and venous bleeding; (5) shock; (6) severe fracture; (7) height fall; (8) impact injury; (9) other accidents. If the patient meets the standard, the accompanied doctor will notify the emergency surgeons and trauma surgeons by telephone and doctors of emergency surgery and trauma ward can check the injured situation through the information client terminal and give the pre-hospital doctors guidance for medical treatment. In severe and intractable patients, accompanied doctors may also request information center to get help from the director of trauma center. With the help of the information system, the emergency surgery department is well

prepared before patients arrive (necessary rescue supplies and trauma doctors with relevant skills are well prepared) to open green channel. Immediately after the emergency hand-over, the emergency surgeon and nurse will be in charge of emergency operation. After being sent to the Resuscitation Rescue Unit, the wound will be immediately tested for vital signs and open venous access, and doctors of traumatic surgical ward will be instructed to give first aid. For patients with thoracoabdominal trauma who have unstable hemodynamics (shock), emergency bedside FAST ultrasound (the doctor can routinely perform FAST) can quickly determine the pleural effusion, pneumothorax and other injuries,^{2,28} which can shorten the diagnosis time. Consultation should be strengthened and "life-saving surgery" should be performed as soon as possible if they have definite indications for surgery,¹¹ including bleeding control, pollution control, so as to avoid further injury. If the patients have no indications for surgery, they should be sent to trauma ICU as soon as possible for further recovery.

Our 120 command center has 28 employees, including 9 doctors, 10 nursing dispatchers, and 9 drivers. Dispatchers are all practicing nurses with medical background. After being trained by emergency doctors for 3 months, they will be able to guide the first witnesses to carry out the basic treatment of the injured in the early stage and to help carry out early treatment of the injured as soon as possible. The integrated pre-hospital and in-hospital treatment starts at any time according to the need, greatly improving the success rate of severe trauma treatment. In 2014, Vice Governor Zheng Jiwei approved the trauma first aid system in our hospital and specifically instructed Zhejiang Provincial Health Planning Commission to promote our model.

Conclusion

According to the shortage and current situation of severe trauma treatment in county-level hospitals of China, the establishment of trauma medical centers and an integrated treatment mode can not only improve the quality of trauma care, but also help to improve first aid level in the administrative area of a county so as to save more patients' lives. In addition, through the training, assistance and guidance of the higher-level hospitals, it will eventually improve the overall level of trauma treatment in this county and help to establish an efficient, timely and comprehensive emergency system, and become a template for regional trauma treatment system in the administrative area of a county.

The establishment of trauma centers needs the government to play an important role. After all, this is a public welfare project. However, the establishment of trauma centers in public hospitals in the county administrative region, which is integrated with pre-hospital 120 emergency medical services, may be one of the relatively mature and quick modes currently used by primary hospitals to treat serious injuries.

In addition, at present, the leaders of trauma in county-level hospital are very scarce. The traumatologists who can lead the treatment of multiple traumas have yet to be cultivated. The China Trauma Treatment Training (CTCT) conducted by the Trauma Physician Branch of the Chinese Medical Association (CTCT) have carried out more than 26 sessions in China, which may accelerate the training of trauma personnels, but also need to increase the training scope and process. The personnel training should also be strengthened in the county hospitals with trauma surgery department, because the limited operation and multiple injuries treatment cannot meet the further needs of reserve personnel. This needs China's trauma experts to make emergency planning and design and support of trauma workers.

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