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A Case of Severe Trauma with Iliac Vascular Injury was Treated using a Time-Based Chain Approach

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Abstract: Severe trauma often involves complex injuries, leading to high disability and fatality rates. Effective treatment requires prompt and coordinated efforts across multiple disciplines to enhance success rates. Time-based chain rescue is crucial in managing severe trauma. A patient with chest and abdominal injuries and hemorrhagic shock was transferred from an ambulance to our hospital. Our trauma team-initiated pre-hospital first aid, utilized an emergency green channel, and conducted rapid ultrasound, collaborating across disciplines. The patient eventually recovered and was discharged.

Keywords: Severe trauma; Hemorrhagic shock; Time point of trauma; Chain-type treatment

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1. Introduction

With societal development, trauma has become the fifth leading cause of death globally, while severe trauma has emerged as the primary cause of death among young and middle-aged adults in China [1,2]. Severe trauma is often caused by violent factors such as falls from heights, traffic accidents, and workplace injuries. These patients present with critical conditions that progress rapidly, frequently leading to multi-tissue and multi-organ dysfunction. Such injuries are often accompanied by adverse events like massive hemorrhage and vascular occlusion. The key factor for patient survival is receiving timely, accurate, and highly efficient team-based treatment within a short timeframe [3]. This study presented a case report of a patient with severe trauma complicated by iliac vascular injury admitted to the Emergency Trauma Center of Changzhou Seventh People's Hospital. Drawing on our center's clinical experience in managing such cases, we discuss the diagnosis and treatment of severe trauma complicated by iliac vascular injury, aiming to provide insights for the management of similar trauma patients.

2. Case data

Patient, male, 58 years old, laborer. On July 5, 2024, at 08:50, he was transported to the hospital via 120 emergency services after being struck in the chest and abdomen by a steel pipe for 10 minutes. At 08:40, while working, the patient was accidentally struck in the chest and abdomen by a steel pipe. Immediately after the injury, he developed abdominal pain that progressively worsened, accompanied by numbness in the right lower limb. The prehospital emergency physician assessed the patient as conscious with a distressed expression. Physical examination findings: Temperature: 36.8 °C, Heart rate: 125 beats/min, Blood pressure: 102/81 mmHg, Oxygen saturation: 90%. TISS score: 17. Intravenous access was established for fluid resuscitation, supplemented with oxygen via face mask. Preliminary assessment indicated the patient met the criteria for "Ambulance Critical Trauma Patient Early Warning" and was triaged via telephone alert to the emergency department. At 09:15, the ambulance arrived at the emergency department. The patient was admitted directly to the resuscitation room via the green channel. The emergency surgeon examined the patient: T 36.6 °C, heart rate 135 bpm, blood pressure 92/78 mmHg, oxygen saturation 95%, shock index 1.47, altered mental status, agitated and restless, unable to communicate verbally. No external head injuries. Bilateral pupils equal and round, diameter 3 mm, with active light reflexes. Scattered contusions on chest and abdominal walls. Right lower abdomen purple and swollen. Right thigh swollen with limited mobility. Patient uncooperative for remainder of examination. No significant past medical history; denies history of hypertension, diabetes, coronary heart disease, or other chronic conditions. 09:20 Initial assessment completed. Preliminary diagnosis: 1. Multiple trauma: Thoracic injury, abdominal injury, vascular injury? 2. Complication of injury: Traumatic hemorrhagic shock. 09:25 Bedside rapid ultrasound reveals splenic hematoma, perihepatic hematoma, and pelvic hematoma. The patient is in critical condition. Immediately activate the trauma response team. Simultaneously initiated emergency transfusion protocol. At 09:30, completed central venous catheterization and administered tranexamic acid for hemostasis, supplemented with analgesic and sedative therapy. At 09:48, commenced infusion of 2 units of Type A red blood cells and 200 mL of frozen plasma. At 09:55, completed plain and contrast-enhanced CT scans of the chest and abdomen (see **Figure 1**). Examination findings: Fracture of the left 11th rib; suspected splenic rupture with subcapsular hematoma, minimal perihepatic hemorrhage, and pelvic hematoma; occlusion of the right iliac artery. ISS score: 27. Admitted to the operating room at 10:00 for surgery. Intraoperatively, complete transverse transection of the small intestine and mesentery in the right lower abdomen was observed, with bleeding from the mesenteric stump (see **Figure 2**). Partial small bowel resection with intestinal anastomosis and mesenteric repair was performed. Surgery concluded at 12:25, with the patient's vital signs gradually stabilizing. At 13:40, the Interventional Radiology Department conducted percutaneous selective angiography, confirming occlusion of the right external iliac artery (see **Figure 3**). Right external iliac artery stenting was performed, followed by right iliac artery balloon angioplasty and right external iliac artery thrombectomy. Good blood supply was restored to the external iliac artery (see **Figure 4**). The patient was admitted to the ICU for further treatment postoperatively. The patient was discharged in good condition on July 31, 2024.

Figure 1. Abdominal CT reveals intra-abdominal hemorrhage.

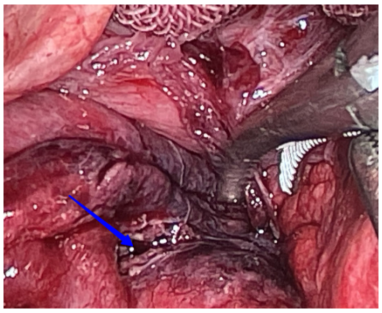

Figure 2. Intraoperative findings reveal intestinal perforation and mesenteric hemorrhage.

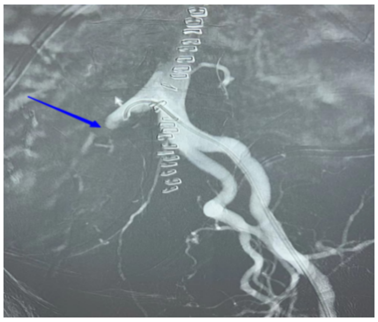

Figure 3. Contrast imaging reveals occlusion of the external iliac artery.

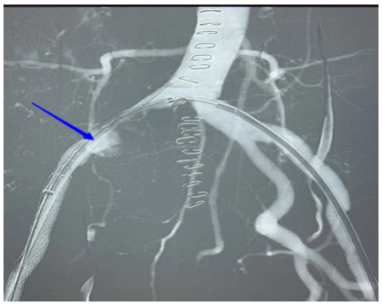

Figure 4. Lateral iliac artery recanalization.

3. Discussion

Multiple trauma constitutes a distinct disease category, and how to provide more effective treatment for patients with severe multiple injuries has become a hot topic and major challenge in the field of emergency medicine [4]. The previous treatment model primarily involved transporting patients to the emergency department for initial care. Upon admission, emergency physicians would sequentially call for specialist consultations based on the location and severity of injuries. This approach resulted in prolonged treatment times, low efficiency, and a lack of comprehensive treatment capabilities [5]. Patients with this condition often present a "triple contradiction": the contradiction between the complexity of injuries and the urgency of treatment, the contradiction between multiple organ injuries and the fragmentation of specialized care, and the contradiction between high treatment costs and uncertain prognosis [6]. The traditional treatment model reveals three major shortcomings: 1. Time delay: Studies indicate that the average time from hospital admission to surgery for severely injured patients reaches 118 minutes, with mortality increasing by 12% for every 30-minute delay [7]. 2. Inefficient collaboration: The single-specialty consultation model increases decision-making time by over 40%. 3. Fragmented resources: A study by Peking Union Medical College Hospital indicates that the lack of an integrated treatment system reduces medical resource utilization by 35% [8]. The International Trauma Care Consortium (ITACCS) proposes the "Time Window Theory", emphasizing that the first 60 minutes post-injury constitute the golden hour for critical care. Within this period, the initial 10 minutes (the platinum hour) determine the survival rate for 80% of hemorrhagic shock patients [9]. Recent studies suggest that improving critical care for severely injured patients requires shifting from individual efforts to collaborative teamwork, and replacing tiered consultations and hierarchical reporting with rapid response, swift decision-making, and prompt treatment by team members, a necessary approach to enhance the quality of care for critically injured patients [10].

Starting in June 2023, our hospital implemented a time-based chain-of-care approach for treating severely injured patients, which essentially represents a restructuring of the trauma care process. The system encompasses two major modules: pre-hospital emergency care and in-hospital treatment. It establishes standard timelines for each treatment phase, dividing complex resuscitation procedures into distinct time-based milestones. Each milestone is assigned a target time threshold, with individual accountability assigned for resuscitation responsibilities. This approach breaks away from traditional sequential workflows, enabling simultaneous execution of diagnostic procedures and resuscitation efforts. The successful treatment of this patient was achieved through the hospital's time-based chain-of-care model and the comprehensive trauma-related specialty care capabilities.

This patient's journey from injury to operating room took only 80 minutes (injured at 08:40, surgery commenced at 10:00). The 15-minute rapid prehospital transport secured critical time for subsequent treatment, aligning with findings reported by Liu Haixia et al. on the effectiveness of "battle trauma treatment centers". Through prehospital alerts and pre-positioned hospital teams, the time to resuscitation for critically ill patients can be reduced to under 45 minutes. The core advantages of this model are twofold: First, it enables earlier intervention by initiating critical care measures, such as establishing intravenous access and maintaining vital signs, during the prehospital phase to prevent deterioration. Second, it facilitates resource prepositioning through an "ambulance critical care alert" mechanism, allowing the hospital trauma team to prepare personnel, equipment, and blood products before patient arrival, significantly accelerating response times. During the prehospital emergency phase, prehospital emergency physicians rapidly conduct trauma assessments and initiate prehospital resuscitation. The 5G transmission system enables real-time sharing of vital signs. Establishing intravenous access for fluid resuscitation and administering oxygen via face mask maintains blood oxygen levels, alleviating patient anxiety while stabilizing vital functions. Seamless coordination with hospital emergency triage reduces in-hospital handover time and minimizes preparation delays for in-hospital resuscitation. Rapid prehospital treatment and transport lay the foundation for subsequent in-hospital care, achieving "hospital admission upon arrival".

Treatment time is an independent factor influencing the prognosis of patients with severe trauma. Zhang Jigang et al. confirmed through a study of 1,263 trauma patients that those with a pre-hospitalization delay exceeding 60 minutes had a 30-day mortality rate 2.3 times higher than patients with delays under 30 minutes. In this case, the treatment process strictly adhered to critical time points at each stage, with a total emergency room and resuscitation time of 45 minutes. This fully complies with the "time-sensitive" principle for managing severe trauma. During the in-hospital resuscitation phase, our trauma resuscitation team comprises emergency department and trauma center medical staff with clearly defined responsibilities. Each team consists of 3 physicians and 2 nurses: Physician C handles endotracheal intubation, airway protection, and central venous catheterization. Nurse A manages venous access, while Nurse B is responsible for blood collection and medication preparation. Upon receiving prehospital emergency notification for a severely injured patient, the hospital immediately activates its emergency response team. A green channel is opened upon the patient's arrival. Within 5 minutes of admission, initial assessment and venous blood sampling are completed. Within 10 minutes, bedside rapid ultrasound confirms visceral bleeding, triggering the trauma team response. Deep venous catheterization is completed within 15 minutes. Blood transfusion begins within 33 minutes. Contrast-enhanced CT is completed within 40 minutes. The patient enters the operating room for surgery within 45 minutes. The rescue process is seamlessly interconnected, minimizing the time patients with severe trauma spend waiting for treatment while enhancing the continuity and rigor of care. The efficient implementation of this process relies on three key measures: First, the application of standardized assessment tools, the TI score (17 points) is used pre-hospital to rapidly identify critically ill patients, while the ISS score (27 points) is employed in-hospital to quantify injury severity, providing objective criteria for determining treatment priorities. Second is the integration of point-of-care rapid diagnostic technologies: Bedside ultrasound (FAST examination) can identify splenic, hepatic, and pelvic hemorrhages within 10 minutes, eliminating the time delays associated with traditional imaging studies. This aligns with the "ultrasound-guided injury control" concept proposed by Du Zhe et al., the technique elevates the diagnostic accuracy for intra-abdominal hemorrhage to 92%, significantly reducing decision-making time for surgical interventions. Finally, the optimization of the emergency transfusion process: From initiating the transfusion protocol to commencing red blood cell infusion took only 18 minutes (09:30–09:48). This achievement stems from the hospital's implementation of a "rapid blood transfusion pathway for trauma patients". Through measures such as pre-stocking blood and rapid ABO blood typing, the traditional transfusion preparation time was reduced by 50%. Precise control of critical time points not only enhances rescue efficiency but also enables visual management of treatment quality through "timeline tracing". In this case, each operational node is documented, providing data support for subsequent process optimization. This aligns with the findings of comparative studies by Jiang Shirong et al., the integrated trauma emergency model achieves a 68% higher treatment documentation completeness rate than traditional models, facilitating continuous improvement.

The primary challenge in treating this patient lies in the combination of abdominal organ injuries and iliac vascular injuries, requiring on-site decision-makers to possess multidisciplinary trauma management capabilities. Iliac vascular injuries occur in approximately 3–5% of severe trauma cases, yet carry a mortality rate as high as 40–60%, primarily due to uncontrollable massive hemorrhage and subsequent distal limb ischemia and necrosis [11]. This patient also presented with a ruptured mesentery and intra-abdominal hemorrhage, significantly increasing the complexity of treatment. Research has demonstrated that the MDT model can reduce treatment decision errors in complex trauma patients by 42% and increase treatment success rates by 27%. In this case, our department established a clear sequence of "damage control first, staged reconstruction second" through preoperative discussions, thereby avoiding the limitations of single-specialty decision-making. This approach was crucial to the successful treatment. Following thorough consultation between the Trauma Center and the Vascular Intervention Department, exploratory laparotomy is performed first to identify the bleeding site, followed by damage control surgery (DCS). Definitive surgery is then conducted by the relevant specialty. This strategy aligns with the damage control surgery (DCS) concept recommended by the International Trauma Society, for patients with an ISS score > 25, the mortality rate for definitive surgery performed in a single stage reaches 58%, whereas DCS reduces mortality to 29% [7]. During the emergency room phase, through the collaborative efforts of the emergency trauma team, the patient was smoothly transferred to the operating room with a delay time of 45 minutes. In the surgical phase, the trauma center performed exploratory laparotomy to confirm the diagnosis, followed by intestinal resection and mesenteric repair to promptly "turn off the tap" and control bleeding. Once vital signs stabilized, the patient was transferred to the interventional radiology department for vascular management, where endovascular intervention was performed, achieving rapid vascular recanalization. Endovascular therapy has now become the preferred treatment for iliac artery occlusion. Studies indicate that the vascular recanalization rate achieved through endovascular therapy is comparable to that of open surgery, while offering advantages such as minimal trauma, rapid postoperative recovery, and shorter hospital stays. Additionally, endoscopic treatment avoids the trauma of secondary surgery, making it particularly suitable for patients with concomitant abdominal infections or coagulation disorders. This aligns with the rapid postoperative recovery observed in this case. The patient underwent intensive care unit (ICU) monitoring postoperatively, receiving anti-inflammatory therapy and treatment to correct coagulation dysfunction. The patient recovered well and was discharged successfully 26 days after surgery.

One of the key factors in this patient's survival was the timely provision of effective treatment. The timeliness of trauma care demonstrates that patients can achieve optimal therapeutic outcomes through interventions administered within a specific "time window". The successful treatment of this patient was achieved by the hospital's implementation of a severe trauma timeline as the central framework. By using time as the key metric, the hospital integrated pre-hospital and in-hospital care, strictly controlled the duration of each treatment phase, and enhanced the efficiency of the rescue efforts. This approach ensured the patient received effective treatment within the shortest possible timeframe. Pre-hospital care for the patient; definitive diagnosis and maintenance of vital signs in the emergency resuscitation room; damage control surgery at the trauma center; specialized definitive surgery. This seamless chain of care ensured successful treatment outcomes, demonstrating the hospital's multidisciplinary collaborative capabilities in managing severe trauma. However, continuous optimization remains possible in the following areas: Early warning technology for vascular injury: Iliopsoas artery injuries often present insidiously. While this case was definitively diagnosed via CTA, the examination took 40 minutes. Introducing bedside vascular ultrasound contrast imaging could provide preliminary assessment of vascular occlusion or rupture within 10 minutes, enabling earlier decision-making for surgical intervention. Regular Team Training: The efficient operation of chain-based treatment relies on seamless coordination among team members. Our hospital conducts monthly trauma simulation drills, focusing on training "time-sensitive response protocols" (e.g., deep venous catheterization within 15 minutes), which has increased team collaboration efficiency by 50%. This achieves seamless integration between skills training and real-world application, consistent with the effectiveness of the "Combat Trauma Center" regular drill mechanism [12].

4. Conclusion

In summary, while models for treating severe trauma vary, the overarching principle remains consistent. Time-based chain-of-care approaches offer advantages such as efficiency and speed, thereby enhancing the success rate of resuscitation for severely injured patients and ensuring effective treatment outcomes. It can comprehensively document the entire treatment process for patients, trace and address issues at each stage for improvement, optimize clinical workflows, control medical quality, enhance the hospital's capacity to treat severely injured patients, reduce adverse event rates, and provide a replicable clinical pathway for complex trauma care. Future efforts should focus on strengthening prehospital-to-hospital information exchange, introducing precision diagnostic technologies, and optimizing team training to address increasingly complex trauma care challenges.

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Disclosure statement

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