



Combined penetrating trauma of the head, neck, chest, abdomen and scrotum caused by falling from a high altitude: A case report and literature review



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ABSTRACT

This report describes an extremely rare case of combined penetrating trauma that includes the head, neck, chest, abdomen and scrotum. A 46-year-old male construction worker fell from a 5-metre-high platform, and a rebar that was fixed vertically on the ground penetrated the scrotum into the pelvic and abdominal cavities, passing through the chest, neck, mouth, and nose to the outside of the body through the left side of the head. The rebar penetrated the oral cavity and was palpable on the anterior side of the neck and abdomen. The head, neck, chest and abdominal CT scan and reconstruction showed brain contusion, fractures of the skull and skull base, sub-arachnoid haemorrhage, palate injury, tongue injury, injury to the right lobe of the thyroid, pleural effusion, pulmonary contusion, cardiac contusion, injury to the left lobe of the lung, neck and mediastinal emphysema, and pneumothorax. Emergency green channels provide a rescue process for urgent and severe cases and smooth and timely diagnostic and treatment process to save patients' lives. The medical staff worked together as a team for the initial evaluation and rescue. Emergency nurses played an important role in communicating, cooperating, managing insulation and pain, and providing psychological counselling, which greatly enhanced the efficiency and quality of the nursing. After the patient underwent surgery, anti-infection treatment, sedatives, analgesics, nutritional therapy, psychological support, and other intensive treatment measures, he recovered well two months after the injury. Follow-up at 5 and 11 months after discharge showed good recovery.

1. Introduction

Penetrating trauma is a type of open injury that simultaneously causes inlet and outlet injuries. Penetrating trauma results in a substantial sequential damage and can affect the subcutaneous tissue, blood vessels, and even multiple organs. Multiple injuries refer to the simultaneous injury of more than two anatomical sites or organs or to the continuous injury of these sites as a result of the same injury factors, with at least one site showing severe trauma [1].

The international literature has described penetrating injuries involving multiple foreign bodies, including sticks, glass, and knives [1–3]. The domestic literature has reported penetrating injuries that were mostly caused by rebar. Rebar is a metal rod that provides reinforcement in concrete structures. The rebar that penetrated the patient had a diameter of approximately 1.5 cm and a length of

approximately 2 m. Injuries often involve a single trauma, such as injury to the eyes, brain, maxillofacial region, chest, abdomen or perineum [4–8]. This case was a type of combined trauma that is extremely rare, making its assessment, treatment and care management very challenging.

2. Time frame

The critical time frame of the patient before and after admission was as follows (See Fig. 1):

3. Case study

A 46-year-old male construction worker was transported to the emergency department by ambulance. The patient was near-

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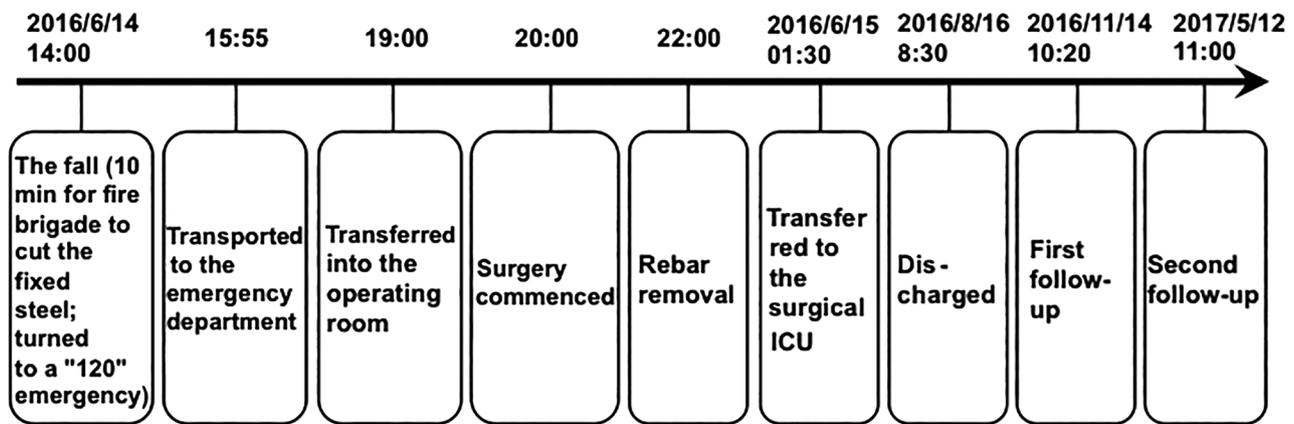


Fig. 1. The critical timeframe of the patient before and after admission.



Fig. 2. Photograph of the patient.

consciousness, in poor spirit, appeared to be suffering and was able to answer questions accurately. His vital signs were as follows: T, 37.6 °C; P, 112/min; R, 30/min; and BP, 121/75 mmHg. The patient fell and was perforated by a piece of rebar two hours before admission. The patient denied having a history of chronic or infectious diseases, had no previous history of trauma or surgery, blood transfusions or genetic disorders (See Fig. 2).

Admission examination: The rebar penetrated the body cavity through the forehead. The patient's pupils were equal in size, approximately 3 mm in diameter, round and sensitive to light. Blood could be seen in the nasal and oral cavities. The rebar penetrated the oral cavity. The auscultation of bilateral respiratory sounds was not very clear. There were no obvious limb abnormalities. Skin bruising was observed in the right upper limb. The muscle strength of the upper limbs was grade V. The muscle strength of the lower limbs could not be examined, although these muscles were without dystonia. The pulsation of the right dorsalis pedis artery was not obvious, and the left dorsalis pedis artery was normal. The bilateral Babinski's reflex was negative. The revised trauma score (RTS) was 10 [9]. The emergency head and body CT reconstruction showed "brain contusion, fracture of skull and skull base, subarachnoid haemorrhage, palate injury, tongue injury, injury to the right lobe of the thyroid, pleural effusion, pulmonary contusion, cardiac contusion, injury to the left lobe of the lung, neck and mediastinal emphysema, and pneumothorax". The primary diagnosis was penetrating trauma comprising severe open head injury, multiple brain contusions, traumatic subarachnoid haemorrhage, skull

fractures, skull base fractures, cerebrospinal fluid leakage, oral penetrating injury, palate damage, tongue damage, thyroid right lobe injury, penetrating injury to the neck, penetrating injury to the chest, right pneumothorax, pleural effusion, pulmonary contusion, cardiac contusion, penetrating injury to the left hepatic lobe, penetrating injury to the diaphragm, penetrating injury to the abdominal cavity and abdominal wall, penetrating injury to the scrotum, and right upper extremity soft tissue contusion (See Fig. 3 and Table 1).

4. Emergency care

Although our emergency centre is one of the best centres in China, we deal with no more than 5 similar cases per year and have experienced a high failure rate. As a result, we faced this challenge with little experience of such complex combined penetrating trauma. For this patient, nurses in the pre-triage and emergency room performed appropriate first-aid measures simultaneously.

4.1. Pre-triage nurse

The patient was admitted at 15:55, which was the time of the shift change at the emergency department. According to the emergency disease classification criteria, the nurses collected and evaluated the patient's history, including the mechanism of injury before admission, the condition of the injury, vital signs, preadmission treatment and general condition. The patient was classified as critical, and the trauma

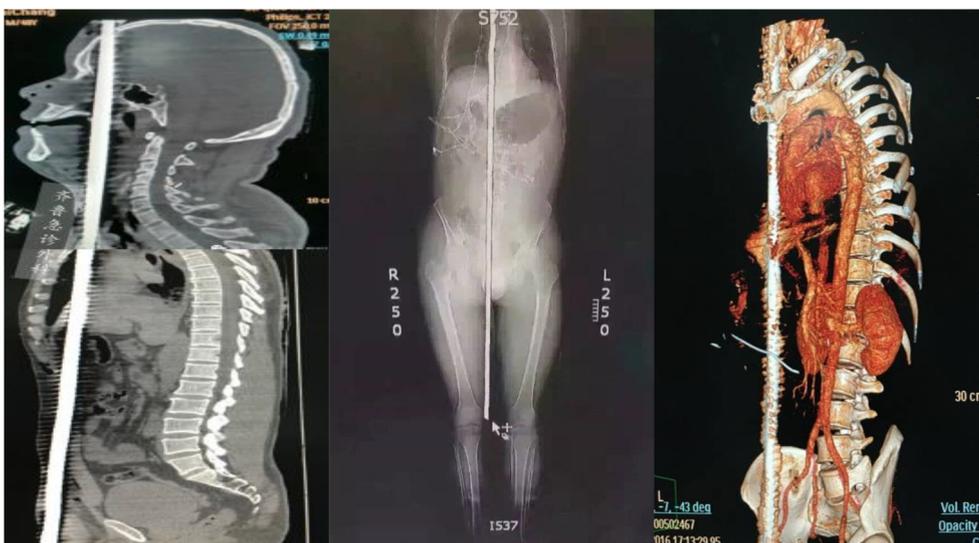


Fig. 3. The CT of the patient.

team started treatment immediately [10].

The following procedures were performed. ① The pre-screening nurse immediately informed the emergency room nurses, opened a green channel and ② immediately informed the head nurse of the need for the emergency deployment of human resources. ③ The pre-triage nurses assisted the entire trauma team with coordinating consultations with multiple departments and reporting the trauma procedure, the patient’s level of consciousness, pupil reflexes, examination results and treatments that were performed after the team commander arrived so that the patient would be stable for transfer [1]. ④ A standard trauma evaluation with the emergency room nurses was performed. Preliminary assessments of the airway were performed while protecting the cervical, respiratory, circulatory, and neurological regions from exposure to the environment, prioritizing the safety of the airway, ensuring breathing and circulation, and controlling bleeding. Further evaluations were performed.

4.2. Emergency room nurse

The goals of treatment were to rescue and prolong life, reduce bleeding, prevent shock, protect the wound, fix fractures and prevent complications. However, foreign bodies can tamponade the wound and have a potential haemostatic effect [2]. If the foreign body was removed without adequate preparation, secondary damage or severe bleeding could occur. To prevent this, the emergency room nurses took the following emergency measures. ① For the standard trauma

assessment, the nurses communicated with the patient to determine airway patency and observed whether nausea and vomiting occurred. The nurses cleared nasal and oral secretions and provided sufficient oxygen to ensure respiratory and circulatory stability. The nurses also ensured the oxygen supply to the vital organs, namely, the brain and kidneys. ② Fluid resuscitation was performed to prevent haemorrhagic shock. A double intravenous access was established immediately, and infusion was performed per the doctor’s prescription. ③ Changes in the patient were closely observed, and vital signs were closely monitored. ④ Emergency control of active bleeding was performed. ⑤ A comprehensive assessment of pain was performed with a numerical rating scale (NRS), and the evaluation score was 6, indicating mild pain, so analgesics were not used. ⑥ Psychologically, the patient was apathetic, and his limbs were shaking. Fear-based emotions beyond the injury pain were likely. In addition, the patient was a middle-aged man who served as the backbone of his family. As the incident occurred suddenly, the patient was accompanied by his co-workers, with no family members around him. The emergency nurses held the patient’s hand and told him that we would make every effort to treat him and that his family members had been informed. This care helped the patient to calm down and cooperate with treatment. We contacted the patient’s family as soon as possible so that they could be with him, which supported the patient psychologically.

The patient was then transferred to the emergency department. Emergency staff observed the patient through electrocardiogram monitoring. They also moved the patient carefully to prevent injury.

Table 1
Summary of the initial assessment, clinical examination and diagnostic results.

Assessment	Findings
Vital signs	T, 37.6 °C; P, 111/min; R, 30/min; BP, 121/75 mmHg
Physical Examination	Almost conscious; Poor spirit Pupils were equal in size, approximately 3 mm, and were round and sensitive to light. The rebar penetrated through the oral cavity. Bilateral respiratory sounds were not very clear. No obvious limb abnormalities The muscle strength of the upper limbs was grade V; Muscle strength of lower limbs could not be examined, though without dystonia. Pulsation of the right dorsalis pedis artery was not obvious, and the left was normal. Bilateral reflex of Babinski’s signs: negative The modified trauma score (RTS) was 10.
Disease history	No previous history of trauma or surgery, blood transfusions and genetic disorders.
Examinations	CT reconstruction showed “brain contusion, fracture of skull and skull base, subarachnoid hemorrhage, palate injury, tongue injury, injury to the right lobe of the thyroid, pleura effusion, pulmonary contusion, cardiac contusion, injury to the left lobe of the lung, neck and mediastinal emphysema, pneumothorax”.

Psychological care was necessary and relieved the patient's depression. During this period, the patient's basic vital signs were stable, and he was moved to the department safely.

5. Diagnostic evaluation

This case was diagnosed primarily through inquiry case history and a CT scan.

Assessment and grading: The patient's condition (including vital signs, consciousness, respiratory support, circulatory support, and major clinical problems) was assessed, and the transit time was estimated to determine the transport classification.

Communication and explanation: ① Communication with the patient and his family was necessary to inform them of the risks and obtain their informed consent and cooperation. ② The emergency staff communicated with the receiving department after the patient was sent to radiology (similar to the process followed when the patient was transferred to the operating room) by informing the radiologists of the patient's specific condition, estimating the transition time, and signing the forms.

Full preparation: ① For transport staff preparation, an emergency department nursing team leader and two nurses with over three years of work experience and two doctors were utilized. ② The transport equipment was portable and included transport sheets; an oxygen bottle; a transport monitor; an oropharyngeal airway device; a simple respirator; a transport ventilator; two micro-pumps; an AED; portable suction devices; and an appliance for punctures and drugs, such as epinephrine, dopamine, amiodarone, midazolam, lidocaine, atropine, and physiological saline. ③ The patient's condition was re-evaluated before transport. When the patient's vital signs were stable, the staff checked the drainage pipe and other devices to ensure that they were fixed properly to facilitate smooth transport. ④ To prepare the receivers, the emergency green channel was opened, and transport orders were received. The receivers and elevator operators were immediately notified. The patient's condition, vital signs, equipment use, drug use and arrival time were communicated to fully prepare for his reception after transport.

Normal transport: The active monitoring of the patient's vital signs and condition changes ensured respiratory and circulatory stability according to the airway A (airway), B (breathing), C (circulation), D (disability), E (systemic exposure) evaluation principles. The best transit route was determined, and transit was stable and rapid. During transportation, two healthcare workers stood on each side of the rebar steadily, lifted both sides of the exposed rebar, and fixed the rebar to prevent secondary damage. The patient's pain rating was assessed constantly.

Standardization of management: The patient was graded as stable for transport. If his condition deteriorated during transport, immediate rescue was to be performed. If the patient needed to wait, no more than 5 min wait time was permitted.

5.1. Multi-team cooperation

Summary and evaluation: The benefits and risks were re-evaluated after transport to assess the stability and rationale of transport, the transport personnel, and the relevance and predictability of the planned measures. The effectiveness of communication was subsequently evaluated (See Table 2).

6. Therapeutic intervention

The patient was transferred to the operating room after the examination. The patient underwent tracheotomy, craniothoracoabdominal laparotomy, intracranial pressure probe implantation, debridement and suturing, and foreign body removal. Surgery involved cardiothoracic surgery, neurosurgery, abdominal surgery, ENT surgery,

Table 2

The table of RTS (Revised Trauma Score).

The Revised Trauma Score			
Glasgow Coma Scale (GCS)	Systolic Blood Pressure (SBP)	Respiratory Rate (RR)	RTS value
13–15	> 89	10–29	4
9–12	76–89	> 29	3
4–8	50–75	6–9	2
4–5	1–49	1–5	1
3	0	0	0



Fig. 4. Remove the rebar from the body.

and emergency surgery, and the best surgical strategy over the shortest time possible was discussed with multiple participating departments. More than 30 doctors from different departments performed over five hours of surgery to remove the rebar from the scrotum, and damage was successfully repaired. The patient was sent to the emergency surgical ICU for further treatment after the operation (See Fig. 4).

7. Postoperative rehabilitation

7.1. Infection prevention

Because rust, slag cement, and fabric were present in the wound channel and because pathogens could have been introduced into the body, prolonged use of antibiotics was necessary [4]. The patient experienced three post-surgical stages: the postoperative acute phase (± 2 weeks), the residual infection period (2–4 weeks), and repeated infections (6–8 weeks). Based on bacterial culture and drug susceptibility test results, adjustments were made in the use of vancomycin, meropenem, prayer music and other antibiotic drugs, and red and blue light irradiation was performed three times per day during the repeated infection stage [4].

7.2. Complication prevention

Complications compounded the patient's condition; therefore, the healthcare workers closely monitored his vital signs. Observations of the colour and amount of drainage from the drainage tube allowed the prevention or early detection of complications [5]. In addition, the patient received oral nutritional support with a nasogastric tube, and an

intermittent pneumatic compression (IPC) pump was used to prevent venous thromboembolism (VTE).

7.3. Psychological care

Postoperative psychological care is easily overlooked but should be primarily provided by nurses.

① Fear and anxiety: We should be fully aware of the importance of the family in rehabilitation because the family's support and cooperation are an important foundation for patient rehabilitation. In this case, we suggested planned visits and increased the visitation time. This type of supportive psychotherapy, such as cognitive therapy or exposure therapy, may aggravate the disease.

② Depression: Trauma, work relationships, healthcare costs, and prognosis can result in depression. Medical staff should aim to provide the patient with increased social support that addresses multiple factors, such as medical issues, life, and diet, to create a homelike rehabilitation environment.

③ Posttraumatic stress disorder (PTSD): This patient demonstrated boredom, general malaise, abdominal pain and discomfort, sleep disorders, night waking with delirium, and fever. PTSD after a stressful event refers to a period when a patient experiences a reaction that is mainly prolonged and seriously affects his or her psychological and social functions. PTSD is commonly observed after sudden natural disasters and traumatic social experiences. Our patient received olanzapine and oxazepam oxalate in addition to relaxation training and was encouraged to communicate, listen to music and read the newspaper.

8. Follow-up and outcome

The patient was discharged on August 16, 2016.

The first follow-up took place on November 14, 2016, 3 months after discharge. The patient felt good, reported good self-evaluations, and had no cerebrospinal fluid leakage, no sleep disturbance, and no neurological dysfunction. He continued to rest at home without working. The patient was able to recall the accident but did not want to talk about it.

On May 12, 2017, the date of second follow-up, the telephone number provided was disconnected.

9. Discussion

Studies examining the factors that can affect the clinical efficacy of penetrating wound therapy have shown that demographic factors (age, gender, cause of injury) are not important factors that affect mortality [11]. However, the medical supervision team during transportation, the duration of transport, vital signs on admission (blood pressure, heart rate, breathing, consciousness), the timing of surgery (elective or emergency), and the presence of significant organ damage are important predictors of survival.

Clear awareness and an ability to answer questions correctly make inquiry an important means of obtaining subjective information. However, the patient had an accent, and his maxillofacial region was injured, making it difficult for him to close his mouth. Therefore, in this case, the patient's ability and willingness to talk and the ability of the medical staff to hear him clearly were related to the subsequent care measures. Notably, such accidents always involve a third-party site. These accidents involve not only the injury but also several civil legal compensation resources after the incident, so the authenticity of the event should be taken seriously. The description of the falling injury may be uncertain, and the medical staff should have reservations about unreliable answers. Therefore, nurses need to perform a brief inquiry to obtain descriptions from both the patient and his co-workers and must obtain a detailed medical history that is as realistic as possible based on observational, physical, and laboratory examinations and other objective data.

The CT scan is an accurate and rapid evaluation method and was the primary diagnostic method used in this case [3]. However, patient transport became the major obstacle due to the perforating injury. The rebar outside the body was easy to touch, and once it was touched, secondary damage was unavoidable. Second, shaking during transportation caused the displacement of the rebar, and if the rebar touched internal regions such as the heart, lungs, nerves, and blood vessels, the consequence would be deadly to the patient. Therefore, transportation security became a fundamental priority. A new study describes standardized grading transport processes that greatly reduce the risk of transport, including assessment and grading, communication and explanation, full preparation, normal transport, response management standardization, and summary evaluation [12].

The patient did not have injuries to the brain, heart, lungs, trachea or large blood vessels, which was beneficial for survival. In addition, the fact that the transfer of the patient to the hospital only took 10 min not only reduced the patient's level of fear but also provided the opportunity for immediate rescue.

The emergency green channel is an effective mechanism for the treatment of patients with critical illness, and it has become the consensus among the emergency departments of national hospitals to provide efficient service measures for critically ill patients. Emergency green channels provide a rescue process for urgent and severe cases and a smooth and timely diagnosis and treatment process to save patients' lives, thereby improving the success rate for rescuing patients and reducing medical risk. After the patient was admitted, the green channel was opened, and the medical staff worked together as a team for the initial evaluation and rescue. Emergency nurses played an important role in communicating, cooperating and guiding personnel by communicating with and building the nursing trauma team, using neck and spine plates, performing routine blood/blood type examinations and the CT scan, administering haemostatic drugs, managing insulation and pain, and providing psychological counselling. All of these measures greatly enhanced the efficiency and quality of the nursing.

The doctors were leading the trauma team. The early treatment flow chart for serious trauma patients was the established procedural control process, and the time standard was in accordance with each rescue period. This shortened the time from the early control of the injury to the diagnosis and surgical preparation and truly improved the efficiency of treatment. Cooperation with radiology, the operating room, the ICU, the surgical plan and other relevant departments established a multi-professional collaboration team, developed treatment programmes, and carried out timely intervention. These measures not only improved the patient's recovery but also played a positive role in reducing pain, eliminating psychological disorder and maintaining limb function.

Different members cooperated in this multi-disciplinary team. Pre-hospital care staff was mainly responsible for the early and rapid location of endangered patients, effective communication with emergency centres, performing primary assessments and providing necessary treatment. Clinicians do a great deal of work, including rapid assessment, accurate diagnosis, multi-disciplinary cooperation, surgery, and precise and comprehensive treatment. Coordinators communicate with each member of the team, make every effort to save time and monitor the entire rescue process. The nurses observe the patient's basic vital signs and changes in the disease and provide careful and comprehensive nursing care, communication and psychological comfort. In addition, social-psychological support for both patients and their families and for workers is necessary. Through the continuous improvement of the emergency green channel management process, the laborious and complicated diagnosis and treatment processes are simplified. Specific psychological intervention measures, namely, emotionally guiding patients to cooperate with treatment, promotes a positive attitude among patients and their family members when they are faced with disease, thereby emphasizing human intervention. All of our work facilitates the early prevention of risk factors and promotes the clinical

Role delegation table of trauma team



Team	Role
Pre-hospital care	Early fast find endanger patient, effective communication with emergency center, primary assessment and necessary treatment
Clinicians	Fast assessment, accuracy diagnosis, multi-discipline cooperation, surgery, precise and comprehensive treatment
Coordinators	Communication with each member of the team, make every effort to save time and monitor the entire rescue process
Examinations	Exact and necessary examinations, effective communications with clinicians, and advanced technology help make right diagnoses
Nursing	Monitor the patient’s basic vital signs, change of disease, careful and comprehensive nursing, communication and psychological comfort
Social-Psychological support	Social-psychological support both for the patients and their family, workers
Green-channel	An effective mechanism to provide efficient service measures for critically ill patients. make every effort to save time and keep close connection among each member.

Fig. 5. The diagram of the emergency green channel.

curative effect, thereby contributing to better recovery (See Fig. 5).

10. Patient perspective

The patient communicated that the first witness dialled “119” and “120” for help immediately, that the patient did not touch the foreign body and that he was grateful for the help of his workers. The patient received emergency aid and had a great fear of death. As the health care measures were successfully implemented, his level of fear decreased, and the patient expressed satisfaction with the entire medical assistance process. The patient was able to return to work and be completely independent. The main organs were normal, and he could perform normal activities. We thought he received successful treatment and that his social, physiological, and psychological health recovered.

Informed consent

The details of this study were explained to the patient. He knew the

purpose of this study, understood the procedures and possible benefits and risks and agreed to participate in and cooperate with this study.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

Ethical statement

The institutional review board approved this study for human investigation. The details of this study were explained to the patient. He knew the purpose of this study, understood the procedures and possible benefits and risks and agreed to participate in this study and cooperate.

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