



Case Report

Uncontacted tire explosion causing trauma to bilateral lower extremities: A case report

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ABSTRACT

It is uncommon for tire explosion related injuries on the lower extremity. The bilateral lower extremities were injured by tire explosion when the patient was seated in a bus. She sustained an open fracture with partial bone loss in the right calcaneus (a comminuted fracture in the right ankle joint) and a closed comminuted fracture in the left tibia and fibula. This damage was caused by uncontacted tire explosion, thanks to a thick floor between the exploded tire and the patient's feet. This type of injury on lower extremity caused by uncontacted tire explosion was uncommon.

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Several cases of injuries caused by explosion of a tire have been reported, where most cases are facial injuries and upper extremity injuries.^{1–4} However, tire explosion related injuries on the lower extremity are uncommon. Our case of tire explosion injury was a rare one, in which the bilateral lower extremities of the patient were injured by tire explosion when she was seated in the bus. Explosion related injuries occur at a relatively low rate, which can be classified into fragment injury or blast injury based on the mechanism.^{5,6} Thus, it is critical to identify the injury type for efficient treatment. We examined the cause to be secondary blast injury, and this case was treated with success. This study served as an ideal reference for future diagnosis and treatment for tire explosion related injuries.

Case report

In August 2014, a 62-year-old woman took a bus and her seat was just above the left rear wheel where the tire explosion occurred. The bus was moving forward on suet road when the

left rear wheel exploded spontaneously of an unknown cause. The bus did not roll over after tire explosion, and the driver employed emergency brake and evacuated passengers. Fewer than ten people were in the bus. The floor was blown open and both legs of the patient in this study were injured. She sustained an open fracture with partial bone loss in the right calcaneus, a comminuted fracture in the right ankle joint and a closed comminuted fracture in the left tibia and fibula (Fig. 1). The vascular status of the bilateral dorsalis pedis arteries remained normal. The heart Doppler ultrasound did not show any sign of heart injury. The internal bleeding and rupture was not found in abdominal CT. A CT scan of the thorax revealed no hemopneumothorax and pulmonary edema, while there were no rib fractures. Blood gas analysis showed normal blood oxygen saturation. The patient did not report any difficulty in breathing. There was no hearing impairment after the check-up. Finally, the emergency surgery was given, rather than conservative treatment. On the right side, because of the open fracture, physiological saline, hydrogen peroxide, chlorhexidine and iodine volts were used for a thorough debridement of wound. The devitalized skin and muscle tissue were removed completely. The devitalized and heavily-contaminated vessels were ligated and cut off in the end. The free nerve was covered by normal tissue, but not sutured and marked. The open fracture with partial bone loss of the right

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Fig. 1. The patient sustained an open fracture with partial bone loss in the right calcaneus, a comminuted fracture in the right ankle joint (A) and a closed comminuted fracture in the left tibia and fibula (B).

calcaneus was treated with debridement and covered by vacuum sealing drainage. An external fixator was used to stabilize the ankle joint. On the left side, during the same surgery, open reduction and internal fixation were used to fix the fracture of left tibia and fibula as conventional methods (Fig. 2). Post-operatively, cefuroxime and tinidazole were administered as antibiotic prophylaxis. One week later, the wound in the right heel was covered with sural neurocutaneous flap and the flap survived well (Fig. 3). Four weeks later, the patient was discharged, but the patient refused to accept the surgery of calcaneus reconstruction.

Discussion

Explosion injuries occur occasionally, mainly due to firecrackers, home-made explosive devices or industrial and domestic explosives.^{7–11} Injuries caused by tire explosion are rare but may lead to severe trauma. Significant morbidity can result from the force of tire explosion. Exploding truck tires mainly leads to severe facial and eye injuries, intracranial lesions or limb trauma.^{12,13} Only a few articles described upper limb trauma due to explosion of truck tires.^{14,15} Tire explosion injuries to the head, face and upper extremity are reported more frequently, and tire explosion related injuries occur most frequently in tire-related works such as tire inflation or repair. Injuries to the lower extremity due to tire explosion are rare. Tires should be considered as compressed air tanks, where the average pressure is 8–9 bars for truck tires, 2.5–3 bars for car tires, and 2–2.5 bars for wheelbarrows and pushcarts ($1 \text{ bar} = 1.02 \text{ kg/cm}^2 = 102 \text{ kpa}$).¹⁶ The Insurance Institute of Highway reproduced an explosion of an inflating tire causing the multi-piece assembly scattered at the speed of 100 miles per hour.¹⁴ High inflating pressure and low safety distance are the main factors responsible for this occurrence. The extent of the trauma is determined by the explosion, transmission medium, and distance to the explosion focus. A safety distance of 2.5 m from the inflating tire is recommended. If the wheel is not fixed, its components including the wheel rim could be as harmful as missiles.

It is necessary to analyze the injury mechanism for the treatment. There are two main possible injury mechanisms: fragment injury or blast injury. The fragment injury refers to projectiles in the explosion process from all kinds of explosive weapons such as landmines, guns, bombs or missiles hit the body and then trigger the loss of normal structure and function. According to different pathogenesis, blast injury is divided into four levels: primary, secondary, tertiary and fourth grade.¹⁷ In primary blast injury, shock



Fig. 2. The left tibia and fibula of the patient was treated by internal fixation (A, B) and the right ankle joint was treated by external fixation at various fracture sites (C, D).



Fig. 3. The wound in the right heel was covered with sural neurocutaneous flap which survived well.

wave is main cause to damage. However, penetrating injury or secondary blast injury is caused by pieces of explosives, nails, glass, wood or other flying objects which hit victims. The cause of tertiary injuries is either blowing away and hitting objects with hard surface by the heated explosion wind, or fractures and bone injuries induced by hitting collapsed buildings. Fourth grade injuries are different from the above mentioned ones, in which the impaired discomfort or symptoms are relevant to existing conditions and complications, such as burn, suffocation, poison and mental trauma. Exploding tires produce blast waves. Unlike most commonly seen tire explosion injuries, the patient we reported was seated in a moving bus when the tire explosion occurred. There was a thick floor between the exploded tire and the patient's feet, and tire explosion was blocked by the car undercarriage and car seats, thus it could not be classified as fragment injury. The majority of the blast was also blocked by the car undercarriage and car seats, therefore, it was classified as blast injury. However, the patient was not found with hearing impairment after the medical test. At the same time, we found no abnormal changes of internal organs by X-ray and CT examination for the patient with chest, abdominal CT, or electrocardiogram and color Doppler ultrasound. The blood oxygen saturation of the patient was normal. So the possibility of primary injury could be ruled out. This damage was caused by a uncontacted tire explosion in which the floor was pounded by blast wave caused by explosion, or the broken tires and rims. The patient's feet suffered secondary blast injury. The injury mechanism was more like the injury of the drivers in the tank resulted from mine explosion. The treatment was given according to the principles of fragment injury.

The debridement is needed 6–8 h after injury. A debridement of the necrotic structures and primary antibiotic prophylaxis are essential for wound healing and avoiding secondary complications such as infections. The treatment for completely broken blood vessels can include conservative observation, ligation, anastomosis and autologous vascular transplantation. The impaired blood vessels should be matched to the left part after removing the injured section, rather than being sewed directly. It is difficult to determine the range of the damage and the nerves should not be excessively trimmed, so we recommend coverage by free soft tissue or vacuum sealing drainage. The doctor should pay attention to the following factors at the stage of early treatment: thorough cleaning of injury site, no sewing of the nerves, no removal of the impaired somatic part of nerves or the free nerve ending. In order to prevent the spread of contamination, intentionally enlarging the injury for seeking the other end of the injured nerve should be avoided. The free nerve end should not be labeled by operation suture, instead, normal tissues can be used to cover the free nerve end, in order to promote wound healing and passive joint movement. The

treatment of the fractures includes both internal fixation and external fixation. The treatment of open injury of the right calcaneus proceeded in two stages: stage 1, the wound was treated with debridement and covered by vacuum sealing drainage; stage 2, the wound was covered with sural neurocutaneous flap one week later. This patient underwent two stages of therapies. The calcaneus defect needed to be reconstructed, but the patient refused to accept the surgery of calcaneus reconstruction.

In the Department of Orthopaedic Trauma, we did not take the implementation of psychological treatment at early stage for lack of experiences. Through the in-depth analysis on this case, we recommended early psychotherapy for this kind of injuries.

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