Management of Severe Thoracic Impalement Trauma Against Two-Wheeled Horse Carriage: A Case Report and Literature Review

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Abstract Thoracic injuries in general are of great importance due to their high incidence and high mortality. Thoracic impalement injuries are rare but severe due to the combination of cause, effect and result. This study's primary objective is to report the case of a young man who was impaled by a two-wheeled horse carriage shaft while crashing his motorcycle in a rural zone. An EMT-B ferry was called at the crash scene and a conscious patient was found, sustaining a severe impalement injury to the left hemithorax, suspended over the floor by the axial skeleton with the carriage shaft coming across his left chest. As a secondary objective, a literature review of thoracic impalement injuries is performed. Cases of thoracic impalement injury require unique and individualized care based on injury severity and affected organs. Reported protocols for managing impalement injuries are entirely anecdotal, with no uniformity on impaled patient's approach and management. In penetrating trauma, it is essential not to remove the impaled object, so that possible vascular lesions remain buffered by the object, avoiding major bleeding and exsanguination haemorrhage. Severed impaled thoracic patients should be transferred to a specialist centre for trauma care, as these lesions typically require complex multidisciplinary treatment. High-energy thoracic impalement injuries are rare and hold a high mortality rate, due to the complexity of trauma and associated injuries such as thoracic wall and lung lesions. Modern

medicine still seems limited in cases of such seriousness, not always with satisfactory results.

Keywords Impalement · Thorax · Trauma

Introduction

Thoracic injuries in general are of great importance due to their high incidence and high mortality [1]. They account for 20–30 % of trauma-related deaths [2, 3]. Most deaths occur on the crash site, resulting from injuries involving the dangerous zone *Zeidler* or associated with lesions of the central nervous system. Of those who survive the initial trauma and arrive at the hospital, 15 % have a high mortality rate, often preventable with simple and immediate diagnostic/therapeutic measures. Less than 10 % of blunt trauma and between 15 and 30 % of penetrating thoracic injuries require a thoracotomy [1]. Its main indications are associated with the involvement of the heart, great vessels, lung parenchyma and the intercostal vessels [3].

Thoracic impalement injuries are rare but much more severe due to the combination of cause, effect and result [4]. High kinetic energy usually results in severe multiple injuries culminating in high mortality rates [5]. Only a few cases have been reported worldwide in patients who survived without some degree of sequel [5].

The management of complex thoracic trauma demands trained and experienced staff, requiring special attention from the crash scene to intra-hospital care, preferably conducted in a trauma centre [4].

The primary objective of this study is to report the case of a severe thoracic trauma resulting from impalement, describing the difficulties and complexity of care in treatment. As a

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secondary point, we review the literature on the management of such complex injury. To our knowledge, this is the first report of chest impalement related with such intense mechanism of trauma.

Case Report

This is a 19-year-old man, motorcycle driver, using a helmet, with a history of alcoholism, victim of a frontal impact against the shaft of a no-horse-parked two-wheeled horse carriage. The motorcycle crash occurred in a rural zone, 40 km away from a referral trauma centre. A local fire department rescue EMT-B ferry was called at the crash scene. Once there, the emergency technician found a conscious patient, sustaining a severe impalement injury to the left hemithorax. The individual was found suspended over the floor by the axial skeleton, with the carriage shaft coming across his left chest. Firefighters sectioned the wooden carriage shaft (12 cm in diameter) and transported the patient in a lateral position to a secondary emergency hospital in the rural zone. On admission, the patient was hypotensive and tachycardic (BP 60×40 mmHg and HR 130 bpm). Bilateral closed chest tube drainage and resuscitation with 2000 mL of lactated Ringer associated with transfusion of two packed red blood cells, according to the ATLS® protocol, were performed. After stabilization, surgeon-to-surgeon phone contact was performed for transferring the patient to a referenced trauma centre.

The patient was brought by an advance rescue unit (with a doctor on-board), 2 h after the initial event in the left lateral position, immobilized on a rigid board, intubated and with bilateral thoracic drainage (Fig. 1). On admission to the trauma centre, the patient was on mechanical ventilation with inspiratory oxygen fraction (FIO₂) of 100 %, SatO₂ 92 %, BP 170×110 mmHg, HR 112 bpm and Glasgow coma scale 3. The revised trauma score is 3.51. Arterial blood gases revealed Hb 13.8, pH 7.17, BE -12.6, HCO₃ 15.4 and lactate 6.8. The patient was immediately transferred to the operating theatre for removal of the impaled object and injury control. The fire department crew followed the trauma team to the operating room (OR) and performed the sectioning of the wood piece, to allow the supine position and ideal anaesthetic-surgical access (Fig. 2).

An anterior–posterior exploratory thoracotomy was performed, from entrance wound site to exit wound site, allowing the removal of the object under direct vision. The surgical procedure was performed under general anaesthesia with non-selective oro-tracheal intubation (Fig. 3). The following injuries were identified on surgical inventory: an American Association for the Surgery of Trauma Class IV injury (major segmental or lobar airway leak) to the left lung

and multiple rib fractures with loss of bone tissue (rib avulsion) and muscle. There were no cardiac or major vessel injuries (injury severity score 16, trauma and injury severity score 76). Two more packed red blood cells units and 4 units of fresh frozen plasma (FFP) were transfused in accordance with the 1:1 ratio (two PRBC's at the rural hospital, two more at the referred trauma centre and 4 units of FFP in the trauma centre). Non-anatomic left segmental pneumonectomy was performed with a linear stapler, as well as cavity wash with saline solution, removal of devitalized tissue, removal of relevant foreign bodies and closing of the thoracic cavity with anterior and posterior pleural drainage, according to our implemented protocol (Fig. 4).

Lastly, intra-operative arterial blood gases revealed a respiratory acidosis: pH 7.26, BE -3.9, HCO₃ 22.6, lactate 5.9 and Hb 10.6. The patient was referred to the trauma intensive care unit (TICU) and intubated without vasoactive drugs. Tetanus vaccination and antibiotic therapy with amoxicillin + clavulanic acid were administered.

On the first post-operative day, residual pneumothorax was resolved with continuous vacuum aspiration of the drainage system. The patient evolved with paradoxical breathing and high respiratory ventilator resistance. By this time, neuromuscular blockade with pancuronium was chosen in order to better control respiration and compliance to mechanical ventilation. Intensive respiratory physiotherapy was initiated. Chest tube presented low output to the right. Posterior left chest tube had an output of 300 mL of serous-bloody secretion. Anterior left chest tube persisted with air leaking. Control labs showed enlargement of international normalized ratio (1.58) and hyperfibrinolysis (173.1 %), reflecting a severe coagulopathy status. Sequential organ failure score (SOFA) was used as a routine in all critical patients in our TICU and equalled the value of 6 on the first post-trauma day.

On the third day after surgery, this young man presented with pulmonary atelectasis and important ventilatory restriction, improving after emergency bronchoscopy and subsequent aspiration of an airway mucous plug. Also on this date, the patient started with haemodynamic instability, coursing with low blood pressure and tachycardia, the time when the assistant team chose to start vasoactive drugs (norepinephrine, dose 0.07 µg/kg/min) and urine alkalinization (CKT 7212), fearing renal failure due to severe chest trauma, destruction of muscular tissue and subsequent rhabdomyolysis.

Over the seventh post-operative day, the patient progressed with acute respiratory distress syndrome (ARDS) (PaO₂/FiO₂ <100) and pulmonary sepsis. After consulting the Committee for Control of Hospital Infection, a broad-spectrum beta-lactam antibiotic (imipenem) was initiated, associated with polymyxin B guided by previously requested cultures. Without showing clinical improvements

Fig. 1 Trauma centre emergency room

and anticipating a prolonged length of stay, the TICU team chose to perform a tracheostomy on the eighth day of hospitalization, the day that evolved with acute tubular necrosis requiring haemodialysis for acute renal failure.

On the 12th day in the TICU, the patient presented empyema through chest tube and cardiorespiratory arrest in pulseless electrical activity, reversed with resuscitation manoeuvres, according to the protocols established by the American Heart Association. However, this young man deceased on the 13th post-operative day due to septic shock (norepinephrine 1.15 µg/kg/min) and multiple-organ failure (SOFA 14).

Literature Review and Discussion

Cases of thoracic impalement are rare and require unique and individualized care based on injury severity and affected organs [6]. The mechanism and severity of trauma must be evaluated immediately to determine appropriate resuscitation and management [4]. Reported protocols for managing impalement injuries are entirely anecdotal, with no uniformity on impaled patient's approach and management, although general principles of trauma care apply in these specific infrequent cases [7, 8]. Attention to airway, breathing and circulation is paramount. The pre-hospital phase of care is even more crucial. The main goals in thoracic trauma resuscitation include optimizing tissues oxygen delivery, bleeding control and replacement of intravascular volume [7].

Fig. 2 After firefighters' performance (sectioning the wood piece on the OR) to allow the patient's supine position

In penetrating trauma, it is essential to not remove the impaled object, so that possible vascular lesions remain buffered by the object, avoiding major bleeding and exsanguination haemorrhage [4, 6, 9–11]. To maintain the airway and ventilation, early intubation may be indicated [4]. A chest tube should preferably be placed prior to initiation of mechanical ventilation in anticipation of the possibility of installing a tension pneumothorax, severe and potentially lethal condition [12]. After ventilatory and haemodynamic stabilization, the patient should be transferred to a specialist centre for trauma care, as these lesions typically require complex multidisciplinary treatment.

Previous contact with the trauma centre is important, to the extent that the emergency team, surgery and anaesthesia teams, blood bank and intensive care unit (ICU) can be prepared for the arrival of the patient. According to Balukbas et al., early contact with the surgeon is essential to reduce mortality and late morbidity [13].

The vast majority of patients with penetrating chest trauma do not need thoracotomy [3, 14], which may not apply to impalements.

Surgical and anaesthesia teams must be fast and accurate. Although selective intubation was not performed in the presented case, it facilitates access and repair of intra-thoracic lesions, when available. Intravenous induction agents such as propofol and thiopental may cause blood pressure drop due to vasodilation and direct myocardial depression. Therefore, these should be avoided or administered in titrated doses in haemodynamically unstable patients or in patients with suspected cardiovascular

Fig. 3 Intraoperative period

compromise. Ketamine is considered useful to induce anaesthesia in patients with cardiac tamponade, which produces stimulation of the sympathetic nervous system [7]. Also, use of lidocaine on anaesthetic inductions may be useful once cardiovascular compromise is present.

Noit, in a case report of thoracic impalement, stressed the importance of decontamination of the pleural cavity due to dirt and organic debris and inorganic leaked by the mechanism of chest trauma [11]. All necrotic tissue must be removed, but care must be taken to preserve viable lung, because an expanded lung is a good protection against empyema [15]. Thus, we believe that the debridement of the lesion associated with extensive washing of the thoracic cavity can eventually lead to a better prognosis.

Soon after surgical repair, surgical team must insufflate lung parenchyma to prevent atelectasis [6]. Usually patients have a better survival rate when injury is restricted to the lung [6]. Pulmonary bleeding tends to be self-limited due to the low pressure of the pulmonary vessels and high

thromboplastin concentration in their tissues, associated with lung expansion in the pleural cavity promoting effect of compression on the bleeding vessels [6].

There is no consensus on antibiotic prophylaxis aimed to prevent infectious complications in impalement chest trauma [16]. We agree with Bosman et al. that it is prudent to use cephalosporin on prophylaxis for penetrating injuries transfixing the chest [16]. A tetanus vaccination should not be forgotten, as impaling objects often have high infective potential [15].

The major septic complications related to penetrating chest trauma include empyema, lung abscess, pericarditis, osteomyelitis and mediastinitis [16]. A CT scan is, to date, the best diagnostic method for these mentioned complications. The incidence of empyema in penetrating chest trauma varies between 2 and 25 % and in between 35 and 75 %. *Staphylococcus aureus* is the isolated germ [16, 17]. This is the most frequent infectious complication in thoracic trauma, and once established, early pleural decortication (up to

Fig. 4 Final aspect and the impaled object

2 weeks) is the treatment of choice. The earlier the approach, the less complications and hospitalization will be [18].

The incidences of systemic inflammatory response syndrome, infectious complications, ARDS and multiple-organ dysfunction system are substantially higher in patients with severe chest trauma. The severity also results in a significant increase in ventilation time, ventilation-associated pneumonia and length of stay in ICU [19]. Therefore, it is imperative to establish priorities in terms of time and surgery on multiple trauma cases (definitive care versus damage control), to avoid complications [19].

The direct traumatic injuries to the lung and systemic inflammatory response result in serious changes in alveolar–capillary. This leads to acute lung injury or ARDS, increasing the severity of pulmonary dysfunction. The excessive bronchial secretion predisposes to lobar collapse and lung volume reduction, leading to pneumonia in 50 % of cases. Often, bronchial secretions create a dense mucous plug obstructing its bronchus, eventually being necessary to perform emergency bronchoscopy for its clearance. Adding to these factors, there is a significant reduction in ventilation/perfusion ratio by decreasing the oxygen supply to vital organs [20].

The current treatment for lung injury is supportive only, aimed to alleviate inflammatory lung condition found in ARDS. This is through intensive care, haemodynamic monitoring, cautious volume resuscitation, fluid balance and adequate protective ventilation [20]. The mechanical ventilation strategies include the use of high tidal volumes (6–12 mL/kg), allowing mild hypercapnia and respiratory acidosis. If this technique fails, independent pulmonary ventilation is another ventilation strategy, allowing one-lung ventilation, whereas the other is blocked artificially to isolate the fluids or secretions, thus avoiding contamination of the non-injured lung [21]. Another useful option is independent two-lung ventilation, allowing different parameters either for the healthy lung or the injured lung.

In cases of severe ARDS and when all other treatment strategies have failed, extracorporeal membrane oxygenation (ECMO) can be used as a temporary substitute for the injured lungs that either do not ventilate or do not oxygenate. The major goal is to increase the lungs rest time, giving it time to recover from trauma. According to the Cesar trial, which compared the use of traditional treatment with ECMO for severe ARDS, a significant survival improvement was observed in the ECMO group. Unfortunately, this therapeutic option is only available in few specialized centres worldwide and further research is needed [19, 21].

Despite all the available management and treatment strategies, impalement to the chest remains a high mortality mechanism of injury.

Conclusion

Impalement thoracic injuries are rare and hold a high mortality rate, because of the complexity of trauma and associated injuries. A specialized centre with a well-trained, multidisciplinary team of professionals is an essential piece in the management of chest injuries arising from complex penetrating mechanisms. Modern medicine still seems limited in cases of such seriousness, not always with satisfactory results.

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