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Case Report

A case of cardiac impalement injury with severe shock treated surgically after diagnosis using computed tomography and managed *via* extracorporeal membrane oxygenation in the hybrid emergency room[☆]

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ABSTRACT

The Hybrid Emergency Room System (HERS) allows clinicians to perform life-saving procedures without having to transfer patients. Several studies have reported the effectiveness of the HERS in the treatment of blunt trauma patients. However, the use of a hybrid emergency room (ER) for the treatment of penetrating cardiac injuries, including impalement injuries, has not been reported. We present the case of a patient with cardiac impalement injury that was diagnosed *via* computed tomography (CT) and was managed *via* extracorporeal membrane oxygenation (ECMO) in the hybrid ER and *via* surgery in the operating room. A 55-year-old man was transferred to our hybrid ER due to a penetrating wood injury through the right thoracic region. The patient had unstable vital signs. A CT scan revealed a pericardial effusion, right lung contusion, and bilateral pneumothoraces. There were no signs of hemothorax or aortic injury. Veno-arterial-ECMO was performed in preparation for surgery. The patient was then transferred to the operating room. Pericardiotomy and cardiac repair were performed, and the ECMO was discontinued post-operatively. The patient was discharged on postoperative day 10 without complications. The hybrid ER allows rapid CT examination without relocation. Thus, it facilitates the formation of a timely and effective treatment plan. This report documents the successful management of a cardiac impalement injury in the HERS.

Introduction

Establishing the diagnosis immediately and rapidly providing the appropriate treatment are essential in the treatment of patients suffering from cardiac impalement injuries. However, these are difficult to achieve in severe cases [1].

Hybrid emergency room (hybrid ER) was installed in our hospital's emergency department. The room contains a sliding CT scanner, CT examination and intervention table, moveable C-arm, monitor screen, and a mechanical ventilator. In general, the Hybrid

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Emergency Room System (HERS) is defined as a novel trauma workflow system that includes the role of the ER, emergency CT room, interventional radiology (IVR) room, and operating room. All life-saving procedures including airway management, emergency surgery, and transarterial embolization can be performed on the table without relocating the patient [2–4].

We report the case of a hemodynamically unstable patient with a cardiac impalement injury, diagnosed using CT examination. The patient underwent rapid resuscitation *via* veno-arterial-extracorporeal membrane oxygenation (VA-ECMO) in our hybrid ER and was successfully treated *via* surgery.

Case presentation

A 55-year-old man was transferred to the hybrid ER due to a penetrating wood injury through the right thoracic region. While the patient was working at a construction site, the wood dropped from a height of 3 m and penetrated his right thoracic region. The wood had a diameter of 7×2 cm and a length of 32 cm. The patient had unstable vital signs with a blood pressure of 52/35 mm Hg, heart rate of 101 bpm, oxygen saturation of 83 % with a 10-L mask, and a Glasgow Coma Scale score of 15 (E4V5M6). The patient had jugular venous distension (Fig. 1) and the ultrasound scan revealed pericardial effusion. A tension pneumothorax was immediately excluded using fluoroscopic imaging. Obstructive shock secondary to cardiac tamponade was suspected. A CT scan was performed while the patient was resuscitated to confirm the diagnosis. The CT revealed pericardial effusion, right lung contusion, and bilateral pneumothoraces. There were no signs of hemothorax or aortic injury (Fig. 2). Emergency surgery was indicated, but since the patient was in a state of peri-arrest, transport to an operating room (OR) was not feasible. Thus, VA-ECMO was performed to stabilize his hemodynamic status in preparation for the surgery. The preparations for the surgery were conducted simultaneously with the patient's intubation, VA-ECMO, and chest drainage of the left intercoastal area in the hybrid ER. The patient was transferred after his vital signs had stabilized. Pericardiotomy was performed and the hematoma was removed. After the wood had been extracted, (Fig. 3) ECMO support was weaned and removed. The total ECMO time was 90 min. The patient's vital signs stabilized after ECMO removal, and he was transferred to the intensive care unit. He was extubated on the first postoperative day. The patient was discharged on postoperative day 10 without complications.

The patient provided written informed consent for the publication of this case report.

Discussion

Impalement injuries are defined as penetrating injuries involving large foreign bodies impaling the human body. The high-energy impact of these traumas causes extensive local tissue destruction with elements of both blunt and penetrating injury [5]. Few cases have been reported of those who reach the emergency department owing to the small number of survivors [1].

According to some reports, patients suffering from penetrating thoracic injuries are transferred directly to the OR and resuscitated. The management of penetrating cardiac injuries, including impalement injuries, in the hybrid ER has not been reported previously. We report the case of a patient suffering from a cardiac impalement injury who was diagnosed using CT scan and was resuscitated *via* VA-ECMO in the hybrid ER and was then treated with surgery in the OR. Although we were aware that it was an unconventional measure, we still transferred the patient to the hybrid ER intentionally. This is a pioneering case report that shows the usefulness of the HERS in penetrating injuries.

The effectiveness of the HERS in the treatment of trauma patients has been reported in several studies. According to Kinoshita et al.,

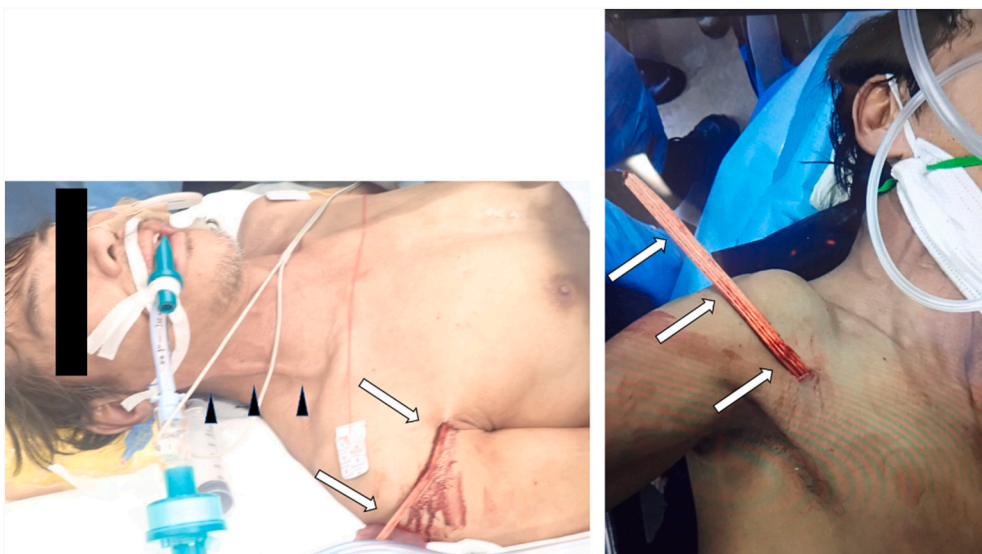


Fig. 1. Patient with the penetrating wood injury in the right thorax (arrows), showing possible jugular venous distension (arrowheads).

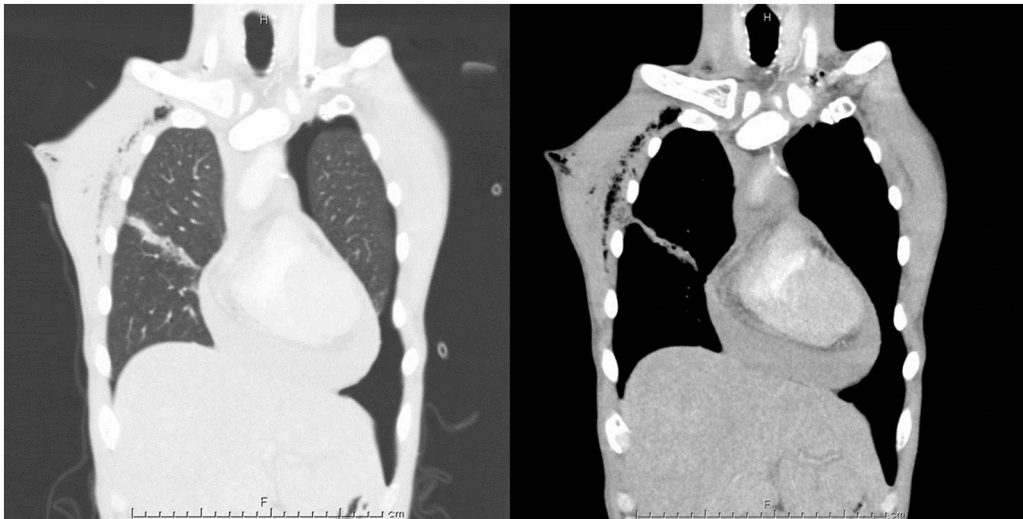


Fig. 2. Chest computed tomography revealed a pericardial effusion, right lung contusion, and bilateral pneumothoraces.



Fig. 3. The wood was removed surgically.

using a hybrid ER resulted in a decreased mortality rate and time to CT scan initiation among blunt trauma patients. Moreover, the duration of emergency bleeding control procedures was also shorter in patients treated in the hybrid ER than in those who received the conventional treatment [2]. However, there is insufficient data on the use of the HERS in the treatment of patients with penetrating trauma. Despite the lack of evidence, the HERS remains a viable treatment option for impalement injuries.

First, the HERS allows the immediate conduction of CT examination, particularly for patients in shock. The management of impaled patients is individualized based on the severity of the injury, affected organs, and the type of shock (obstructive, hemorrhagic, or both). We can predict the clinical course to a certain extent using CT examination; therefore, we determine the priority of treatment and prepare for a back-up plan. However, transporting patients to the CT equipment can compromise their clinical condition. The HERS allows immediate CT scan examination without requiring patient relocation. In penetrating injuries, it may be quicker to begin the surgery by transferring patients directly to the OR. However, diagnosis using a CT scan in the hybrid ER may make treatment safer and more reliable, providing clinicians with a better picture and enabling them to manage a wide variety of cases.

Secondly, some indwelling devices, particularly ECMO or intra-aortic balloon occlusion, can be applied more safely and rapidly in the hybrid ER compared to the conventional emergency room. The cannula can be immediately and safely placed using moveable C-arm fluoroscopy and ultrasonography equipment guidance with the HERS. A retrospective study demonstrated that the hybrid ER significantly reduced the incidence of cannulation complications in patients undergoing ECMO [6].

The patient in the present case was considered to be in obstructive shock secondary to cardiac tamponade. Although the patient was in a state of peri-arrest, pericardiocentesis was not performed to avoid major bleeding caused by blood pressure elevation. In addition, the probability of hemorrhagic shock was low based on the CT examination. Thus, VA-ECMO was implemented to stabilize the patient. It also served as a cardiopulmonary bypass in preparation for cardiac surgery. In some cases, VA-ECMO or cardiopulmonary bypass was performed to facilitate cardiac surgery among patients with impalement injuries. In this case, it was useful for completing the definitive surgical intervention. In addition, VA-ECMO was successfully conducted without complications.

However, performing surgery in the hybrid ER has two disadvantages. First, cardiopulmonary bypass is not feasible in areas with less electrical outlets and space. Second, the hybrid ER is less sterile than an OR; while this may vary between facilities, it probably applies to most HERS.

In summary, we believe that use of the HERS is valuable for patients experiencing penetrating injuries, as per this case. The HERS allowed the prompt identification of the injured organs and an appropriate surgical plan was constructed without having to transport the patient. Furthermore, more treatment options, including VA-ECMO, became available for this case. The use of the HERS has the potential to enhance the speed and quality of the diagnosis and treatment of impalement injuries.

Conclusions

This report documents the successful surgical treatment of a patient with a cardiac impalement injury that was diagnosed *via* CT and safely managed *via* VA-ECMO. The HERS is useful in the management of cardiac impalement injury.

Ethics statement

The patient provided informed consent.

Consent statement

The patient provided written informed consent for publication of this case report.

Funding statement

No funding was obtained for this study.

Conflict of interest

None.

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