Use of magnets in minimally invasive surgery of shrapnel wounds

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The widespread use of rocket and artillery systems is a feature of modern warfare in Ukraine, and in this regard, the prevalence of shrapnel wounds, the proportion of which is 56.7%. The proportion of multiple and combined injuries is 27.4%. By anatomical location, the most common injuries were to the extremities (57.1%), with a significant increase (up to 26.6%) in the frequency of head injuries, mainly due to mine–blast trauma [1]. The relatively low incidence of injuries to the chest and abdomen (7.0 and 5.5 per cent, respectively) is explained by the use of personal protective equipment. At the same time, such injuries are among the most severe, and they account for 46% of the causes of death in the hospital setting [1].

The proportion of chest wounds caused by firearms during the Anti–Terrorist Operation (ATO)/Joint Forces Operation (JFO) in 2014–2016 ranged from 7.4 to 11.7% of the total number of wounds. Unfortunately, the mortality rate due to such injuries remains high, ranging from 12.2 to 25%. The severity of the injury, surgical tactics and outcome of treatment depend on the ballistic and anatomical morphological characteristics of the wound [2].

The clinical and epidemiological study of chest wounds in servicemen who participated in the ATO/JFO allows to identify the factors that determine the adequate diagnostic and treatment tactics and to calculate the necessary resources of the medical service to provide effective care.

The structure of chest wounds is dominated by shrapnel wounds – 72.2%, explosive wounds account for 17.5%, and bullet wounds – 10.3%. Among shrapnel wounds, non–penetrating wounds account for 80.9%, and among explosive and bullet wounds – 62.8 and 61.5%, respectively [2].

Chest injuries are characterised by their severity as mild (26.8%), moderate (44.2%) and severe (29.1%). Most often, severe trauma is observed in bullet wounds (50.9%), in explosive wounds the incidence of severe trauma is 26.6%, and in shrapnel wounds – 23.8%. In moderate injuries and severe internal injuries, 3/4 of patients have severe trauma [3].

In case of mine and blast wounds of the chest, doctors face serious medical problems that arise as a result of exposure to explosive devices. These injuries have a pathogenetic feature that is determined not only by the penetration of a projectile into the body, but also by the impact of the shock wave and the throwing effect [3].

Among the key features of such injuries is barotrauma due to the airborne shock wave caused by the explosion, which propagates and damages the tissues it encounters. In the chest, this can lead to lung rupture, tissue crushing and other pressure–related injuries. The projectile effect is caused by the movement of projectile fragments or other objects generated during an explosion that can penetrate deep into the chest tissue, causing significant damage along the way. The throwing effect is particularly dangerous, as fragments can move with high speed and energy, causing severe injuries. In a mine–blast chest injury, not only the penetration of a projectile is possible, but also concomitant injuries such as fractured ribs, scapula, clavicle, sternum, and damage to blood vessels and internal organs. This can be accompanied by the development of complex clinical scenarios, including open and tension pneumothorax, ongoing intrapleural bleeding, and other dangerous conditions.

Mine–blast wounds to the chest require a comprehensive approach to treatment and surgery. Understanding the pathogenesis and characteristics of these injuries is a key to successful treatment and improving the prognosis for victims.

Shrapnel wounds of the chest can occur as a result of the explosion of artillery shells, mines, grenades, and other similar devices [4] and have serious consequences due to damage to various structures of the chest [5].

The use of magnets in the process of removing metal fragments is promising and effective [6]. Magnetic surgical instruments made of titanium and non–corrosive plastic can be used repeatedly. Its multifunctionality lies in the availability of different nozzles of different diameters, which allows you to work with wound channels of different sizes. Magnets can be used to both diagnose (search for) fragments and remove them through wound channels.

The flexible magnet, specially designed for use in non–linear wound channels, opens up new possibilities for precise and rapid fragment removal. It also enables the removal of encapsulated fragments.

Advantages of using magnets in surgery

Accuracy and speed of the operation. The magnet allows

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you to accurately determine the location of the fragment in the body, which contributes to an effective and fast operation. Reducing the risk of complications. Magnetic instruments help reduce the risk of bleeding and the amount of surrounding tissue removal.

Reduced trauma. The use of magnets reduces the size of the incision, which facilitates postoperative recovery and haemostasis.

We present a clinical observation of the surgical treatment of a patient with severe shrapnel wound of the chest.

In 2023, patient K., 46 years old, came to the National Scientific Centre of Surgery and Transplantation named after O. O. Shalimov with complaints of significant shortness of breath, chest pain, especially on the left and near the heart, inability to take a full breath, which significantly limited his physical abilities. Recently, he received a severe shrapnel wound to his chest in the combat zone.

During the examination of the patient using computed tomography (CT) of the chest cavity (CC), a metal fragment was found in the pericardium measuring 8 × 9 mm (Fig. 1).

After a thorough analysis, it was decided to perform a full–scale surgical intervention: thoracoscopic removal of the metal fragment.

The course of the surgical intervention

Preparation and placement of trocars. After preparing the surgical field and placing the patient in the supine position, i.e. in the prone position (Fig. 2), 3 trocars were inserted into the pleural cavity on the right.

Inspection and search for the fragment. During the revision, no visible pathology was found. The mediastinal part of the pleura was opened, and further revision revealed scar tissue in the mediastinal soft tissue in the pericardial projection.

Use of a magnetic device. A magnetic device was inserted into the pleural cavity to accurately determine the location of the fragment and its subsequent removal (Fig. 3). A metal fragment in the pericardium was identified.

Removal of the fragment and wound closure. The pericardium was opened, a fragment with a fragment was excised under the control of a magnet and successfully removed. The mediastinal pleura was sutured. Drainage was installed in the pleural cavity on the right.

The operation was complicated due to the difficult location of the fragment in the pericardium (Fig. 4). The size of the fragment was 9 × 8 mm (Fig. 5). The use of a magnetic instrument for thorascoscopic surgery proved to be very effective. This innovative technology made it possible to accurately determine the location of the fragment and remove it.

Result and postoperative period. The patient's recovery after the operation was successful (Fig. 6), and he was discharged from the hospital on the 5th postoperative day.

This clinical observation demonstrates the importance of combining high–tech methods and the professionalism of medical practice.
of medical staff to successfully treat complex injuries and save patients' lives.

Conclusions

The use of magnetic instruments in minimally invasive thoracoscopic surgery is effective and promising, as it allows for increased accuracy, reduced trauma, and easier removal of metal fragments from the thoracic cavity. The introduction of these technologies into widespread surgical practice during modern warfare may improve the outcomes of treatment of patients with gunshot and shrapnel wounds requiring thoracoscopic intervention. Treatment of shrapnel wounds of the chest should be comprehensive and innovative. The introduction of the latest techniques, such as the use of magnetic surgical instruments, can significantly improve the outcomes of treatment of victims and increase the chances of their full recovery.

Thoracoscopic surgery is an effective method of treating patients with chest injuries, including pericardial
The use of magnetic instruments in such interventions has attracted considerable interest. The present clinical observation demonstrates the importance and benefits of these innovations.

Localisation accuracy. Magnetic instruments allow surgeons to pinpoint the exact location of metal objects in the patient's body, which is important when fragments can become lodged in hard-to-reach areas such as the pericardium.

Minimally invasive procedure. The use of magnetic instruments makes it possible to perform thoracoscopic operations with smaller incisions and minimal tissue intervention, which contributes to a quicker patient recovery and a shorter postoperative period.

Increase the effectiveness of hemostasis. When removing metal fragments from damaged tissues by reducing the surface of tissue revision, magnetic instruments contribute to effective haemostasis, which is a key aspect of the treatment of gunshot wounds to the chest.

Minimisation of traumatic effects. The use of magnetic instruments during thoracoscopic surgery minimises traumatic effects on the surrounding tissues, which contributes to a quicker patient recovery and reduced pain intensity after surgery.

Ukrainian surgeons strive to make a significant contribution to improving the effectiveness of medical care during the hostilities caused by the Russian aggression and continue to develop and improve approaches to minimise trauma during surgical interventions.

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