

Migration of foreign bodies of firearms origin

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Abstract

Objective. To analyse the results of diagnosis and treatment of wounded with gunshot combat trauma, in which foreign body migration was recorded, and to determine their optimal algorithm.

Materials and methods. The data of anamnesis, objective clinical and general clinical and laboratory studies, as well as the results of instrumental diagnostics (radiological, endoscopic, ultrasound examinations) of 67 wounded with blind gunshot wounds of various localisations were analysed. Thoracic, laparoscopic and arthroscopic surgical interventions were performed on a video endoscopic stand, and surgical magnetic instruments were used to diagnose and remove ferromagnetic foreign bodies.

Results. The main directions of foreign body migration are the respiratory tract, gastrointestinal tract, vascular bed, cavities (pleural, abdominal, joints) and soft tissues in case of suppurative. Foreign body fixation occurs in the place of narrowing of an artery or vein, distal parts of the respiratory tract, gentle parts of the pleural or abdominal cavity, in organs with structural features (heart, intestine, joint).

Conclusions. Although the migration of foreign bodies of gunshot origin is rare, it requires appropriate attention and response. In case of gunshot penetrating wounds of cavities (thoracic, abdominal, large joints), to which foreign bodies may migrate, preference should be given to minimally invasive endoscopic methods of their removal using modern magnetic instruments.

Keywords: gunshot wounds; foreign bodies; migration; false migration.

The large-scale invasion of Ukraine by the Russian Federation has led to a significant increase in the number of gunshot wounds of various localisations and, accordingly, their share in the overall structure of injuries [1, 2]. At the same time, the frequency of migration of wounding shell fragments is increasing.

Usually, foreign bodies that have penetrated the tissues during a gunshot wound remain in the wound canal. However, subsequently, due to a number of factors, such as active movements of the patient, deficiencies in the sanitation of the wound canal, the development of purulent complications characterised by tissue "melting", blind wounds to anatomical cavities (tendon sheaths, paranasal sinuses), etc., foreign bodies sometimes migrate a considerable distance from the place of their initial penetration. There are reports that a bullet that was in the right ventricle of the heart after being wounded was found 40 days later in the femoral artery, as well as reports of foreign bodies in the heart cavity after jugular vein injuries [3, 4].

Studying the migration of foreign bodies in the cavity or sac of a large joint, given the complexity of its anatomical structure, deep placement in the tissues, in particular the hip joint, favourable conditions for the development of infection and a high rate of disability of the wounded, is of considerable practical importance [4].

In the structure of gunshot wounds of large joints of servicemen who participated in the Anti-Terrorist Operation/ Joint Forces Operation, blind wounds accounted for 78% and

were accompanied by the presence of foreign bodies (metal fragments, bullets, etc.) in the joint cavities and structures that required removal, and the frequency of their free movement in the joint cavity was 9.4% [5].

In general, there is a lack of scientific papers on the migration of foreign bodies of gunshot origin, and such descriptions are occasionally found in the literature, but they are in the form of short reports and have limited information content [6–9], mostly reporting on the migration of foreign bodies that have entered the respiratory tract or digestive system through natural orifices in children [10, 11]. Therefore, the analysis of a significant amount of material and the systematisation of certain provisions regarding the migration of foreign bodies in gunshot wounds is of interest to practicing surgeons.

The aim of the study is to analyse the results of diagnosis and treatment of wounded with gunshot combat trauma, who have foreign body migration, and to determine their optimal algorithm.

Materials and methods

We examined 67 wounded with blind gunshot wounds of various locations who received care at the Military Medical Clinical Centre of the Northern Region between May 2014 and May 2023. All the wounded were men, with an average age of (34.2 ± 0.4) years.

The data from the anamnesis, objective clinical and general clinical and laboratory tests, as well as the results of instru-

mental diagnostics were analysed. All the wounded, depending on the location of the wound, underwent multislice computed tomography (MSCT) of the head, chest and abdominal cavities on a Toshiba Activion 16 with a 0.5 mm tomographic step with and without tomohexol contrast, and radiographic examinations of the head, chest and abdominal cavities, extremities using the X-ray diagnostic complex KRD-50 "INDIASCOP-01" (Ukraine), fibrobronchoscopy, fibrogastroduodenoscopy, fibrocolonoscopy on the video endoscopic stand OLYMPUS CV-170, 2017, ultrasound examination of the neck, chest, abdomen, joints and soft tissues using the GE LoGiQ P8 apparatus.

Thoraco-, laparoscopic, and arthroscopic surgical interventions were performed on the OLYMPUS VISERA 4K UHD OTV-S400, 2021 video endoscopic stand.

Surgical magnetic instruments were used to diagnose and remove ferromagnetic foreign bodies [12].

Results

To understand the process of foreign body migration, we distinguish two stages of foreign body passage: through the wound channel and along the migration pathway, and three main positions: the entry hole, the place where the foreign body begins to migrate, and the place where it is fixed (*Fig. 1*).

The identification of these two stages and three positions is important for the diagnosis and scope of surgical treatment.

When a foreign body of gunshot origin migrated through the respiratory tract, the entryway was recorded: on the face – 4 (6.0%) observations, on the neck – 1 (1.5%) observation; gastrointestinal tract: on the face – 2 (3.0%), on the lateral abdomen – 15 (22.4%); vascular bed: 3 (4.5%) on the lateral surface of the chest, 5 (7.5%) on the anterior and lateral surfaces of the abdominal wall; into the pleural, abdominal, and joint cavities: 7 (10.4%) on the lateral surface of the chest,

7 (10.4%) on the lateral abdomen, and 21 (31.3%) on the anterior and lateral surfaces of the joint.

In joint injuries, foreign body migration was detected within the shoulder joint in 4 (6.0%) of the wounded, the hip joint in 1 (1.5%) of the wounded, and the knee joint in 16 (23.9%) of the wounded, which is related to the size of the joint. In chest and abdominal wounds, the entry wounds were located on the lateral parts of the body, which is explained by the protection provided by body armour.

The wound canal with foreign body migration according to MSCT has the following structural features: clear directionality, structural changes in tissues around different densities of the wound canal, air bubbles along the wound canal, blind ending, and the foreign body is detected at different distances from the wound canal ending. When performing contrast studies of the great vessels and the heart, areas of contrast extravasation into the haematoma are identified, which confirms damage to the great vessel. The length of the wound channel ranged from 20 to 285 mm, with an average of (146 ± 2.4) mm.

The main directions of foreign body migration were: respiratory tract – 5 (7.5%) observations, gastrointestinal tract – 17 (25.4%) observations, vascular bed – 8 (11.9%) observations, pleural, abdominal, joint cavities – 35 (52.2%) observations, soft tissues with suppuration – 2 (3.0%) observations.

The path of migration of a foreign body of gunshot origin through the vascular bed from the place of its origin to the place of fixation of the foreign body was as follows through the right renal vein into the right inferior pulmonary artery – 1 (1.5%) observation; through the pulmonary artery trunk into the right inferior pulmonary artery – 1 (1.5%); through the inferior vena cava into the right ventricle of the heart – 1 (1.5%); through the pulmonary vein into the left ventricle of the heart – 1 (1.5%); through the heart into the internal carotid

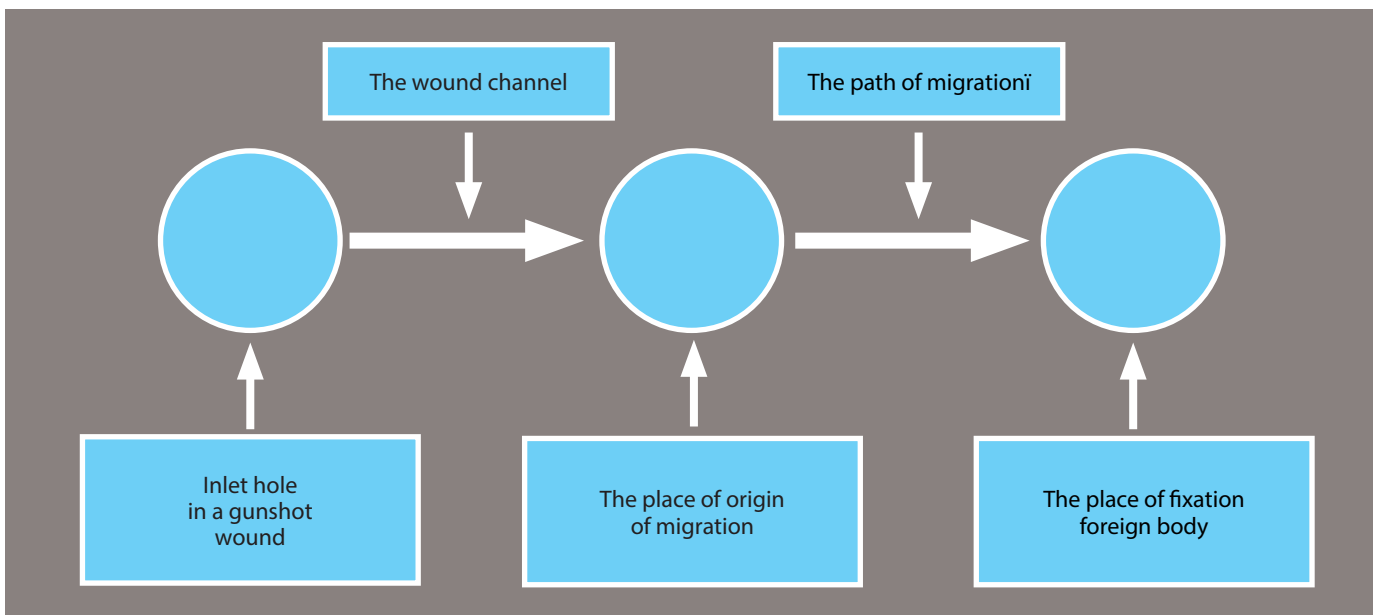


Fig. 1.
Schematic representation of the foreign body migration process.

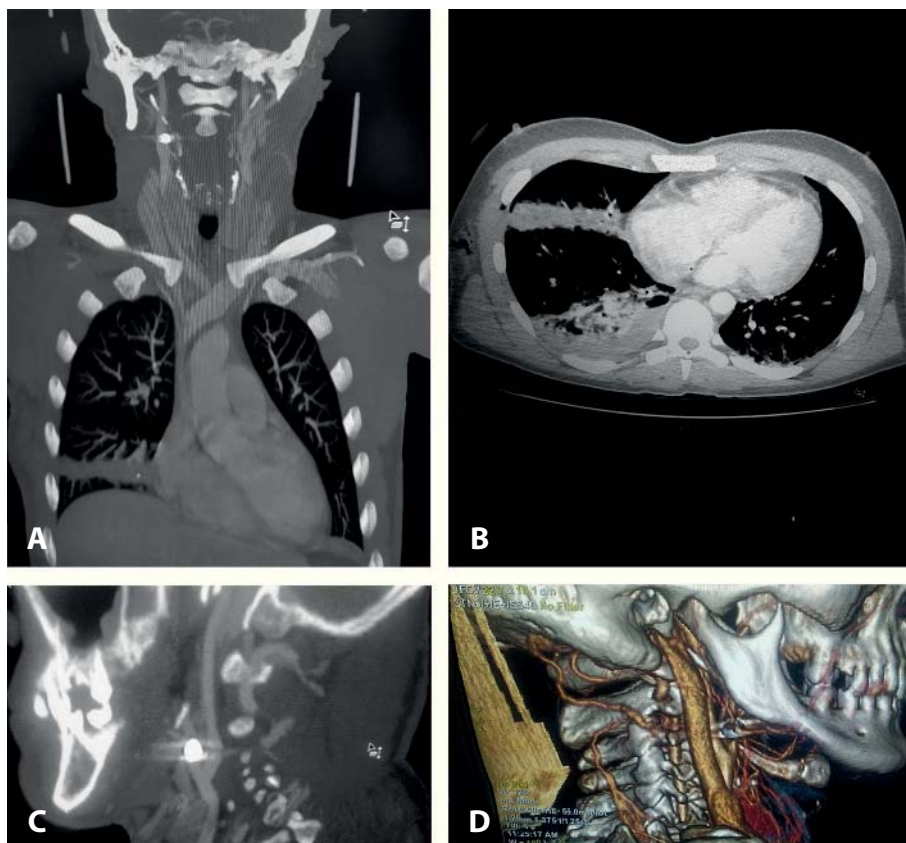


Fig. 2.
MSCT angiography of the neck
and chest cavity:

- A – coronal projection (metal fragment in the projection of the internal carotid artery on the right, pulmonitis in the right lung along the wound channel);
B – axial projection (pulmonitis in the right lung along the wound channel, right-sided hemothorax);
C – sagittal projection (metal fragment in the lumen of the internal carotid artery on the right);
D – 3D reconstruction (metal fragment in the lumen of the internal carotid artery on the right).

artery on the right – 1 (1.5%), through the inferior vena cava into the right inferior pulmonary artery – 1 (1.5%); through the left renal vein into the right ventricle of the heart – 1 (1.5%); through the portal hepatic vein into the vein of liver segment VII – 1 (1.5%). The place of onset of foreign body migration was noted in the oral cavity in 6 (8.9%) of the wounded, in the trachea in case of neck wounds – in 1 (1.5%), in the pleural cavity – in 8 (11.9%), in the abdominal cavity – in 6 (8.9%), in the joint cavity – in 21 (31.3%), in the soft tissues of the lower limb – in 2 (3%), in the stomach – in 1 (1.5%), in the small intestine – in 7 (10.4%), and in the colon – in 7 (10.4%).

By the place of fixation and removal of the foreign body, the distribution of wounded was as follows: trachea – 2 (3.0%), right main bronchus – 3 (4.5%), stomach – 2 (3.0%), liver – 1 (1.5%), small intestine – 7 (10.4%), colon – 8 (11.9%), pleural sinuses – 8 (11.9%), pelvis – 4 (6.0%), abdominal flanks – 2 (3.0%), internal carotid artery on the right – 1 (1.5%), left ventricle of the heart – 1 (1.5%), right ventricle of the heart – 2 (3.0%), right pulmonary artery – 3 (4.5%), hip joint cavity – 1 (1.5%), knee joint cavity – 16 (23.9%), shoulder joint cavity – 4 (6.0%), soft tissues of the thigh and lower leg – 2 (3.0%).

The migration of a foreign body can be single-stage or gradual. Single-stage migration occurs when a foreign body enters a vessel, airway, gastrointestinal tract, or cavity during an injury and is immediately fixed. Gradual migration occurs when a foreign body gradually changes its location, which can be recorded using radiological methods. Single-stage migration was observed in 11 (16.4%), and phased migration in 56 (83.6%) of the wounded.

In a gunshot blunt wound to the face or neck with damage to the oropharynx, a foreign body could migrate through the airways during aspiration, through the digestive tract during swallowing, and through the tissue spaces of the neck during suppuration.

Sometimes, foreign body migration is detected intraoperatively when it is not found at the site of previous identification. An example is gastric, small or large intestinal injuries, when there is a blind spot at the beginning of the foreign body migration, and the foreign body itself is not palpable or detectable.

Fixation of a foreign body occurs at the site of narrowing of an artery or vein, in the distal parts of the respiratory tract, in the gentle parts of the pleural or abdominal cavity, in organs with structural features (heart, intestine, joint).

In terms of time, foreign body migration can be instantaneous, short-term, and prolonged. Migration of a foreign body immediately at the time of injury is defined as instantaneous. Short-term migration lasts for hours or days before complications develop. Prolonged migration is associated with the development of purulent complications. In our study, instant migration of a foreign body was noted in 11 (16.4%) of the wounded, short-term migration in 54 (80.6%), and prolonged migration in 2 (3.0%).

Foreign body migration can occur spontaneously or provoked. Spontaneous migration occurs for no apparent reason, while provoked migration occurs during surgery, movement, or suppuration. Spontaneous migration was observed in 50 (74.6%) and provoked migration in 17 (25.4%) patients.

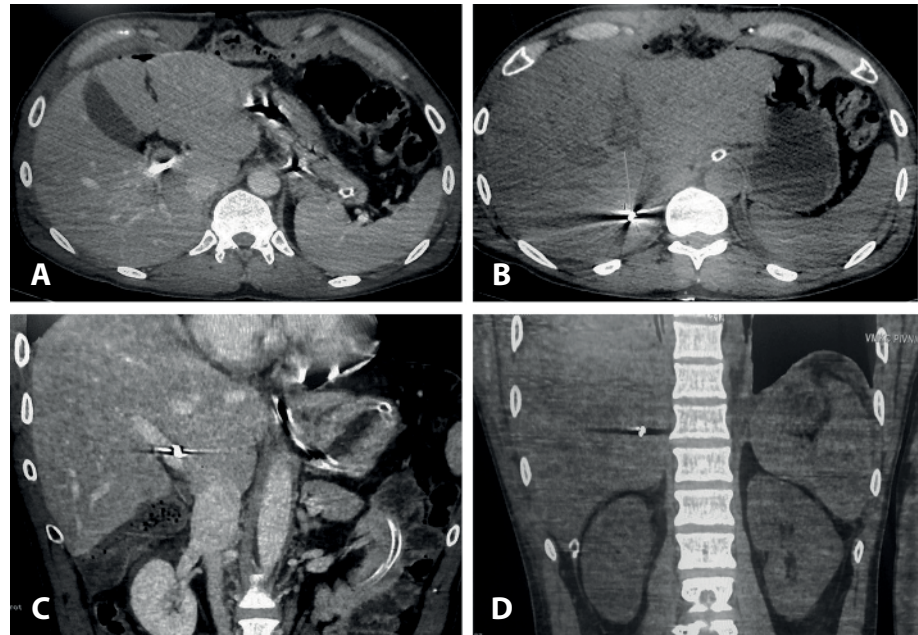


Fig. 3.
MSCT angiography of abdominal organs after gunshot shrapnel penetrating abdominal wound:
A – axial projection on day 1 (metal fragment is located in the projection of the bifurcation of the portal vein);
B – axial projection on day 2 (metal fragment is located in the vein of liver segment VII);
C – coronal projection on day 1 (metal fragment is located in the projection of the bifurcation of the portal vein);
D – coronal projection on day 2 (metal fragment is located in the vein of liver segment VII).
The length of the metal fragment migration path was 45 mm

The observations of a gunshot shrapnel perforating wound of the soft tissues of the right shoulder, a blind penetrating wound to the right chest, contusion of the right lung, right-sided haemothorax, a perforating wound of the heart (without hemopericardium) with migration of a foreign body into the internal carotid artery on the right are indicative (Fig. 2) and a gunshot shrapnel penetrating wound of the abdomen, when a metal fragment migrated from the bifurcation of the portal hepatic vein to the vein of liver segment VII (Fig. 3).

According to the distance from the end of the wound canal to the place of foreign body fixation, we distinguish three distances of its migration: short – up to 100 mm (Fig. 4), medium (100 to 1000 mm) and long (more than 1000 mm). In our study, a short distance of foreign body migration was noted in 24 (35.9%), medium – in 35 (52.2%), and long – in 8 (11.9%) injured. The length of the foreign body migration path ranged from 25 to 1225 mm. The average foreign body migration distance was (32 ± 0.7) , (486 ± 8.2) and (1068 ± 5.7) mm, respectively.

During surgery for a left hip joint injury with a 5.45×39 mm bullet in the cavity, it migrated from the central to the anterior joint during movements in the joint (Fig. 5). The migration

distance was 2.8 cm. The ball was removed using a surgical magnetic instrument.

There is also a false migration of a foreign body when it is located in a damaged organ with a mesentery or in an organ that moves within the cavity (omentum, lung), and is fixed, which is confirmed by radiation control methods, and physiologically moves with the organ during movements or changes in body position.

Foreign bodies were removed during surgical interventions: endoscopic – in 6 (8.9%) patients, thoracoscopic – in 6 (8.9%), laparoscopic – in 4 (6.0%), arthroscopic – in 21 (31.3%), through thoracotomy – in 6 (8.9%) and laparotomy – in 15 (22.4%), and open access (through skin incision and removal in soft tissues) – in 3 (4.5%). Thus, 37 (55.2%) foreign bodies were removed using minimally invasive methods, and 24 (35.8%) were removed using open access. Six (8.9%) foreign bodies were removed naturally.

Surgical magnetic instruments were used in 61 (91%) patients: flexible device for removal of ferromagnetic foreign bodies – in 23 (37.7%), magnetic multifunctional instrument for diagnostics and removal of metallic ferromagnetic foreign bodies – in 22 (36.1%), magnetic instrument

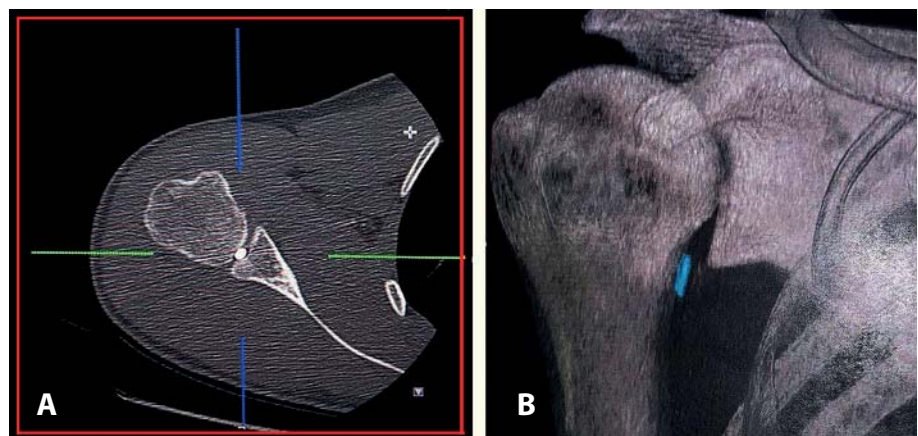


Fig. 4.
MSCT of the right shoulder joint:
A – axial projection on the 1st day after the injury (intra-articular foreign body, namely a metal fragment, is located between the articular surface of the scapula and the humeral head);
B – 3D reconstruction on the 3rd day after the injury (intra-articular foreign body is located below the lower edge of the articular cavity of the scapula).

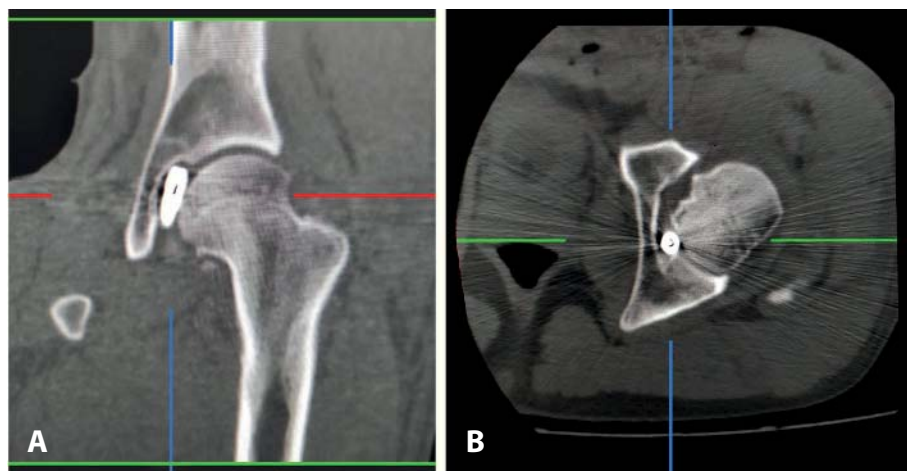


Fig. 5.
MSCT of the left hip joint with the presence of an intra-articular foreign body of 5.45 mm, located between the articular surface of the acetabulum and the femoral head: A – frontal projection, B – axial projection.

for endovideoscopic diagnostics and removal of metal ferromagnetic foreign bodies from pleural and abdominal cavities – in 8 (13.1%), endoscopic magnetic device for removal of foreign bodies – in 6 (9.8%), endosurgical magnetic instrument with variable angle of inclination of the magnetic part – in 2 (3.3%).

Discussion

According to the statistics on gunshot wounds and relevant reports in the foreign and domestic literature, foreign body migration is rarely observed [13].

The discrepancy between the direction of the wound canal and the location of the foreign body and the reduction in its size is highly likely to indicate that it has migrated.

Usually, foreign body migration occurs within the cavity (pleural or abdominal, articular), through natural (arteries, veins, respiratory tract, gastrointestinal tract) or pathological (in case of suppuration) routes.

The main method of diagnosing the presence of foreign bodies and detecting their migration is X-ray. Examination in several projections is mandatory. Computed tomography is advisable, and in case of suspicion of a foreign body in the projection of the main vessels or in their lumen, angiographic examination is necessary.

The use of a comprehensive diagnostic approach makes it possible to identify false migration of foreign bodies, which is important for choosing the tactics of surgical treatment.

When foreign body migration occurs during surgery, the surgeon must be prepared to use additional intraoperative examination methods.

In the presence of foreign bodies and their migration, especially into the joint cavity, it is advisable to use surgical magnetic instruments, which reduces the duration of the operation and the number of possible complications.

Conclusions

Although the migration of foreign bodies of gunshot origin is rare, it requires appropriate attention and response.

The absence of a foreign body in the wound canal, when its presence is indicated by anamnestic data and clinical signs,

indicates that it migrated within the cavity, either naturally or pathologically.

In case of gunshot penetrating wounds of cavities (thoracic, abdominal, large joints), to which foreign bodies may migrate, preference should be given to minimally invasive endoscopic methods of their removal using modern magnetic instruments.

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Conflict of interest. The authors who contributed to this study have declared that they have no conflicts of interest in relation to this manuscript.

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