

Minimally Invasive Surgery Trauma

Laparoscopic and Robotic
Approach

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Actual Experience Using Minimally Invasive Surgery in Battlefield from Ukraine

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Video-Assisted Thoracoscopy (VATS)

Terminology

Video-thoracoscopy (derived from the Latin “video”, meaning “to look”, and the Greek “θώραξ”, meaning “thorax”, referring to the chest, and “σκοπέω”, meaning “scope”, meaning “to look”, “to observe”) is a diagnostic and therapeutic method aiming to examine the pleural cavity and chest organs by using a special endoscopic video camera. In this technique, the video camera and surgical instruments are typically inserted separately through the 5–12 mm thoracoports. Also, video-thoracoscopy might be performed by using multi-port video-thoracoscopy.

In contrast to video-thoracoscopy, thoracoscopy is a method of visualising the surgical space performed not through the video camera-monitor system but with the help of an optical direct visualisation device, namely a thoracoscope. At present, this method is not employed due to the indisputable benefit of video-thoracoscopy.

Video-assisted thoracoscopic surgery (VATS) is a minimally invasive surgical technique in which access to the pleural cavity and chest organs is achieved through an incision of up to 5.0 cm in length made in one of the intercostal spaces. The video

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camera is inserted either through the same incision or through an additional thoracoport. A fundamental aspect of VATS is the absence of wound dilators, which are employed in other techniques to reduce the risk of injury to the intercostal vascular and nerve bundles. In instances where a wound dilator is positioned within the surgical incision, even when performing mini-accesses (incisions up to 5.0 cm), such surgical procedures are designated as video-assisted thoracotomy (mini-thoracotomy) or video-assisted thoracotomy (mini-thoracotomy).

General Principles for Video-Thoracoscopy Application for the Management of the Wounded Patients

Video-thoracoscopic surgery places more rigorous demands on the preoperative examination and the precision of the preoperative diagnosis in wounded patients. This is because, during video-thoracoscopy, the operating team has a restricted view of the surgical field within a two-dimensional confined space, limited ability to manipulate intrathoracic organs, and the inability to perform manual palpation of organs. Consequently, in the preoperative period, the surgeon must have a comprehensive understanding of the patient's condition in order to evaluate the feasibility of performing minimally invasive surgery and anticipate the surgical trajectory, considering individual anatomical characteristics.

Prior to the surgical procedure, the anaesthesiologist and the surgeon should plan specific features of anaesthetic support during the surgical operation. In the event of the discovery of concomitant pathology, it is incumbent upon the surgeon to engage in discourse with the relevant specialists in order to circumvent any potential risks that may arise during the course of surgery and in the postoperative period.

It is incumbent upon the surgeon to undertake a critical assessment of clinic's capabilities, correlating them with the potential danger to the patient and the risk of possible complications. This is particularly crucial when acquiring new techniques. It is of the utmost importance that the surgeon's ambitions are never placed above the life and health of the patient, which is an important ethical and professional aspect.

It is unethical to perform video-thoracoscopy without the requisite technical equipment to perform the full scope of the operation.

For the optimal execution of video-thoracoscopy, it is imperative to address key considerations such as the selection of anaesthesia, the patient's position on the operating table, the number and placement of trocars, the precise revision of the pleural cavity, and the intricacies of technical manoeuvres during the procedure.

Indications and Contraindications for Video-Thoracoscopy in War Settings

The timing and purpose of video-thoracoscopy for chest wounds and traumas allow for the distinction of the following indications and contraindications:

1. A video-thoracoscopy is an emergency procedure that should be performed within 1–2 h of admission to a deployed field hospital or other medical military facility. This is done to exclude or eliminate the consequences of life-threatening gunshot wounds.
2. An urgent procedure is indicated within 48 h after injury occurs. This is performed for the management of haemothorax or haemopneumothorax in cases where the drainage of the pleural cavity is ineffective.
3. A delayed procedure is undertaken to eliminate early and late pleural complications or to remove foreign bodies that do not threaten the life of the wounded.

Indications for video-thoracoscopy in the context of gunshot wounds and chest trauma.

1. Emergency video-thoracoscopy is indicated in the following circumstances:
 - (a) Penetrating chest wound in the “heart zone”
 - (b) Small and moderate haemothorax or haemopneumothorax
2. Urgent video-thoracoscopy is indicated in the following circumstances:
 - (a) Intrapleural bleeding that persists at a rate of 300 ml or more for a minimum of 1 h
 - (b) Emphysema of the soft tissues of the chest, which improves with adequate drainage within 1 day
 - (c) Diaphragmatic injury with a predominant clinical picture of thoracic injury
 - (d) The presence of a “rib valve” for video-assisted fixation of floating ribs
3. Postponed video-thoracoscopy is indicated for the following:
 - (a) Preservation of leakage in the pleural cavity with adequate drainage for 3 days
 - (b) The presence of foreign bodies in the chest wall, lung and mediastinum, which may lead to complications
 - (c) Control and correction in case of dysfunction of drainage tubes
 - (d) Pleural complications (coagulated haemothorax, infected haemothorax, pleural effusion, pleural empyema, etc.) that occurred within 14 days of the injury

It is important to note that all video thorascopies must be conducted under optimal combat and medical conditions.

The following conditions preclude the use of video-thoracoscopy in the management of gunshot wounds and chest trauma:

- A. Absolute contraindications include
 1. The presence of the agonal state in the wounded
 2. Coagulopathy of various genesis that cannot be corrected
 3. Gunshot wounds with significant haemodynamic disorders
 4. Unstable haemodynamics with ineffective anti-shock therapy
 5. Acute myocardial infarction
 6. Acute cerebrovascular accident

7. Advanced haemothorax
 8. Haemomediastinum with compression of the airways and central vessels
 9. Reliable signs of damage to the trachea and large bronchi
 10. Reliable signs of oesophageal injury
 11. Large chest defects and penetrating gunshot wounds with open pneumothorax or haempneumothorax
 12. Insufficient material and technical support for minimally invasive surgical interventions
 13. Insufficient level of surgeons' training skills in video-thoracoscopic operations
- B. Relative contraindications
1. Intolerance to single-lung ventilation
 2. Obliteration of the pleural cavity on the side of the gunshot wound
 3. Previous thoracotomy on the side of the gunshot wound
 4. Thoracoabdominal injuries with a predominant pattern of damage to the abdominal cavity

Conversion During Video-Thoracoscopy

While video-thoracoscopy offers significant diagnostic and therapeutic capabilities, several conditions require conversion to open surgery at the stage of pleural cavity revision or during the main stage of surgery. The term “conversion” means a transition from video-assisted mini-thoracotomy to traditional thoracotomy, or vice versa. It is recommended that video-assisted mini-thoracotomy be employed whenever feasible, as it offers the benefits of minimal trauma, optimal visualisation, and the potential for open surgery, which is particularly advantageous in patients with injuries.

Indications for Conversion in Chest Wounds and Traumas

1. Ineffectiveness of single-lung ventilation and low-volume ventilation.
2. Emergence of unstable haemodynamics that cannot be corrected with medication.
3. Inability to perform a complete revision of the pleural cavity and its organs by video-thoracoscopy.
4. Infeasibility of the operation in the presence of haemopericardium or heart injury.
5. Detection of injuries to the main vessels.
6. Detection of a tense mediastinal haematoma.
7. Persistent haemorrhage in the event of vascular damage to the pleural cavity, where video-thoracoscopy is unable to promptly halt the bleeding.
8. Identification of gunshot wounds to the lung apex.
9. Detection of a significant gunshot wound to the lung.
10. Detection of tracheal, large bronchial or oesophageal wounds.

11. The risk of inadequate suturing of the lung wound (especially in the area of its root).
12. The surgeon's decision to perform conversion due to intraoperative findings will increase the duration of the intervention compared to open surgery.

The Positioning of the Wounded on the Operating Table

The positioning of the wounded on the operating table is contingent upon the type of gunshot wound, the functional status of the casualty and the purpose of the surgical intervention. If the casualty is placed in the supine position, a roller is positioned beneath the chest on the side of the surgical incision. This serves to partially enlarge the intercostal spaces and facilitate access to the chest organs. It is preferable to position the upper limb of the injured individual in a manner that differs from the conventional approach, which involves extending the arm over the head and resting it on an armrest. Instead, the limb should be positioned and secured below the body in a posterior abduction position at the shoulder joint, with flexion at the elbow joint and pronation at the wrist joint. This position of the limb helps to prevent injury to the brachial plexus branches due to incorrect positioning and ischaemia of the limb tissues and does not interfere with the manipulation of surgical instruments and a video camera during surgery. The advantages of supine positioning are its simplicity and speed, as well as the ability to perform the majority of surgical techniques on the anterior, upper and lower mediastinum, lung root, anterior and lateral lung, and anterior and lateral chest walls. Additionally, it provides the anaesthetist with free access to the main veins. The anaesthetist can gain free access and control of the intubation tube, manipulate it with ease, and perform sanitary fibrobronchoscopy with greater technical proficiency during surgery. Furthermore, there is less respiratory distress during single-lung ventilation and less cardiac distress. However, the most significant disadvantages of placing the patient in the supine position are the considerable limitations it imposes on the surgeon's view and ability to manipulate the posterior chest wall, the posterior surface of the lung, and the near-total absence of the possibility of accessing the posterior mediastinum.

To facilitate lateral positioning of the patient on the operating table, a roller is placed beneath the table to widen the intercostal spaces on the side of the surgery. The patient is positioned on the uninjured side, lying prone. The upper limb on the surgical side is positioned and secured on the armrest situated in front of and above the head, with the shoulder and elbow joints in a flexed position. The upper limb on the uninjured side is positioned in a straight manner on the armrest with flexion of the shoulder joint. The lower limb on the "healthy" side is flexed at the hip and knee joints, while the non-surgical side is extended. The advantages of positioning a patient on their side include the ability to comprehensively examine the majority of the chest and mediastinum structures on the surgical side, as well as the capacity to utilise surgical techniques in these areas. From a technical perspective, the position of the patient on their side is universally applicable to the operating surgeon, as it allows for the completion of a range of tasks. However, this position also has

notable disadvantages. In the event of surgical intervention with separate lung ventilation, the lung on the side of the intervention is excluded from ventilation, while the lung on the uninjured side in the lateral position experiences reduced ventilation rates. This results in a notable decline in the oxygenation of tissues. In the absence of separate lung ventilation, the potential for pathological secretions (blood or pus) to enter the lung on the uninjured side via the bronchial tree during surgery represents a further risk of impaired ventilation and reduced oxygenation of human tissues. The utilisation of carbon dioxide insufflation into the pleural cavity, resulting from the displacement of mediastinal organs, has the potential to cause a significant deterioration in lung ventilation, blood oxygenation and cardiovascular activity. Furthermore, the lateral position of the patient presents certain challenges with regard to the performance of rehabilitation fibrobronchoscopy during surgery. While the lateral position of the patient on the operating table offers certain advantages, it should only be employed in cases of wounded patients with a high functional reserve of the lungs and cardiovascular system.

The abdominal position on the operating table is indicated only when wide access to the posterior mediastinum or posterior chest wall is necessary and the requisite surgical procedures cannot be performed in the supine or lateral position. Furthermore, the abdominal position presents challenges for anaesthetic practitioners in monitoring the intubation tube and performing sanitary fibrobronchoscopy during surgery. In cases where surgery is performed for an extended period (3–6 h) in the abdominal position, various positional manifestations may occur, including pressure ulcers, plexitis, and brachial plexus neuritis.

It can be concluded that there is no definitive optimal position for gunshot wounds and chest injuries on the operating table. The decision regarding the position of the wounded on the operating table is dependent on several factors, including the type of wound, the trajectory of the wound canal, the extent of damage to the internal organs of the chest, the functional reserves of the vital organs of the wounded, the intended outcome of the surgical intervention, and the technical capabilities of anaesthetic and surgical support. Consequently, this decision is made on a case-by-case basis.

Principles of Pleural Cavity Revision in Patients with Combat Trauma

The insertion of thoracoports through existing post-traumatic gunshot wounds is not a recommended procedure in the majority of cases. This is because the location of such wounds does not always meet the requirements for a comprehensive examination of the pleural cavity. Furthermore, the insertion of a thoracoport through a gunshot wound limits the ability to examine and manipulate the wound itself from the pleural cavity. Additionally, the procedure does not comply with the rules of asepsis, as all penetrating gunshot wounds are primarily contaminated. Nevertheless, if the surgical intervention allows for the introduction of a video thoracoscope or one of the “working” instruments to provide the optimal location for the main stage

of the operation, then it is permissible to install a thoracopore through the wound gunshot canal. Nevertheless, such manipulations should only be performed after the gunshot wound canal has undergone thorough surgical treatment.

The most logical sequence for examining the pleural cavity is based on the principle of priority. The pericardium is initially examined, followed by the mediastinum and lung root. If the revision reveals evidence of damage to the heart or major vessels, it is recommended that the operation be continued using the traditional open method. Subsequently, the diaphragm is examined. In the event of damage being identified, a decision must be made as to whether further video-thoracoscopy, video-laparoscopy or laparotomy is required. Subsequently, the lung and chest wall are subjected to a final examination. This sequence of revision circumvents the potential for missteps that may arise when a surgeon promptly identifies a wound channel opening on the parietal pleura with a lung injury and commences suturing while failing to consider the possibility of more significant injuries.

In the event of bilateral pneumothorax, the examination of the pleural cavities is conducted in an alternating sequence. In this case, the full functioning of one lung is first established by draining the pleural cavity and eliminating pneumothorax, which is confirmed by X-ray examination. In cases of bilateral pneumothorax, the initial priority should be the elimination of pneumothorax on the right side, given that a more rapid and pronounced disruption to haemodynamic function occurs due to the superior ease with which the superior and inferior vena cava can be compressed by air compared to the aorta. It can be reasonably deduced that decompression of the right pleural cavity will result in a more rapid stabilisation of haemodynamic parameters than decompression of the left pleural cavity.

Each video-thoracoscopy must be followed by a comprehensive chest revision to guarantee the reliability of haemostasis, lung aerostasis, and the integrity of adjacent organs.

The Principles of Video-Thoroscopic Removal of Foreign Bodies (Bullets and Fragments)

The indications for the removal of bullets and fragments using video-thoroscopic techniques are the presence of a foreign body in the peripheral zone of the lung, in the tissues of the chest wall, or of freely located bodies in the pleural cavity. The use of video-thoroscopic techniques for the removal of foreign bodies located in the root of the lung is contraindicated due to the high probability of damage to the large vessels of the lung and the occurrence of massive bleeding.

In the majority of cases, the video-thoroscopic removal of bullets and fragments located in the middle zones of the lung is an ineffective procedure due to the substantial mass of lung tissue, which precludes the accurate determination of the foreign body's precise location. Furthermore, the attempted removal of such foreign bodies carries a significant risk of injury to the intrapulmonary vessels of the lung, which can be challenging to access and treat using minimally invasive techniques. Furthermore, the creation of a substantial wound channel following the removal of

a foreign body makes complete suturing a challenging endeavour. In light of the aforementioned considerations, the lung may exhibit a violation of its tightness in the early postoperative period, as well as the formation of an intrapulmonary haematoma.

The removal of bullets and fragments located in the mediastinum using video-thoracoscopy is only feasible if no damage has been sustained to the mediastinal organs and large vessels. In the event of damage to the mediastinal organs and large vessels (pericardium, heart, trachea, large bronchi, oesophagus, etc.) during the removal of mediastinal foreign bodies, it is not advisable to prolong the operation through a minimally invasive method. Instead, a transition to thoracotomy is required. In certain cases, however, it may be possible to complete the operation video-thoroscopically through an individualised approach.

In the event of technical difficulties during the removal of a bullet or fragment by the video-thoroscopic method, which could result in a significant prolongation of the surgical intervention or potentially lead to damage to organs and major vessels, a transition to an open intervention should be considered. It is therefore evident that conventional X-rays are insufficient for the assessment of the feasibility of a video-thoroscopic removal of foreign bodies in the preoperative period. It is imperative to utilise spiral computed tomography of the chest organs with three-dimensional reconstruction and to conduct a comprehensive analysis of the obtained images, with a clear representation of the topographical and anatomical features of the area of the intended surgical intervention, and an assessment of the actual technical possibilities of video-thoracoscopy. As a consequence of the unavailability of SCT of the OGK at the II level of medical care in military mobile hospitals and advanced surgical groups, the removal of bullets and fragments should be postponed until the provision of care at a higher III and IV level. The removal of foreign bodies via video-thoracoscopy at the second level of care is feasible only when performing operations for urgent indications, provided that there are no technical challenges in detecting and removing a bullet or fragment.

A notable limitation of video-thoracoscopy is the inability to perform direct palpation of anatomical structures, as well as palpatory detection and clarification of the location of foreign bodies within the chest organs. Consequently, a variety of techniques and instruments have been employed in clinical settings to ascertain the precise location of foreign bodies. Such modern devices include endoscopic ultrasound devices and devices for endoscopic tactile mechanoreception. In routine clinical practice, intraoperative fluoroscopy is employed for the detection of foreign bodies during surgical procedures.

Additionally, intraoperative utilisation of a magnet is a potential avenue for exploration. This necessitates the utilisation of endosurgical instruments that are responsive to the magnetic field. Before the utilisation of such instruments, it is imperative to ascertain that upon connection of the magnet to the component of the instrument that will be situated extracorporeally, magnetic contact will be established between the tip of the instrument and the metallic object. Nevertheless, this approach can only be employed in the presence of magnetically sensitive projectiles and fragments.

In instances where the precise location of the foreign body remains uncertain following a video-thoracoscopic examination of the pleural cavity and instrumental palpation of the lung, the method of direct lung palpation may be employed. In this manner, the operating surgeon's finger is inserted through the thoracoportal passage in closest proximity to the foreign body within the chest. The lung is then fixed using an endoscopic atraumatic clamp to prevent its displacement during palpation. This method allows for the detection of foreign bodies in the peripheral zones of the lung, which would otherwise remain undetected during visual inspection through a video camera.

Following the removal of a foreign body from the lung parenchyma, it is essential to monitor the haemostasis and aerostasis of the lung. Any bleeding vessels are then treated with electrocoagulation or ligation. Any areas of the lung that are leaking are then sutured.

It should be noted that in the case of gunshot wounds to the peripheral parts of the lung, due to the high kinetic energy and the presence of residual burning gunpowder on the surface of the wounding shells, thermal cauterisation of the lung tissue occurs along the wound channel. This often results in the preservation of the tightness of the lung. Consequently, the suturing of lung tissue following the removal of a bullet or fragment is not always feasible.

Video-Thoracoscopy for Cardiac Gunshot Wounds (Haemopericardium, Tamponade)

A gunshot wound to the heart is life-threatening and associated with high mortality. Fast evacuation of these patients to the stage of qualified surgical care (Role 3 and 4 hospitals) and timely and high-quality diagnosis of such wounds are the basis for successful surgical treatment. In the presence of haemopericardium and tamponade, left-sided thoracotomy is the basic approach to resuscitation. The use of video-thoracoscopy is an additional possible approach in the presence of highly qualified specialists and equipment, with mandatory consideration of the condition of the wound.

N.B! In the presence of a haemothorax, it is necessary to drain the pleural cavity of the affected side before video-thoracoscopy, with possible subsequent autohaemotransfusion.

N.B.! The surgical team must be ready for rapid repositioning if necessary!

Position of the patient on the operating table is supine; the right side can be used if there are no contraindications.

Access: The trocar insertion points and their number do not differ from those used in typical surgical accesses for visualisation and access to the heart.

Technique: Surgical intervention in the presence of haemopericardium (Fig. 27.1) and cardiac tamponade should be performed rapidly.

1. Complete high-quality visualisation of the heart and selection of a safe area of the pericardium for dissection (Figs. 27.2 and 27.3).
2. The pericardial wall is then grasped with a thoracoscopic clamp with soft branches and dissected with scissors.

Fig. 27.1 Illustration of video-thorascopic pericardial dissection

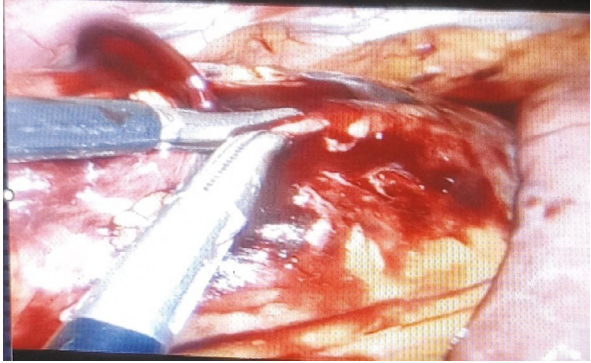


Fig. 27.2 Video-laparoscopy: removal of a foreign body “flash” in a gunshot wound to the right liver lobe

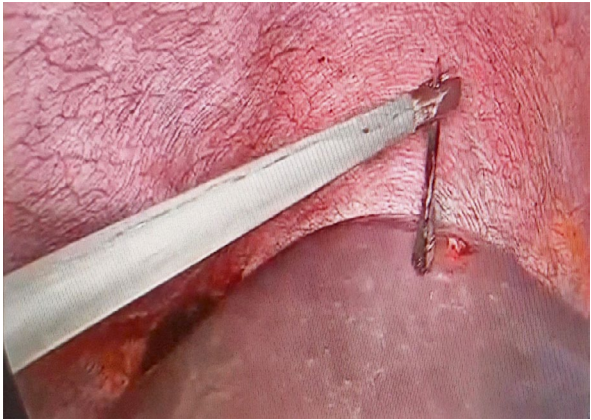
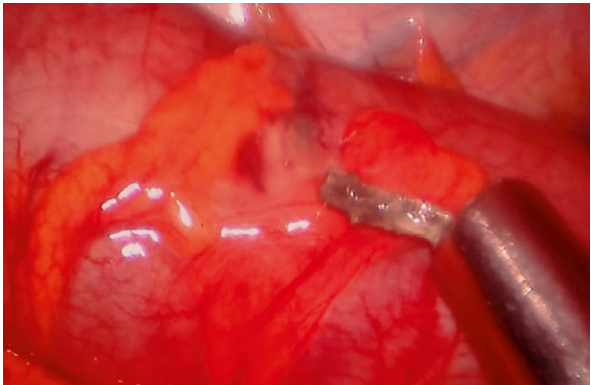


Fig. 27.3 Video-laparoscopy view of the gunshot shrapnel wound of the small intestine segment, followed by removal of metal fragments with a magnet tool



3. The release of a large amount of blood under pressure should not cause panic in the surgeon and the operating team! The most important person in this situation is the anaesthetist—his clear instructions will be the basis for further action.
4. Once the condition has been stabilised and the haemopericardium has been eliminated, the anaesthesiologist will notify the attending physician of all vital signs. At this point, it is necessary to remove blood from the pleural cavity using an electric suction device.
5. It is essential to monitor for active bleeding from the site of the heart injury!

N.B.! In most cases, the right part of the heart is accompanied by active bleeding, which requires prompt and effective surgical intervention. The decision regarding the choice and method of suturing is at the discretion of the surgeon. Video-thoracoscopic suturing of a heart wound on a working heart is a technically challenging procedure.

6. In the absence of active bleeding, the surgical intervention is concluded with the cleansing of the pleural cavity and the establishment of drainage.

N.B.! A patient who has sustained a gunshot wound to the heart, following the removal of haemopericardium and tamponade, requires prompt transfer to a highly specialised cardiac surgical centre. If bullets or fragments are present in the heart, subsequent fatal complications may ensue.

Video-Laparoscopy

Terminology: The term “video-laparoscopy” is derived from the Latin “video”, meaning “to watch”, “to see”, and the Greek “lapara”, meaning “groin” or “abdomen”. The term “σκοπεο” (scope), which translates to “I look, I observe”, is a contemporary diagnostic and therapeutic approach that employs a specialised endoscopic video camera for the examination of the abdominal cavity. In this technique, the video camera and surgical instruments are most often installed through separate incisions, with 5–12 mm special ports being used. An example of the video-laparoscopic image is shown on Fig. 27.4, an Illustration of video-laparoscopy with a gunshot wound to the abdomen.

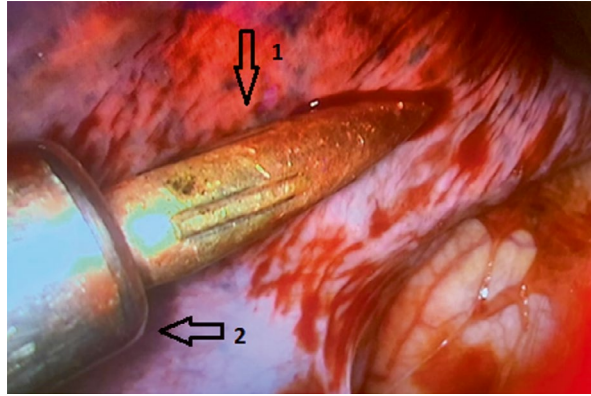
General Principles of Video-Laparoscopy for Gunshot Wounds

Indications and Contraindications for Video-Laparoscopy

Video-laparoscopy can be performed for diagnostic or therapeutic purposes.

1. Emergency video-laparoscopy (within the first 1–2 h after the injury) is performed upon admission to a mobile hospital or other medical institution to prevent or treat the consequences of gunshot wounds that threaten life.
2. Urgent video-laparoscopy must be performed within 3 h.

Fig. 27.4 Video-laparoscopy showing the step of bullet (marked as 1) removal by using a surgical magnet (marked as 2)



Indications for video-laparoscopy for gunshot wounds and life-threatening injuries:

1. Emergency video-laparoscopy (within the first 1–2 h after the injury) is performed upon admission to a deployed field hospital or other medical facility to prevent or treat the consequences of gunshot wounds that threaten life.
2. Urgent video-laparoscopy must be performed within 3 h.

Indications for video-laparoscopy for gunshot wounds and life-threatening injuries:

1. To verify the diagnostic service of the penetration of the nature of the damage
2. In the presence of penetration of gunshot damage to the abdominal cavity with stable haemodynamics
3. In the presence of haemoperitoneum and free fluid in the abdominal cavity

Contraindications to video-laparoscopy for gunshot wounds

1. Agonal state of the wounded
2. Severe condition—shock of the III and IV stages
3. Multiple penetrating gunshot wounds of the abdomen
4. Combined severe wounds of the skull, chest organs, torso, and limbs
5. Presence of defects of the abdominal wall
6. Presence of eventration of internal organs
7. Gunshot wounds with significant haemodynamic disorders
8. Unstable haemodynamics with the ineffectiveness of anti-shock therapy
9. Acute myocardial infarction
10. Acute cerebral circulation disorders
11. Reliable clinical signs of heart injury

A. Relative contraindications

1. Severe thoracoabdominal injuries with a predominant pattern of damage to the abdominal organs
2. History of acute myocardial infarction
3. Heart failure class 3–4 according to the NYHA classification
4. Presence of heart failure
5. History of heart and aortic surgery
6. Coagulopathy
7. Portal hypertension
8. Diffuse peritonitis
9. Previous abdominal surgery
10. Obesity stage II or higher (BMI >35 kg/m²)
11. Severe obstructive pulmonary disease
12. Lack of experience in surgery
13. Technically complex and time-consuming

Video-Laparoscopy for Gunshot Injuries to the Diaphragm

In the context of contemporary gunshot wounds to the diaphragm, it is essential to recognise that these injuries have a direct impact on the thoracoabdominal area. To a lesser extent, there is also involvement of the abdomen and thorax. Such injuries are considered as severe, with damage to the internal organs of the chest and abdominal cavities. Timely and accurate diagnosis is fundamental to the success of surgical treatment.

N.B.! Once a thoracoabdominal wound has been identified, and there are no contraindications to video-laparoscopy. The next step is to drain the pleural cavity as appropriate for the affected side.

The patient is positioned supine on the operating table. It is also possible to utilise the lateral position.

Access: The site of trocar introduction and the number of trocars used do not differ from those employed during surgical procedures on the upper abdomen. The primary objective is to ensure the convenience of the surgical procedure and to facilitate a comprehensive video examination of the damaged portion of the diaphragm.

Technique: At revision, the presence of air is noted, which serves as a sign of gunshot damage to the diaphragm. The abdominal cavity is usually seen with haemoperitoneum, which may also be present in the event of damage to other porous organs. In the event of a gunshot wound to the diaphragm, damage is sustained to the diaphragmatic surface.

1. In the context of video-laparoscopy, it is of paramount importance to rapidly ascertain the nature of the gunshot wound to the diaphragm by the AAST classification (American Association for the Surgery of Trauma). The AAST comprises five grades, from I to V, which are used to assess the severity of diaphragmatic injuries [1, 2]. In addition to this, the possibility of operating

video-laparoscopically must be assessed. In the event of significant diaphragmatic defects accompanied by the presence of internal organ eversion into the thoracic cavity and persistent active bleeding, a conversion to open surgery is indicated. Time must not be wasted! The primary objective is to save the life of the wounded individual!

N.B.! In the event of a damaged diaphragm during video-laparoscopy, it is possible to perform a pleural cavity sanitation procedure with blood removal and the quick removal of existing foreign bodies (such as bullets and/or fragments of projectiles) using a surgical magnet tool.

2. It is recommended to suture the damaged diaphragm with non-absorbable suture material, with sufficient tissue grip in the suture maintained to prevent the suture eruption and failure of the suture site.
3. In such cases, the optimal choice is a continuous type of suture, with knotted sutures proving particularly efficacious.
4. Following the end of the surgical procedure, it is imperative to observe any signs of tightness or haemorrhage. It is also possible that other injuries may have been sustained. The subdiaphragmatic space should be drained.

Video-Laparoscopy for Gunshot Injuries to the Liver and Gallbladder

A gunshot injury to the liver and gallbladder might be diagnosed as thoracoabdominal injury, which necessitates a meticulous and comprehensive examination of both the chest and abdominal cavities.

The Procedure Protocol

The patient is positioned supine on the operating table.

Access: The number and location of trocars inserted during the procedure are consistent with those typically used for surgical interventions on the liver and gallbladder.

Technique: In the course of a video-laparoscopy for gunshot wounds to the liver and gallbladder, the presence of haemoperitoneum of varying sizes is discerned through the observation of signs indicative of intra-abdominal bleeding and the detection of bile impurities.

1. The assessment of gunshot injury to the liver should follow the AAST (American Association for the Surgery of Trauma, 1994) classification [2, 3]. The subsequent step of the procedure entails the evacuation of blood, clots, and bile through the utilisation of an electric suction apparatus. A comprehensive and accurate revision of the injured area is essential for a successful operation (Fig. 27.2).

N.B! Should the necessity arise, the Pringle manoeuvre must be performed.

It should be noted that according to the Advanced Trauma Life Support (ATLS) definitions set forth by the American College of Surgeons Trauma Committee, a casualty is considered an “unstable” patient if they exhibit any of the following: systolic blood pressure below 90 mmHg with a heart rate above 120 beats per minute, signs of vasoconstriction of the skin (cool, clammy,

decreased capillary refill), altered level of consciousness, and/or shortness of breath [4].

2. If a comprehensive revision of the region of the gunshot injury to the liver, particularly the diaphragmatic surface, is necessary, the liver should be mobilised along its ligaments (the falciform ligament and the ligamentum teres hepatis).
3. If the liver sustains a minor tangential or marginal gunshot injury according to the AAST I–II degree classification, it is possible to perform suturing of the damaged area with intracorporeal P-shaped Vicryl sutures. It is recommended that argon plasma coagulation, other forms of coagulation and the utilisation of contemporary local haemostatic agents (FloSeal, Hemopatch, Surgicel) be employed.
4. In cases where foreign bodies (such as bullets or other projectile fragments) are present within the liver parenchyma, it is essential to exercise caution when considering their removal via endovideosurgical methods. This is due to the potential for significant bleeding to occur.

In all other cases where liver injuries have been diagnosed according to the AAST classification grades III, IV, or VI, conversion is indicated. It is recommended that, where feasible, liver packing be performed following the principles of damage control surgery (DCS).

5. Following the endovideosurgical treatment of a gunshot liver injury, the subhepatic space is drained.

In the event of a diagnosed gunshot wound to the gallbladder, the surgical tactics include endovideosurgical cholecystectomy. The assessment of the nature of the gunshot injury to the gallbladder is conducted by the AAST (American Association for the Surgery of Trauma) classification system [2].

In the event of technical difficulties, it is important to consider the potential options for cholecystectomy, including approaches from the neck, the bottom, or a combination of both. It is crucial to emphasise the importance of preserving the gallbladder in cases of gunshot wounds.

N.B.! It is also essential to have a comprehensive understanding of the anatomy of the liver, gallbladder, and extrahepatic bile ducts. This knowledge enables the rapid identification of critical anatomical structures and the accurate assessment of the nature of the gunshot wound, which in turn informs the subsequent surgical approach.

Video-Laparoscopy for Gunshot Wounds to the Stomach

The patient is positioned supine on the operating table.

Access: The insertion places of trocars and their number do not differ from the typical accesses for gastric surgery.

Technique: Video-laparoscopy starts with the revision of the abdominal cavity concerning the presence of wounds to the stomach, or in case of haemoperitoneum of various sizes with signs of intra-abdominal bleeding and into the gastric lumen, the presence of content in the stomach and bile impurities.

1. A rapid assessment of the nature of the gunshot wound to the stomach is essential during video-laparoscopy by the AAST (American Association for the Surgery of Trauma) classification [2].

N.B.! In contemporary gunshot wounds of the stomach, it is essential to consider the potential for damage to the posterior wall of the stomach. If a revision of the posterior wall of the stomach is required, this should be performed by dissection using electrocoagulation of the gastric ligament (lig. gastrocolicum).

2. In case of a minor tangential or marginal gunshot wound to the stomach (AAST I or II grades), it is possible to proceed with intracorporeal two-row Vicryl sutures. A variety of contemporary staplers may be employed for marginal stapling resection of the affected regions of the stomach. It is important to note that the appropriate cassettes should be utilised for gastric surgery.
3. Intraoperative fibro-gastroscopy is indicated to check for foreign bodies (bullets, projectile fragments, etc.) within the stomach followed by their removal in case of identification. This procedure is also undertaken to prevent gastric bleeding.
4. Conversion is indicated for all other cases with a significant gunshot wound to the stomach and according to the AAST classification (III, IV, VI grades). If feasible, gastric resection should be considered by the principles of damage control surgery (DCS). In the presence of peritonitis, surgery with anastomosis is contraindicated.
5. Following laparoscopic gastric surgery, a leak test should be conducted by introducing air into the gastric tube.
6. Following laparoscopic gastric surgery, the abdominal cavity is drained and a nasogastric tube is placed.

N.B.! An understanding of the anatomy is beneficial in rapidly identifying crucial structures within the stomach, evaluating the characteristics of the gunshot wound, and determining the most appropriate subsequent surgical approach.

Video-Laparoscopy in the Context of Gunshot Wounds to the Small Intestine

In contemporary gunshot wounds of the small intestine, it is important to note that isolated injuries to a single segment of the intestine are uncommon. In most cases, multiple injuries to different segments at varying levels are caused by a single projectile. To achieve complete visualisation and to avoid all areas of potential gunshot injury, it is essential to perform an audit from the duodenojejunal junction to the ileocecal angle (Fig. 27.3).

The patient is positioned supine on the operation table.

Access: The locations of trocar insertion and the number of trocars should not differ from those typically employed for surgical procedures on abdominal hollow organs. Additional trocars may be inserted if necessary.

Technique: In the context of video-laparoscopy in cases of gunshot wounds to the small intestine, the presence of varying degrees of haemoperitoneum is usually expected, accompanied by the presence of bile and small intestinal contents.

1. A rapid assessment of the nature of the gunshot wound to the small intestine according to the AAST classification is essential during video-laparoscopy [2]. This should include the removal of blood, clots, bile, and small intestinal contents using an electric suction device. A comprehensive and accurate examination of the small intestine is essential for a successful surgical outcome.

N.B.! To conduct a qualitative revision of all segments of the small intestine, it is essential to utilise special atraumatic laparoscopic instruments. Additionally, it is necessary to move the strand of the large forceps into the epigastrium, extending to the liver. Furthermore, changing the position of the operating table from the lateral position to the Trendelenburg position will facilitate the visualisation of all segments of the small intestine.

2. In the presence of a minor, tangential, marginal gunshot wound of the small intestine according to the AAST classification of grade I or II, it is possible to suture the area of the gunshot wound with intracorporeal nodal Vicryl sutures.

Subserous haematomas and non-penetrating wounds should be subject to a minimum of treatment and closed with separate nodal sutures. Furthermore, intramural haemorrhage into the small bowel wall should be considered as a sign of perforation. In case of a gunshot wound measuring up to half the diameter of the intestine lumen, resection with a three-quarter anastomosis is recommended. Resection of the small intestine may be indicated for cases with multiple perforations in the following conditions: short area of the intestine loop, complete obstruction of the intestine, wall rupture, large size and irregular configuration of the gunshot defect, longitudinal tears of the intestine, a wound or large haematoma in the mesenteric margin of the intestine, as well as detachments from the mesentery. Additionally, resection may be necessary in cases of transverse mesenteric tear with ischaemia or necrosis of the intestinal wall. In case of a gunshot wound to the mesentery of the small intestine, it is of the utmost importance to ascertain the viability of the affected intestinal segment and, if necessary, to perform an obstructive resection. The damaged intestine segment may be resected with application of the surgical stapler. It is crucial to utilise the appropriate cassettes for small bowel surgery, as this is a vital aspect of the procedure.

3. The decision to perform a video-laparoscopic obstructive resection of the damaged segment of the small intestine by damage control surgery (DCS) tactics must be justified. In the event of diagnosed significant gunshot injuries to the small intestine (AAST III, IV, V grades), it is not feasible to perform a comprehensive qualitative revision of all its segments. In such cases, conversion is the recommended course of action.

In the absence of contraindications, the intestine resection may be performed with anastomosis using a linear stapler apparatus of the “side-to-side” type. An alternative approach is a mini-laparotomy with extracorporeal anastomosis, which may be performed by using a stapler or manually. In the context of these surgical procedures, a case-by-case approach is essential, taking into account the condition of the patient, the duration of the surgical intervention, the existing caseload of patients requiring surgery in combat settings, and the surgeon’s skills. In the event of peritonitis, the performance of surgery with anastomosis is contraindicated.

4. The application of special surgical magnets may facilitate the removal of foreign bodies (such as bullets or projectile fragments) from the intestinal lumen or mesentery. It is important to note that haemorrhage may occur following their removal.
 5. The surgery must be finished with the installation of the drainage tubes to the abdominal cavity, and a nasogastric tube is inserted for decompression purposes.
- N.B.! Awareness of the anatomical structures involved is beneficial in rapidly identifying the essential anatomical features of the small intestine, evaluating the characteristics of the gunshot wound, and selecting the optimal surgical approach. In these surgical interventions, the surgeon's skills are of paramount importance.

Video-Laparoscopy for Gunshot Wounds to the Colon

In patients with gunshot wounds to the colon, it is important to note that mesoperitoneal injuries present with varying clinical signs, and diagnosis might be challenging to diagnose such an injury in the first place. This increases the likelihood of undiagnosed wounds to the colon, which might subsequently lead to complications and increase mortality. Gunshot wounds to the abdomen with injury to the colon and the subsequent development of faecal peritonitis represent a significant and potentially fatal complication.

The patient is positioned supine on the operation table.

Access to the surgical site is achieved by the following approach: the insertion sites for the trocars and the number of trocars used do not differ from those typically employed in colon surgery.

The technique employed for patients with gunshot injury to the colon is described below.

1. It is imperative to rapidly ascertain the nature of the gunshot wound of the colon by the AAST classification [2], which necessitates the removal of blood and colon contents through the utilisation of an electric suction device. In the event of faecal contamination of the abdominal cavity, the area must be thoroughly cleaned with antiseptic solutions in a sterile environment. A comprehensive and meticulous revision and mobilisation of the colon, particularly the mesoperitoneal sections, is pivotal to the success of the surgical procedure.

N.B.! To achieve a high-quality revision of all parts of the colon, it is essential to utilise special atraumatic laparoscopic instruments, relocate the large cecum to the epigastrium in proximity to the liver, reposition the loops of the small intestine, and alter the orientation of the operating table from the lateral and the Trendelenburg positions.

N.B.! It should be noted that further visualisation of the gunshot wounds of the colon be required, intraoperative fibro-colonoscopy represents a valuable diagnostic option.

2. In the presence of a minor, tangential, marginal gunshot wound to the colon, classified as AAST grade I or II, it is possible to suture the area with intracorporeal two-row nodal Vicryl sutures. The wound must be less than 1.0 cm in diameter. The articulating suturing and cutting device Echelon Flex EC 60 and its

analogues may be employed to perform marginal stapling resection of the gunshot wound. We have previously conducted such surgical procedures and have achieved favourable clinical outcomes.

The indications for obstructive resection of the colon include the following injuries, according to the AAST classification: grades III, IV, and V multiple gunshot defects in a limited area of the intestine, as well as complete interruption of the intestine. In addition, the following conditions require surgical intervention: a large size and irregular configuration of the gunshot defect, longitudinal tears of the intestine, a wound or large haematoma in the mesenteric margin of the intestine, as well as detachments from the mesentery. Furthermore, transverse tear of the mesentery with ischaemia or necrosis of the intestinal wall necessitates surgical intervention. In such cases, the principles of DCS must be adhered to. In the event of a modern gunshot wound to the colon with faecal contamination, it is contraindicated to perform a primary anastomosis.

3. Video-laparoscopy allows for the performance of a range of colostomies for colon wounds caused by gunshot injuries, including Hartmann-type operations, which involve creating a stoma at the site of the gunshot wound. It is important to note that the mobilisation of the colon must be performed correctly during such operations to avoid any tension or deterioration of the blood supply.
4. Following the completion of video-laparoscopic surgery on the colon, the abdominal cavity, pelvis and nasogastric tube are duly drained, and the nasogastric tube is placed.
5. An application of surgical magnet tools should be considered in the case-based approach to remove projectiles, bullets, or shells with the ferromagnetic properties (Fig. 27.4).

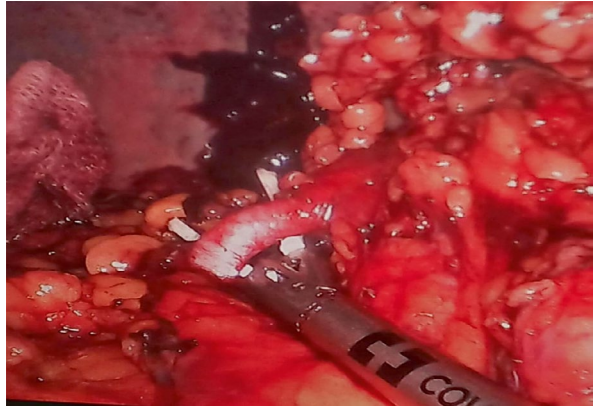
N.B.! A comprehensive understanding of the anatomy is essential for rapidly identifying the crucial structures within the colon, and its associated vasculature, and accurately assessing the severity of the gunshot wound and the extent of contamination. This information is crucial for determining the appropriate surgical approach and tactics. In these surgical procedures, the surgeon's experience and professional skills are of paramount importance. Given the time-consuming nature of surgical interventions, it is essential to consider the condition of the wounded, the flow of other wounded, and the combat and tactical situation. The tactics of DCS are of particular significance for such wounded individuals.

Video-Laparoscopy in Case of Gunshot Wounds of the Spleen

In the case of existing entrance or exit gunshot wounds, primary surgical treatment is required. During endovideosurgery, it is necessary to perform tamponade on these wounds with a napkin and antiseptics, as well as temporary skin sealing (using a skin clamp or suture) to facilitate a full-fledged carboxyperitoneum. Following video-laparoscopy, these gunshot wounds should be evaluated and the decision should be made whether or not to close the gunshot entry wounds by suturing.

It worth mentioning, that in cases of gunshot wounds to the spleen, splenectomy is the preferred surgical option. This is due to the high risk of rebleeding during video-laparoscopic organ-preserving surgery, considering the high-damage

Fig. 27.5 Photograph of video-laparoscopy view showing mobilisation of the splenic artery in the patient with a gunshot wound to the spleen



ballistics properties of modern wounding projectiles. An illustration of laparoscopic removal of the spleen is shown in Fig. 27.5.

The patient may be positioned in one of two ways: (1) lying on their back, or (2) lying on their right side (right lateral position).

Access: The number and placement of trocars remain consistent with a typical splenectomy for various injuries.

Technique: In the event of a gunshot injury to the spleen, the presence of varying degrees of haemoperitoneum with indications of intra-abdominal bleeding is identified during video-laparoscopy.

1. During video-laparoscopy, it is essential to rapidly ascertain the nature of the gunshot spleen injury by the AAST classification [2], with the removal of blood and clots via an electric suction device. A comprehensive and meticulous revision of the spleen is paramount to the success of the procedure.
2. In the presence of minor tangential or marginal gunshot damage to different splenic poles, organ-preserving surgery is a viable option according to the AAST grade I classification. It is recommended that argon plasma coagulation, coagulation and the use of modern local haemostatic agents (FloSeal, Hemopatch, Surgicel) be employed. In all other cases, splenectomy is the recommended course of action.
3. To mitigate the bleeding from the damaged splenic parenchyma, it is recommended to tamponade the area with a napkin, which will reduce blood leakage and enhance visualisation.

N.B.! An understanding of the relevant anatomy is beneficial in facilitating rapid identification of crucial structures, such as the splenic artery and its branches, as well as the splenic vein. It is essential to recall the necessity of dissecting the splenic ligaments and mobilising them. This entails the initial dissection of the medial ligament, which should commence immediately from the splenic gate.

4. The mobilisation of the splenic gate should be performed expeditiously and meticulously, with the arteries and veins clipped utilising splenic traction and constant electrocautery. Following the completion of the splenectomy, it is imperative to conduct meticulous monitoring of the haemostatic process.
5. The excised spleen is placed in a reservoir bag. It is possible to destroy the spleen in the reservoir, which will facilitate the removal of its remains from the abdominal cavity. Alternatively, the entire macrophage can be removed through a separate incision in a specific location.
6. In the event of the presence of foreign bodies (such as bullets or fragments), the latter should be extracted using dedicated magnetic instruments if they are situated near the damaged spleen.
7. The bed of the removed spleen is drained through a separate trocar puncture, or one of the access points for laparoscopic instruments in the left hypochondrium may be utilised.

N.B! The removal of foreign bodies is not a priority in the context of the treatment of wounded individuals. It is necessary to take into account the condition of the wounded person, the time required for their search and removal, which should not be lengthy, and their size and location.

N.B! The efficacy of a video-laparoscopic splenectomy for gunshot wounds is contingent upon the expertise of the surgeon, the proficiency of the operating team, and the presence of clear indications for this surgical intervention.

Video-Laparoscopy for Management of Gunshot Wounds to the Kidney

Before performing video-laparoscopy, it is essential to diagnose the presence of the contralateral kidney and confirm its integrity using supplementary instrumental techniques, such as ultrasonography.

If an entrance or exit gunshot wound is present, primary surgical treatment must be conducted at the time of endovideosurgical intervention. This may entail the packing of the wound area with surgical pads followed by washing the cavity with antiseptic solutions, as well as the temporary sealing of the skin (using a skin clamp or suture). Following the performance of video-laparoscopy, it is imperative to conduct an evaluation of the entrance and exit (if applicable) gunshot wounds and to decide whether or not to suture the gunshot holes.

Position of the wounded on the operating table.

The wounded are positioned on the operating table in one of two ways: (1) supine or (2) lateral (right or left).

Access: The trocars and their number are the same as in a typical nephrectomy for various diseases.

Technique: It should be noted that in the case of a gunshot wound to the kidney, a retroperitoneal haematoma of varying sizes is usually expected. The presence of the haematoma is the indicator of the damage to the kidney and a sign of retroperitoneal bleeding.

1. In the event of a wide retroperitoneal haematoma, it is necessary to open it to conduct a comprehensive revision of the gunshot wound area of the kidney.
2. It is of the utmost importance to remove any blood clots and identify the source of bleeding using an electric suction device.
3. To reduce the signs of bleeding from the renal parenchyma, it is possible to tamponade this area with a napkin.
4. The extent of the gunshot wound should be evaluated according to the AAST classification system [2].
5. It is recommended that organ-preserving surgery be performed whenever feasible. This procedure involves the use of electrocautery to seal the injury and suturing of the gunshot wound to the kidney in cases where the injury is classified as AAST I, II, or III grades.
6. In the event of the presence of foreign bodies (bullets, fragments), it is imperative that these are removed with the assistance of specialised magnetic tools from the kidney parenchyma, perinephric tissue, or other pertinent anatomical regions.

It should be noted that the removal of foreign bodies is not a priority. Instead, the condition of the wounded, the time required for their search and removal (which should be limited), and their size and location must be taken into account.

7. In the event of a substantial gunshot injury to the kidney (AAST IV or V grades), the patient should undergo a nephrectomy.

N.B.! Knowledge of anatomy is beneficial in rapidly identifying crucial anatomical structures, such as the renal artery, vena cava (which may be present in multiple locations), and ureter. It is important to be aware of the anatomy and location of the inferior vena cava, aorta, duodenum, and spleen, as these structures may be of significance in the context of the injury.

8. The procedure should be carried out as rapidly as possible, with the injured kidney being mobilised medio-laterally. It is then necessary to visualise the relevant anatomical structures, namely the renal artery, renal vein, and ureter, and to perform the appropriate clips: artery → vein → ureter → nephrectomy.
9. It is imperative to maintain control of the haemostatic process.
10. The excised kidney is placed in a bag, which serves as a reservoir. A further incision is made in a specific location to facilitate the removal of the macro drug. The bed of the excised kidney is drained through a separate trocar puncture.

N.B.! The success of video-laparoscopic nephrectomy in gunshot wounds is contingent upon the professionalism of the surgeon, the operating team, and the presence of clear indications for this surgical intervention.

Suggested references of the combat trauma from the Russo-Ukrainian war are listed below [25–30].

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