

Case of gunshot injury to the liver by a hand-made modified sniper bullet: organ-preserving surgical management with damage control tactics and transpapillary biliary decompression

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Combat penetrating gunshot injuries are frequently associated with damage to the liver. A bile leak and an external biliary fistula (EBF) are typical complications. Biliary decompression is commonly applied for the management of EBF. Furthermore, there is insufficient data available regarding the characteristics of combat trauma and its management in the context of ongoing hybrid warfare in East Ukraine.

A 23-year-old male was admitted with a thoracoabdominal penetrating gunshot wound (GSW) that was caused by a high-energy multiple metal projectile (a fragmented sniper bullet). Damage control tactics was applied at all 4 levels of military medical care. Endoscopic retrograde cholangiopancreatography (ERCP), endoscopic sphincterotomy, and placement of a biliary stent were used for evaluation and biliary decompression. Stent occlusion was treated with stent replacement and scheduled ERCP. Partial EBF was diagnosed based on the primary wound defect of the liver and was closed without surgical intervention on the 34th day after injury. Acute cholecystitis was associated with ERCP and was managed with cholecystostomy.

The combination of operative and nonoperative techniques for the management of the combat GSW to the liver is effective, along with the application of damage control tactics. Scheduled ERCP is effective for the management of EBF, so liver resection can be avoided. The transpapillary intervention with stent placement was successfully used for biliary decompression. Early post-traumatic stent occlusion can be diagnosed and effectively managed by scheduled ERCP as well as stent replacement with a large-diameter stent inserted as close as possible to the site of bile leak.

KEYWORDS

liver injury, biliary decompression, multiple projectile wounds, thoracoabdominal injury, damage control tactics, stent occlusion, war in Ukraine, hybrid warfare.

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The war in certain districts of Donetsk and Luhansk oblasts within the Donbas area of Ukraine has been ongoing since 2014 and is classified in Ukraine as a Joint Forces Operation (JFO). This type of armed conflict could be defined as a «hybrid war», a term that has been introduced in previously published reports [1–4]. Due to the deployment of

modern high-energy weaponry against the regular army, new surgical challenges have emerged in the ongoing warfare in East Ukraine, which include various clinical features and rare trauma cases such as hydrodynamic liver rupture or pulmonary embolism caused by a metal fragment [1, 2, 5]. It is worth mentioning that the use of high-energy weaponry is

associated with penetrating projectiles, causing severe gunshot wounds (GSW) of the liver [6]. Furthermore, improvised explosive devices and bullets that have been manually modified for sniper rifles by cutting an «X» on their tips are frequently used and associated with severe trauma due to their ballistic characteristics [7]. Such a bullet is a kind of deformed ammunition, causing fragmentation upon striking the target and creating more severe damage, including liver injury [8].

The wounding mechanism of gunshot projectiles to the liver is associated with the direct mechanical effect on the parenchyma, followed by the formation of primary and secondary necrosis areas, periwound molecular contusion, as well as further spread of a side shock wave with the formation of a temporary pulsating cavity, which is a common ballistic feature of high-energy weaponry, indicating energy spread to the adjacent tissues around GSW [7]. In addition, a hydrodynamic wave should also be considered as a damage factor in thoracoabdominal gunshot injury [2]. Furthermore, thoracoabdominal gunshot injury resulting from high-energy weapon use is a clinical challenge for military surgeons because of the differential spread of projectiles, leading to a mismatch of the entrance wound with the localization of organ injury [2, 9]. GSW of the liver is commonly associated with profuse internal bleeding, which frequently causes the death of patients who have not undergone urgent surgical or nonoperative management during the «golden hour» after injury. Therefore, the application of «damage control» tactics along with nonoperative management such as endoscopic retrograde cholangiopancreatography (ERCP) is highly recommended for selective patients [10–13]. In those who were treated, certain hepatic complications might be seen, such as a bile leak and an external bile fistula (EBF), biloma, bleeding, abscesses, cholecystitis, and liver failure [14, 15]. It should be noted that early administration of transpapillary interventions is important for decompression of the biliary tree due to the relatively high frequency of EBF (up to 21 % of cases) [13, 16–19].

The management of GSW of the liver with EBF in patients with thoracoabdominal injury is currently under debate [11, 12, 16, 20, 21]. There is insufficient data available regarding combat trauma and its management in the context of ongoing hybrid warfare. In order to further specify the characteristics of combat GSW to the liver and to share the experience of military surgeons, we report a case of a combat patient with a thoracoabdominal GSW associated with the liver injury and EBF, who was treated with the help of damage control tactics and

scheduled ERCP. In this case report, we demonstrate the effectiveness of military medical care in real combat settings.

Case presentation

A 23-year-old healthy male soldier was injured by a high-energy weapon. GSW was caused by multiple projectiles. Clinical management of the patient was performed according to the National Military Medical Doctrine adopted in Ukraine, which is based on the IV Levels of care as further detailed [1, 2, 22].

Basic Level – First Medical Care

First aid was provided immediately at the scene. The patient was administered butorphanol 1.0 ml and an aseptic bandage was applied at the site of the bullet inlet hole. At the Basic Level, major injuries were diagnosed, necessitating an evacuation as well as subsequent triage and treatment at the higher level of medical care. Therefore, the patient was evacuated by the military ambulance to the central district hospital in Bakhmut city (Donetsk Region, Ukraine), which is a Level II hospital.

Level II – Qualified Surgical Care

The «golden hour» criterion was followed because the patient was admitted to the surgical department within an hour after injury. At the time of admission, a penetrating GSW was detected due to an inlet bullet hole measuring 2.0 × 2.5 cm in the right paravertebral region at the level of the 9th thoracic vertebra.

Right-sided non-tension hemopneumothorax (1050 ml of blood), post-traumatic lower lobe pneumonia, diaphragm wounds, multifragmentary gunshot fracture of the transverse processes Th9, Th10 and 9–10th ribs on the right, spinal cord contusion, traumatic shock II degree, severe coma (6 scores by Glasgow coma scale), and hemorrhagic anemia were also diagnosed. A heart contusion was revealed during echocardiography. Further examination showed unstable hemodynamics (supported by sympathomimetics) and traumatic shock. The obtained clinical findings indicated a critical condition of the patient.

Hemopneumothorax was treated by thoracocentesis in the 7th intercostal space along the middle axillary line. The drainage of the right pleural cavity was performed according to Belau and resulted in 1050 ml of bright red blood. Further monitoring of the thoracic drain showed no signs of bleeding. Although GSW was localized in the thoracic area, an abdominal injury was suspected. To test that hypothesis, the patient was subjected to laparocentesis and bright red blood was also received from the abdomen, indicating persistent intra-abdominal

bleeding as well as coexistence of abdominal and thoracic injuries (i.e., thoracoabdominal). To stop bleeding, a midline laparotomy was performed and 500 ml of bright red blood with clots were removed from the abdomen. The examination revealed multiple wounds to the right lobe of the liver (Sg₅–Sg₈ – grade III AAST liver injury scale). The main wound canal was identified in the Sg₇ with a diameter of 4 cm, and further inspection of the liver showed multiple metallic shrapnel projectiles within the right lobe as well as within the abdominal cavity. The source of persistent intra-abdominal bleeding was diagnosed in the liver, showing multiple penetrating and perforating wounds on the diaphragmatic and visceral surfaces of the right lobe (Sg₅–Sg₈). The largest wound track was identified on the visceral surface of the Sg₇ with a diameter of 4 cm. Such liver injury was classified as grade III on the AAST scale according to the American Association for the Surgery of Trauma and AIS severity III (Liver Injury Scale, revision 2018) [12, 23, 24]. Damage control tactics was considered. Therefore, GSWs of the liver were stitched, and 5 gauze tampons were inserted in the wound area (i.e., perihepatic packing), followed by the placement of drainage tubes in the subhepatic space and the pelvic cavity. For resuscitation, the patient received a transfusion of crystalloids (2200 ml), colloids (500 ml), fresh frozen plasma (780 ml), and red cell mass (1260 ml).

The analysis of the entry GSW showed a round-shaped defect with a maximum diameter of 2.5 cm. The course of the wound track, from back to front and from top to bottom, suggested a potential thoracoabdominal injury. Further GSW examination revealed multiple small bone fragments from the fractured ribs and vertebrae as well as numerous metallic projectiles. Taking into consideration the severity of trauma and the high risk of bleeding, the patient was treated in the operation theatre but not in the intensive care unit (ICU) during the entire time after admission. 12 hours after injury, the decision was made to transfer the patient to a higher level of medical care. The patient was then transported under endotracheal intubation and mechanical ventilation to the Military Medical Clinical Center of the Northern Region (Level III) in Kharkiv city.

Level III – Specialized Surgical Care

At admission to Level III, the patient's condition was stable. However, the Simplified Acute Physiology Score (SAPS II) resulted in 75 points, which indicated severe illness. Right-side lung auscultation revealed diminished breath sounds over the entire surface of the lung in addition to harsh breathing above the lungs on the left side. Without the use

of vasopressors, the patient's hemodynamics was stable, with a blood pressure of 110/60 mm Hg and a regular heart rate of 74–78 beats per minute. The palpation of the anterior abdominal wall showed no peritoneal signs, and bowel sounds were hypoactive at abdominal auscultation. On digital investigation, the feces were light brown in color. The urine output was sufficient, demonstrating light yellow-colored urine from the urine catheter. A hemorrhagic fluid of 200 ml was obtained from a drainage tube in the subhepatic space, 210 ml from the right pleural cavity, and a small amount from the pelvic cavity. The obtained hemorrhagic content was a red-colored fluid, with an absence of clots and a hemoglobin concentration of up to 30 g/L, indicating a mixture of lysed red cells with the serous exudate. Both the postoperative wound and the inlet GSW were clean and without any signs of bleeding.

The analysis of laboratory tests revealed severe blood and plasma loss, showing anemia (Hb 83.1 g/L), thrombocytopenia ($99 \cdot 10^9/L$), hypoproteinemia (48.5 g/L), hypocalcemia (1.27 $\mu\text{mol/L}$). Further testing showed reactive leukocytosis $11.6 \cdot 10^9/L$, ALT – 900.3 U/L, AST – 619.2 U/L, and microhematuria 10–12 red blood cells per field of view. The laboratory findings indicated blood loss and post-traumatic cytolysis, which was consistent with the severity of thoracoabdominal injury.

Electrocardiography was performed to evaluate heart function. It revealed sinus rhythm with a heart rate of 75 beats per minute and diffuse metabolic abnormalities in the myocardium caused by a decrease in T wave amplitude in leads I, II, and V₂–V₄, which was represented by changes in hemodynamics. A chest X-ray showed signs of non-tension right-side pneumothorax with less than 10% of the affected tissue. Lumbar puncture was performed according to the National Medical Military Doctrine to check the possible bleeding for a diagnosis of subarachnoid hemorrhage. The analysis of cerebrospinal fluid revealed xanthochromic cerebrospinal fluid with a protein concentration of 3.3 g/L, positive Pandy's reaction and weakly positive Nonne-Apelt, indicating no signs of spinal pathology. Cytological examination of cerebrospinal fluid showed cytolysis of 160 cells/ μL , of which lymphocytes and segmented neutrophils constituted 15% and 85%, respectively.

According to the National Military Medical Doctrine adopted by the Military Medical Department of the Ministry of Defense of Ukraine in July 2014, a whole-body computed tomography (CT scan) is routinely performed at Level III for all patients with penetrating and perforating GSW to detect any potential minor injuries [1]. At Level I and Level II, CT scanning is not available. A whole-body

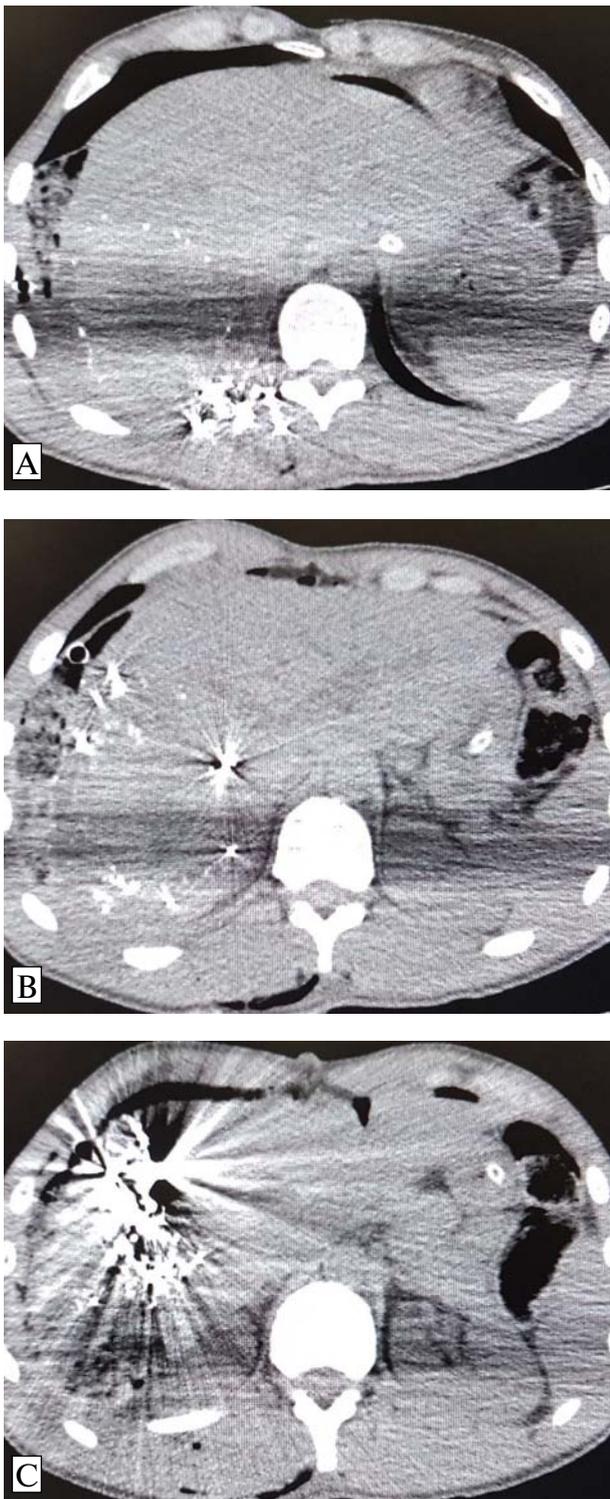


Figure 1. Abdomen CT scan of the patient on the 4th day after the multiple projectile bullet gunshot thoracoabdominal injury. (A) Illustration of the multiple shrapnel of metallic density and bone fragments after gunshot multi-fragmented fracture of the transverse processes of Th9, Th10, 9th and 10th ribs on the right in the area of the inlet bullet wound; (B, C) Illustration of the multiple shrapnel of metallic density within the right lobe of the liver with the background of traumatic destruction and post-traumatic edema of the liver parenchyma

CT scan was performed at Level III. The lower lobe of the patient's right lung showed signs of post-traumatic pneumonitis. Multiple fragments of metal density were found in the lower lobe of the right lung (5–9 mm in greatest diameter (GD) and within the soft tissues on the right side of the patient's back (2–4 mm in GD). Multi-fragmented fractures of the right transverse processes Th9, Th10, 9th and 10th ribs were also observed on the right side (Fig. 1A). The analysis of abdominal CT scans showed pancreatic edema and signs of GSW of the liver caused by multiple fragments of metallic density (5–9 mm in GD) in the Sg₅-Sg₈ (Fig. 1B, 1C). Similar fragments of metallic density (2–3 mm in GD) were also identified between intestinal loops. The overall study of CT scans was consistent with findings at laparotomy revision.

Resuscitation therapy was performed by the administration of crystalloid solutions, solution of 20% albumin (500 mL), fresh frozen blood plasma (1230 mL), red cell mass (1360 mL), antibacterial therapy (Ceftriaxone 2 g/day, Metronidazole 1500 mg/day, Levofloxacin 500 mg/day), antisecretory therapy (Pantoprazole 40 mg/day), hepatoprotectors (Ademetionine – 1000 mg/day), central cholinomimetics (Choline Alfoscerate – 1000 mg/day), beta-blockers (Metoprolol tartrate 5 mg/day), painkillers, as well as parenteral nutrition.

Within 3 days after injury, rapid initial bleeding and contamination control and resuscitation were achieved. Therefore, the application of damage control tactics was considered successful. However, the patient required more intensive and advanced surgical management, which was available at the higher level of medical care. Thus, the patient was evacuated by air transport to Level IV at the National Military Medical Teaching Center (Kyiv city) on the fourth day after injury.

Level IV – Highly-Specialized Surgical Care

At admission to the Department of Surgery at the National Military Medical Teaching Center in Kyiv, the patient underwent relaparotomy. Taking into consideration GSW to the liver and damaged diaphragm, a Rio-Branco incision was chosen over the Makuuchi incision to get optimal access to the right upper quadrant zone. The intraoperative revision showed an absence of profuse bleeding from GSW to the liver Sg₆–Sg₇. Further inspection showed multiple small GSWs, but neither bleeding nor bile leak could be determined. Minor traumatic tissue defects on the diaphragmatic surface of the right lobe of the liver (Sg₅–Sg₇) were identified, stitched and coagulated. Further examination revealed a GSW on the visceral surface of the right lobe of the liver

with a cavity of $4.0 \times 3.0 \times 4.0$ cm filled with a large blood clot, which was removed. Using a bipolar instrument, additional coagulation of the wound surface of the liver defects was performed, followed by closing the GSW track with an omentum flap (i.e., hepatoomentopexy). A five-millimeter polyvinyl chloride tube was inserted near the largest wound canal of the liver as well as into sub- and suprahepatic spaces, whereas the pelvic cavity was drained through separate drainage tubes.

After relaparotomy, ERCP was performed to evaluate bile ducts and to perform their decompression. The high risk of secondary liver necrosis, intrahepatic edema, and formation of EBF due to the ballistic effect of multiple high-energy projectiles to the liver that were frequently observed during 6

years of management of similar cases of combat patients was an indication for ERCP in the absence of jaundice or damage to hepatic ducts. Contrast-enhanced ERCP demonstrated a common bile duct (CBD) with a diameter of 3 mm, whereas the right and left hepatic ducts were 1 mm in diameter (Fig. 2A). The contrast media extravasation to the perihepatic space was revealed at the border of Sg_1 and Sg_8 of the liver, followed by subsequent intensification after tight filling of the bile ducts (Fig. 2B). As we expected, there was observed deposition of the contrast media into the gallbladder, indicating insufficient bile flow. An attempt was made to insert the thinnest (7 Fr) stent into the right lobar duct, but it was not successful due to the small diameter of the lumen. To achieve sufficient bile flow into the

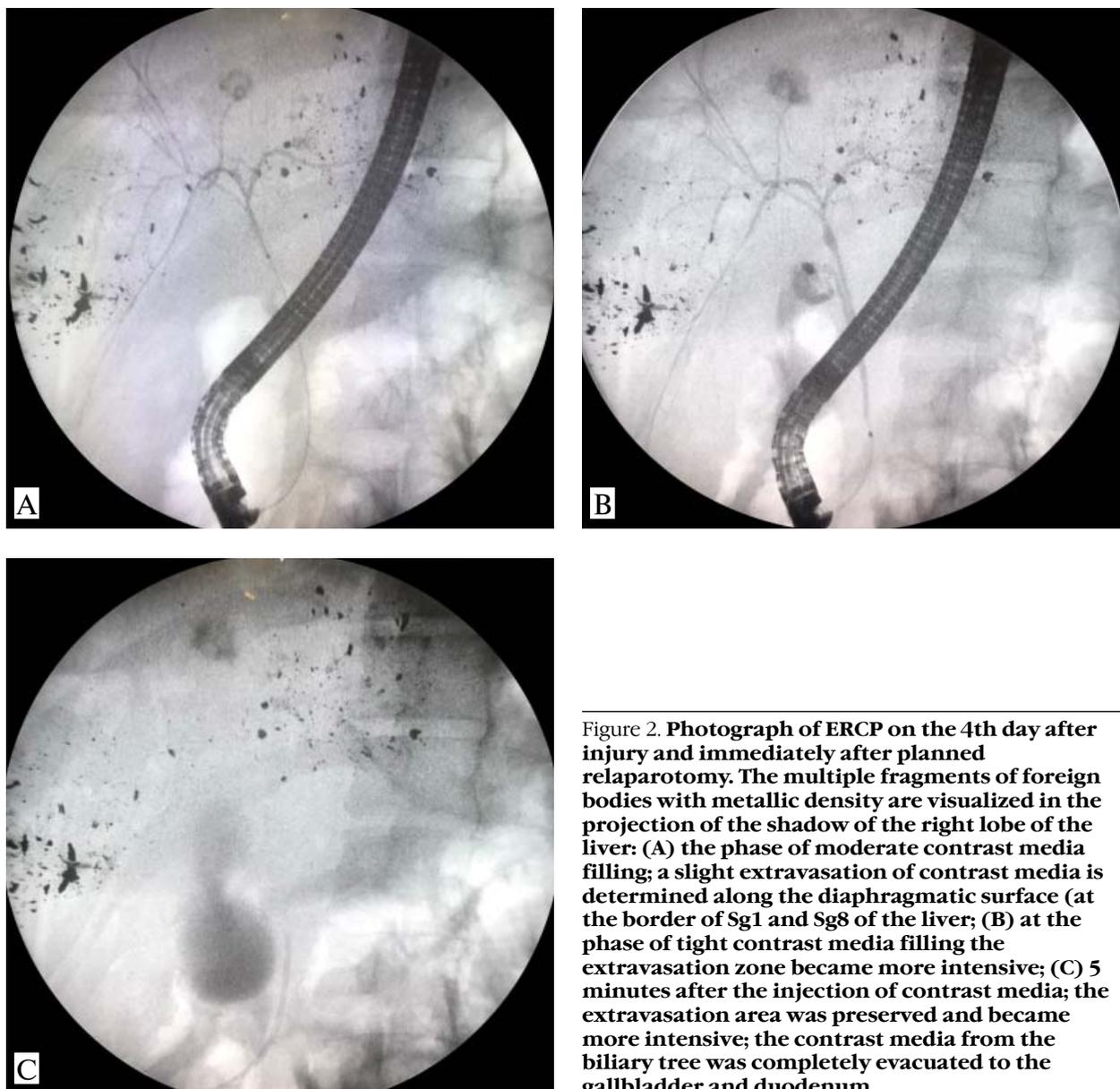


Figure 2. Photograph of ERCP on the 4th day after injury and immediately after planned relaparotomy. The multiple fragments of foreign bodies with metallic density are visualized in the projection of the shadow of the right lobe of the liver: (A) the phase of moderate contrast media filling; a slight extravasation of contrast media is determined along the diaphragmatic surface (at the border of Sg_1 and Sg_8 of the liver); (B) at the phase of tight contrast media filling the extravasation zone became more intensive; (C) 5 minutes after the injection of contrast media; the extravasation area was preserved and became more intensive; the contrast media from the biliary tree was completely evacuated to the gallbladder and duodenum

duodenum, the endobiliary decompression of the biliary system was performed by endoscopic sphincterotomy (EST). An endobiliary teflon stent (7 Fr, 50 mm) placed in the CBD restored bile flow into the duodenum (Fig. 2C).

In the postoperative period, a bile leak was determined neither through the drainage tubes from the suprahepatic nor from the subhepatic space or pelvic cavity. However, there was detected a bile leak of 30–70 ml/day through the drainage tube from the area of the main GSW canal at the visceral surface of the Sg₇ of the liver, indicating the formation of a partial EBF. It should be noted that from the 2nd day after relaparotomy (day 6 after injury), the patient had a daily defecation with brown feces, indicating that physiological derivation of the bile to the duodenum was sufficient. However, the severe injury to the liver was considered, so daily ultrasonography (US) monitoring of the hepatobiliary zone was administered.

On the 5th day after relaparotomy (day 7 after injury), US examination revealed a unechogenic area with heterogeneous content and a dimension of 66 × 39 mm, indicating intrahepatic hematoma. Laboratory findings showed leukocytosis – $15.6 \cdot 10^9/L$, serum amylase – 224 U/L, urinary amylase – 2,653 U/L, which were specific signs of endogenous intoxication and post-traumatic pancreatitis. During the following 2 days, the patient received conservative treatment, which resulted in the significant reduction of blood amylase to 205 U/L and urinary amylase to 1,772 U/L (day 9 after injury). Meanwhile, endogenous intoxication remained high, with a fever up to 38 °C and a leukocytosis of $19.2 \cdot 10^9/L$. This observation indicated the resorption of necrotic tissues after post-traumatic decomposition of the liver, so the combination of piperacillin (16 g/day) and Tazobactam (2 g/day) was administered. However, on the 8th day after relaparotomy (day 12 after injury), the leukocytosis remained high ($15.9 \cdot 10^9/L$) and acute pathology in the abdomen was hypothesized. To check that hypothesis, a multislice CT scan of the abdomen was performed. On CT scan, we detected a tense and expanded (46 mm wide) gallbladder with a content density of 74–80 HU, indicating acute cholecystitis. Taking into consideration the high risk of surgery and according to damage control principles, a US-guided percutaneous cholecystostomy was performed to treat acute cholecystitis and 150 ml of inspissated bile with an admixture of pus was received.

On the following day after cholecystostomy (9th day after relaparotomy and day 13 after injury), the daily volume of bile leaking from the partial EBF (i.e., the drainage tube from the main GSW) was

significantly increased, indicating the inefficiency of previously performed endobiliary stenting of CBD. Hence, we decided to perform ERCP in order to check the endobiliary stent and to attempt the installation of a stent with a larger diameter. Contrast-enhanced ERCP established the absence of filling defects, and further inspection showed the CBD diameter of 3 to 6 mm, and both right and left hepatic duct diameter of 1 mm, indicating normal biliary tree. However, a new zone of extravasation of the contrast media was identified at the border of Sg₅ and Sg₆ of the liver, whereas the previous place of extravasation at the border of Sg₁ and Sg₈ was not visualized even in the phase of tight filling (Fig. 3A). Taking into consideration such findings at ERCP, a stent obstruction was suspected and the decision was made to replace the previously installed stent with the other stent of a larger diameter and longer length (8.5 Fr, 70 mm). Bile flow to the duodenum was restored after the stent replacement. The inspection of the removed stent from the CBD showed near to total obstruction by inspissated bile and necrotic masses from the wound as well as by desquamated epithelium from the bile ducts without blood clots, indicating the phenomenon of biliary sludge.

Two days after the replacement of the CBD stent (day 15 after injury), white blood cell count decreased to $8.3 \cdot 10^9/L$ and serum amylase to 66.3 U/L, indicating clinical improvement for the course of post-traumatic pancreatitis and endogenous intoxication. A bile leak through the partial EBF decreased from 250 to 160 mL/day, suggesting proper functioning of the new CBD stent. The drainage tube was removed from the suprahepatic space, while about 50–60 mL/day of serous content was obtained through the tube from the subhepatic space. The US of the hepatobiliary zone showed the absence of free fluid in the abdominal cavity as well as the signs of reduction of previously identified intrahepatic hematoma.

Further postoperative evaluation revealed stabilization of bile leak through the EBF from the main wound cavity of the liver in a volume of about 200 ml/day (3–7th day after the CBD re-stenting). According to the findings, the right hepatic duct did not drain properly or there was a new leak site for bile extravasation. On the 20th day after injury, the patient underwent contrast-enhanced ERCP to check that hypothesis. As a result, no changes were observed in the CBD (5–7 mm in diameter) and at the site of the new stent, and CBD had no filling defects. The right and left lobar hepatic ducts were also normal (2–3 mm in diameter). However, on the border of the Sg₅–Sg₆ and in the Sg₇ area, there were observed new zones of extravasation of the

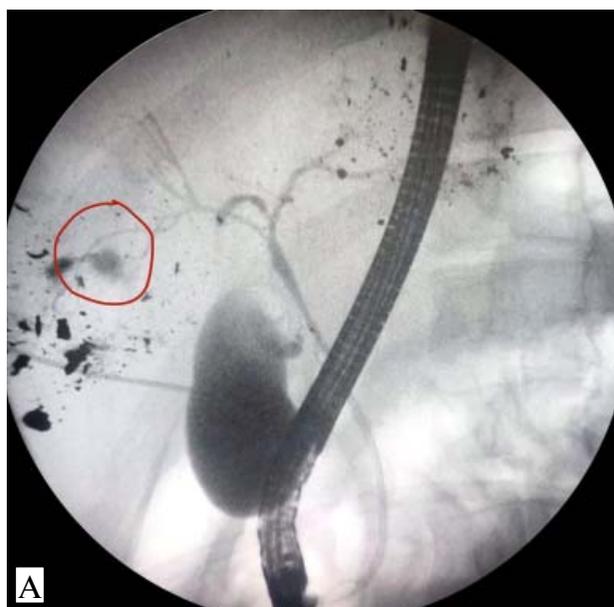


Figure 3. Photographs of ERCP illustrating the biliary tree and gallbladder on the 9th (A) and 16th day (B, C) after the primary endobiliary stenting (the 13th and 20th day after injury, respectively): (A) ERCP illustration at the phase of tight contrast filling on the 13th day after injury showing the zone of contrast media extravasation at the border of Sg₁ and Sg₈ of the liver which was not determined even in phase of tight contrast filling, but the new zone of extravasation appeared at the border of Sg₅ and Sg₆ of the liver (marked by a circle). The stent (7.0 Fr) was replaced by a stent with a larger diameter (8.5 Fr); (B) illustration of ERCP on the 20th day after injury, two zones of the contrast media extravasation are shown: the first zone is located at the boundary of Sg₅ and Sg₆ of the liver; the second zone is located at the Sg₇ of the liver and closer to the 8th segment of the liver. The phase of not tight contrast filling; (C) illustration of ERCP on the 20th day after injury: other 7 Fr stent was installed into the right hepatic duct without removing the stent within CBD. There was a phase of not tight contrast filling. The extravasation zones were more contrasting

contrast media, which were not determined during previous transpapillary interventions (Fig. 3B, 3C), indicating insufficient bile flow. A free flow of bile toward the duodenum was noted after an additional stent (7 Fr, 150 mm) was placed in the right hepatic duct parallel to the stent in the CBD (Fig. 4). Within the following 3 days after the right hepatic duct stenting, the bile leak rate through the EBF, arising from the area of the main GSW canal of the liver, significantly decreased from 200 to 30 mL/day, which was a sign of normal functioning stents. Furthermore, this clinical observation was consistent with the absence of a bile leak into the abdominal cavity. On the 14th day after stenting of the right hepatic duct (day 34 after the injury), the bile leak

through the drainage tube from the main GSW canal of the liver was very low, which was an indication for the removal of the drainage tube. However, 100–200 ml/day of unchanged bile were received through the cholecystostomy tube, which indicated proper functioning of hepatic stents as well as the patient's recovery from cholecystitis.

In the subsequent post-traumatic period, there was an episode of an allergic reaction (urticarial fever) to the antibacterial drug (a combination of piperacillin and Tazobactam), which was treated by 2 plasmapheresis sessions. Postoperative wounds of the soft tissues and the diaphragm healed without any complications. Post-traumatic pneumonitis was also effectively managed. The cholecystostomy tube

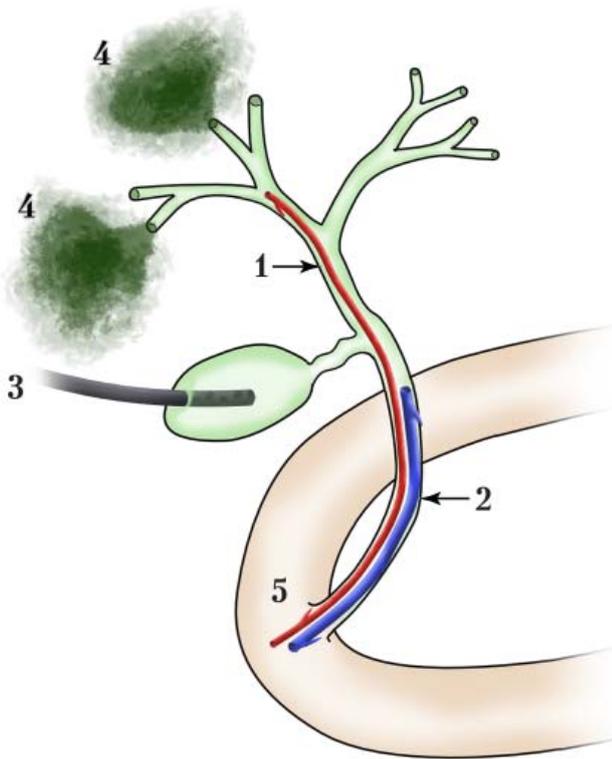


Figure 4. The schematic illustration of endobiliary stents for decompression of the bile ducts on the 20th day after injury (the scheme corresponds to the intraoperative images in Figure 4 (B and 4C): 1 – the stent (7 Fr, 150 mm) in the right hepatic duct toward the sectional ducts, draining the extravasation zones of contrast media; 2 – the stent within CBD (8.5 Fr, 70 mm); 3 – cholecystostomy tube; 4 – the zones of contrast media extravasation from the border of Sg_5 – Sg_6 of the liver and from Sg_7 of the liver; 5 – the area of major papilla of the duodenum

was removed on the 43rd day after the injury. On the 45th day after the injury, a contrast-enhanced ERCP was performed, showing neither changes in the biliary system nor extravasation of contrast media. Therefore, the decision was made to remove both endobiliary stents. After the completion of rehabilitation measures, the patient was discharged from the hospital on the 52nd day after injury in satisfactory condition.

In this study, we have shown a case of successful management of a combat patient with severe thoracoabdominal injury associated with GSW to the liver caused by multiple high-energy projectiles. This case report is an example of the effective application of damage control surgery as well as transpapillary biliary decompression in the patient with multisystem causality in hybrid warfare. Furthermore, this case report provides new evidence of specific features of combat trauma and its management in the combat area of JFO in East Ukraine,

which is consistent with previous publications [1, 2, 4, 22]. In our opinion, this case report presents the evolution of the pathomorphosis of combat injury to the liver, which is associated with the improvement of high-energy weapons. This case report is also supported by data from our previous cases of the hydrodynamic damage (rupture) of the liver resulting from projectile injury of the chest without diaphragm damage in case of using high-energy multiple launch systems by an enemy (e.g. «Grad», «Smerch», «Tornado-C») [2].

Damage control tactics is a standard strategy for the management of combat and civilian patients with severe GSWs [1, 2, 25, 26]. In this case, rapid initial control of bleeding was achieved by temporary packing, although resection of the affected segments of the liver can also be considered in combat cases [16]. Similar to other reports, the current case showed that temporary liver packing is the effective method of choice in case of a severe liver injury as compared to liver resection [15, 27, 28]. According to published reports, liver resection is associated with a higher frequency of complications and high mortality [20, 23, 29]. Therefore, liver packing as a part of damage control tactics was performed at lower levels of military medical care, which is also confirmed by our earlier reports and is in line with other studies which suggest anatomical hepatic resection in such cases only at Level IV [1, 2, 6, 30]. It should be noted that nonoperative management is frequently used for the treatment of GSW to the liver [31]. However, similar to other studies, we did not apply such tactics in this case because of the unstable hemodynamics of the patient [10, 28, 32]. In addition, damage control tactics was used for acute cholecystitis, which was treated with the help of cholecystostomy. This observation is consistent with Cazauran et al., suggesting cholecystostomy instead of cholecystectomy for high-risk surgical patients [31].

Liver injury in combat patients is usually associated with a bile leak and EBF, which is a clinical challenge [20, 29, 33, 34]. In this study, we presented an effective approach to biliary decompression in the case of multiple GSWs to the liver associated with a bile leak and EBF. Biliary decompression can be achieved by the application of various techniques and their combinations, such as EST, biliary stenting, nasobiliary bile drainage [11, 16, 17, 31]. The application of one or several of the above-mentioned methods is aimed at minimizing the pressure gradient between the biliary system and the lumen of the duodenum in order to provide bile flow into the digestive tract but not into the EBF. Studies show that a permanent decrease in the bile leak rate

through EBF is the main condition for its spontaneous closure [17, 20]. In our opinion, the most optimal approach to the bile ducts' decompression in GSW injury to the liver is a combination of EST and endobiliary stenting. However, such an opinion is in contrast to Chandra et al., suggesting performing EST alone, but in line with other studies [16, 19, 33]. It should be noted that conventional treatment of non-combat injury to the liver is associated with less severe trauma to the patient, and therefore EST alone can be considered. However, damage control surgery and EST with stent application are regarded as a safe and reliable approach in the management of biliary leak [11, 16, 20, 29].

Similar to other studies, we have also diagnosed a partial EBF, caused by the failure of the drainage function of the endobiliary stent [10, 16, 20]. Similar to our previous report and other studies, we have not detected any evidence of an EBF relationship to the specific clinical features of this patient [1, 10, 31].

In line with Kwon et al., we hypothesized that the stent occlusion in the early post-traumatic period was due to the obstruction of its lumen by inspissated bile with accumulations of desquamated ductal epithelium and necrotic masses from the area of traumatic destruction of the liver parenchyma [35]. We consider that increased desquamation of the epithelium lining of the bile ducts is a secondary event due to secondary ischemic changes in the periwound tissue after the spread of the energy from the injuring projectile, which is a speculation. In this study, we have also demonstrated the management of biliary stent occlusion. It is worth mentioning that biofilm formation plays a key role in the sludge accumulation in the stent wall, however complete pathogenesis of the occlusion remains unclear [36]. However, according to published studies and the National Military Medical Doctrine of Ukraine, it is recommended to perform scheduled replacement of the stent with a larger diameter stent, which was also performed in the current study [35–37].

In this clinical case, we reported a closure of EBF after scheduled ERCP and without using resection methods, which is in line with other studies of civilian cohorts [11, 17, 20, 29, 34]. To our best knowledge, this is the first report to describe the EBF closure in a case of thoracoabdominal GSW to the liver by using only ERCP without liver resection. It should be noted that based on our six-year clinical experience of combat-related trauma management [1, 2, 22], we came to the conclusion that performing transpapillary interventions every 7–10 days would be highly beneficial. Such an approach to ERCP is considered a planned (scheduled)

transpapillary intervention, which is in line with the principles of damage control tactics in cases of severe GSW to the liver as well as in line with the paradigm of early prediction and prophylaxis of post-traumatic complications [1, 2, 16].

Conclusions

This case report presents a case of a combat patient who was treated according to the damage control tactics and our 6-year experience in combat GSW management.

The combination of operative and nonoperative techniques for the management of combat GSWs to the liver is effective, along with the application of damage control tactics. For the management of EBF, planned ERCP is an effective strategy, so liver resection can be avoided. The placement of a stent during a transpapillary intervention resulted in successful biliary decompression. Early post-traumatic stent occlusion may be identified and effectively treated with planned ERCP and stent replacement with a larger diameter stent.

DECLARATION OF INTERESTS

The authors declare that they have no conflicts of interest.

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ETHICS APPROVAL AND WRITTEN INFORMED CONSENTS STATEMENTS

The study was approved by the ethical committee at the National Military Medical Clinical Center of Ministry of Defense of Ukraine, Kyiv, Ukraine.

Consent to publish. Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for its review by the Editor-in-Chief of this journal.

Availability of data and material. All data generated or analyzed during this study are included in this published article.

AUTHORS CONTRIBUTIONS

I. Khomenko — study conception and design, acquisition of data; I. Tsema — acquisition of data, analysis and interpretation of data, literature review, drafting of the manuscript; K. Humeniuk — acquisition of data, analysis and interpretation of data, literature review; V. Slobodanyk — analysis and interpretation of data, critical revision, drafting of the manuscript, literature review and analysis, drafting of the manuscript; D. Rahushyn — acquisition of data, analysis and interpretation of data, preparation of figures.

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Випадок вогнепального поранення печінки кустарно-модифікованою снайперською кулею: органощадне хірургічне лікування з тактикою контролю ушкоджень і транспапілярною біліарною декомпресією

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Бойові проникаючі поранення часто супроводжуються пораненням печінки. Жовчотеча та формування зовнішньої біліарної нориці (ЗБН) зазвичай є ускладненнями таких поранень. Біліарну декомпресію рутинно застосовують для лікування ЗБН. Механізми бойової травми печінки остаточно не відомі, а методи її лікування в умовах гібридної війни на сході України потребують додаткових досліджень.

Наведено власне клінічне спостереження. У чоловіка віком 23 роки діагностовано торако-абдомінальне вогнепальне поранення високоенергетичними множинними металевими уламками (фрагментована снайперська куля). Тактика контролю ушкоджень застосована на всіх чотирьох рівнях надання медичної допомоги. Діагностика ЗБН та біліарна декомпресія проведені за допомогою ендоскопічної ретроградної холангіопанкреатографії (ЕРХПГ), ендоскопічної сфінктеротомії та постановки пластикового біліарного стенту. Оклюзію стенту усунуто шляхом заміни стенту і виконання програмних ЕРХПГ. Часткова ЗБН, діагностована в ділянці основного ранового дефекту печінки, самостійно закрилася на 34-й день після поранення. Гострий холецистит, асоційований з ЕРХПГ, потребував проведення холецистектомії. Комбіноване застосування оперативних та неоперативних методів лікування бойових поранень печінки є ефективним у разі дотримання тактики контролю ушкоджень. Застосування програмних ЕРХПГ виявилось успішним для лікування ЗБН, що дало змогу уникнути проведення резекції печінки. Ефективна біліарна декомпресія досягнута за рахунок транспапілярних втручань та ендобіліарного стентування. Оклюзія ендобіліарного стенту може бути діагностована в ранній посттравматичний період та ефективно усувається за допомогою програмних ЕРХПГ, а також рестентуванням стентами більшого діаметра якомога ближче до місця жовчотечі.

Ключові слова: поранення печінки, біліарна декомпресія, множинне уламкове поранення, торако-абдомінальне поранення, тактика контролю ушкоджень, оклюзія стенту, війна в Україні, гібридна війна.

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