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Multistage Surgical Treatment of Multisystem Closed Abdominal Trauma: Standardization of the Approach

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INTRODUCTION The multisystem closed abdominal trauma is accompanied by a high mortality rate, and exceeding the minimum required volume of surgery in an extremely difficult patient's condition often leads to an unfavourable outcome.

AIM OF STUDY Standardization of staged treatment of patients with severe concomitant closed abdominal trauma.

MATERIAL AND METHODS This review presents the latest information obtained as a result of studying domestic and foreign literature on the issue of multistage surgical treatment of severe multisystem closed abdominal trauma. The concept of damage control, its stages are described step by step, indications for types of surgical interventions are specified. The literature data on the results of clinical application of the technique from the standpoint of evidence-based medicine are presented.

CONCLUSION A clear knowledge of the required volume of surgical intervention at each stage of treatment of patients with severe concomitant closed abdominal trauma, the main points of intensive care, the criteria for patient stabilization and indications for relaparotomy improve the results of treatment for this category of victims.

Keywords: tactics of multistage treatment, closed abdominal trauma, laparostomy, tamponade of the parenchymal organs, endovascular hemostasis

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BPsyst – systolic blood pressure
ACS – abdominal compartment syndrome
APTT – activated partial thromboplastin time
IV – intravenous
DIC syndrome – disseminated intravascular coagulation syndrome
Du – duodenum
GIB – gastrointestinal bleeding
GIT – gastrointestinal tract
GB – gallbladder
CAI – closed abdominal injury
ILV – artificial lung ventilation
ITT – infusion-transfusion therapy
INR – international normalized ratio
UB – bladder
IVC – inferior vena cava
NS – nephrostomy
ARF – acute respiratory failure
SRCSMSS – single-row continuous serous-muscular-submucosal suture
PDR – pancreatoduodenal resection
Pn – pancreas
FFP – fresh frozen plasma

SE – splenectomy
LT – liver tamponade
LI – liver injury
CS – cholecystostomy
CE – cholecystectomy
TBI – traumatic brain injury
HR – heart rate
EBAO – endovascular balloon aortic occlusion
EN – enteral nutrition
ES – epicystostomy
AAST — American Association for the Surgery of Trauma
DCS — damage control surgery

When physiology is severely undermined,
attempts to restore anatomy
are counterproductive.
Moshe Shine, 2010

Combined trauma, the mortality rate in which even in well-equipped specialized hospitals is more than 45%, is one of the three main causes of mortality in the population, and in people under the age of 45 it has long come to the fore [1]. Among deaths as a result of all types of injuries, the share of combined injuries accounts for more than 60% [1, 2].

Urgent surgical interventions for polytrauma should be aimed only at saving live, be minimally traumatic and comply with the principles of tactics of multi-stage surgical treatment — DC (damage control surgery) [3, 4]; in severe concomitant abdominal trauma, this is a "shortened" laparotomy – hemostasis and contamination control, intensive care and programmed reconstructive surgery [4, 5]. DC is indicated for patients with severe trauma and hemorrhagic shock, signs of ongoing bleeding leading to metabolic acidosis, hypothermia, and coagulopathy (Evidence level B, strength of recommendation 1; B1) [1, 3, 5–7], and allows to save up to 50-75% of patients with severe trauma [2, 3].

Indications for DC tactics were formulated by prof. A. Hirshberg and then such indications were expanded by other researchers [1–6, 8–10]:

I. Associated with the amount of damage and the complexity of the surgical intervention:

A. Inability to stop bleeding in a direct way:

1. Damage to great vessels of the neck of hard-to-reach localization (internal carotid artery and internal jugular vein at the base of the skull, vertebral artery);

2. Damage to large vessels of the mediastinum, chest wall, initial parts of the subclavian artery;

3. Severe damage to the liver and vessels of the retroperitoneal space (retrohepatic part of the inferior vena cava (IVC), abdominal aorta, etc.);

4. Damage to vessels of the small pelvis (including ruptured intrapelvic hematomas) and gluteal region;

5. Unstable fractures of the posterior semi-ring of the pelvis.

B. The presence of combined and multiple injuries with massive blood loss (more than 4 liters):

1. Multiorgan injuries of the neck, chest, abdomen, pelvis in combination with damage to the great vessels, traumatic brain injury (TBI) with a Glasgow coma score of less than 8 points, or intracerebral hematoma;

2. Associated injuries (C1) with competing sources of bleeding;

3. Injuries requiring complex reconstructive interventions (plastic of the trachea and larynx, pancreatoduodenal resection (PDR), complex vascular plastic).

II. Associated with the severity of the condition and the developed complications:

A. Physiological indications [5, 11]:

1. Unstable hemodynamics requiring inotropic support (BPsyst less than 70 mm Hg) lasting more than 2 hours;

2. Severe metabolic acidosis (pH less than 7.2), serum lactate more than 5 mmol / L (B1), deficiency of BE bases less than -10–15 mmol / L;

3. Hypothermia (body temperature less than 34 ° C);

4. Electrical instability of the myocardium, cardiac arrest at the prehospital stage [4].

B. Increased healing requirements:

1. Massive blood transfusions (more than 10 doses of erythrocyte mass) in the pre- and intraoperative periods;

2. Surgery lasting more than 90 minutes.

C. Occurrence of intraoperative complications:

1. Coagulopathy (activated partial thromboplastin time - APTT more than 60 s or 1.5 times more from the upper limit of normal, thrombocytopenia less than 90x109 L) (C1), DIC syndrome III – IV gr. and, as a consequence, the inability to stop bleeding;

2. Inability to close the laparotomic wound due to peritonitis, intestinal paresis, increased intraperitoneal pressure.

III. Medical and tactical indications («medical resources control») [3]:

A. Massive admission of the injured patients when performing the minimum amount of emergency surgery (after medical triage), even if the victim, due to his condition, is able to undergo the operation in full [12];

B. Insufficient qualification of the surgeon to perform complex reconstructive surgery;

C. Limited manpower and resources of the medical service, lack of surgical resources. After the arrival of additional physicians and the beginning of the functioning of the required number of operating rooms, the use of this tactic is discontinued.

In hemodynamically stable patients in the absence of the above indications, a primary radical surgery is performed (C1) [6, 7].

DC tactics is carried out in three steps [1, 2, 4]. In 2001 J.W. Johnson additionally highlighted the fourth ("zero") stage — ground zero, which involves the provision of prehospital and preoperative medical care (the fastest transportation to the hospital, the simplest measures to stop bleeding, prevention of hypothermia, the start of massive infusion therapy) [4].

Stage I of DC tactics for abdominal injury — reduced primary emergency surgery (up to 90 minutes). Tasks of this stage [1, 3]:

1. Temporary or permanent hemostasis [4, 10]. Emergency surgery is indicated for patients with ongoing massive intra-abdominal or retroperitoneal bleeding and hemorrhagic shock (A1) [1, 5–7, 9] for health reasons — laparotomy with temporary closure of the abdominal cavity [4, 11].

I. Injury of the great vessels of the abdominal cavity and retroperitoneal space. Tactics:

a) identification of the location of the damaged vessel;

b) ensuring rational access to it [8];

c) temporary hemostasis:

— finger pressure of the vessel in the wound;

— the imposition of clamps, turnstiles above and below the site of injury (clamping of the aorta just below the diaphragm or "resuscitation thoracotomy" — thoracophrenolaparotomy (additional incision along the seventh intercostal space) and clamping the aorta over the diaphragm [4, 5, 8] up to 20–30 minutes with systolic blood pressure — BPsyst no more than 70 mm Hg, multiple sources of bleeding (C1) [1, 8]; vascular isolation of the liver in case of damage to the retrohepatic IVC and hepatic veins, etc. [4, 8]);

— the use of endovascular balloon catheters or by insertion balloon catheters into the wound channel [8] (installation of a balloon-obturator through the femoral artery to the level of the 1st zone of the abdominal aorta in case of uncontrolled subphrenic bleeding from parenchymal organs, vessels of the abdominal cavity and retroperitoneal space and severe arterial hypotension (C2) [4, 8, 9, 13, 14]; insertion of two-balloon, three-channel endovascular catheters (with a channel for bypassing the blood flow detour the injury site) through the femoral artery / vein, respectively, so the injury is situated between the two balloons [15]; temporary occlusion of damage to a large vessel with Foley, Fogarty catheters, Sengstaken – Blakemore probe inserted through its defect [4, 5, 8]). A systematic review of the literature from MEDLINE, PubMed, Cochrane Oral Health Group E. Gamberini et al., 2017 [16] on 1355 patients proved that endovascular balloon occlusion of the aorta (EVBA) is necessary for resuscitation in severe subphrenic bleeding. M.B. Wikström et al., 2020 [17] have carried out an experimental modeling of damage to the retrohepatic IVC, for temporary hemostasis, a combination of endovascular balloon occlusions of the aorta and IVC was used, and the method was shown to be effective for stopping bleeding without a systemic drop in arterial pressure while maintaining cardiac output;

d) nature of the operations is determined depending on the type of damage to the vessel. Concept – to avoid any complicated reconstruction [4, 8, 18–20], but only stopping bleeding: restoration of large blood vessels and ligation of minor ones:

— it is possible to ligate (if recovery is impossible) [4, 5, 18]: celiac trunk; renal artery / vein with a complete break (on the left, if possible) with preservation of the testicular vein and of the opposite kidney [12]; splenic artery; left and right gastric arteries; upper and lower pancreatic-duodenal arteries [20]; gastroepiploic arteries; superior mesenteric artery distal to the origin of the first small bowel branch [8, 18], colonic branches of the superior mesenteric artery, except for the middle colonic artery [20]; inferior mesenteric artery; common hepatic artery proximal to the discharge of the gastro-duodenal artery [8], right / left hepatic artery [9, 18]; one hepatic vein; infrarenal part of IVC; one of the three main tributaries of the portal vein; portal vein with its complete intersection, intact hepatic artery and hemorrhagic shock [9, 18, 20]; internal iliac artery, iliac veins [20].

— compulsory restoration (lateral seam – with transverse ruptures of no more than 1/2 of the vessel's circumference), longitudinal ruptures no more than 1.5 cm in length [8]; patch made of synthetic material; temporary prosthetics (shunting) – with complete intersection or rupture of the vessel more than 1/2 circles, through defect, rupture of the intima with thrombosis when endovascular treatment is impossible [8, 18]; endoprosthetics with stent grafts – in case of stable hemodynamics and incomplete intersection of the vessel, pseudoaneurysm, intramural hematoma [14, 20, 21]) subject to [4, 5, 16, 18]: abdominal aorta; superior mesenteric artery proximal to the origin of the first small bowel branch, middle colon artery; suprarenal IVC (including atriocaval shunting [4, 15, 19]); common and external iliac arteries [14, 20].

II. Liver injury (LI). Primary surgical intervention in severe LI should be aimed at prompt hemo- and bile stasis, followed by transfer of the patient to the second stage of DC (A2) tactics [1, 9, 22].

In the presence of intense bleeding from the liver parenchyma, deep ruptures with damage to segmental vessels, bimanual compression of the organ or Pringle's maneuver is initially performed [2, 4, 15, 22].

In cases of minor injuries, it is possible to suture the tears, use physical methods of hemostasis, local hemostatic agents [1, 9, 22]. Preparations based on blood coagulation factors (Tissucol Kit), Collagen (hemostatic collagen sponge, Tachocomb, Avitene, Trombokol), gelatin (Surgifoam, FloSeal, Spongostan, Gelfoam, Hemasept), cellulose (Surgicel) are used in combination with other methods, including tamponade, in case of venous or moderate parenchymal bleeding (C1) [4, 6, 7]. In recent decades, preparations based on synthetic zeolites have been developed that are using to stop intense external and internal bleeding (Hemostop, Combat Gauze, Celox, HemCon, QuikClot) [4].

In case of LI grade IV–V on the AAST scale and large blood loss, rupture or instability of the subcapsular hematoma, massive trauma to both lobes, damage to the posterior hepatic IVC, the impossibility of stopping bleeding by traditional methods, the presence of hypothermia, acidosis, coagulopathy, hemodynamic instability, also with concomitant TBI damage to other parenchymal / hollow organs produce liver tamponade (LT) (C2) [1, 2, 4, 9, 15, 22, 23] as the main method at the first stage of treatment in 48–64% of cases, the fatality rate reaches 46–52% [23]. Extended interventions, including shunting ones, in such conditions increase mortality to 60–88% [5, 23]. It is better to make the decision about LT immediately after revision of the abdominal organs before the development of DIC. [22, 23].

Ten to twenty tampons are tightly placed on the liver until the bleeding stops [4, 9, 22, 23], better for local hemostasis tampons are applied directly on the wound surface for less traumatic removal of tampons in the third stage of DC [23] and after "wrapping" the liver with a mesh of polyglactin 910 (Vicryl) or catgut [4]. The tampons are not brought out to the anterior abdominal wall. Organ dissection reduces the effect of LT [4,

23]. J.P. Hazelton et al. (2015) [19] compared in an experiment the effectiveness of LT and atriocaval shunting in combination with LT-modeling of damage to the suprahepatic IVC. The survival rate of animals with LT was significantly higher than that of those who, in addition to packing, underwent to atriocaval shunting. According to B.V. Sigua et al. (2015) [15], the use of gauze LT within the DC concept reduced mortality in victims from 100 to 50%. J.J. Segura Sampedro et al. (2019) [24] developed and experimentally successfully tested the VacBagPack for LT, which is devoid of the negative aspects of conventional gauze tamponade, such as abdominal compartment syndrome (ACS) or ongoing bleeding. If the bleeding after LT has stopped, then the operation ends with drainage of the abdominal cavity and bile ducts (more often using cholecystostomy – CS).

Insufficient effectiveness of LT occurs in arterial bleeding, while selective ligation of the hepatic artery or embolization is indicated [5, 9, 25], which increases the survival rate of patients with severe LI to 65.5% [25].

III. Spleen injury. In case of damage to the spleen of IV–V degrees on the AAST scale, detachment from the leg, extensive crushing and rupture, excluding the functioning of the organ in the future, rupture passing through the gate of the spleen, the impossibility of its suturing, eruption of sutures in combination with unstable hemodynamics (A2) [3, 4, 26, 27], agonal state, multiple damage to other organs of the abdominal cavity and retroperitoneal space, signs of widespread peritonitis, age over 65 years, splenomegaly, pronounced periprocess, flabby parenchyma, coagulopathy, splenectomy (SE) is indicated [1, 2, 5, 26].

When the spleen is detached from its leg, spleen parenchyma is destroyed, SE is performed at the first stage. In other cases, temporary hemostasis is carrying out by applying a clamp (clip) to the vascular pedicle of the spleen, "wrapping" it with a mesh and using a tamponade [2, 26, 27]. If the bleeding stops, then further tactics are determined at the third stage of DC tactics; in the case of ongoing bleeding SE is performed [4, 5, 27].

IV. Pancreas (Pn) injury. If the tail of the pancreas is damaged, distal resection is performed using a linear stapler [2]; if the head and body are damaged – stopping bleeding is to carry out (coagulation, local application agents, cryotherapy, suturing of blood vessels), drainage of the damaged area (C2) [28, 29], if possible – drainage of the main pancreatic duct, plugging and marsupialization of the omental bursa [2, 5]. Closed aspiration drains are critical for controlling the release of pancreatic juice. It is advisable to drain the bile ducts (more often by cholestostomy) and perform nasointestinal intubation with a double-lumen probe along the Treitz ligament at 40–60 cm [5, 29] for the purpose of decompression and further enteral nutrition (EN).

V. Kidney injury. For ruptures with ongoing bleeding, renorrhaphy with absorbable suture material is indicated [12], with drainage of the perirenal space. With moderate venous and coagulopathic bleeding – organ tamponade (C1) [2, 4, 12]. In cases of massive kidney injuries that penetrate the pelvic system, especially in the area of the hilum, with injury to the vessels of the renal pedicle, life-threatening ongoing bleeding from ruptures with hemodynamic instability, nephrectomy is indicated (C1) [1, 12, 13]. Its incidence is 9, 22 and 83% for trauma of III, IV and V degrees on the AAST scale, respectively. Before removing the kidney, make sure there is a second functioning kidney! For this purpose, the leg of the injured kidney is clamped with a tourniquet, 5 ml of 0.4% indigo carmine solution is injected intravenously. The appearance of colored urine from the urinary catheter in 5–10 minutes indicates the intact function of the second kidney. But in a victim with severe concomitant trauma and shock, with AD less than 80 mm Hg the function of the second kidney can be drastically reduced. In such cases, one has to be guided by the results of examination and palpation of the second kidney [12], as well as using ultrasound.

In case of severe damage to a single kidney or bilateral injury, an attempt should be made to preserve the kidney by ligating segmental vessels, imposing a nephrostomy tube (NS), wrapping the kidney with an absorbable mesh [4, 12, 13] and using tamponade (C1) [12]. Non-viable kidney tissue is excised, the wound is stitched. When tight muscle tissue is placed under stitches, application means of hemostasis are used (acellular matrix, fibrin glue, etc.) [12]. Nephrostomy tube is inserted into the kidney defect, fixed to the fibrous capsule, and is output through an opening in the lumbar region.

2. Contamination control.

Technical requirements: elimination of damage to hollow organs. The formation of intestinal stomas and anastomoses do not produce [2, 4].

I. Stomach trauma with a single rupture – suturing with a continuous single-row serous-muscular-submucosal suture (SMSS) in the transverse direction [2], with massive destruction – atypical (hardware) resection without imposing a gastroenteroanastomosis [1, 4, 5]. Revision of the posterior gastric wall, nasogastric decompression and insertion of the probe behind the Treitz ligament for early EN are required.

II. Duodenal (Du) injury. For a single rupture – suturing with the SMSS in the transverse direction [1, 5]. Numerous studies have not revealed significant differences between the diverticulization of the duodenum after suturing its defects and simple suturing of lesions [5, 28, 30]. In case of multiple ruptures, separation from the stomach, antrum resection is performed with an apparatus without imposing an anastomosis [4, 31], tamponade to stop bleeding, drainage of the damaged area, CS. In case of severe damage to the duodenum, the head of the pancreas and the common bile duct, hemostasis is performed (suturing of bleeding vessels / tamponade) and the prevention of leakage of the contents of the hollow organs into the free abdominal cavity: suturing of the duodenum wall [4, 28, 30] with the setting of a nasogastroduodenal probe below the suture level with active aspiration [5] and a probe distally the Treitz ligament for EP, external drainage of the bile and pancreatic ducts, abdominal cavity, retroperitoneal space and omental bursa (C2) [28, 30] double-lumen silicone drains (possibly as a stage of pancreatoduodenal resection (PDR) [2, 30]). In case of damage to the anterior wall of the duodenum, examination of its posterior wall is required after mobilization of the Du according to Kocher [2].

III. Injury of the gallbladder (GB), common bile and hepatic ducts. In case of incomplete rupture of the gallbladder, its wall is to be sutured with an atraumatic needle, capturing only the serous, muscular membranes and submucosa [4]. With hematoma less than 50% of the surface of the wall of the gallbladder and / or concomitant damage to the liver, pancreas, duodenum, CS is performed [2]. In case of partial and complete detachment of the gallbladder, with full rupture or hematoma, which captures more than 50% of its wall, CE is indicated [1, 4, 32].

In case of marginal damage to the common bile and hepatic ducts, 1–2 precision sutures with prolene or vicryl 5–6/0 are applied [2], and in case of a 1/2 diameter defect, a T-shaped drainage is introduced [1, 5, 28, 32]. In case of complete break of the common bile and hepatic ducts, an end suspended hepaticostomy is applied [4, 28], and if the attempt fails, then the subhepatic space is drained [32].

IV. Small bowel injury. Small subserous hematomas (I degree) and incomplete ruptures after revision are immersed with serous-muscular interrupted sutures made of non-absorbable material in a transverse direction to the bowel course [4]. In the presence of one or more ruptures at a considerable distance from each other, when their size is less than 1/2 of the intestine diameter, suturing with the help of the SRCSMSS is indicated [1, 4, 31]. In case of significant damage (the presence of more than 2 ruptures in an area of 10 cm or 2 ruptures at a distance of less than 5 cm from

each other, with wall defects of more than a semicircle (III degree), with complete intersection of the intestine, extensive crushing of its wall, detachment of the intestine from the mesentery by for more than 5 cm, transverse rupture of the mesentery with ischemia or necrosis of the intestinal wall) resection is to be performed [2, 5, 31] with the closure of the ends with a purse-string or single-row suture, a linear stapler, application of clamps, nasogastrointestinal intubation with a Miller-Abbott double-lumen probe of the proximal intestine [1], stopping bleeding. No anastomosis is constructed (delayed anastomosis tactics) [2, 4, 5, 31].

V. Colon and rectal trauma. Non-penetrating tears and hematomas are immersed in interrupted sutures. In case of a single rupture, suturing is performed using the SRCSMSS [2, 33, 34]. In case of extensive damage to the intestinal wall, a through defect, the presence of several, close location of defects (up to 5–6 cm from each other) more than 1/3 of the circumference, malnutrition of the intestinal wall (if the mesentery of the colon is ruptured more than 10 cm), obstructive resection is performed [1, 5, 31, 34] with the closure of the ends with a purse-string or single-row suture, hardware suture, application of clamps, the distal and proximal sections of the intestine are immersed in the abdominal cavity [4], intubation of the small intestine [31, 33, 34], the introduction of a gas tube and anus divulsion are performing.

In case of rectal trauma, only stopping life-threatening bleeding with tamponade of the pelvic cavity and suturing intraperitoneal ruptures by imposing a SRCSMSS in the transverse direction [1, 5, 31].

VI. Injury of the ureter, bladder (UB), urethra. In case of lateral damage to the ureter (less than 1/2 of the circumference), a ureteral stent is placed along the guide string through the area of injury and the defect is sutured with interrupted sutures with a thin absorbable thread [12]. In case of unstable condition of the victim, complete transection, ligation of the ureter is preferable, NS and delayed plastic surgery are indicated [2]; also temporary hanging ureterostomy is possible (C1) [4, 12]. In case of late diagnosis – NS with stent (preferred) [5] or without it (C1) [13]. Retrograde stenting is usually ineffective in such cases.

In case of intraperitoneal injury to the UB after laparotomy and suturing the defect with two rows of absorbable sutures (mucous-detrusor) [1, 2, 12] they carry out the placement of a urinary catheter [5] and the imposition of an epicystostomy – ES (when extensive damage or combined spinal trauma with urinary disorders is observed) (A1), tamponade and drainage of the small pelvis [4, 12, 13]. With a small extraperitoneal rupture of the UB outside the neck, the absence of unstable fractures of the pelvis, damage to the rectum and vagina, conservative treatment is possible with the installation of a large-diameter urethral catheter or the imposition of trocar ES (C1) [2, 4, 13]. The tears located on the front wall of the UB and available for suturing are closed with double-row sutures from the outside. It is possible to examine the UB through a cystostomy access from the inside using mirrors and to suture the lesions, followed by drainage the perivesicular tissue [1]. In case of combined ruptures with a transition to the neck of the UB or Lietot triangle (V degree on the scale AAST), separation of the cervix from the urethra bilateral retrograde ureteral stenting with external urine diversion is performing [4].

For urethral trauma and hemodynamic instability, ES is performed (A1) [1, 12], drainage of peri-vesicular tissue in case of damage to the posterior urethra [13].

3. Temporary closure of the laparotomic wound. The method of its closure should provide quick and low-trauma multiple access to the abdominal cavity, create good conditions for full revision and sanitation, protect the abdominal organs, implement the principle of decompression and adequate drainage of the abdominal cavity, minimize the risk of developing purulent complications, maximize the subsequent reconstruction of the anterior abdominal wall [4, 5, 11]. For this, a laparostomy is more often formed, especially in the presence of risk factors for the development of ACS (clause II of the indications for DC tactics (C1)) [1, 4, 5, 11, 31].

The method of laparostomy is possible in two conditional versions: open and closed technology, with the latter, the wound of the abdominal wall is closed with temporary devices [11, 31, 35].

With open technology, the intestine and abdominal cavity are not isolated from the external environment. Considering that in this case, the intestinal loops may dry out and the wound reinfected, the organs are covered with nylon bandages, perforated plates made of soft plastic, perforated synthetic film, permeable synthetic mesh (Vipro I, Vipro II, Gore-tex, Marlex), esistant to infection [31, 35]. The use of composite semi-absorbable materials (Vicryl or Dexon) allows them to be used directly above the intestine, to drain the abdominal cavity through an implant [4, 31, 35].

Closed technologies imply the temporary closure of the operating wound without changing the volume of the abdominal cavity by bringing the edges of the skin wound with a single-row suture, using a skin stapler or applying clamps (not recommended in case of a threat of ACS development [4, 31, 35]) or using various wound protectors: temporary stitches, Bogota bag (A2) [11], Wittmann patch, device for treatment by the method NPWT (Negative Pressure Wound Therapy) (C1) [31, 35–37] in combination with abdominal reapproximation anchor (ABRA) system; Vacuum-assisted wound closure and mesh-mediated fascial traction — VAWCM [36], which accelerates the timing of the final closure of the laparotomic wound, reduces the risk of developing severe abdominal sepsis in peritonitis, ACS (B2) [11, 36], mortality, length of hospital stay, cost of treatment [11, 31, 36, 37].

To control hemostasis, a thick drainage is installed in the pelvic cavity. After an emergency laparotomy, the patient should be left in the operating room for 2–3 hours, so that when bleeding resumes, time is not lost on preparing for relaparotomy [4, 5, 37].

2nd stage – Damage Control Resuscitation – intensive therapy to stabilize vital body functions, detailed identification of lesions with possible endovascular hemostasis, consultations of related specialists [1, 3, 10]. Tasks of this stage and ways to achieve them [4, 6, 7]:

1. Adequate combined pain relief [2, 38];

2. Infusion-transfusion therapy (ITT):

а) it is recommended to start ITT with the use of balanced crystalloid solutions (A1) [6, 10] and avoid excessive use of 0.9% sodium chloride solution (C2) [10];

б) in patients with concomitant TBI, the use of hypotonic solutions (Ringer's lactate) (C1) [6], as well as glucose solutions, should be avoided due to the risk of intracellular edema of the brain tissue [10];

в) the use of colloids should be limited due to adverse effects on hemostasis, their infusion is indicated at initial resuscitation (C2) [6, 7, 10].

г) hypertonic fluids are recommended in hemodynamically unstable patients (C2) [10]. To prevent hypertransfusion syndrome, low-volume hemodilution with hypertonic-hyperoncotic solutions is preferable (HyperHAES, Hemostabil). Hemodilution caused by the redistribution of fluid due

to the infusion of hypertonic solution has a positive hemorheological effect, especially in combination with the simultaneous infusion of colloids [6, 10];

д) it is necessary to maintain the target hemoglobin level – 70-90 g/l (C1) [6, 7]. Optimal hemoglobin or hematocrit concentrations for maintaining hemostasis in patients with massive transfusion have not been established [6, 10].

3. Correction of coagulopathy [6, 7]:

а) for patients with massive blood loss, transfusion of fresh frozen plasma (FFP) in a ratio with erythrocytes and platelets 1: 1: 1 (B1) is recommended, without waiting for laboratory tests [4, 6, 10];

б) it is recommended to administer FFP to maintain the APTT level not higher than 1.5-fold increase from the normal range [38] against the background of bleeding (C1) at an initial dose of 10–15 ml / kg [7, 10];

в) in victims without severe bleeding, plasma transfusion is not recommended (B1) [10];

г) special importance in trauma to the chest and abdomen should be given to blood reinfusion [5]. I.M. Samokhvalov et al. (2016) [39] carried out experimental modeling of liver damage with massive blood loss and hypothermia, followed by LT and blood reinfusion. It has been proven that blood reinfusion restores the coagulation potential and oxygen transport function of the blood, and the earlier it is performed from the moment of the first operation, the higher the effect. The use of DC tactics using the blood reinfusion method can reduce the operational risk before the final surgery. The use of hardware autohemotransfusion allows to reduce the time of removing victims from shock and the volume of donor blood by 2.5 and 6.5 times, respectively, and also to reduce mortality from blood loss [4, 6, 37];

д) it is recommended to use cryoprecipitate at a fibrinogen level of less than 1.5–2.0 g/l (C1) [6, 7]. The starting dose is 50 mg / kg (15–20 doses of the drug). In this situation, the administration of fibrinogen is also indicated (initial dose 3–4 g (C1)) [6, 7];

е) platelet transfusion is recommended to maintain their level above 50x109 / L, with the likelihood of continuing bleeding associated with thrombocytopenia (C1), with platelet dysfunction (C2) [6, 7], while taking antiplatelet drugs (C2) [6, 7, 38]. In patients with ongoing bleeding and concomitant TBI, it is recommended to maintain their level above 100x109 / L (C2) [6, 7]. Starting dosage – 4-8 units or one package obtained by the apheresis method (C2);

g) it is necessary to maintain the level of ionized calcium within the normal range (not less than 0.9 mmol / l) during blood transfusion (C1) [6, 7];

з) concentrate of the prothrombin complex (octaplex, prothromplex 600; 25-50 U / kg) is indicated for the previous administration of vitamin K-dependent oral anticoagulants (A1), rivaroxaban, apixaban, edoxaban, dabigatran ethixylate (C2) together with tranexamic acid at a dose of 15 mg kg intravenously (iv) [6, 7, 10];

и) in intensive care of traumatic bleeding, while maintaining coagulopathy, despite the use of the above means, the use of recombinant activated coagulation factor VII (rFVIIa) "NovoSeven" (C2) [6, 7] is shown, which reduces the volume of blood transfusions in patients with closed abdominal trauma (CAT).

4. Elimination of acidosis: there are currently no clear recommendations on the use of medications. Sodium bicarbonate is contraindicated in acute respiratory failure (ARF). Tris (hydroxyethyl) aminomethane is not well understood, it is not administered for oliguria. Avoid hypoventilation and large infusions of 0.9% sodium chloride solution [6, 7, 10];

5. Long-term respiratory support:

a) it is recommended to avoid hypoxemia (A1) [6, 7];

b) indications for prolonged artificial lung ventilation (ALV):

- reoperations to stop bleeding, DC tactics [10];
- pre- and intraoperative hypotension requiring inotropic support [10];
- blood loss over 1500 ml, clinical picture of hemorrhagic shock [2, 7];
- delayed recovery of spontaneous breathing;
- multiple fractures of the ribs and sternum (damage to the chest frame) [10];
- unreliable surgical hemostasis in case of tissue crush, extensive retroperitoneal hematoma [10].

c) in traumatized patients with massive blood loss, normoventilation is recommended (PaO2 no more than 200 mm Hg; PaCO2 35–40 mm Hg) (B1) [6, 7, 38]. According to E. Damiani et al. (2014) (cited from [38]), hyperventilation during mechanical ventilation leads to an increase in mortality in patients with polytrauma. Arterial blood gases monitoring required;

г) due to the risk of developing acute respiratory distress syndrome, early use of a small inspiratory volume (6–7 ml / kg body weight) with a moderate maximum permissible expiratory concentration (up to 5 mbar) is recommended, especially in patients with bleeding [7];

e) indications for tracheostomy [2]:

- the need for mechanical ventilation with an estimated period of at least 10 days;
- discharge of a large amount of thick sputum, difficulty in sanitation through the endotracheal tube;
- severe trauma to the lungs and chest, especially bilateral [10];
- lack of adequate spontaneous breathing and a tendency to improve respiratory function 3-4 days after the start of mechanical ventilation with an endotracheal tube [10];
- combined chest injury, TBI [4].

6. Preventive antibiotic therapy (A1) [31, 35] – IV generation cephalosporins (cefepime 2 g 2–3 doses/day) or "protected" cephalosporins (ceftazidime IV 2 g 3 doses day; sulperazon IV 1 + 1 g 3 doses/day), fluoroquinolones of the III–IV generation (moxifloxacin 250 ml i.v. 1 dose/day; levofloxacin i/v 0.5 g 1–2 doses/day or 1 g 1 r / day) in combination with metronidazole [33], carbapenems (thienam–imipenem + cilastatin 0.5–1 g IV every 6–8 hours, Meronem 0.5–1 g IV every 8 hours, doripenem 0.5 g IV every 8 h) in monotherapy [1, 10, 37]. With the development of purulent-septic complications – targeted therapy based on the results of cultures on microflora and determination of its sensitivity to antibiotics. With gram-positive microflora (staphylococci, enterococci), the drugs of choice are vancomycin, zyvox or cubicin; with gram-negative (Escherichia coli, Klebsiella, Proteus, Acinetobacter) – sulperazon, amikacin.

7. Prevention / treatment of ACS [10, 31, 35, 37] – nasojejunal intubation, if possible transanal decompression of the colon and hypertensive enemas, percutaneous drainage of intra-abdominal fluid accumulations, potassium preparations, prokinetics (metoclopramide, erythromycin (A1) [35]), adequate pain relief (prolonged epidural block) (B2) [11, 35], Mechanical ventilation, sedation, neuromuscular blockade with the use of muscle relaxants (B2) [35], balanced infusion therapy (A1) [35], antioxidants; improvement of microcirculation; diuretic therapy and continuous venous hemofiltration / ultrafiltration if large infusions are required (B2) [5, 35].

8. Early nutritional support in patients with laparostomy (C1) [11, 31, 37] is complete parenteral nutrition for 3–4 days, followed by switching to mixed nutrition (usually for 7–10 days). EN should be started as early as possible during the functioning of the gastrointestinal tract – GI tract (C1) [11], it should be delayed in case of highly productive proximal intestinal-cutaneous fistula and the impossibility of installing the feeding probe distal, in the presence of acute intestinal insufficiency (C2) [11].

EN increases the rate of wound healing and closure of fascia, reduces catabolism, the frequency of pneumonia and fistulas, length of hospital stay and costs [11]. Compared to long-term total parenteral nutrition, early EN reduces septic complications, especially in case of CAT and TBI [10];

9. Warming the victims [10, 38]. More than half of patients with intra-abdominal bleeding suffer from hypothermia. A decrease in the patient's body temperature (when measured in the esophagus) to 34° C is accompanied by 4 times more mortality than at a temperature of 35° C [6, 7]. A decrease of 1° C leads to a 10% decrease in the function of coagulation factors. Rapid patient rewarming action is required (C1) [1, 10]:

a) passive external warming (removing cold damp clothes, covering with blankets, increasing the ambient temperature to 29-30 ° C);

b) active external warming (warm air flow, warming blankets, heated mattresses, heating pads);

в) active warming of the internal environment of the body (heating up to 39 ° C of crystalloid solutions, humidification and warming of supplied oxygen, use of warm gastric / thoracic / pleural lavage, devices for artificial warming of patients, extracorporeal methods of recirculation – veno-venous and arteriovenous shunts) [10].

10. In the absence of response to infusion therapy, inotropic drugs (dopamine, adrenaline) (C1) are used to maintain the target blood pressure [7]. Inotropic drugs are recommended for myocardial dysfunction (C2) [1, 6, 7].

11. The introduction of hemostatic drugs – tranexamic acid in case of traumatic bleeding or at risk of its occurrence in a loading dose of 1 g in 10 minutes in the first hour from the moment of injury (which reduces the risk of death due to bleeding by 2.5%), followed by IV infusion of 1 g over 8 hours (A1) [1, 6, 7, 10].

12. Prevention of stress bleeding from the upper gastrointestinal tract (A1) - the introduction of proton pump blockers (A1) [10, 35]. The risk is highest in patients with chronic alcoholism, with TBI and burns of more than 30% of the body surface, and these conditions are often accompanied by CAT. The absolute indications for prevention are mechanical ventilation, hypoxia (ARI increases the risk of gastrointestinal bleeding (GIB) by 15.6 times), hypotension (increases the risk of GIB by 3.7 times), coagulopathy (increases the risk of GI by 4, 3 times), sepsis (increases the risk of GIB by 2 times) [10];

13. After stopping bleeding, mechanical prevention of thrombus formation by intermittent pneumatic compression (C1) should be used [6, 10]. Pharmacological prevention of thrombus formation should be started within 24 hours after reaching the final hemostasis (B1) [6, 7, 10] optimally low molecular weight fractionated heparins (A1) [35].

In the course of intensive therapy, the main parameters are monitored (heart rate (HR), blood pressure - in the event of hypotension after initial stabilization, when there is a need for blood transfusion of 2 or more doses of erythrocyte mass per hour, indications for relaparotomy are given), body temperature, measurement is mandatory intra-abdominal pressure (B1) [31, 37] by assessing the pressure in the UB (in the absence of damage) every 2-4-6 hours, depending on the severity of the condition (with an increase of more than 20 mm Hg, relaparotomy is indicated [5]), the number of erythrocytes, hemoglobin (the initial normal hemoglobin values can conceal bleeding (B1) [6, 7]), urine output, respiratory and coagulogram parameters (APTT, INR, fibrinogen and platelet count (A1) [6, 7]), blood biochemical parameters). Pulmonary artery catheterization (Swan-Ganz oximetric catheter) is performed to obtain continuous information on oxygen delivery and consumption [38]. Also determine lactate and base deficiency (B1) [6, 7], wich are independent predictors of survival [7, 38]. Patients whose lactate level returns to a range of less than 2 mmol / L within 24 hours is likely to survive; after 48 hours – 77%, more than 48 hours — 13% [6, 7, 10].

In order to diagnose early aspiration of gastric contents into the airways, traumatic injury to the tracheobronchial tree and ensure adequate patency of the bronchi, it is necessary to use fibrobronchoscopy from the first day of mechanical ventilation. It is necessary to re-identify injuries. Angiography is performed to determine the source of previously unknown or secondary bleeding (due to the occurrence of false arterial aneurysms, arteriovenous fistulas, hemobilia, hematuria) and possible embolization (A2) [12, 23, 25, 26] or stenting [4, 5]. K. Matsushima et al. (2020) [25] in the analysis of 1675 patients showed that the use of hepatic angioembolization after laparotomy with stopping bleeding is accompanied by a lower mortality. E.R. Faulconer et al. (2018) [20] conducted a review of the data of the American Association for the Surgery of Trauma, which included 1143 patients with arterial injuries (without complete intersection) of different localization, and concluded that endovascular hemostasis options, compared with open techniques, reduce the need for blood transfusion , are accompanied by less mortality, despite a longer hospital stay. There are publications on endoprosthetics of the retrohepatic IVC and iliac veins, aorta, portal vein, renal vessels with stent grafts [14, 20, 21] (A1) in trauma.

The duration of the second phase of DC tactics is 24–96 hours [5, 10]. The criteria for stabilizing the state of the injured are: BPsist at least 100 mm Hg, heart rate no more than 100 per 1 min, shock index less than 1, lack of inotropic support, restoration of urine output more than 1 ml / kg / h; body temperature more than 35 ° C, hemoglobin not less than 100 g / l, hematocrit not less than 30%, blood serum lactate less than 2.5 mmol / l; BE more than -4 mmol / L [5, 10, 39]. Third stage – repeated planned surgical intervention [1, 4] with a thorough revision of all injuries to exclude the omission of undetected injuries [3, 5]. The scope of interventions can also be limited, as most patients are in a state of subcompensation [3].

Priority surgical interventions are:

1. Final restoration of large vessels (removal of tampons, staplers, ligatures, temporary shunts; application of a circular vascular suture or vessel prosthetics) [5, 8, 18]. At this stage, CE may be required after ligation during the first operation of the right hepatic artery or celiac trunk [4].

2. Re-revision of tamponade areas with replacement of tampons with hemostatic drugs (hemostatic sponges or films) or with reconstructive operations on parenchymal organs [4].

I. Liver injury. In case of crushing of the liver, its fragmentation, damage to the lobar and segmental vessels with a high probability of necrosis of the liver tissue, an atypical resection is performed [1, 2, 5, 9, 15, 22]. In case of recurrence of bleeding and the impossibility of visualizing its source, repeated tamponade is indicated [23].

Until recently, liver transplantation in trauma was considered casuistry [22], but M.A. Ribeiro Jr. et al. (2015) [40] analyzed the results of this operation in 46 patients in who, due to the severity of organ damage, other hemostasis options could not be performed, the survival rate was 76%. Main indications: necrosis of liver tissue after packaging or resection with an increase in acute liver failure [40].

II. Spleen injury. In case of resumption of bleeding after removal of tampons and removal of the clamp from the vascular pedicle, as well as in case of necrosis of the spleen tissue, SE is indicated [1, 4, 26, 27].

III. Pancreas trauma. Resection methods of treatment are used with the participation of a specialized team of surgeons [1]. Further treatment of patients with pancreatic injury is carried out according to the treatment regimen for pancreatic necrosis [28] using the entire arsenal of minimally invasive techniques (endoscopic retrograde cholangiopancreatography, pancreatic duct stenting, puncture-drainage and transluminal methods of treatment) [1, 4].

IV. Kidney injury. In case of resumption of bleeding after removal of tampons, ligation of renal vessels at the first stage and / or their embolization, as well as with renal necrosis, nephrectomy is indicated [1, 2, 12]. In case of trauma to the renal pole, revealing devitalized tissue, it is possible to perform resection with nephropyelo- or pyelostomy [4, 13].

3. Reconstructive interventions on hollow organs.

I. Stomach trauma. After atypical resection – the imposition of gastroenteroanastomosis [1, 4].

II. Injury of the duodenum (DU)). With pronounced narrowing of the intestine after suturing the wound at the first stage, the threat of inconsistency of the sutures, temporary diverticulization of the DU is shown: anterior gastrotomy in the antrum, suturing of the mucous membrane in the pylorus with an absorbable thread, gastrojejunostomy on a long loop and Brown's fistula are performed [2, 28, 30, 31]. After the antrum resection, the Roux-en-Y anastomosis is applied. With pancreatoduodenal injury, PDR is performed (C2) (in case of devascularization or massive damage to the pancreatoduodenal zone, involvement of the ampulla, proximal part of the pancreatic duct or distal part of the common bile duct) [1, 4, 28, 30] or diverticulization of the duodenum and drainage of surgical zones. With extensive damage to the intestine distal to the large duodenal papilla, an anastomosis is made between the proximal part of the duodenum (above the defect) and the loop of the small intestine disconnected by Roux, the distal part of the duodenum is muffled [2, 30].

III. Травма общего желчного и печеночного протоков. Перевод концевой гепатикостомы в билиодигестивный анастомоз с отключенной по Ру петлей тонкой кишки на погружном дренаже [2, 28, 32].

IV. Small bowel injury. If there is a significant narrowing of the bowel lumen after its suturing at the first stage, as well as in the case of necrosis after ligation of the mesenteric vessels, resection is performed [4, 31]. After bowel resection using delayed anastomosis tactics – anastomosis with a stapling device or with the help of SRCSMSS [1]. There is no difference in inconsistency between manual and hardware anastomosis [1, 5, 31]. After resection of the ileum, if the terminal (outlet) section does not exceed 10 cm in length, ileotransverse anastomosis end to side is performed [1].

V. Colon and rectal trauma. After suturing the antimesenteric edge of the intraperitoneally located sections of the colon, if there is doubt about the reliability of suturing, it is possible to perform extraperitonization of the intestinal area with the sutured defect [1, 31].

After resection, the viability of the resected areas is reassessed and an intestinal anastomosis or colostomy is formed (C1) [2, 5, 31, 33]. Delayed anastomosis does not increase colostomy frequency, complications, and mortality [31, 33, 34]. Colostomy is preferable in severe peritonitis with the formation of intra-abdominal abscesses, severe intestinal wall edema, metabolic acidosis [1, 2, 5].

In case of damage to the rectum after suturing, at the first stage, a double-barreled sigmostoma according to Maidl is formed [4, 31]. With multiple intraperitoneal ruptures of the rectum and rectosigmoid section, ruptures of more than 1/2 of the intestinal circumference, crushing of the intestine with areas of necrosis and complete detachment of the intestine, the site is resected and the adductive end is removed in the form of an unnatural anus [1]. The outlet end is plugged (like the Hartmann operation) [4, 31]. In the cases of extraperitoneal ruptures, along with a double-barreled sigmostomy, drainage of pararectal tissue is performed, the defect of the intestinal wall is sutured from the lumen side with single-row interrupted sutures through all layers [1, 31].

VI. Trauma to the ureters, UB, urethra. In case of injury of the UB gr. V after bilateral retrograde ureteral stenting, an attempt is made to suture the cervix of the UB with the urethra on a urinary catheter with drainage of paravesical tissue [13].

In case of extensive damage to the ureter after uretero- or nephrostomy, transureteroureteroanastomosis (w / 3 and s / 3) / ureteroneocystoanastomosis (n / 3) / Boari plasty (n / 3) / ileal intestinal graft interposition (extended defect) are carried out [2, 12].

In case of urethral injury – in delayed period, endoscopic recanalization, urethroplasty are performed [12, 13].

4. Sanitation and drainage of cavities and cellular spaces (abdominal cavity, paravesical and pararectal spaces) [1, 4].

At the third stage of DC tactics, not only reconstructive operations, but also programmed sanitation relaparotomies can be performed [1, 35].

With prolonged (more than 5 days) open abdominal guidance, contraction of the aponeurosis occurs. In this case, it is possible to close the abdominal cavity with skin flaps with the formation of a ventral hernia. [35, 36]. The final reconstruction of the abdominal wall may be delayed for several months. Early (after 4–7 days) complete closure of the laparotomic wound after laparostomy has advantages over delayed surgery (C1) [2, 5, 11, 31, 36].

CONCLUSION

A clear knowledge of the required volume of surgical intervention at each stage of treatment of patients with severe concomitant closed abdominal trauma, the main points of intensive care, the criteria for patient stabilization and indications for relaparotomy improves the results of treatment of this category of victims. The use of DC tactics in decompensated patients requires minimization of surgical aggression at the first stage, the earliest possible stabilization of vital body functions and reconstructive surgery with the possibility of re-assessing the nature of the damage to select the optimal tactics at the third stage; so the possible lack of experience of doctors providing the aid at the first stage is leveled.

REFERENCES

1. Zatevakhin II, Kiriyenko AI, Sazhin AV (eds.). *Neotlozhnaya abdominal'naya khirurgiya*. Moscow: OOO "Meditsinskoye informatsionnoye agentstvo"; 2018. (In Russ.).
2. Bouillon B, Pieper D, Flohé S, Eikermann M, Prengel P, Ruchholtz S et al. Level 3 guideline on the treatment of patients with severe/multiple injuries. *Eur J Trauma Emerg Surg.* 2018;44:3–271. PMID: 29654333. PMCID: PMC7095955. https://doi.org/10.1007/s00068-018-0922-y
3. Goncharov AV, Samokhvalov IM, Suvorov VV, Markevich VYu, Pichugin AA, Petrov AN. Problems of staged treatment of patients with severe concominant injuries in a regional trauma system. *Polytrauma*. 2017;4:6–15. (In Russ.).
4. Duchesne J, Inaba K, Ali Khan M. *Damage Control in Trauma Care. An Evolving Comprehensive Team Approach.* Switzerland: Springer International Publishing; 2018. https://doi.org/10.1007/978-3-319-72607-6
5. Pape HC, Peitzman AB, Rotondo MF, Giannoudis PV. *Damage Control Management in the Polytrauma Patient. Second Edition*. Switzerland: Springer International Publishing; 2017. https://doi.org/10.1007/978-3-319-52429-0
6. Spahn D, Bouillon B, Cerny V, Duranteau J, Filipescu D, Hunt B et al. The European guideline on management of major bleeding and coagulopathy following trauma: fifth edition. *Crit Care*. 2019;23(1):98. https://doi.org/10.1186/s13054-019-2347-3
7. Bobovnik SV, Bulanov AYu, Grigor'yev EV, Zabolotskikh IB, Lebedinskiy KM, Sin'kov SV. et al. Protokol reanimatsii i intensivnoy terapii pri ostroy massivnoy krovopotere. Klinicheskie rekomendatsii. *Obshcherossiyskaya obshchestvennaya organizatsiya "Federatsiya anesteziologov i reanimatologov"*, 2018. (In Russ.) Available at: https://congress-med.ru/assets/files/2018/2018-rossijskie-rekomendaczii-po-neotlozhnoj-pomoshhi-pri-ostroj-krovopotere.pdf [Accessed 06 Nov 2020]
8. Pereira BMT, Chiara O, Ramponi F, Weber DG, Cimbanassi S, Simone BD, et al. WSES position paper on vascular emergency surgery. *World J Emerg Surg*. 2015;10:49. PMID: 26500690. PMCID: PMC4618918. https://doi.org/10.1186/s13017-015-0037-2
9. Coccolini F, Coimbra R, Ordonez C, Kluger Y, Vega F, Moore EE et al. Liver trauma: WSES 2020 guidelines. *World J Emerg Surg*. 2020;15:24. PMID: 32228707. PMCID: PMC7106618. https://doi.org/10.1186/s13017-020-00302-7
10. Spinella PC. *Damage Control Resuscitation. Identification and Treatment of Life-Threatening Hemorrhage*. Switzerland: Springer International Publishing; 2020. https://doi.org/10.1007/978-3-030-20820-2
11. Coccolini F, Roberts D, Ansaloni L, Ivatury R, Gamberini E, Klugeret Y, et al. The open abdomen in trauma and non-trauma patients: WSES guidelines. *World J Emerg Surg*. 2018;13:7. PMID: 29434652. PMCID: PMC5797335. https://doi.org/10.1186/s13017-018-0167-4
12. Kitrey ND, Djakovic N, Gonsalves M, Kuehhas FE, Lumen N, Serafetinidis E, et al. EAU Guidelines on Urological Trauma. *European Association of Urology*, 2016. (In Russ.). Available at: https://uroweb.org/wp-content/uploads/EAU-Guidelines-Trauma-2014-Russian-%D0%A0%D0%B5%D0%BA%D0%BE%D0%BC%D0%B5%D0%BD%D0%B4%D0%B0%D1%86%D0%B8%D0%B8-%D0%95%D0%90%D0%A3-%D0%BF%D0%BE-%D1%82%D1%80%D0%B0%D0%B2%D0%BC%D0%B5-%D0%B2-%D1%83%D1%80%D0%BE%D0%BB%D0%BE%D0%B3%D0%B8%D0%B8.pdf [Accessed 06 Nov 2020]
13. Coccolini F, Moore EE, Kluger Y, Biffl W, Leppaniemi A, Matsumura Y, et al. Kidney and uro-trauma: WSES-AAST guidelines. *World J Emerg Surg*. 2019;14:54. PMID: 31827593. PMCID: PMC6886230. https://doi.org/10.1186/s13017-019-0274-x
14. Reva VA, Samokhvalov IM. Endovascular Surgery in the War. *Angiology and Vascular Surgery*. 2015;21(2):166–175. (In Russ.).
15. Sigua BV, Zemlyanoy VP, Dyukov AK. Closed Abdominal Injury With Liver Damage. *Grekov's Bulletin of Surgery*. 2015;174(1): 9–15. (In Russ.). https://doi.org/10.24884/0042-4625-2015-174-1-9-15
16. Gamberini E, Coccolini F, Tamagnini B, Martino C, Albarello V, Benni M, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta in trauma: a Systematic Review of the Literature. *World J Emerg Surg*. 2017;12:42. PMID: 28855960. PMCID: PMC5575940. https://doi.org/10.1186/s13017-017-0153-2
17. Wikström MB, Krantz J, Hörer TM, Nilsson KF. Resuscitative Endovascular Balloon Occlusion of the Inferior Vena Cava Is Made Hemodynamically Possible by Concomitant Endovascular Balloon Occlusion of the Aorta-A Porcine Study. *Journal of Trauma and Acute Care Surgery*. 2020;88(1):160–168. PMID: 31397743. https://doi.org/10.1097/TA.0000000000002467
18. Feliciano DV, Moore EE, Biffl WL. Western Trauma Association Critical Decisions in Trauma. Management of Abdominal Vascular Trauma. *Journal of Trauma and Acute Care Surgery*. 2015;79(6):1079–1088. PMID: 26680144. https://doi.org/10.1097/TA.0000000000000869
19. Hazelton JP, Choron RL, Dodson GM, Gerritsen JA, Khan S, VanOrdenet KE, et al. Comparison of Atriocaval Shunting With Perihepatic Packing Versus Perihepatic Packing Alone for Retrohepatic Vena Cava Injuries in a Swine Model. *Injury*. 2015;46(9):1759–1764. PMID: 25900557. https://doi.org/10.1016/j.injury.2015.04.014
20. Faulconer ER, Branco BC, Loja MN, Grayson K, Sampson J, Fabian TC, et al. Use of Open and Endovascular Surgical Techniques to Manage Vascular Injuries in the Trauma Setting. *Journal of Trauma and Acute Care Surgery*. 2018;84:411–417. PMID: 29462113. https://doi.org/10.1097/TA.0000000000001776
21. Chun Y, Cho SK, Clark WC, Wagner WR, Gu X, Tevar AD, et al. A Retrievable Rescue Stent Graft and Radiofrequency Positioning for Rapid Control of Noncompressible Hemorrhage. *Journal of Trauma and Acute Care Surgery*. 2017;83(2):249–255. PMID: 28452874. https://doi.org/10.1097/TA.0000000000001534
22. Smolyar AN. Closed Abdominal Trauma. Liver Injuries. Part 1. *Pirogov Russian Journal of Surgery*. 2015;12:5–13. (In Russ.). https://doi.org/10.17116/hirurgia2015125-13
23. Shapkin YuG, Chalyk YuV, Stekol'nikov NYu, Kuzyayev TR. Packing in Surgical Treatment of Severe Liver Damage. *Polytrauma*. 2020;1:18–22. (In Russ.). https://doi.org/10.24411/1819-1495-2020-10003
24. Segura-Sampedro JJ, Pineño-Flores C, Craus-Miguel A, Morales-Soriano R, González-Argente FX. New Hemostatic Device for Grade IV-V Liver Injury in Porcine Model: a Proof of Concept. *World J Emerg Surg*. 2019;14:58. PMID: 31889989. PMCID: PMC6916102. https://doi.org/10.1186/s13017-019-0277-7
25. Matsushima K, Hogen R, Piccinini A, Biswas S, Khor D, Delapena S, et al. Adjunctive Use of Hepatic Angioembolization Following Hemorrhage Control Laparotomy. *Journal of Trauma and Acute Care Surgery*. 2020;88(5):636–643. https://doi.org/10.1097/TA.0000000000002591
26. Coccolini F, Montori G, Catena F, Kluger Y, Biffl W, Moore EE, et al. Splenic Trauma: WSES Classification and Guidelines for Adult and Pediatric Patients. *World J Emerg Surg*. 2017;12:40. PMID: 28828034. PMCID: PMC5562999. https://doi.org/10.1186/s13017-017-0151-4
27. Maslyakov VV, Barsukov VG, Uryadov SE, Gorbelik VR, CHumanov AYu, Kulikov SA. Role of the Damage Control Tactics in Patients with Abdominal Injuries Associated with Damage to the Spleen. *Vestnik Meditsinskogo Instituta "Reaviz": Reabilitatsiya, Vrach i Zdorov''e*. 2019;5:116–124. (In Russ.).
28. Coccolini F, Kobayashi L, Kluger Y, Moore EE, Ansaloni L, Bifflet W, et al. Duode-No-Pancreatic and Extrahepatic Biliary Tree Trauma: WSES-AAST Guidelines. *World J Emerg Surg*. 2019;14:56. PMID: 31867050. PMCID: PMC6907251. https://doi.org/10.1186/s13017-019-0278-6
29. Ho VP, Patel NJ, Bokhari F, Madbak FG, Hambley JE, Yon JR, et al. Management of Adult Pancreatic Injuries. A Practice Management Guideline from the Eastern Association for the Surgery of Trauma. *Journal of Trauma and Acute Care Surgery*. 2017;82(1):185–199. https://doi.org/10.1097/TA.0000000000001300
30. Ferrada P, Wolfe L, Duchesne J, Fraga GP, Benjamin E, Alvarez A, et al. Management of Duodenal Trauma. *Journal of Trauma and Acute Care Surgery*. 2019;86(3):392–396. https://doi.org/ 10.1097/TA.0000000000002157
31. Sartelli M, Chichom-Mefire A, Labricciosa FM, Hardcastle T, Abu-Zidan FM, Adesunkanmi AK, et al. The Management of Intra-Abdominal Infections from a Global Perspective: 2017 WSES Guidelines for Management of Intra-Abdominal Infections [Published Correction Appears in World J Emerg Surg. 2017 Aug 2;12:36]. *World J Emerg Surg.* 2017;12:29. PMID: 28702076. PMCID: PMC5504840. https://doi.org/10.1186/s13017-017-0141-6
32. Pereira R, Vo T, Slater K. Extrahepatic bile duct injury in blunt trauma. *Journal of Trauma and Acute Care Surgery*. 2019;86(5):896–901. https://doi.org/10.1097/TA.0000000000002186
33. Tatebe LC, Jennings A, Tatebe K, Handy A, Prajapati P, Smith M, et al. Traumatic Colon Injury in Damage Control Laparotomy — a Multicenter Trial. Is It Safe to Do a Delayed Anastomosis? *Journal of Trauma and Acute Care Surgery*. 2017;82(4):742–749. https://doi.org/10.1097/TA.0000000000001349
34. Cullinane DC, Jawa RS, Como JJ, Moore AE, Morris DS, Cheriyan J, et al. Manage-Ment of Penetrating Intraperitoneal Colon Injuries. A Meta-Analysis and Practice Management Guideline from the Eastern Association for the Surgery of Trauma. *Journal of Trauma and Acute Care Surgery*. 2019;86(3):505–515. https://doi.org/10.1097/TA.0000000000002146
35. Grigor'ev EG, Krivtsov GA, Plotkin LL, Pribytkova OV, Sovtsov SA. Acute peritonitis. Clinical recommendations. *Russian Society of Surgeons.* Moscow, 2017. (In Russ.). Available at: http://xn----9sbdbejx7bdduahou3a5d.xn--p1ai/upload/nkr_peritonit_ispr_1-3.pdf [Accessed 06 Nov 2020]
36. Wang Y, Alnumay A, Paradis T, Beckett A, Fata P, Khwaja K, et al. Management of Open Abdomen After Trauma Laparotomy: A Comparative Analysis of Dynamic Fascial Traction and Negative Pressure Wound Therapy Systems. *World J Surg.* 2019;43:3044–3050. https://doi.org/10.1007/s00268-019-05166-w
37. Smith JW, Matheson PJ, Franklin GA, Harbrecht BG, Richardson JD, Garrison RN. Randomized Controlled Trial Evaluating the Efficacy of Peritoneal Resuscitation in the Management of Trauma Patients Undergoing Damage Control Surgery. *J Am Coll Surg*. 2017;224(4):396–404. PMID: 28137537. https://doi.org/10.1016/j.jamcollsurg.2016.12.047
38. Dats AV, Dats LS, Khmelnitskiy IV. The Structure of Defects of Medical Assistance in Polytrauma. *Polytrauma*. 2017;3:23–29. (In Russ.).
39. Samokhvalov IM, Nosov AM, Karev EA, Seleznev AB, Vasilev MA, Zhirnova NA. Experimental Observation of Effectiveness Blood Reinfusion on Application of Damage Control Tactics. *Emergency Medical Care*. 2016;17(3):56–60. (In Russ.) https://doi.org/10.24884/2072-6716-2016-17-3-56-60

40. Ribeiro MA Jr, Medrado MB, Rosa OM, Silva AJ, Fontana MP, Cruvinel-Neto J, et al. Liver transplantation after severe hepatic trauma: current indications and results. *Arq Bras Cir Dig*. 2015;28(4):286–289. PMID: 26734803. PMCID: PMC4755185. https://doi.org/10.1590/S0102-6720201500040017

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