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APPLICATION OF MODIFIED PACKING IN THE COMBINATION TREATMENT OF EXTENSIVE TRAUMATIC LIVER INJURIES

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Introduction. Traumatic liver injuries are a significant challenge in modern emergency surgery. Developing new methods for surgical hemostasis of traumatic liver injuries is an extremely relevant task in urgent surgery.
Objective. Development and testing of surgical hemostasis for traumatic liver injuries using a modified packing technique.
Materials and methods. A new method of surgical hemostasis for traumatic liver injuries was developed using cadaveric material. The clinical trial included 27 patients with severe traumatic liver injuries (AAST Grade IV). Patients were divided into the main (n = 14) and control (n = 13) groups. Patients in the main group were treated using a new method of surgical hemostasis for traumatic liver injuries, involving tamponade of the liver wounds with Surgitamp hemostatic gauze impregnated with Molselect G-50 granular sorbent, followed by modified liver packing with strips of polypropylene mesh implant. In the control group, surgical hemostasis was performed by tamponading the liver wound with hemostatic sponges followed by suturing. The effectiveness of the proposed method was evaluated based on the following parameters: definitive hemostasis, number of recurrent hemorrhages, number of recurrent operations, mortality, hospital stay duration, intensive care unit stay duration. Statistical analysis of the study results was performed using the Statistica 10 software.
Results. The application of modified packing in the combination treatment of patients with severe traumatic liver injuries increased the reliability of definitive hemostasis from 46.2% to 92.8% (p = 0.0391), reduced the number of re-bleeding episodes and re-operations from 38.4% to 7.1% (p = 0.0391), and decreased the mortality rate from 38.4% to 14.2% (p > 0.05).
Conclusions. The application of the new combined method of surgical hemostasis improved the treatment outcomes for patients with severe traumatic liver injuries by increasing the reliability of definitive hemostasis, reducing re-bleeding and re-operations, and lowering mortality.

Keywords: abdominal trauma; liver injuries; intra-abdominal bleeding; surgical hemostasis; Surgitamp; Molselect G-50; modified packing

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Compliance with the ethical principles: the study was conducted in compliance with the requirements and norms of the Helsinki Declaration. The study was approved by the Ethics Committee of the Voronezh State Medical University (Protocol No. 2 of 05.04.2022). All patients signed an informed consent for treatment, as well as for the use of anonymized medical data and photographs. The cadaveric material was provided by the Voronezh Regional Pathological Bureau. The permission for the provision of cadaveric material complied with the provisions of the current legislation.

Potential conflict of interest: the authors declare no conflict of interest.

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ПРИМЕНЕНИЕ МОДИФИЦИРОВАННОГО ПАКЕТИРОВАНИЯ В КОМПЛЕКСНОМ ЛЕЧЕНИИ ОБШИРНЫХ ТРАВМАТИЧЕСКИХ ПОВРЕЖДЕНИЙ ПЕЧЕНИ

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Введение. Травматические повреждения печени представляют собой серьезную проблему современной ургентной хирургии. Разработка новых методов хирургического гемостаза травматических повреждений печени является крайне актуальной задачей неотложной хирургии.
Цель. Разработка и апробация хирургического гемостаза при травматических повреждениях печени путем применения модифицированного пакетирования.
Материалы и методы. На кадаверном материале разработан новый метод хирургического гемостаза при травматических повреждениях печени. В клиническом исследовании приняли участие 27 пациентов с тяжелыми травматическими повреждениями печени (IV степень по AAST). Пациенты были разделены на две группы: основную (n = 14) и контрольную (n = 13). В лечении пациентов основной группы применен новый способ хирургического гемостаза травматических повреждений печени, заключающийся в тампонировании ран печени гемостатической марлей «Сургитамп», пропитанной гранулированным сорбентом «Молселект G-50», с последующим модифицированным пакетированием печени полосками полипропиленового сетчатого импланта; в контрольной группе хирургический гемостаз выполняли путем тампонирования раны печени гемостатическими губками с последующим ушиванием раны. Эффективность применения методики оценивали по следующим показателям: окончательный гемостаз, количество повторных кровотечений, количество повторных операций, летальность, длительность стационарного лечения, длительность пребывания в ОРИТ. Статистическую обработку результатов исследования проводили в программе Statistica 10.

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Результаты. Применение модифицированного пакетирования в комплексном лечении пациентов с тяжелыми травматическими повреждениями печени позволило повысить надежность окончательного гемостаза с 46,2 до 92,8% (p = 0,0391), снизить количество повторных кровотечений и операций с 38,4 до 7,1% (p = 0,0391) и уменьшить уровень летальности с 38,4 до 14,2% (p > 0,05).
Выводы. Применение нового комбинированного метода хирургического гемостаза позволило улучшить результаты лечения пациентов с тяжелыми травматическими повреждениями печени за счет повышения надежности окончательного гемостаза, уменьшения повторных кровотечений и операций, снижения летальности.

Ключевые слова: абдоминальная травма; повреждения печени; внутрибрюшное кровотечение; хирургический гемостаз; Сургитамп; Молселект G-50; модифицированное пакетирование

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Финансирование: исследование выполнено без спонсорской поддержки.

Соответствие принципам этики: исследование проведено с соблюдением требований и норм Хельсинкской декларации. Исследование одобрено этическим комитетом ФГБОУ ВО ВГМУ им. Н.Н. Бурденко (протокол № 2 от 05.04.2022). Все пациенты подписали информированное согласие на лечение, а также использование обезличенных медицинских данных и фотографий. Кадаверный материал предоставлен бюджетным учреждением здравоохранения Воронежской области «Воронежское областное патолого-анатомическое бюро». Разрешение на предоставление кадаверного материала соответствовало положениям действующего законодательства.

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INTRODUCTION

Traumatic injuries to the abdominal organs represent a serious problem in modern emergency surgery. According to statistics, abdominal trauma accounts for 1.5–36.5% of all traumatic injuries. However, the mortality rate for injuries to the abdominal organs reaches extremely high figures — approximately 60%. Furthermore, the majority of the victims are of young and working age, which underscores the significant medical and social importance of this problem [1, 2].

A distinct category of injuries in abdominal trauma comprises those to the parenchymal organs. Damage to the spleen is most frequently encountered in clinical practice. Liver injuries rank second in the structure of abdominal parenchymal organ injuries, yet they represent a considerable challenge for global surgery. Severe liver injuries are often accompanied by the development of difficult-to-control intra-abdominal hemorrhage and the onset of hepatocellular insufficiency in the postoperative period in cases of massive liver crush injury, which are the primary causes of unsatisfactory treatment outcomes for victims with liver trauma and high mortality rates (up to 50% or more) in such injuries [3–5].

Most recent studies concerning the problem of traumatic liver injuries have been focused on refining tactical approaches to the management of liver trauma, the application of endovascular hemostasis technologies, and the improvement of methods for surgical hemostasis of liver injuries [6]. Among the tactical approaches for the management of severe combined injuries, the strategy of staged surgical treatment, so called “damage control surgery,” is gaining increasing adoption. This strategy aims to shorten the initial phase of operative intervention, followed by stabilization of the patient’s condition and performance of the definitive surgical stage under more favorable circumstances. The strategy of damage control surgery currently demonstrates favorable outcomes; however, it does not address all aspects of the surgical management of severe traumatic liver injuries due to the development of early recurrent hemorrhages in patients with massive hepatic parenchymal damage [7–9].

An important modern achievement in the management of abdominal trauma, and primarily intra-abdominal hemorrhages, has been the adoption of the Non-Operative Management (NOM) strategy [10, 11]. The NOM strategy implies conducting a strict patient selection process and equipping hospitals with angiographic suites, coupled with a mandatory system for dynamic monitoring of patient condition [12]. However, most Russian hospitals providing emergency care to patients with abdominal trauma lack the appropriate facilities, which limits the applicability of the NOM strategy in the treatment of patients with liver injuries [13].

The primary current method for the management of severe traumatic liver injuries in patients with unstable hemodynamics is emergency operative intervention — midline laparotomy. Its main objective is to achieve reliable hemostasis of intra-abdominal hemorrhage [14, 15]. A multitude of methods for hemostasis of liver injuries, both temporary and definitive, have been developed and are used in clinical practice; however, none of them can be considered fully satisfactory due to the high incidence of recurrent hemorrhage in the postoperative period [16, 17]. The development of new methods for surgical hemostasis of traumatic liver injuries remains an extremely urgent task in modern emergency surgery [18].

In this study, we set out to develop and test a surgical hemostasis method for traumatic liver injuries through the application of modified perihepatic packing.

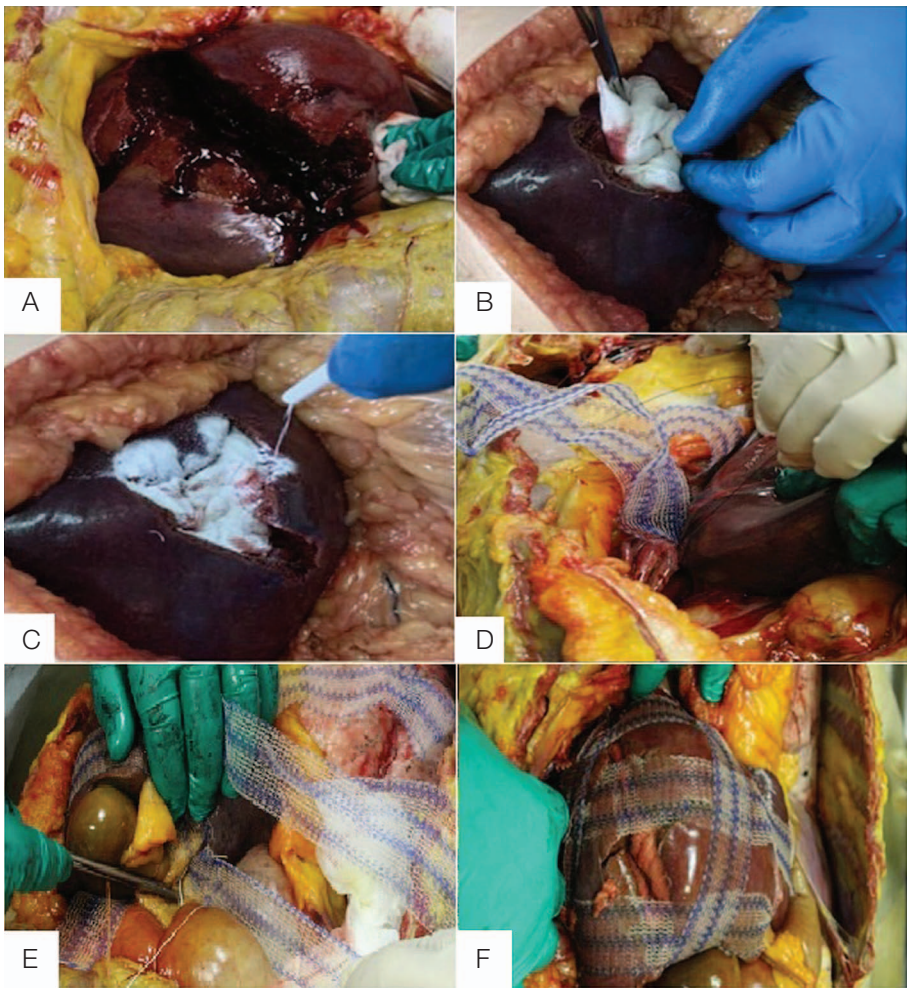
MATERIALS AND METHODS

Earlier, we conducted preliminary experimental studies to investigate the feasibility of a modified perihepatic packing technique for surgical hemostasis in laboratory animals [19].

In addition, we conducted preliminary studies on cadaveric material to develop a surgical technique for the application of modified perihepatic packing. The studies were carried out on seven unfixed male cadavers with a mean age of 34.5 ± 3.2 years, who had died from causes unrelated to traumatic injuries or diseases of the abdominal organs. The cadavers were provided by the Voronezh Regional Pathological Anatomy Bureau. The authorization for the provision of the cadaveric material complied with the provisions of the current legislation.[1] The time interval from death to the study procedure did not exceed 24 h.

In each research subject, a traumatic liver injury was simulated. To that end, following a total laparotomy, the right lobe of the liver was exteriorized into the surgical wound and placed on a supporting platform/table.

At a distance of 40 cm from the liver surface, a 250 g steel weight was suspended from a laboratory stand using a thread. Upon readiness, the thread securing the weight was burned through with a gas burner flame, causing the weight to fall vertically and impact the diaphragmatic surface of the right liver lobe, resulting in the formation of a liver wound (Fig. 1A). The simulated liver wound was tightly packed with Surgitamp



Photographs taken by the authors

Fig. 1. Stages of modified perihepatic packing on a cadaveric model: A — simulated contused wound of the right liver lobe; B — tamponade of the liver wound with Surgitamp hemostatic material; C — application of Molselect G-50 granular sorbent; D — fixation of the polypropylene mesh implant strips to the diaphragm; E — fixation of the mesh implant strips along the visceral surface of the liver; F — final appearance of the liver after modified perihepatic packing

[1] Decree of the Government of the Russian Federation No. 750 "On the Approval of the Rules for the Transfer of Unclaimed Bodies, Organs, and Tissues of a Deceased Person for Use in Medical, Scientific, and Educational Purposes, as well as the Use of Unclaimed Bodies, Organs, and Tissues of a Deceased Person for the Said Purposes" (as amended) of 21.07.2012.

hemostatic gauze (Fig. 1B), which had been impregnated with Molselect G-50 granular sorbent (Fig. 1C), after which the right liver lobe was compressed with gauze pads.

To perform the procedure of modified perihepatic packing, mobilization of the right liver lobe was carried out. To that end, the right triangular, coronary, falciform, and round ligaments of the liver were transected with scissors, after which the right liver lobe was exteriorized into the surgical wound. Subsequently, a strip (width 4.0 cm and length 30.0 cm) of a mesh polypropylene implant used for hernia repair was positioned in the sagittal plane. For this purpose, the edge of the mesh implant strip was sutured to the diaphragm with three separate interrupted sutures using polypropylene monofilament (Fig. 1D). Next, the diaphragmatic surface of the liver was wrapped, extending onto the visceral surface; the mesh implant was tensioned to provide compression, and its lower edge was fixed with interrupted sutures to the starting edge of the strip, creating compression and tension. It is important to perform the modified perihepatic packing by maintaining a distance of 1.0–1.5 cm from the edges of the gallbladder; thereafter, it was enveloped with the greater omentum (Fig. 1E).

To provide additional compression in the transverse direction relative to the right liver lobe, three additional polypropylene mesh strips were sutured in place (Fig. 1F). The strips were enveloped with the greater omentum, which was then fixed to the liver capsule with interrupted sutures to prevent the occurrence of intestinal fistulas.

The subsequent phase of the study comprised the clinical evaluation of the modified perihepatic packing technique in patients with liver injuries. A pilot randomized controlled clinical trial was conducted at Bryansk City Hospital No. 1, Voronezh Regional Clinical Hospital No. 1, Voronezh City Emergency Clinical Hospital No. 1, and Voronezh City Emergency Clinical Hospital No. 10. In total, 27 patients with traumatic liver injury were enrolled in the study. The clinical trial design is summarized in Figure 2.

The inclusion criteria for the study were blunt abdominal trauma; patient age 18–80 years; signed informed consent for participation in the clinical trial; Grade IV liver injury according to the American Association for the Surgery of Trauma (AAST) classification [19].

The exclusion criteria for the study were refusal to participate in the clinical trial; moribund state of the patient; allergic reactions to Molselect G-50, Surgitamp, or the polypropylene mesh implant.

The discontinuation criteria for the study were withdrawal of consent for continued participation in the clinical trial; injury to hollow organs, peritonitis; Grade I–III liver injury according to the AAST classification; multiple injuries to abdominal organs; macroscopic signs of liver cirrhosis; a score of > 13 points on the Military Field Surgery scale for determining surgical tactics.

According to the formulated objectives, the patients were divided into two groups: the main group (14 patients) and the control group (13 patients). Patient allocation was performed by random sampling using a random number generator. The patients were comparable in terms of sex, age, nature of traumatic liver injury, structure of associated injuries, and severity of blood loss.

In the main group, the method for surgical hemostasis of traumatic liver injuries, as described in the patent [20], was applied. In the control group, the method for surgical hemostasis of liver wounds involved tamponade of the liver wounds with hemostatic collagen sponges, followed by suturing of the liver wound with 2-0 PGA monofilament.

As part of combined management, patients in both groups received standard conservative treatment in the postoperative period, which included hemostatic and infusion therapy, blood transfusions as indicated, antibiotic therapy, analgesics, and wound dressings.

The study outcomes were assessed based on the following parameters: achievement of definitive hemostasis, number of recurrent hemorrhages and reoperations, operative time, length of stay in the intensive care unit, duration of hospital stay, mortality rate, and the incidence and nature of postoperative complications.

Statistical analysis of the study results was performed using the Statistica 10 software. Standard descriptive statistics were calculated (mean (M), standard error of the mean (m), median (M_e), lower (Q_1) and upper (Q_3) quartiles). The Shapiro–Wilk test was used to assess the normality of distribution for quantitative variables. The significance of differences for quantitative variables between independent groups was determined using Student's t-test (for normally distributed variables) and the Mann–Whitney U-test (for non-normally distributed variables). Analysis of qualitative variables was conducted using Fisher's exact test and the Z-test with Yates' correction. Differences were considered statistically significant at $p < 0.05$.

RESULTS

The general characteristics of the patients enrolled in the study are presented in Table 1.

Table 1 summarized data on the patient groups. Traumatic liver injuries were most frequently encountered in males of working age — 20 (74.1%). These injuries were significantly less common in females — 7 (25.9%) patients. The median age of patients with traumatic liver injuries was 36.0 [30.0; 43.0] years. Analyzing the mechanism of abdominal trauma, it should be noted that road traffic accidents were the predominant cause of traumatic liver injuries (12 (44.5%) patients), followed by catatrauma (fall from height) (9 (33.3%) patients) and domestic injury (6 (22.2%) patients).

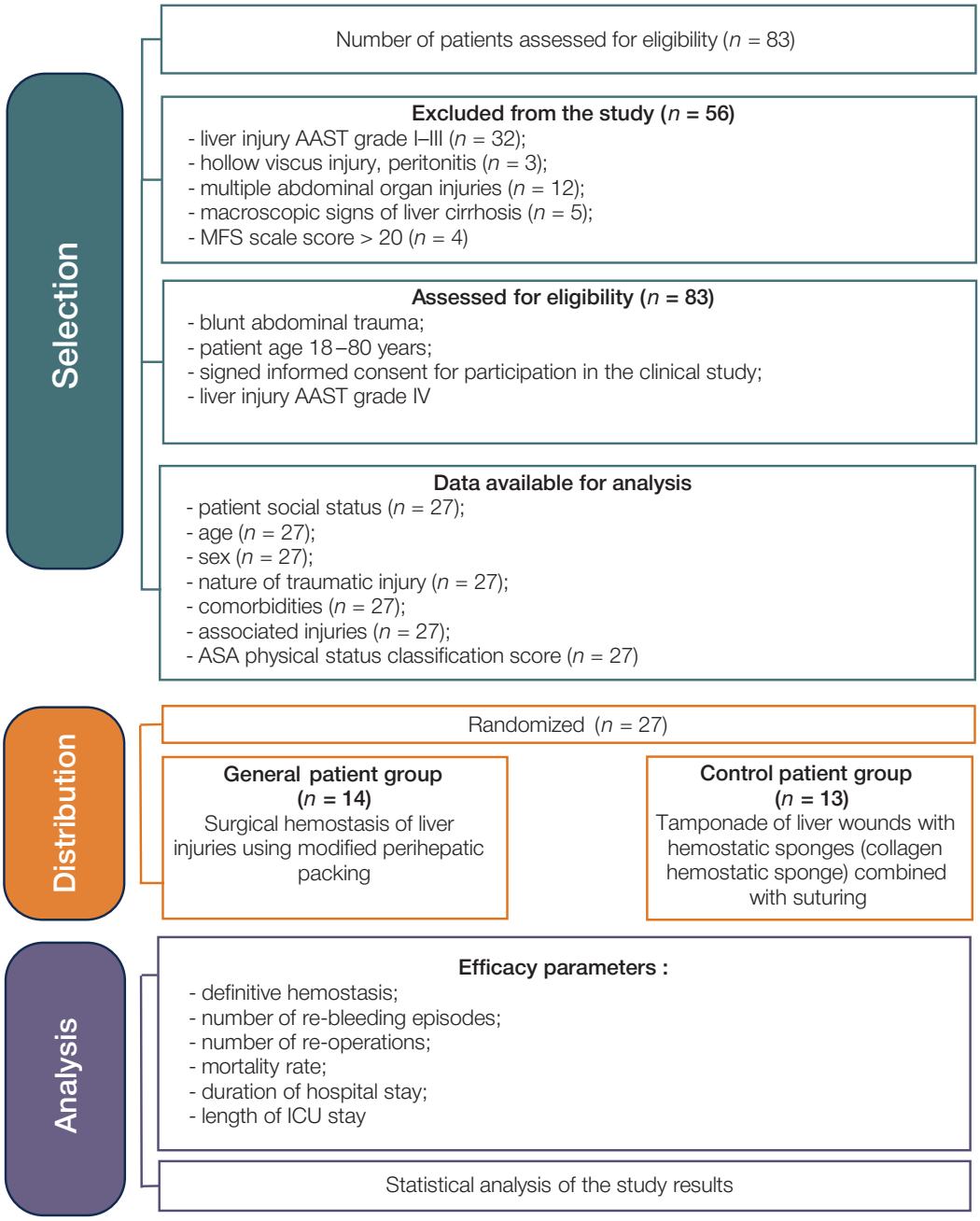


Figure prepared by the authors

Fig. 2. Clinical study design: MFS — Military Field Surgery; ICU — Intensive Care Unit; ASA — American Society of Anesthesiologists; AAST — American Association for the Surgery of Trauma

Among the associated injuries, chest injuries were the most frequent — 17 (32.5%), followed by skeletal trauma — 9 (16.7%), traumatic brain injury — 8 (29.6%), and pelvic injury — 5 (18.5%).

An analysis of comorbidities revealed that patients with abdominal trauma and liver injuries were largely somatically healthy. Comorbid conditions were identified in only 4 (14.8%) patients: coronary artery disease was present in 1 (3.7%) patient, and chronic pancreatitis was found in 3 (11.1%) patients.

As part of combined management of patients in the main group, a new method for surgical hemostasis of traumatic liver injuries was applied. This method involved tamponade of the liver wounds with Surgitamp hemostatic gauze impregnated with Molselect G-50 granular sorbent, followed by modified perihepatic packing using strips of a polypropylene mesh implant [20] (Fig. 3A–F).

We established that immediately after tamponade of the liver wound with Surgitamp hemostatic gauze impregnated with Molselect G-50 granular sorbent, which swells upon contact with blood and increases in volume, the sorbent transformed into a blood-soaked hydrogel. The Surgitamp hemostatic gauze provided compression and enhanced the hemostatic effect. Manual

Table 1. Characteristics of the study groups

Parameter	Main group (n = 14)	Control group (n = 13)	Statistical significance level, p
Currently employed, n (%)	3 (21.4%)	5 (38.5%)	$p > 0.05$
Unemployed, n (%)	8 (57.2%)	8 (61.5%)	$p > 0.05$
Retirees, n (%)	3 (21.4%)	0	id
Age, years $M_e[Q_1; Q_3]$	40 [54.0; 79.0]	36.7 [37.0; 61.0]	$p > 0.05$
Males, n (%)	10 (58.7%)	10 (78.2%)	$p > 0.05$
Females, n (%)	4 (41.3%)	3 (21.8%)	$p > 0.05$
Road traffic injury, n (%)	5 (35.7%)	7 (53.8%)	$p > 0.05$
Fall from height, n (%)	5 (21.4%)	4 (23.1%)	$p > 0.05$
Domestic injury, n (%)	4 (28.6%)	2 (15.4%)	$p > 0.05$
Coronary artery disease, n (%)	1 (83.2%)	0	id
Chronic pancreatitis, n (%)	1 (8.4%)	2 (9.0%)	$p > 0.05$
Traumatic brain injury, n (%)	4 (60.5%)	4 (50.0%)	$p > 0.05$
Chest injuries, n (%)	9 (30.9%)	8 (41.6%)	$p > 0.05$
Skeletal trauma, n (%)	5 (8.6%)	4 (8.4%)	$p > 0.05$
Pelvic bone injury, n (%)	3 (21.4%)	2 (15.3%)	$p > 0.05$
II, n (%)	5 (35.7%)	4 (30.8%)	$p > 0.05$
III, n (%)	7 (50%)	8 (61.5%)	$p > 0.05$
IV, n (%)	2 (14.3%)	1 (7.7%)	$p > 0.05$
III, n (%)	4 (28.6%)	3 (23.2%)	$p > 0.05$
IV, n (%)	6 (42.8%)	5 (38.4%)	$p > 0.05$
V, n (%)	4 (28.6%)	5 (38.4%)	$p > 0.05$

Table compiled by the authors based on original data

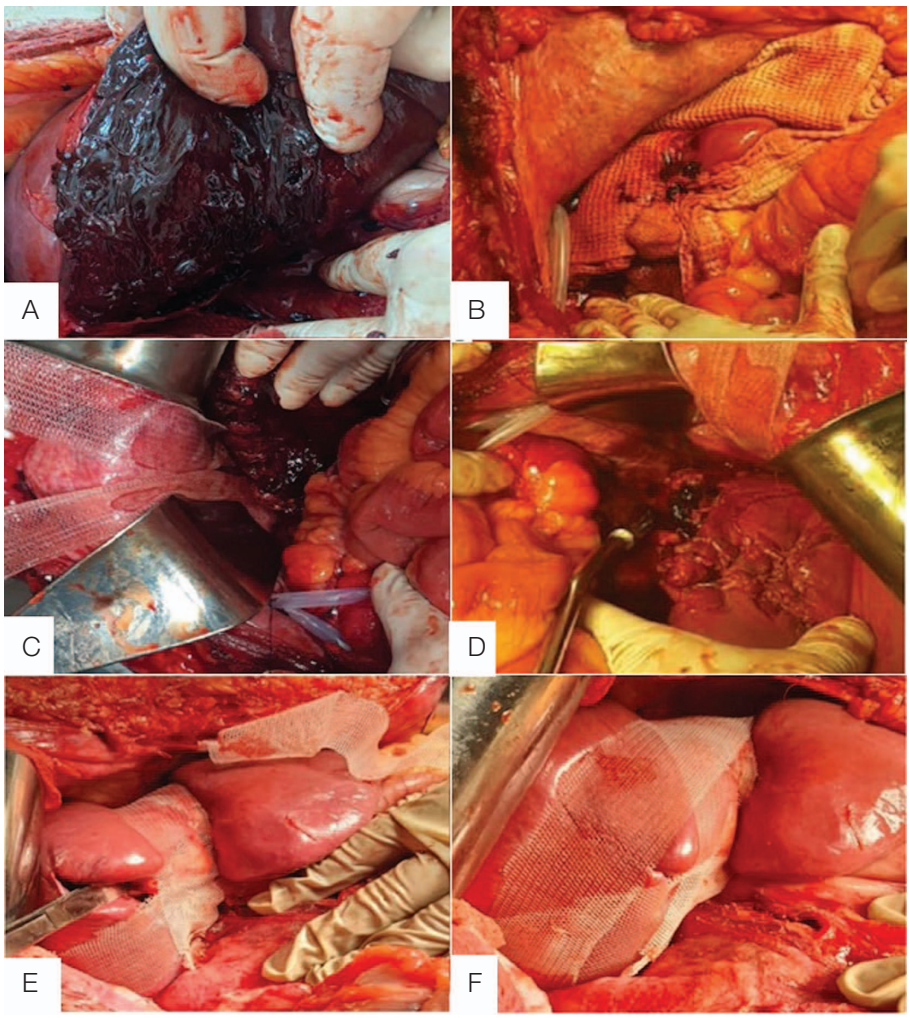
Note: id — insufficient data; n — patient number in the group.

compression of the liver achieved temporary hemostasis; however, upon release of compression, the bleeding recurred.

To achieve definitive hemostasis, the method of modified perihepatic packing with strips of polypropylene mesh implant was employed (the fixation technique is described above), which resulted in the final cessation of bleeding. Definitive hemostasis was achieved in 13 (92.8%) patients in the main group. In one (7.14%) patient from the main group, signs of recurrent hemorrhage were observed on postoperative day 2. The patient underwent emergency reoperation. During the abdominal cavity revision, the source of bleeding was identified as diffuse oozing from the liver wound due to insufficient compression from the tension of the polypropylene mesh implant strips. Additional tightening of the strips led to hemostasis and achievement of definitive control.

In the main group, two (14.3%) patients died. The cause of death was severe polytrauma. According to forensic autopsy findings, no signs of recurrent intra-abdominal hemorrhage were observed in either case.

In the control group, to achieve definitive hemostasis of the liver injuries, the wounds were packed with hemostatic collagen sponges. The sponges became saturated with blood; however, diffuse bleeding from the liver wounds persisted. To achieve definitive hemostasis, the liver wounds were sutured with U-shaped stitches (using 2-0 PGA monofilament) to approximate the wound edges. During suturing of the liver wounds, diffuse oozing from the needle puncture sites was observed, and the



Photographs taken by the authors

Fig. 3. Stages of modified perihepatic packing in a patient with liver injury: A — gross appearance of a traumatic rupture of segments V, VI, and VII of the right liver lobe (AAST Grade IV); B — tamponade of the wound with Surgitamp hemostatic material impregnated with Molselect G-50 granular sorbent, and temporary packing with a gauze towel; C — fixation of the polypropylene mesh implant strips to the diaphragm; D, E — fixation of the mesh implant strips in the transverse direction; F — final appearance of the surgical wound

liver parenchyma was lacerated by the suture material, which complicated the achievement of definitive hemostasis and prolonged the operative time. In five (38.4%) patients in the control group, signs of recurrent bleeding were observed on postoperative days 2–3. These patients underwent emergency reoperation. The source of bleeding in all cases was oozing from the liver ruptures. In the control group, five (38.4%) patients died due to acute blood loss, posthemorrhagic anemia, and associated injuries.

The comparative effectiveness of modified perihepatic packing in the management of traumatic liver injuries is presented in Table 2.

The application of modified perihepatic packing in the combination management of patients with severe traumatic liver injuries (AAST Grade IV) resulted in an increase in the reliability of definitive hemostasis from 46.2% to 92.8% (p = 0.0391), a reduction in the rate of recurrent hemorrhages and reoperations from 38.4% to 7.1% (p = 0.0391), and a decrease in mortality from 38.4% to 14.2% ($p > 0.05$).

The conducted analysis of postoperative surgical complications in the study groups showed that in the postoperative period, one patient in the main group experienced recurrent hemorrhage. The patient underwent emergency reoperation. During the abdominal cavity revision, the source of bleeding was identified as diffuse oozing from the liver wound due to insufficient compression from the tension of the polypropylene mesh implant strips. Additional tightening of the strips led to the cessation of bleeding and the achievement of definitive hemostasis.

In the control group, five patients exhibited signs of recurrent bleeding in the postoperative period. These patients underwent reoperation. Intraoperatively, laceration of the liver parenchyma by the sutures was identified;

Table 2. Comparative effectiveness of management for patients with traumatic liver injuries

Parameter	Main group (*n* = 14)	Control group (*n* = 13)	Statistical significance level, *p*
Definitive hemostasis, *n* (%)	13 (92.8%)	6 (46.2%)	$p = 0.0391$
Recurrent hemorrhages, *n* (%)	1 (7.1%)	5 (38.4%)	$p = 0.0391$
Reoperations, *n* (%)	1 (7.1%)	5 (38.4%)	$p = 0.0391$
Mortality, *n* (%)	2 (14.2%)	5 (38.4%)	$p > 0.05$
Median duration of hospital stay, bed days	10.0 [9.0; 14.0]	16.0 [10.0; 18.0]	$p > 0.05$
Median operative time, min	100.0 [85.0; 120.0]	130.0 [120.0; 150.0]	$p = 0.0022$
Median ICU length of stay, bed-days	3.0 [1.0; 4.0]	5.0 [3.0; 6.0]	$p = 0.011$
Median volume of red blood cell transfusion, mL	1140 [1100; 1200]	1230 [1150; 1900]	$p = 0.0272$
Median volume of FFP transfusion, mL	1175 [1100; 1250]	1430 [1350; 2100]	$p = 0.0001$
Postoperative complications (according to the Clavien–Dindo classification)			
III, *n* (%)	1 (7.1%)	5 (38.4%)	$p > 0.05$
IIIa, *n* (%)	–	1 (7.7%)	id
IV, *n* (%)	–	1 (7.7%)	id
V, *n* (%)	2 (14.2%)	5 (38.4%)	$p > 0.05$

Table compiled by the authors based on original data

Note: ICU — Intensive Care Unit; FFP — Fresh Frozen Plasma; id — insufficient data; *n* — patient number.

additional hemostasis was performed, comprising electrocautery, application of a Tachocomb® patch to the site of diffuse oozing, or additional suturing of the rupture sites. One patient in the control group developed complaints of right upper quadrant pain and weakness in the postoperative period; an abdominal ultrasound was performed, revealing a biloma in the abdominal cavity. The latter complication required ultrasound-guided percutaneous drainage. The outcome was complete resolution, and the patient was discharged in satisfactory condition for outpatient follow-up on day 18. One patient developed disseminated intravascular coagulation (DIC) syndrome in the postoperative period following acute massive blood loss, which required intensive care in the ICU; this complication resolved.

DISCUSSION

Injuries to the abdominal organs represent one of the most challenging and largely unresolved problems in emergency surgery [5, 9]. In the spectrum of abdominal trauma, liver injuries rank second, surpassed only by splenic injuries. However, the highest mortality rates (14–58%) in patients with blunt abdominal trauma are associated precisely with severe liver injuries, which is attributable to massive, difficult-to-control intra-abdominal hemorrhage and the development of hepatocellular insufficiency in the postoperative period [13, 18].

The most frequent cause of mortality in abdominal trauma is traumatic liver rupture complicated by massive hemorrhage. In such cases, two factors are of paramount importance: the promptness and rapidity of surgical intervention and the application of a reliable and effective method for surgical hemostasis [6].

Most surgeons in emergency settings employ wound suturing, electrocautery, and packing. A significant drawback of these methods is the development of ischemic necrotic areas between the sutures. For deep injuries, packing the wounds with omentum, various hemostatic sponges, films, or powdered hemostatic agents is used. However, as practice shows, these often prove to be ineffective. Tamponade of deep wounds with a towel, gauze pad, or any non-resorbable material necessitates reoperation [3].

In cases of extensive traumatic liver injuries, an effective method for hemorrhage control is perihepatic packing of the liver ruptures with a polypropylene mesh implant. This procedure involves mobilization of the liver from all its ligaments while mandatorily preserving venous outflow. However, in the postoperative period, after stabilization of all patients, reoperation is required to perform definitive surgical repair [1].

The presented data indicate that while numerous methods for hemostasis in liver injuries exist, none of them is fully satisfactory. In this context, the development of new methods for surgical hemostasis of traumatic liver injuries remains a relevant problem in emergency surgery.

Prior to the initiation of the clinical trial, we conducted multifunctional integrated morphological, morphometric, and immunohistochemical studies in laboratory animals to develop a new method for surgical hemostasis [3]. In a series of *in vivo* experiments, it was initially demonstrated that the application of Surgitamp hemostatic agent and Molselect G-50 sorbent effectively controls moderate parenchymal bleeding in models of bleeding liver wounds. Furthermore, in experiments using models with active hemorrhage from liver wounds, the developed technique of combined surgical hemostasis — utilizing hemostatic agents and modified perihepatic packing — demonstrated high efficacy in achieving local hemostasis [19].

In accordance with the aim of our clinical study, the newly developed method of surgical hemostasis with modified perihepatic packing [20] was applied to the most severely affected category of patients with traumatic liver injury complicated by active hemorrhage (AAST Grade IV).

CONCLUSION

A new method for surgical hemostasis has been developed and introduced into clinical practice. This method involves tamponade of liver wounds with Surgitamp hemostatic gauze impregnated with Molselect G-50 granular sorbent, followed by modified perihepatic packing using strips of a polypropylene mesh endoprosthesis. This approach has improved treatment outcomes for patients with severe traumatic liver injuries by enhancing the reliability of definitive hemostasis, reducing the incidence of recurrent hemorrhages and reoperations, and lowering the mortality rate.

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