https://doi.org/10.23934/2223-9022-2019-8-4-396-408

# Surgical Hemostasis for Severe Multisystem Pelvic Injuries

*I.V. Kazhanov[1, 2]*, A.Y. Demko[1], V.A. Manukovsky[1], S.I. Mikityuk[1, 2], V.A. Reva[1, 2], E.A. Kolchanov[1], D.V. Pavlov[1]*

**Department of Multisystem Trauma**
**[1] I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine**
**3A Budapeshtskaya Street, St. Petersburg 192242, Russian Federation**
**[2] S.M. Kirov Military Medical Academy of the Ministry of Defense of the Russian Federation**
**"Zh" Academika Lebedeva Street, St. Petersburg 194044, Russian Federation**

*** Contacts:** Igor V. Kazhanov, Cand. Med. Sci., Leading Researcher of the Department of Multisystem Trauma, I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine. Email: carta400@rambler.ru

**RELEVANCE** For the treatment of patients with severe multisystem pelvic trauma accompanied by pelvic bleeding, many algorithms have been proposed that have different procedures for the use of various methods of surgical hemostasis, but none of them may guarantee the complete arrest of pelvic bleeding. The purpose of this study was to estimate clinical efficacy and developed algorithm, aimed at timely diagnosis of intrapelvic bleeding and its complete arrest with the help of different methods of surgical hemostasis in patients with severe concomitant injury of the pelvis. The article analyzes the results of treatment of 168 patients with unstable pelvic ring injuries and signs of intrapelvic bleeding, who were treated in two trauma centers of the first level in St. Petersburg: I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine and Military Surgery Clinic of S.M. Kirov Military Medical Academy in 2010-2018. The victims were divided into two statistically homogeneous groups. In the comparison group (75 people), the pelvic ring was mechanically stabilized with the Ganz C-clamp or the anterior part of the pelvis was fixed with an external fixation device (EFD), and the arrest of the ongoing pelvic bleeding was expected due to occur due to the effect of biological tamponade. In the main group (93 people), after mechanical stabilization of the pelvic ring, various methods of surgical hemostasis were used: balloon occlusion of the aorta, pelvic tamponade, angiography with embolization. The choice of method for surgical haemostasis after trauma depended on the severity of the affected condition of hemodynamic parameters, availability of life-threatening consequences of damage to other areas of the body and the efficacy of previously applied method for intrapelvic bleeding arrest. The introduction of modern diagnostic and treatment algorithm, aimed at complete hemostasis in patients with ongoing intrapelvic bleeding reduced the overall mortality rate by 1.7 times, mortality within 24 hours of admission by 2.3 times, as well as the duration and the volume of blood transfusion therapy by 3 and 1.8 times.

**Key words:** polytrauma, unstable pelvic ring injuries, retroperitoneal pelvic hematoma, surgical hemostasis, Ganz C-clamp, external fixation, pelvic tamponade, angiography and embolization, iliosacral osteosynthesis

**For citation** Kazhanov IV, Demko AY, Manukovsky VA, Mikityuk SI, et al. Surgical Hemostasis for Severe Multisystem Pelvic Injuries. *Russian Sklifosovsky Journal of Emergency Medical Care.* 2019;8(4):396–408. https://doi.org/10.23934/2223-9022-2019-8-3-396-408 (in Russ.)

**Conflict of interest** Authors declare lack of the conflicts of interests

**Acknowledgments** The study had no sponsorship

**Affiliations**

| | |
|---|---|
| Igor V. Kazhanov | Candidate of Medical Sciences, Leading Researcher of the Department of Multisystem Trauma, I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine, S.M. Kirov Military Medical Academy of the Ministry of Defense of the Russian Federation, Head of Department of the Clinic of Military Field Surgery, https://orcid.org/0000-0003-2880-2630 |
| Andrey Y. Demko | Doctor of Medical Sciences, Professor, Deputy Chief Physician for Surgery of the I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine, https://orcid.org/0000-0002-5606-288X |
| Vadim A. Manukovsky | Professor, Dr. Med. Sci., Deputy Director for Clinical Work, I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine, https://orcid.org/0000-0003-0319-814X |
| Sergey I. Mikityuk | Cand. Med. Sci., Senior Lecturer of the Training Center, I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine, Head of Department of the Clinic of Military Surgery, S.M. Kirov Military Medical Academy of the Ministry of Defense of the Russian Federation, https://orcid.org/0000-0003-3765-8984 |
| Victor A. Reva | Cand. Med. Sci., Lecturer of the Training Center, I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine; Lecturer of the Department of Military Surgery, S.M. Kirov Military Medical Academy, https://orcid.org/0000-0001-6705-9849 |
| Evgeny A. Kolchanov | Emergency Doctor of the Emergency Department, I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine, https://orcid.org/0000-0001-9716-4981 |
| Dmitry V. Pavlov | Clinical Resident, I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine, https://orcid.org/0000-0003-1412-4920 |

ARD — anesthesia and resuscitation department
BFS-CA — Battlefield Scale – Condition upon Admission
BFS-D (MT) — Battlefield Scale – Damage, Mechanical Trauma
EFD — external fixation device
EVBOA— endovascular baloon occlusion of the aorta
EPT — extraperitoneal pelvic tamponade
IIA — internal iliac artery

ISS — Injury Severity Scale
MSCT — multispiral computed tomography
MSCTA — multispiral computed tomography with angiography
REBOA — resuscitative endovascular ballon occlusion of the aorta
SBP — systolic blood pressure

## INTRODUCTION

Pelvic injuries in patients with polytrauma are revealed in 3–9% of cases [1, 2], and mortality in such patients ranges from 8 to 23% of cases [3]. Irreversible hemorrhage due to intrapelvic bleeding is the main cause of mortality in the acute period of trauma in 10–58% of cases [3–6]. As a rule, among the victims, people of working age with a high level of severity of damage prevail (*ISS* score > 25). Continued pelvic bleeding is the main cause of hemodynamic instability of patients with severe pelvic trauma and, of course, requires the active use of various methods of surgical hemostasis. Quite often, pelvic injuries are combined with severe damage to other areas, primarily the abdominal organs, which becomes a challenge for the surgeon in determining the priority source of bleeding and choosing the sequence for eliminating the life-threatening consequences of injuries.

There are various methods of temporary or final surgical hemostasis of intrapelvic bleeding, each having own indications, contraindications and conditions for use, advantages and disadvantages. At present, for the treatment of patients with severe concomitant injury of the pelvis, accompanied with intra-pelvic bleeding, there is a set of algorithms which differ in various methods of surgical hemostasis, but none of them can be guaranteed to provide a final arrest of intrapelvic bleeding or considered to be the "gold standard" [7–9].

**The aim of the study** was to evaluate the clinical efficacy of the developed algorithm aimed at timely diagnosis of intra-pelvic bleeding and its final arrest using various methods of surgical hemostasis in patients with severe multisystem pelvic trauma.

**Research Objectives:**

1. To develop a treatment and diagnostic algorithm in order to achieve surgical hemostasis in patients with severe multisystem pelvic trauma.

2. To compare results of treatment of victims with signs of ongoing intrapelvic bleeding, who underwent different volume of emergency specialized medical care, consisting in mechanical stabilization of the pelvic ring (or other additional methods of surgical hemostasis were used such as pelvic tamponade, angiography and embolization, balloon occlusion of the aorta).

## MATERIAL AND METHODS

We analyzes the results of treatment of 168 patients with severe multisystem injury of the pelvis, accompanied with intra-pelvic bleeding, admitted for treatment in the trauma center of two of the first level of St. Petersburg: I.I. Dzhanelidze St. Petersburg Research Institute and the Clinic of Military Field Surgery of S.M. Kirov Military Medical Academy from 2010 to 2018.

All the victims were of working age, the mean age was 41.0 ± 16.8 years. There were 103 men (61.4%), 65 women (38.6%). Most of patients (131; 77.9%) were delivered to trauma centers within an hour from the moment of injury. The circumstances of the injury were traffic accident (95 patients, 56.5%), falling from a height (62, 36.9%) and compression (11, 6.5%).

All patients were assessed accroding to scales: ISS (Injury Severity Scale) BFS-D (MT) (Battlefield Scale – Damage, Mechanical Trauma), Glasgow Coma Scale, BFS-CA score (Battlefield Scale – Condition upon Admission) [10]. We also assessed the shockogenicity of the injury according to the method of Y.N. Tsibin (1975) [11]. For a more accurate assessment of the severity of the condition, pathophysiological signs indicating acute massive blood loss and shifts of homeostasis in the body were additionally taken into account according to the simplified table scheme developed by *H.C. Pape*, which allows clinical classes to be distinguished [12].

The study included affected having unstable pelvic ring damage and symptoms of intrapelvic bleeding and classified according to severity of the condition to different classes: a) borderline; b) unstable; c) critical condition (with the effectiveness of resuscitation measures). Most patients (132, 78.1%) had hemodynamic instability, which was determined by the conservation of systolic blood pressure (SBP) below 90 mm Hg despite performed infusion therapy of 2,000 ml of crystalloid, as well as the presence of minimum vasopressor inotropic support.

Intrapelvic bleeding was confirmed by changes in hemodynamic parameters, red blood dynamics, and the presence of a large retroperitoneal pelvic hematoma. Medium and large retroperitoneal hemorrhages were classified as “large retroperitoneal pelvic hematomas”, according to the classification of I.Z. Kozlov (1988) [13]. The prevalence of retroperitoneal pelvic hematoma in the victims was evaluated by the results of multispiral computed tomography (MSCT) of the pelvis and abdomen, or intraoperatively during laparotomy or laparoscopy. Some of the victims were evaluated according to clinical data due to their extremely serious condition and non-transportability (subcutaneous hemorrhages showing the spread of the pelvic hematoma to the perineum, anterior abdominal wall, scrotum, labia and detected by rectal and vaginal manual examination). It should be noted that the presence of a large retroperitoneal pelvic hematoma was confirmed in all the victims according to the protocols of the forensic medical examination.

When formulating indications for emergency operations in one volume or another, as well as determining their sequence, the severity of the condition of the victim was taken into account immediately upon admission to the anti-shock operating trauma center. For patients with severe multisystem pelvic trauma and unstable hemodynamics, specialized medical assistance included X-ray examination of the chest and pelvis, ultrasound of the pleural and abdominal cavities, pericardium in a reduced volume, and the application of an antishock pelvic dressing. Ultrasound in a reduced volume allowed us to estimate the amount of free fluid in the abdominal cavity by a standard method. The volume of fluid was determined as an insignificant amount (less than 500 ml) if in one of the anatomical spaces of the abdominal cavity (most often in the Morrison space) the separation of the peritoneal leaflets was less than 2 cm.

In critically injured patients, emergency surgical aids were used as part of the tactics of staged damage treatment and their control *(Damage Control Surgery)* on damaged areas of the body. Emergency operations were performed to provide temporary or final surgical hemostasis: endovascular balloon aortic occlusion (EVBOA), pelvic tamponade, pelvic angiography followed by embolization, stabilization of the unstable pelvic ring using one of the methods or their combination (pelvic dressing, Ganz clamp, external fixation device - EFD).

According to the universal *AO/ASIF* classification of fractures *(M. Tile , M.E. Muller )*, vertically unstable pelvic ring injuries were detected in 89 (53.3%), rotationally unstable fractures were revealed in 79 patients (46.7%). Given the damage mechanism

pelvic ring classification of *J. Young and A. Burgess* (1990), the distribution was as follows: anterolateral compression was in 27 (16.1%) patients; lateral compression was in 55 (32.7%) parients; vertical shift was in 44 (26.2%) patients; combined damage was in 42 (24.9%) patients.

Patients were divided into two statistically homogeneous groups. The control group (75 patients) consisted patients, who underwent stabilization of pelvic ringwith EFD *"ARETE"* , "KST-1", "MKTs" (Russia) or with Ganz clamp (*DePuy Synthes*, Switzerland), and no additional methods of surgical hemostasis after mechanical fixation were used for intrapelvic bleeding arrest. It was believed that extrafocal fixation of an unstable pelvic ring provides reliable stabilization of bone fragments and reduces the pelvic cavity. The intrapelvic bleeding arrest was achieved through the development of biological tamponade effect, wherein increasing intracavitary pressure in the retroperitoneal space by filling it with blood clot formation and decrease in pressure occurred in the damaged vessels pelvic before the alignment of these figures.

In the main group (93 patients) in addition to the mechanical stabilization of pelvic ring we used various methods of surgical intrapelvic bleeding arrest: pelvic tamponade, EVBOA. The provision of specialized medical care to victims of this group was carried out taking into account the developed treatment and diagnostic algorithm aimed at the complete arrest of pelvic bleeding (Fig. 1).

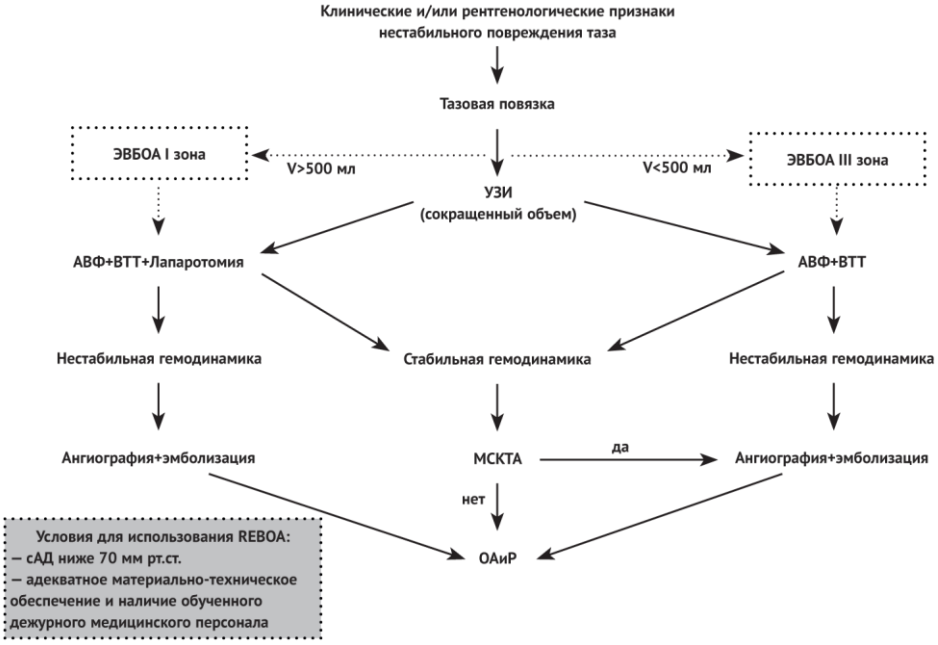


Fig. 1. Therapeutic and diagnostic algorithm for achieving hemostasis in surgical patients with severe trauma of the pelvis and unstable hemodynamics

Notes: EFD — external fixation device; EPT — extraperitoneal pelvic tamponade; MSCTA — multispiral computed tomography with angiography; DAR — department of anesthesiology and resuscitation; EVBOA — endovascular balloon occlusion of aorta; SBP — systolic blood pressure

Table 1 shows the comparison of the studied groups by gender, age, the rate of blood pressure upon admission, the severity of damage and the condition of the victims, taking into account average values of indicators of various scales of mechanical injuries.

*Table 1*

**The structure and characteristics of groups, n (%), M±m**

| Index | Main group ($n_1$ = 93) | Comparison group ($n_2$ = 75) |
|---|---|---|
| Men<br>Women | 56 (60.3)<br>37 (39.7) | 47 (62.7)<br>28 (37.3) |
| Mean age, years | 39.7 ± 16.3 | 43.0 ± 20.4 |
| Glasgow Coma Scale | 9.7 ± 3.3 | 8.9 ± 3.0 |
| SBP <90 mm Hg | 73 (78.5) | 59 (78.6) |
| SBP> 90 mm Hg | 20 (21.5) | 16 (21.3) |
| Damage severity, ISS score | 37.4 ± 9.6 | 39.5 ± 9.4 |
| Damage severity, BFS-D (MT) score | 15.9 ± 10.9 | 16.6 ± 10.1 |
| Condition Severity, BFS-CA score | 36.9 ± 9.3 | 43.0 ± 15.7 |
| Damage severity, Y.N. Tsibin scale | 12.7 ± 5.2 | 13.4 ± 5.4 |
| Criterion T (Y.N. Tsibin ), hours | - 4.3 ± 18.1 | - 5.2 ± 18.4 |

Notes: BFS-D (MT) score— battle-field surgery score — damage–mechanical trauma; BFS CA score — battle-field surgery score — state upon admission; SBP — systolic blood pressure; ISS — Injury Severity Scale

Qualitative characteristics of the used assessment scale damage and severity of condition in patients id presented in Table 2.

*Table 2*

**Characteristics of the studied groups**

| Index | Main group ($n_1$=93) | Comparison group ($n_2$=75) |
|---|---|---|
| Damage severity, BFS-D (MT) score | | |
| from 1 to 12 points | 40 (43.0%) | 25 (33.3%) |
| more than 12 points | 53 (57.0%) | 50 (66.7%) |
| Condition severity, BFS-CA score | | |
| from 13 to 20 points | 3 (3.2%) | 4 (5.4%) |
| from 21 to 31 points | 6 (6.5%) | 7 (9.3%) |
| from 32 to 45 points | 70 (75.3%) | 51 (68.0%) |
| more than 45 points | 14 (15.1%) | 13 (17.3%) |
| Criterion T (Y.N. Tsibin, 1975), hours | | |
| Positive forecast | 9 (9.7%) | 6 (8.0%) |
| Doubtful forecast | 17 (18.3%) | 12 (16.0%) |
| Negative forecast | 67 (72.0%) | 57 (76.0%) |
| Damage severity, ISS score | | |
| from 17 to 25 points | 5 (5.4%) | 3 (4.0%) |
| from 26 to 40 points | 37 (39.8%) | 30 (40.0%) |
| more than 40 points | 51 (54.8%) | 42 (56.0%) |
| Condition severity, clinical class (according to H.C.Pape, 2005): | | |
| - border | 34 (36.6) | 28 (37.3) |
| - unstable | 43 (46.2) | 33 (44.0) |
| - critical | 16 (17.2) | 14 (18.7) |

Notes: BFS-D (MT) score — battle-field surgery score — damage–mechanical trauma; BFS CA score — battle-field surgery score — state upon admission; SBP — systolic blood pressure; ISS — Injury Severity Scale

As can be seen from the above Table 2, more than 90% of patients had severe trauma (*ISS* over 25), and severe condition (BFS-CA over 32) with a poor prognosis. 35.5% of the victims had combined abdominal damage with ongoing intraperitoneal bleeding.

The distribution of victims depending on the type of damage to the pelvic ring is presented in Table 3.

*Table 3*

**Types of unstable lesions of pelvic ring n=168**

| Pelvic damage | Main group ($n_1$=93) | Comparison group ($n_2$=75) |
|---|---|---|
| Classification of Tile M., Muller M.E. AO/ASIF (1996, 2007) | | |
| - rotationally unstable (Type B) | 43 (46.2) | 36 (48.0) |
| - vertically unstable (Type C) | 50 (53.8) | 39 (52.0) |
| Classification of Young J., Burgess A. (1990) | | |
| - anterior-posterior compression (type AP) | 13 (13.9) | 14 (18.7) |
| - lateral compression (type LC ) | 30 (32.3) | 25 (33.3) |
| - vertical shift (type VS) | 25 (26.9) | 19 (25.3) |
| - combined (type CM) | 25 (26.9) | 17 (22.7) |

In addition to intrapelvic bleeding various life-threatening consequences of stated failures of other body regions occurred (tab. 4), including 84 affected (50%) with 2 or more life-threatening consequences of damage to other areas of the body.

*Table 4*

**Life-threatening effects of damage, n (%), M±m**

| Index | Main group ($n_1$=93) | Comparison group ($n_2$=75) |
|---|---|---|
| Abdominal bleeding | 35 (37.6) | 25 (33.3) |
| Intrapleural bleeding | 3 (3.2) | 1 (1.3) |
| External bleeding | 7 (7.5) | 5 (6.7) |
| Open or intense pneumothorax | 4 (5.3) | 10 (10.6) |
| Asphyxia of various genesis | 9 (9.7) | 10 (10.75) |
| Brain compression | 1 (1.3) | - |

Final hemostasis was determined by a change in the following parameters: SBP, the volume and duration of replacement blood transfusion therapy, and in the main group, additionally, after stabilization of hemodynamic parameters, according to the results of pelvic MSCT with intravenous contrast enhancement or diagnostic pelvic hypertension.

The database of the victims was created in the program *Microsoft Office Excel*, 2010 ( *Microsoft* , USA). Statistical analysis of the data was carried out using the application package *BioStat*, 2009 (*Analyst Soft Inc.*, USA). When assessing the significance of the differences between the average values in the samples, the confidence coefficient (*p*) was calculated using the Student *t*-test. All survivors who participated in this research study gave written informed consent.

## RESULTS AND DISCUSSION

Upon admission of victims with severe multisystem pelvic trauma and signs of ongoing intrapelvic bleeding, intensive anti-shock therapy was started at the same time as emergency diagnostic measures and surgical interventions. The first step of rendering the affected specialized surgical aid, according to the existing medical diagnostic algorithm for complete intrapelvic bleeding arrest was mechanical fixation of unstable pelvic ring. It should be noted that in the absence of pelvic fixation in a pre-hospital stage in the examination, the pelvic bandage or pelvic belt ("Medplant", Russia or *"T-POD"*, USA) were applied. In the future, the method of surgical fixation of the pelvis depended on the type of damage to the pelvic ring. Vertically unstable injuries of the posterior structures of the pelvis were fixed with a Ganz clamp (*DePuy Synthes*, Switzerland), while parts of the victims were supplemented with anterior EFD frame for fixation. Rotationally unstable pelvic injuries were fixed with EFD. In 11 patients (11.8%) of the main group the posterior pelvis was additionally fixed with ilio-sacral screws.

In unstable (17, 41.5%) and critical (24, 58.5%) patients pelvic tamponade was performed (extraperitoneal, transperitoneal, or combined) after mechanical fixation of the ring due to the pelvic unstable hemodynamics continuing for a period of another 30 minutes. Pelvic tamponade was performed in the absence of other sources of bleeding.

In 12 (12.9%) critical patients with unstable hemodynamics (SBP less than 70 mm Hg) EVBOA was performed. In most cases (9 patients), the balloon was installed in the I zone of the aorta (in the presence of ultrasound signs of moderate or significant accumulation of free fluid in the abdominal cavity), in 3 cases it was installed in the III zone of the aorta (in the absence of

ultrasound signs of the presence of free fluid or with a small amount in the abdominal cavity, less than 500 ml).

At the same time, surgical interventions were performed to eliminate the life-threatening consequences of injuries in other areas: drainage of pleural cavities; laparotomy, intra-abdominal bleeding arrest; sanitation of the tracheobronchial tree to eliminate asphyxiation; primary surgical treatment of wounds with ongoing external bleeding control, decompressive craniotomy due to compression of the brain by intracerebral hematoma (Table 5).

*Table 5*

**The structure of emergency operations in the anti-shock operating room**

| Types of operations | Main group ($n_1$ =93) | Comparison group ($n_2$ =75) |
|---|---|---|
| Laparotomy for damage of abdominal organs | 31 (33.3) | 22 (29.3) |
| Diagnostic laparotomy | 5 (5.4) | 11 (14.7) |
| Medical and diagnostic laparoscopy (damage to the abdominal organs was diagnosed) | 4 (4.3) | 3 (4.0) |
| Diagnostic laparoscopy (large pelvic retroperitoneal hematoma) | 7 (7.5) | 2 (2.7) |
| Thoracocentesis, drainage of the pleural cavity in pneumothorax | 18 (19.3) | 11 (14.7) |
| Thoracotomy, intrapleural bleeding arrest | 3 (3.2) | 1 (1.3) |
| Elimination of asphyxia of various origins | 7 (7.5) | 9 (12.0) |
| Trepanation | - | 1 (1.3) |
| Thoracotomy, clamping of the thoracic aorta | 1 (1,1) | 3 (4.0) |
| External bleeding arrest | 7 (7.5) | 5 (6.7) |

Computed tomography with intravenous contrast was performed on 31 patients (33.3%). As a result, extravasation of contrast agent was revealed in 6 cases, vascular contrast rupture was revealed in 2 cases. In most clinical cases, retroperitoneal pelvic hematoma spread to the level of kidneys (105 patients, 62.5%) and to the level of the diaphragm (63, 37.5%). In 121 patients (72.0%), a large retroperitoneal pelvic hematoma with a volume of more than 500 ml was confirmed by computed tomography. The prevalence of retroperitoneal pelvic hematoma was specified during diagnostic laparoscopy or laparotomy in 85 clinical cases (50.6%). In 48 patients (28.6%) due to their extremely serious condition, the presence of retroperitoneal pelvic hematoma was confirmed by clinical data.

In the clinical classes “borderline” (4 patients) and “unstable” (3 patients), under condition of stabilization of hemodynamic parameters or maintaining unstable hemodynamics with minimal vasopressor and inotropic support, pelvic hypertension was performed. Indications for its implementation were as follows: intraoperative detection of increasing retroperitoneal pelvic hematoma; signs of damage to the vessels of the pelvic cavity according to MSCT with intravenous contrast enhancement (extravasation of the contrast agent, stop contrast or loss of contrast, false aneurysm), need for blood transfusion of 4 or more units of blood components within 24 hours from the moment of injury or 6 units within 48 hours in the absence of non-pelvic sources of bleeding. Indirect signs of damage to the arteries of the pelvic cavity during diagnostic hypertension were extravasation of the contrast agent, rupture of the vessel, and pseudo-aneurysm. When damage to the arterial vessels of the pelvis was detected, they were embolized. In 2 cases, selective lumbar-iliac and superior gluteal artery embolization was performed, in 2 cases, non-selective embolization of the internal iliac artery was performed. It should also be noted that in 9 patients hypertension was performed after pelvic tamponade in order to control hemostasis, while the arterial source of intra-pelvic bleeding was detected in 6 cases. Selective (4 observations) and non-selective (2 observations) embolization of damaged arterial branches was performed (Table 6).

*Table 6*

**Methods of surgical hemostasis used**

| Types of operations | Main group ($n_1$ =93) | Comparison group ($n_2$ =75) |
|---|---|---|
| Fixation of anterior pelvis with EFD | 47 (50.5) | 67 (89.3) |
| Fixation of posterior pelvis with Ganz clamp | 6 (6.4) | 4 (5.3) |
| Simultaneous fixation of the anterior and posterior pelvic structures | 29 (31.1) | 4 (5.3) |
| Combined fixation (EFD + internal osteosynthesis) | 11 (11.8) | - |
| Extraperitoneal pelvic tamponade (EPT) | 26 (27.9) | - |
| Transperitoneal pelvic tamponade (TPT) | 11 (11.8) | - |
| Combined pelvic tamponade (CPT) | 4 (4.3) | |
| Diagnostic pelvic angiography (AG) | 16 (17.2) | |
| Isolated | 7 (7.5) | |
| With embolization | 4 (4.3) | - |
| After pelvic tamponade | 9 (9.8) | |
| With embolization | 6 (6.5) | |
| Endovascular balloon occlusion of the aorta (EVBOA) | 12 (12.9) | - |

The correlation between the type of the pelvic ring fracture and the diagnosed damaged vessels of the system of the internal iliac artery (IIA) was not detected due to the small number of observations. In most cases, only one damaged artery was revealed.

During the period of relative stabilization of the victim's condition (from 12 to 48 hours after the injury) or during the period of complete stabilization of the vital functions of the body after relief of complications (2 weeks after the injury), the final osteosynthesis of the damaged pelvic ring with various immersion structures was performed or the EFD was left as the final treatment options in the comparison group.

The overall mortality of the victims in the comparison group was 53 (70.7%), of which 34 patients (45.3%) died on the first day. In the main group, the overall mortality rate was 39 (41.9%), of which 18 patients died on the first day (19.3%). One of the main causes of death of the victims in the first days after the injury was acute irreversible blood loss. In victims of the third period of traumatic disease (the maximum likelihood of complications development), almost the same frequency of visceral and generalized infectious complications was observed (Table 7).

*Table 7*

**The results of treatment, n (%), M±m**

| Options | Main group ($n_1$ =93) | Comparison group ($n_2$ =75) | p <0.05 |
|---|---|---|---|
| Overall mortality | 39 (41.9) | 53 (70.7) | + |
| Mortality within 24 hours: | 18 (19.3) | 34 (45.3) | + |
| Irreversible blood loss | 12 (12.9) | 25 (33.3) | + |
| Disseminated intravascular coagulation (DIC) | 6 (6.4) | 9 (12.0) | + |
| Complication development rate | 65 (69.9) | 49 (65.3) | - |
| Multiple organ failure | 6 (6.4) | 5 (6.7) | - |
| Visceral (pneumonia, peritonitis, etc.) and generalized infectious (sepsis) complications | 13 (14.0) | 11 (14.7) | - |
| Pulmonary embolism | 1 (1.1) | 1 (1.3) | - |
| Fat embolism | 2 (2.1) | 1 ( 1.3) | - |
| Survived | 54 (58.0) | 22 (29.3) | + |
| Complete control of the intrathoracic source of bleeding | 82 (88.2) | 44 (58.7) | + |
| Blood transfusion over 24 hours, unit (1 unit = 250 ml) | 6.4 ± 3.1 | 11.2 ± 3.7 | + |
| Duration of blood transfusion, days | 1.4 ± 0.6 | 2.5 ± 3.7 | + |

The effectiveness of the implementation of the treatment and diagnostic algorithm using modern methods of diagnosing ongoing intrapelvic bleeding and methods of surgical hemostasis aimed at final bleeding control was evaluated by the duration and volume of replacement blood transfusion therapy, as well as by the results of radiology research methods (using MSCT with intravenous contrast enhancement or pelvic hypertension).

In the main group, the duration of blood transfusion was 1.4 ± 0.6 days, while in the first day 6.4 ± 3.1 units of blood preparations were required. In the comparison group, the duration of blood transfusion was 2.5 ± 3.7 days; 11.2 ± 3.7 units of blood preparations were required during the first day. There are statistically significant differences in the compared groups between the need for average volumes of blood substitute drugs, measured in units (1 unit = 250 ml), and the total duration of blood transfusion replacement therapy per day.

The use of a modern diagnostic and treatment algorithm to achieve surgical hemostasis in patients with severe multisystem pelvic trauma and intrapelvic hemorrhage reduced the overall mortality rate by 1.7 times; mortality from life-threatening consequences of injuries (up to a day) – 2.3 times, mortality due to irreversible blood loss – by 2.6 times. The effectiveness in achieving the final surgical hemostasis was increased by 1.5 times. The length of hospital stay decreased by 1.4 times and amounted to 37.4 ± 35.1 days. When analyzing the compared groups, there were no statistical differences in the frequency of mortality from complications, the frequency of development of common, purulent-infectious, visceral purulent-infectious, non-infectious complications.

A treatment option for a patient with severe combined pelvic trauma is presented as a clinical observation.

Clinical observation

A 33-year-old male patient Z. received a severe multisystem injury to the head, neck, chest, abdomen, pelvis, limbs. The diagnosis was: "Open craniocerebral injury. A brain contusion of moderate severity. Tear-contused wound of the right frontoparietal region. Closed chest injury with a fracture of the left clavicle, body of the left scapule. Closed abdominal injury with rupture of the spleen of III degree. Continuing abdominal bleeding. Hemoperitoneum (800 ml). Multiple pelvic trauma. Closed rotationally unstable pelvic ring damage: fractures of the right pubic and sciatic bones, lateral mass of the sacrum to the right, partial rupture of the pubic joint, fracture of the right acetabulum. Partial detachment of the urethra in the area of the mouth of the bladder. Continuous pelvic bleeding. Multiple limb trauma. Open (*Gustilo* IIIa) comminuted fracture of the diaphysis of the left femur. Tear-contused wound of the lower third of the right thigh. Acute massive blood loss. Traumatic shock of the III degree". Upon arrival in the anti-shock operating blood pressure of 70 and 35 mm Hg , heart rate 127 beats/min. The severity of injuries: *ISS* score 29, BFS-D (MT) 10.8 points, BFS-CA 43 points, Glasgow Coma Scale score 10.

The victim was classifies as unstable. Emergency specialized surgical care was provided according to the suggested

diagnostic and treatment algorithm. During the examination, the pelvic ring was fixed with an antishock pelvic belt. Considering the persistent unstable hemodynamics, the extensive retroperitoneal pelvic hematoma (up to the diaphragm level) detected during laparotomy with splenectomy, extraperitoneal pelvic tamponade was performed after fixation of the unstable pelvic ring using EFD. An epicystostomy was made. Relative stabilization of hemodynamic parameters was noted against a background of vasopressor and inotropic support reduced to minimal levels. Next, the primary surgical treatment of head wounds and an open fracture of the left femur with extrafocal EFD fixation was performed. In order to monitor the effectiveness of EPT and clarify the type of pelvic damage, MSCT with intravenous contrast was performed (Fig. 2). Signs of damage to the arterial vessel of the pelvic cavity were revealed.

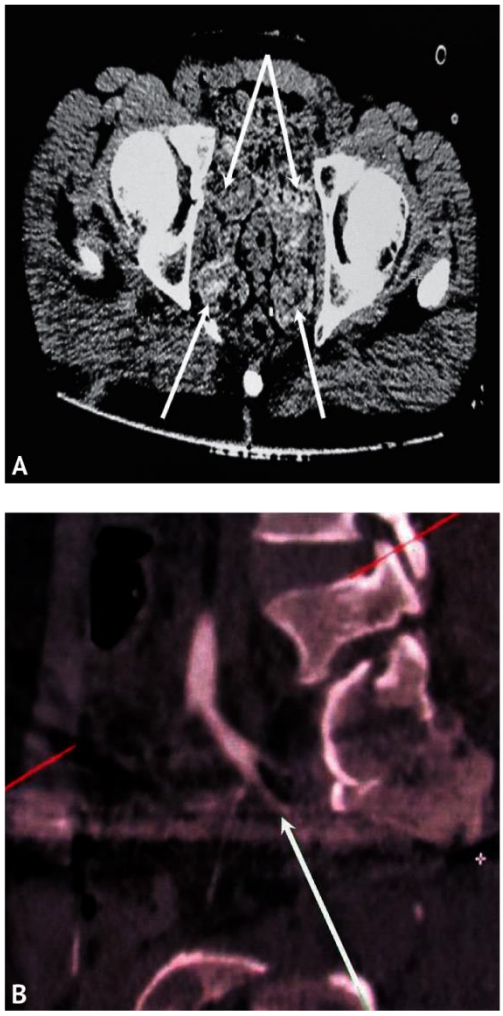


Fig. 2. CT scan of the pelvis with intravenous contrast: A — axial plane at the level of the acetabulum (arrows indicate tampons); B — failure of contrasting at the level of the anterior trunk of the right internal iliac artery (indicated by the arrow)

In order to verify the arterial source of intrapelvic bleeding, diagnostic AH was performed. Stop contrast was revealed at the level of the anterior trunk of the right IIA (Fig. 3), which indirectly indicated it as a possible main source of intrathoracic bleeding. Selective embolization of the damaged blood vessel with *«Terumo»* spirals (Japan) was performed.

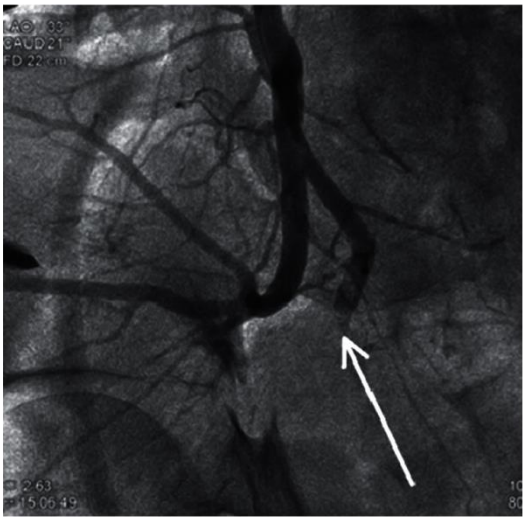

Fig. 3. Diagnostic pelvic angiography after EPT (contrast failre is indicated at the level of the anterior trunk of the right internal iliac artery)

Considering the stable hemodynamic parameters, we performed minimally invasive osteosynthesis of the posterior pelvic ring fracture with an iliac-sacral cannulated screw (Fig. 4).

Fig. 4. X-ray of the pelvis (anteroposterior projection) after fixation with EFD and osteosynthesis with the sacroiliac screw

Tampons from the pelvic cavity were removed on the 3rd day, urethral continuity was restored according to the Albaran – Vishnevsky method on the urinary catheter by means of counter dilation, the pelvic cavity and paravesical tissue were drained according to Buyalsky – Mac-Warter. On the 15th day, a fracture of the femur was fixed by an intramedullary blocking screw. The postoperative course was uneventful. Early rehabilitation treatment was initiated. EFD was removed from the pelvic area on the 30th day, the patient was discharged on the 39th day after the injury. In assessing the long-term results of treatment of the final value according to *S.A. Majeed* scale (1989) [14] was 89, which corresponded to a good functiontional outcome.

## DISCUSSION

The use of various methods of surgical hemostasis in patients with severe concomitant pelvic trauma and ongoing intrapelvic bleeding is actively discussed in the domestic and foreign literature.

Endovascular balloon occlusion of the aorta contributes to raising SBP and internal bleeding arrest, including intrapelvic bleeding. The use of this method is temporary and allows you to gain time to perform additional diagnostics, mechanically fix an unstable pelvic ring, use pelvic tamponade, obtain blood components and start blood transfusion. The disadvantage is that there is a risk of complications, including damages of the femoral artery, incorrect positioning of the balloon in the aorta, the random untargeted catheterization and vascular injury, baloon displacement due to lack of adequate support, severe reperfusion due to prolonged baloon installation, bleeding from areas of vascular access [15, 16].

The literature continues to discuss the issue of indications for IIA ligation on the damage side in the absence of a positive effect of hemostatic therapy, including EFD. There are also opposing points of view. Thus, *J. DuBose* (2010) believes that even bilateral IIA ligation, as a rule, cannot control fatal bleeding, while the mortality rate in such victims is 64.3% [17]. Other authors share this point of view on the basis of negative experience, citing the fact that IIA ligation is not effective due to the fact that arterial and venous collaterals are developed in the pelvic cavity, therefore, there is a high probability of inconsistent hemostasis, and revision of the retroperitoneal hematoma in an attempt to control bleeding from several IIA and subsequent pelvic tamponade through the abdominal cavity leads to fatal consequences [18, 19].

Another point of view is suggested by K.P. Mineyev (1999), who promotes this method as a salvage during ongoing arterial and venous pelvic bleeding, and believes that the ligation of the IIA and their branches is anatomically and functionally acceptable and effective, having successful experience of such operations in 12 patients [20].

Information on the frequency of arterial bleeding was obtained during the analysis of the results of diagnostic pelvic hypertension and ranges from 0.01 to 2.3% for all pelvic injuries [9, 12], with unstable pelvic ring injuries, the frequency increases and ranges from 9 to 80% [21]. Pelvic hypertension with embolization is a safe and extremely effective method of hemostasis for

pelvic fractures complicated by massive arterial bleeding [22]. One of the important advantages of pelvic hypertension is the ability to simultaneously diagnose damage to the arteries of the pelvic cavity and abdominal organs. In 90% of cases, it is possible to embolize a damaged vessel and control ongoing bleeding, which reduces the need for additional surgical interventions. However, there are a number of disadvantages, one of which is that, despite performing AH and embolization, and achieving effective control of pelvic bleeding, simultaneous treatment of injuries to other areas of the body cannot be performed during this procedure.

In the United States and Great Britain, endovascular contrast diagnosis of damage to the arteries of the pelvic cavity is widely used [8, 23]. Timely performed AH with simultaneous hemostatic embolization are considered as important for predicting the survival of the victim, as well as mechanical stabilization of the pelvis at the scene. In turn, in Germany and Austria, the performance of hypertension and embolization is seen to a greater extent as a "second-line" event in cases of intracranial hemorrhage resistant to replacement blood transfusion therapy, which has a significant effect on hemodynamics and cannot be completely controlled by other methods of surgical hemostasis. This position is argued by the fact that only sources of arterial bleeding can be visualized and embolized using AH, while the percentage of such bleeding during pelvic injuries is only 10–20%. The remaining 80% of bleeding due to damage to the pelvis is of venous origin, or bleeding from the fracture surface. In some cases, selective embolization is not possible due to heavy blood loss. For such patients it's best to try to stop pelvic bleeding using blind embolization. For this, two millimeter *Gelfoam* cubes are inserted into the internal iliac artery. The gel spreads and clogs most of the arterial vessels in the bed of the IIA. Such a volume of gel is enough to prevent it from entering the pelvic capillary network and maintain the movement of blood through it, which avoids ischemic complications.

It should be emphasized that sometimes repeated pelvic hypertension is required, especially in those cases when the patient still needs to undergo hemotransfusion replacement therapy, which indirectly indicates persistent intracranial bleeding. Repeated pelvic hypertension is performed with a frequency of 6.7 to 40.0% [22]. *D. Gourlay* showed that in 7.5% of patients with pelvic trauma, who initially underwent embolization, a second pelvic hypertension was performed, which defined intrapelvic bleeding in 80% of cases, of which from another damaged artery - 68% , from an initially embolized artery - in 18%, from both arterial sources - in 14% of cases [24].

*G.C. Velmahos* reported temporary embolization of both IIA in patients with damage to the pelvic arteries, while bleeding could not be managed by selective embolization.

There are articles with analysis of two groups of victims who underwent pelvic tamponade and diagnostic angiography with embolization [25]. The authors noted that in the group where hypertension and embolization were primarily used, the need for blood transfusion therapy was higher than after pelvic tamponade. On the contrary, in the group with EPT, the time between arrival and operation is much shorter, and it is also possible to perform urgent operations simultaneously to eliminate the life-threatening consequences of injuries in other areas of the body such as laparotomy, etc. However, a detailed study of the literary material shows that after pelvic tamponade the frequency of diagnostic AH is from 13.3 to 88.0%, while the source of arterial bleeding can be verified and eliminated by embolization in 62.5–100.0% of cases [5 , 21, 23]. It should be noted that, primarily, patients with pelvic trauma, having stable or transiently changing hemodynamic parameters against the background of infusion-transfusion therapy, and without signs of hypocoagulation, are primarily subject to hypertension. Also, for the implementation of this therapeutic and diagnostic measure, the emergency trauma center must be equipped with appropriate equipment and have trained medical personnel.

Pelvic angiography is uninformative with low blood pressure, therefore, direct surgical hemostasis in the form of pelvic tamponade, which acts as a kind of "bridge" to subsequent hypertension with temporary stabilization of hemodynamics, should be preferred. In order to reduce mortality among patients with severe multisystem trauma of the pelvis and successfully control intrapelvic bleeding we should perform mechanical fixation of bones of the pelvic ring in combination with the methods of surgical haemostasis, but given organizational problems associated with the creation of conditions for performing AH, the most efficient is the implementation extraperitoneal tamponade of the pelvis.

Two approaches to pelvic tamponade are described in the literature, depending on the options for access to the retroperitoneal space: transperitoneal [26] and extraperitoneal [5, 7, 23]. Proponents of transperitoneal pelvic tamponade believe that the technique cannot provide a sufficient effect of tamponade on the side of damage to the pelvic ring, since bleeding will continue on the opposite side. Pelvic tamponade through the abdominal cavity is so ineffective that it leads to the need for massive replacement blood transfusion therapy with ongoing intrapelvic bleeding [19]. With extraperitoneal access, the intact side cannot be open enough to install tampons, and this surgical technique can be recommended if there is no need for emergency laparotomy [9]. However, we believe that EPT has obvious advantages and provides minimal intraoperative blood loss, reduces the risk of developing an abdominal compartment syndrome and repeated life-threatening uncontrolled intrapelvic hemorrhage, while it is possible to remove tampons more than 72 hours after surgery without performing relaparotomy.

When performing an intraperitoneal tamponade, the following disadvantages were noted: a high risk of developing an abdominal compartment syndrome; additional intraoperative blood loss; the need to remove tampons within 24–48 hours from laparotomic access; the presence of a high risk of developing repeated life-threatening uncontrolled intra-pelvic and intra-abdominal bleeding. Implementation of pelvic tamponade with transperitoneal access is only possible when performing laparotomy for abdominal injuries of related organs and detecting increasing or dissected pelvic retroperitoneal hematoma with the loss of "biological tamponade" effect, wherein the combined tamponade pelvis is not completely excluded [9].

The mechanical fixation of the unstable pelvic ring before the use of other surgical methods of hemostasis should not be neglected, let alone rejected, since in the first place it provides strong stabilization of bone fragments. The control of bleeding from the cancellous bone occurs when the wound surfaces are fully combined and adequate inter-fragment compression is achieved, which is ensured by EFD stabilization of the pelvic ring. Optimum conditions are created for the development of biological (physiological) tamponade of the pelvic cavity and antishock effect reducing nociceptive impulses, and there is also the possibility of early mobilization of the victim for various diagnostic and treatment measures. Mechanical fixation of the pelvis in a patient with unstable damage to the pelvic ring and unstable hemodynamics should be done as quickly as possible. Such urgent fixation is included in various algorithms for the treatment of severe injuries such as *Advanced Trauma Life Support (ATLS)* and others [12, 27, 28]. According to these algorithms, stabilization of the damaged pelvis is performed within the first ("golden") hour of the victim's admission to the trauma center.

Recently, the possibility of early minimally invasive osteosynthesis of damaged posterior structures of the pelvis with iliac-sacral screws has been discussed in the literature [29]. A number of authors believe that this osteosynthesis is difficult to recommend for use as part of the *Damage Control Orthopedics* tactics due to the long duration of this intervention, exceeding all reasonable

terms necessary to control bleeding in hemodynamically unstable patients. Also, according to *H.C. Pape* algorythm (2010) , designed to provide specialized trauma care to victims with injuries of the musculoskeletal system with varying degrees of severity, the victims of the studied groups belong to the category that should be treated in accordance with the *Damage Control Orthopedics* tactics, which involves extra-focal fixation of shockogenic body segments, including the pelvis. However, in the "borderline" and "unstable"patients of the main group, while maintaining a general positive tendency to stabilize hemodynamics after performing surgical hemostasis (tamponade, hypertension and embolization), we used minimally invasive osteosynthesis of the damaged posterior pelvic ring with iliac-sacral screws. This surgery was performed on the background of a fixed pelvic ring with anterior frame of EFD. Surgery was performed on average in no more than 30 minutes, while there were no intraoperative restrictions or time delays. The iliac-sacral screws created reliable compression in the damaged posterior structures of the pelvis and provided the final stable fixation. For those victims who initially had the posterior pelvis fixed with the Ganz clamp, osteosynthesis with the sacroiliac screws was performed on the 2nd day after the injury, after the removal of the frame. Critical patients did not need final fixation of the posterior part of the pelvis with iliac-sacral screws in the acute period of injury, since their condition was so unstable that they needed continued intensive care, and all surgical aids were limited in time and volume, not only on the pelvis, but also on other areas of the body. The ability to perform this surgery within 2 days after the injury is discussed individually and must be justified.

Various diagnostic and treatment algorithms are suggested for severe pelvic injury. The structure of the algorithms is diverse. It includes the sequence of therapeutic and diagnostic measures taking into account certain periods, as is customary in modern literature - the "golden hour", considers a different sequence of diagnostic measures (ultrasound, laparocentesis, MSCT with contrast enhancement, diagnostic pelvic hypertension), various approaches to the organization of specialized medical care delivery in the form of the distribution of victims into groups according to the severity of the condition, the presence of signs of hemodynamic instability or the type of damage to the pelvis, emergency operations are discussed: the fixation of multiple pelvic fractures (EFD, Ganz clamp, pelvic fixator), the use of pelvic tamponade, hypertension with selective or non-selective embolization, minimally invasive technologies of osteosynthesis with iliac-sacral screws or transpedicular systems [29–34].

## CONCLUSION

All suggested diagnostic and treatment algorithms have their advantages and disadvantages. Basically, they are recommended for victims who have a polytrauma in peacetime and with a limited flow of admission to the trauma center. However, with massive sanitary losses in armed conflict and in various emergency situations, these algorithms are not always applicable due to the limited resources of the medical service at one stage or another of medical evacuation. It should be noted that in ordinary life, the order of diagnostic measures and the phasing of surgical aids aimed at achieving the final surgical hemostasis in case of unstable pelvic ring injuries is determined by the quality of the on-duty team of the anti-shock operating room, their skills in performing these urgent operations, including minimally invasive endovascular ones, and also the material and technical support of the units of the trauma center, which receives a specific victim with a severe multisystem pelvic injury. None of the ways to stop pelvic bleeding in isolation provides final hemostasis, and only their combined use will contribute to success in the treatment of this category of seriously injured with polytrauma.

## FINDINGS

1. Surgical methods of hemostasis in combination with the mechanical stabilization of the damaged pelvic ring should be actively used in patients with ongoing intra-pelvic bleeding. In this case, a final control of the ongoing bleeding can be achieved in ¾ victims.

2. The choice of the method of surgical hemostasis in case of a pelvic injury depends on the severity of the victim's condition, hemodynamic parameters, the presence of life-threatening consequences of damage to other areas of the body, the effectiveness of the previously performed method of intrathoracic bleeding control, and also the availability of the necessary possibilities and means of emergency duty.

3. The introduction of the developed diagnostic and treatment algorithm aimed at achieving the final surgical hemostasis in patients with severe multisystem pelvic trauma reduced the overall mortality rate by 1.7 times, daily mortality rate by 2.3 times, due to irreversible blood loss - by 2.6 times, as well as reduce the duration and volume of replacement blood transfusion therapy by 1.8 times.

## REFERENCES


1. Biffl WL, Smith WR, Moore EE, Gonzalez RJ, Morgan SJ, Hennessey T, et al. Evolution of a multidisciplinary clinical pathway for the management of unstable patients with pelvic fractures. *Ann Surg*. 2001;233(6):843–850. PMID: 11407336 https://doi.org/10.1097/00000658-200106000-00015
2. Sarin EL, Moore JB, Moore EE, Shannon MR, Ray CE, Morgan SJ, et al. Pelvic fracture pattern does not always predict the need for urgent embolization. *J Trauma*. 2005;58(5):973–977. PMID: 15920411 https://doi.org/10.1097/01.ta.0000171985.33322.b4
3. Hagiwara A, Minakawa K, Fukushima H, Murata A, Masuda H, Shimazaki S. Predictors of death in patients with life-threatening pelvic hemorrhage after successful transcatheter arterial embolization. *J Trauma*. 2003;55(4):696–703. PMID: 14566125 https://doi.org/10.1097/01.TA.0000053384.85091.C6
4. Balogh Z, King KL, Mackay P, McDougall D, Mackenzie S, Evans JA, et al. The epidemiology of pelvic ring fractures: a population-based study. *J Trauma*. 2007;63(5):1066–1073. PMID:17993952 https://doi.org/10.1097/TA.0b013e3181589fa4
5. Chiara O, Fratta E, Mariani A, Michaela B, Prestini L, Sammartano F, et al. Efficacy of extra-peritoneal pelvic packing in hemodynamically unstable pelvic fractures, a Propensity Score Analysis. *World J Emerg Surg*. 2016;11:22. PMID: 27252773 https://doi.org/10.1186/s13017-016-0077-2
6. Gruen RL, Jurkovich GJ, McIntyre LK, Foy HM, Maier RV. Patterns of errors contributing to trauma mortality: lessons learned from 2,594 deaths. *Ann Surg*. 2006;244(3):371–380. PMID: 16926563 https://doi.org/10.1097/01.sla.0000234655.83517.56
7. Pohlemann T, Bosch U, Gansslen A, Tscherne H. The Hannover experience in management of pelvic fractures. *Clin Orthop Relat Res*. 1994;(305):69–80. PMID: 8050249
8. Tesoriero R, Bruns B, Narayan M, Dubose J, Guliani SS, Brenner ML,et al. Angiographic embolization for hemorrhage following pelvic fracture: is it "time" for a paradigm shift? *J Trauma Acute Care Surg*. 2017;82(1):18–26. PMID: 27602911 https://doi.org/10.1097/TA.0000000000001259
9. Tile M, Helfet DL, Kellam JF, Vrahas Mark (eds.). *Fractures of the pelvis and acetabulum*. 4ed. New York: Thieme; 2015.
10. Gumanenko E.K., Samokhvalov I.M. (eds.). *Voenno-polevaya khirurgiya lokal'nykh voyn i vooruzhennykh konfliktov.* Moscow: GEOTAR-Media Publ.; 2011. (In Russ.)
11. Tsibin Yu.N., Gal'tseva I.V., Rybakov I.R. Prognozirovanie iskhodov tyazheloy travmy, oslozhnennoy shokom. In: *Travmaticheskiy shok*. Leningrad: Meditsina Publ.; 1975. pp. 29–34. (In Russ.).
12. Pape HC, Giannoudis PV, Krettek C, Trentz O.Timing of fixation of major fractures in blunt polytrauma: role of conventional indicators in clinical decision making. *J Orthopaedic Trauma*. 2005;19(8):551–562. PMID: 16118563 https://doi.org/10.1097/01.bot.0000161712.87129.80
13. Kozlov I.Z., Gorshkov S.Z., Volkov V.S. *Povrezhdeniya zhivota*. Moscow: Meditsina Publ.; 1988. (In Russ.).
14. Majeed SA. Grading the outcome of pelvic fractures. *J Bone Joint Surg Br*. 1989;71(B):304–306. PMID: 2925751
15. Brenner ML, Moore LJ, DuBose JJ, Tyson GH, McNutt MK, Albarado RP, et al. A clinical series of resuscitative endovascular balloon occlusion of the aorta for hemorrhage control and resuscitation. *J Trauma Acute Care Surg*. 2013;75(3):506–511. PMID: 24089121 https://doi.org/10.1097/TA.0b013e31829e5416

16. Martinelli T, Thony F, Decléty P, Sengel C, Broux C, Tonetti J, et al. Intra-aortic balloon occlusion to salvage patients with life-threatening hemorrhagic shocks from pelvic fractures. *J Trauma*. 2010;68(4):942–948. PMID: 20173661 https://doi.org/10.1097/TA.0b013e3181c40579
17. DuBose J, Inaba K, Barmparas G, Teixeira PG, Teixeira PG, Schnüriger B, et al. Bilateral internal iliac artery ligation as a damage control approach in massive retroperitoneal bleeding after pelvic fracture. *J Trauma*. 2010;69(6):1507–1514. PMID: 20495490 https://doi.org/10.1097/TA.0b013e3181d74c2f
18. Horton RE, Hamilton GI. Ligature of the internal iliac artery for massive haemorrhage complicating fracture of the pelvis. *J Bone Joint Surg Br*. 1968;50(2):376–379. PMID: 5651345
19. Ravitch MM. Hypogastric artery ligation in acute pelvic trauma. *Surgery*. 1964;56:601–602. PMID: 17480145 https://doi.org/10.1515/JPM.2007.049
20. Mineev K.P., Stel'makh K.K. Lechenie mnozhestvennoy i sochetannoy travmy taza. In: *Sovremennye tekhnologii v travmatologii i ortopedii*. Moscow Publ.; 1999: 101–103. (In Russ.).
21. Totterman A, Madsen JE, Skaga NO, Røise O. Extraperitoneal pelvic packing: a salvage procedure to control massive traumatic pelvic hemorrhage. *J Trauma*. 2007;62(4):843–852. PMID: 17426538 https://doi.org/10.1097/01.ta.0000221673.98117.c9
22. Velmahos GC, Chahwan S, Hanks SE, Murray JA, Berne TV, Asensio J, et al. Angiographic embolization of bilateral internal iliac arteries to control life-threatening hemorrhage after blunt trauma to the pelvis. *Am Surg*. 2000;66(9):858–862. PMID: 10993617
23. Burlew CC, Moore EE, Smith WR, Johnson JL, Biffl WL, Barnett CC, et al. Preperitoneal pelvic packing / external fixation with secondary angioembolization: optimal care for life–threatening hemorrhage from unstable pelvic fractures. *J Am Coll Surg*. 2011;212(4):628–635. PMID: 21463801 https://doi.org/10.1016/j.jamcollsurg.2010.12.020
24. Gourlay D, Hoffer E, Routt M, Bulger E. Pelvic angiography for recurrent traumatic pelvic arterial hemorrhage. *J Trauma*. 2005;59(5):1168–1173. PMID: 16385296 https://doi.org/10.1097/01.ta.0000189043.29179.e4
25. Tai DK, Li WH, Lee KY, Cheng M, Lee KB, Tang LF, et al. Retroperitoneal pelvic packing in the management of hemodynamically unstable pelvic fractures: a level I trauma center experience. *J Trauma*. 2011;71(4):E79–E86. PMID: 21610537 https://doi.org/10.1097/TA.0b013e31820cede0
26. Fu CY, Wu SC, Chen RJ, Wang YC, Chung PK, Yeh CC, et al. Evaluation of pelvic fracture stability and the need for angioembolization: pelvic instabilities on a plain film have an increased probability of requiring angioembolization. *Am J Emerg Med*. 2008;27(7):792–796. PMID: 19683106 https://doi.org/10.1016/j.ajem.2008.06.014
27. Miller PR, Moore PS, Mansell E, Meredith JW, Chang MC. External fixation or arteriogram in bleeding pelvic fracture: initial therapy guided by markers of arterial hemorrhage. *J Trauma*. 2003;54(3):437–443. PMID: 12634521 https://doi.org/10.1097/01.TA.0000053397.33827.DD
28. Tan EC, van Stigt SF, van Vugt AB. Effect of a new pelvic stabilizer (T-POD®) on reduction of pelvic volume and haemodynamic stability in unstable pelvic fractures. *Injury*. 2010;41(12):1239–1243. PMID: 21374905 https://doi.org/10.1016/j.injury.2010.03.013
29. Routt ML, Falicov A, Woodhouse E, Schildhauer TA. Circumferential pelvic antishock sheeting: a temporary resuscitation aid. *J Orthop Trauma*. 2002;16(1):45–48. PMID: 16385204 https://doi.org/10.1097/00005131-200201000-00010
30. Durkin A, Sagi HC, Durham R, Flint L. Contemporary management of pelvic fractures. *Am J Surg*. 2006;192(2):211–223. PMID: 16860634 https://doi.org/10.1016/j.amjsurg.2006.05.001
31. Fangio P, Asehnoune K, Edouard A, Smail N, Benhamou D. Early embolization and vasopressor administration for management of life-threatening hemorrhage from pelvic fracture. *J Trauma*. 2005;58(5):978–984. PMID: 15920412 https://doi.org/10.1097/01.ta.0000163435.39881.26
32. Hak DJ, Smith WR, Suzuki T. Management of hemorrhage in life–threatening pelvic fractures. *J Am Acad Orthop Surg*. 2009;17(7):447–457. PMID: 19571300
33. Karadimas EJ, Nicolson T, Kakagia DD, Matthews SJ, Richards PJ, Giannoudis PV. Angiographic embolisation of pelvic ring injuries. Treatment algorithm and review of the literature. *Inte Orthop*. 2011;35(9):1381–1390. PMID: 21584644 https://doi.org/10.1007/s00264-011-1271-1
34. Li Q, Dong J, Yang Y, Wang G, Wang Y, Liu P, et al. Retroperitoneal packing or angioembolization for haemorrhage control of pelvic fractures — quasi-randomized clinical trial of 56 haemodynamically unstable patients with injury severity score. *Injury*. 2016;47(2):395–401. PMID: 26508436 https://doi.org/10.1016/j.injury.2015.10.008

**Received on 04.04.2019**

**Accepted on 25.04.2019**