ECRONICON OPEN ACCESS

EC ORTHOPAEDICS
Research Article

Surgical Hemostasis for Severe Combined Pelvic Injuries

IV Kazhanov[1,2]*, AE Demko[1], VA Manukovsky[1], SI Mikityuk[1,2], VA Reva[1,2], EA Kolchanov[1] and DV Pavlov[1]

[1]Director – MD, State budgetary institution St. Petersburg Research Institute of Emergency Medicine. I.I. Dzhanelidze, St. Petersburg, Russia
[2]Head - Corresponding Member of the Russian Academy of Sciences, Doctor of Medical Sciences, Professor A.Ya. Fisun Federal State Budgetary Military Educational Institution of Higher Professional Education "Military Medical Academy. CM. Kirova "of the Ministry of Defense of the Russian Federation, St. Petersburg, Russia

***Corresponding Author:** IV Kazhanov, Director – MD, State budgetary institution St. Petersburg Research Institute of Emergency Medicine. I.I. Dzhanelidze, St. Petersburg, Russia.

Received: February 16, 2020; **Published:** March 23, 2020

Abstract

Introduction: For the treatment of patients with severe concomitant pelvic trauma, accompanied by intra-pelvic bleeding, many algorithms have been proposed that have different procedures for using various methods of surgical haemostasis, but not one of them can guarantee the final stop of pelvic bleeding.

The aim of the study was to assess the clinical effectiveness of the developed algorithm aimed at timely diagnosis of intra-pelvic bleeding and its final stop using various methods of surgical hemostasis in patients with severe combined pelvic trauma.

Materials and methods: The article analyses the results of treatment of 168 patients with unstable pelvic ring injuries and signs of intra-pelvic bleeding, who were treated in two trauma centers of the first level in St. Petersburg: St. Petersburg Scientific Research Institute of St. Petersburg. I.I. Dzhanelidze and the clinic of military field surgery CM. Kirova from 2010 to 2018 The victims were divided into two statistically homogeneous groups. In the comparison group (75 people), to stop intra-pelvic bleeding, the pelvic ring was mechanically stabilized in isolation by the Ganz frame or at the same time the front part of the pelvis was fixed with an external fixation device (AVF) and the continuation of the ongoing pelvic bleeding was expected due to the effect of biological tamponade. In the main group (93 people) after mechanical stabilization of the pelvic ring, various methods of surgical haemostasis were used: balloon aortic occlusion, pelvic tamponade, angiography with embolization. The choice of the method of surgical haemostasis in case of pelvic trauma depended 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 applied method for stopping intra-pelvic bleeding.

Conclusion: The introduction of a modern diagnostic and treatment algorithm aimed at achieving the final surgical haemostasis in patients with ongoing intra-pelvic bleeding has reduced the overall mortality rate by 1.7 times, the daily mortality rate by 2.3 times and also 1.8 times reduce the duration and volume of replacement blood transfusion therapy.

Keywords: *Polytrauma; Unstable Pelvic Ring Injuries; Retroperitoneal Pelvic Hematoma; Surgical Haemostasis; Ganz Frame; External Fixation; Pelvic Tamponade; Angiography and Embolization; Ileosacral Osteosynthesis*

Introduction

Pelvic injuries in patients with polytrauma are found in 3 - 9% of cases [1,2] and mortality in such patients ranges from 8 to 23% of cases [3]. Irreversible hemorrhage due to intra-pelvic bleeding is the main cause of mortality in the acute period of trauma 10 - 58% of cases [3-6]. As a rule, people of working age with a high level of severity of damage predominate among the victims (on an ISS scale of more than 25 points).

Continued pelvic bleeding is the main cause of hemodynamic instability in 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 poses a difficult task 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 intra-pelvic bleeding, each of which has its own indications, contraindications and conditions for use, advantages and disadvantages. Currently, for the treatment of patients with severe concomitant pelvic trauma accompanied by pelvic bleeding, many algorithms have been proposed that have different procedures for using various methods of surgical hemostasis, but not one of them can guarantee the final stop of pelvic bleeding and is considered the "gold standard" [7-9].

Purpose of the study

To evaluate the clinical effectiveness of the developed algorithm, aimed at timely diagnosis of intra-pelvic bleeding and its final stop using various methods of surgical hemostasis in patients with severe combined pelvic trauma.

Research objectives

- Develop a diagnostic and treatment algorithm to achieve surgical hemostasis in patients with severe combined pelvic trauma.
- Compare the results of treatment of victims with signs of ongoing intra-pelvic bleeding, which performed a different volume of emergency specialized medical care, consisting in mechanical stabilization of the pelvic ring or, in addition to it, the use of other methods of surgical hemostasis (pelvic tamponade, angiography and embolization, balloon aortic occlusion).

Material and Methods

The results of treatment of 168 patients with severe combined pelvic trauma accompanied by pelvic bleeding, who were admitted to treatment at two trauma centers of the first level in St. Petersburg: St. Petersburg Research Institute of SP named after I.I. Dzhanelidze and the clinic of military field surgery CM. Kirova from 2010 to 2018.

All the victims were of working age, the average age was 41.0 ± 16.8 years. There were 103 men (61.4%) and 65 women (38.6%). Most of the victims 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 (56.5%); drop from a height - 62 (36.9%); compression - 11 (6.5%) cases.

All injuries were assessed for the severity of injuries on the ISS, VPH-P (MT) scales and traumatic brain injury on the Glasgow coma scale and the severity of the condition was assessed on the VPH-SP scale [10]. We also assessed the shock genicity of the injury according to the method of Yu.N. Qibina (1975) [11]. For a more accurate assessment of the severity of the condition of the victims, pathophysiological signs indicating acute massive blood loss, shifts of homeostasis in the body according to a simplified table scheme developed by H.C. were additionally considered. Pape, allowing to distinguish the clinical classes of victims [12].

The study included patients with unstable pelvic ring injuries and signs of intra-pelvic bleeding, classified according to the severity of the condition to classes - borderline and unstable, as well as critical (with the effectiveness of resuscitation measures). Most - 132 (78.1%) of the victims had unstable hemodynamics, which was determined by keeping the systolic blood pressure (SBP) index below 90 mm. Hg. Art., despite the performed infusion therapy in the amount of 2000 ml of crystalloid, as well as the presence of minimal vasopressor and inotropic support.

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

When formulating indications for emergency operations in one volume or another, as well as determining their sequence, the severity of the victim's condition was considered immediately upon admission to the anti-shock operating trauma centre. For patients with severe concomitant pelvic trauma and unstable hemodynamics, specialized medical assistance consisted in an X-ray examination of the chest and pelvis, ultrasound of the pleural, abdominal cavities, pericardial volume 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 (< 500 ml) if in one of the anatomical spaces of the abdominal cavity (most often in the Morrison space) the separation of the peritoneal sheets was < 2 cm.

In critically injured patients, emergency surgical aids were used as part of the Damage Control Surgery tactics 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 hypertension with embolization, stabilization of the unstable pelvic ring using one of the methods or their combination (pelvic dressing, Ganz frame, AVF).

According to the classification of M. Tile, M.E. Muller AO / ASIF vertically unstable pelvic ring lesions were detected in 89 (53, 3%), rotationally unstable in 79 (46, 7%) patients. Given the mechanism of damage to the pelvic ring according to the classification of Young J., Burgess A. (1990), the distribution was as follows: anteroposterior compression was in 27 (16.1%); lateral compression- 55 (32.7%); vertical shift- 44 (26.2%); combined type-42 (24.9%).

The victims were divided into two statistically homogeneous groups. The comparison group (75 people) was formed from the victims who had to stabilize the pelvic ring to isolate the pelvic hemorrhage in isolation of the external fixation apparatus "AREET", "KST-1", "MKTs" (Russia) or simultaneously with the Ganz frame (DePuy Synthes, Switzerland) , while any additional methods of surgical hemostasis after mechanical fixation were not used. It was believed that extrafocal fixation of an unstable pelvic ring provides reliable stabilization of bone fragments and reduces the pelvic cavity. The stoppage of intra-pelvic hemorrhage was achieved due to the development of the biological tamponade effect, in which, simultaneously with an increase in intracavitary pressure in the retroperitoneal space due to its filling with blood and the formation of a clot, the pressure in the damaged vessels of the pelvic cavity decreased until the values were equalized.

In the main group (93 people), in addition to mechanical stabilization of the pelvic ring, various methods of surgical stopping of pelvic bleeding were used: pelvic tamponade, angiography with embolization, balloon aortic occlusion. The provision of specialized medical care

to the victims of this group was carried out considering the developed treatment and diagnostic algorithm aimed at the final control of pelvic bleeding (Figure 1).

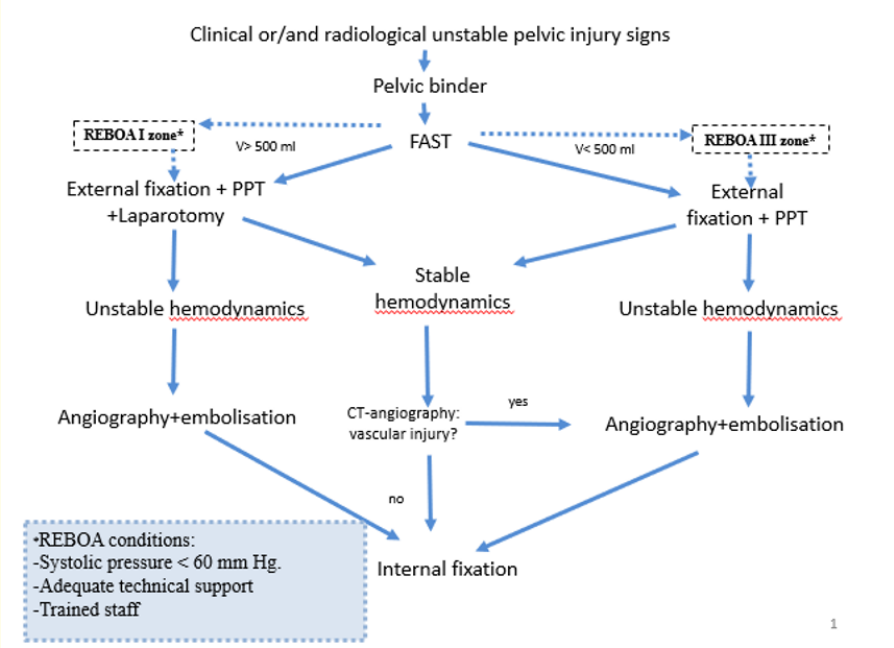


Figure 1: *The treatment and diagnostic algorithm to achieve surgical hemostasis in patients with severe pelvic trauma and unstable hemodynamics.*

Table 1 compares the studied groups by sex, age, systolic blood pressure (SBP) at admission, the severity of the damage and the condition of the victims, taking into account the average values of the indicators of various scales of mechanical injuries.

Indicator	Main group (n_1 = 93)	Comparison group (n_2 = 75)
Men Women	56 (60,3) 37 (39,7)	47 (62,7) 28 (37,3)
Average age, years	39,7 ± 16,3	43,0 ± 20,4
Glasgow Coma Scale	9,7 ± 3,3	8,9 ± 3,0
sAD <90mm cape. st.	73 (78,5)	59 (78,6)
sAD> 90mm cape. st.	20 (21,5)	16 (21,3)
The severity of damage on the ISS scale, points	37,4 ± 9,6	39,5 ± 9,4
The severity of damage on the scale VPH-P (MT), points	15,9 ± 10,9	16,6 ± 10,1
The severity of the condition on the scale of VPH-SP, points	36,9 ± 9,3	43,0 ± 15,7
The severity of damage on a scale of Yu. N. Tsibin, points	12,7 ± 5,2	13,4 ± 5,4
Criterion T (Tsibin Yu.N.), hours	– 4,3 ± 18,1	– 5,2 ± 18,4

Table 1: *The structure and characteristics of groups, n (%), M ± m.*

The qualitative characteristics of the scales used to assess the severity of damage and condition in the victims are presented in table 2.

Indicator	Group the main (n_1 = 93)	Group comparisons (n_2 = 75)
The severity of damage on the scale VPH-P (MT), points		
from 1 to 12 points	40 (43,0%)	25 (33,3%)
more than 12 points	53 (57,0%)	50 (66,7%)
The severity of the condition on the scale of VPH-SP, points		
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 (Tsibin Yu.N., 1975), hours		
Positive outlook	9 (9,7%)	6 (8,0%)
The forecast is doubtful	17 (18,3%)	12 (16,0%)
Negative outlook	67 (72,0%)	57 (76,0%)
The severity of damage on the ISS scale, points		
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%)
Clinical class according to the severity of the condition (according to Rare N.S., 2005):		
• border	34 (36,6)	28 (37,3)
• unstable	43 (46,2)	33 (44,0)
• critical	16 (17,2)	14 (18,7)

Table 2: *Characteristics of the studied groups, n (%).*

As can be seen from table 3, more than 90% of the victims had a severe trauma (on the ISS scale > 25 points) and a serious condition (on the VPH-SP scale > 32 points) with an unfavourable prognosis. 35, 5% of the victims had combined abdominal damage with ongoing intra-abdominal bleeding.

Pelvic damage	Main group (n_1 =93)	Comparison group (n_2 = 75)
Classification 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 Young J., Burgess A. (1990)		
• front-back compression (type AR)	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)

Table 3: *Type of unstable damage to the pelvic ring n = 168, n (%).*

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

In addition to intra-pelvic bleeding, there were various life-threatening consequences of damage to other areas of the body (Table 4), including 84 (50%) of the victims who had two or more life-threatening consequences of damage to other areas of the body.

Indicator	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)	-

Table 4: *Life-threatening effects of damage, n (%), M ± m.*

Final hemostasis was determined by a change in the following parameters: CAD, the volume and duration of replacement blood transfusion therapy and in the main group, additionally, after stabilization of hemodynamic parameters, by the results of pelvic CT with intravenous contrast enhancement or diagnostic pelvic angiography (AH).

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

Results and their Analysis

Upon receipt of victims with severe concomitant pelvic trauma and signs of ongoing intra-pelvic bleeding, intensive anti-shock therapy was started simultaneously with emergency diagnostic measures and surgical interventions. The first stage in the provision of specialized surgical care to the injured, according to the developed diagnostic and treatment algorithm for the final stop of pelvic bleeding, performed mechanical fixation of the unstable pelvic ring. It should be noted that in the absence of fixation of the pelvis at the prehospital stage, an impromptu antishock pelvic dressing or pelvic girdle (Medplant, Russia or T-POD, USA) was applied during the examination. In the future, the method of surgical fixation of the pelvis depended on the type of damage to the pelvic ring. Vertically unstable damage to the posterior structures of the pelvis was fixed by the Ganz frame (DePuy Synthes, Switzerland), while parts of the victims were supplemented with anterior AFF frame for fixation. Rotationally unstable pelvic injuries were recorded by AVF. Eleven injured (11, 8%) of the main group additionally stabilized the posterior pelvic ileo-sacral screws.

Those affected in the clinical classes: unstable - 17 (41, 5%) and critical- 24 (58, 5%) after mechanical fixation of the pelvic ring due to persistent unstable hemodynamics, performed pelvic tamponade in the next 30 minutes using one of the methods (extraperitoneal, transperitoneal, combined) Pelvic tamponade was performed in the absence of other sources of bleeding besides the pelvic.

Twelve (12, 9%) patients who were in critical condition (critical class) with unstable hemodynamics (SBP < 70 mm Hg) performed endovascular balloon aortic occlusion (EVBOA). In most cases (9 people), an obturator balloon was installed in the I aortic zone (in the presence of ultrasonic signs of moderate or significant accumulation of free fluid in the abdominal cavity), in 3 cases - in the III aortic zone (in the absence of ultrasonic signs of free fluid or with a small amount in the abdominal cavity - < 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, stopping intra-abdominal bleeding; sanitation of the tracheobronchial tree to eliminate asphyxiation; primary surgical treatment of wounds with a stop of ongoing external bleeding, decompressive craniotomy due to compression of the brain by intracerebral hematoma (Table 5).

Types of operations	Group the main (n_1 = 93)	Group comparisons (n_2 = 75)
Laparotomy for abdominal injuries	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, stop intrapleural bleeding	3 (3,2)	1 (1,3)
Elimination of asphyxia of various origins	7 (7,5)	9 (12,0)
Trepanation	-	1 (1,3)
Thoracotomy, clamping on the thoracic aorta	1 (1,1)	3 (4,0)
Stop external bleeding	7 (7,5)	5 (6,7)

Table 5: *The structure of emergency operations in the anti-shock operating room, n (%).*

A CT scan with intravenous contrast was performed on 31 (33, 3%) victims, according to the results of which the following were found: extravasation of contrast medium - in 6, vascular contrast interruption - in 2 cases. In most clinical cases, retroperitoneal pelvic hematoma spread to a kidney level of 105 (62.5%) and a diaphragm level of 63 (37.5%) cases. According to CT results, in 121 (72, 0%) patients, a large retroperitoneal pelvic hematoma with a volume of more than 500 ml was confirmed. The prevalence of retroperitoneal pelvic hematoma was specified during diagnostic laparoscopy or laparotomy in 85 (50.6%) clinical cases. In 48 (28.6%) patients, due to their extremely serious condition, the presence of retroperitoneal pelvic hematoma was confirmed by clinical data.

In the clinical classes, borderline- 4 and unstable- 3 patients undergoing stabilization of hemodynamic parameters or maintaining unstable hemodynamics with minimal vasopressor and inotropic support underwent pelvic angiography. Indications for its implementation were: intraoperative detection of increasing in the volume of retroperitoneal pelvic hematoma; the presence of signs of damage to the vessels of the pelvic cavity during SKT with intravenous contrast enhancement (extravasation of the contrast medium, stop contrast or loss of contrast, false aneurysm), as well as blood transfusion need for 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 angiography were extravasation of the contrast medium, vascular rupture and pseudo-aneurysm. When damage to the arterial vessels of the pelvis was detected, they were embolized. In two cases, selective lumbar-iliac and upper gluteal artery embolization was performed and in two cases, non-selective embolization of the internal iliac artery was performed. It should also be noted that angiography was performed on 9 patients after pelvic tamponade in order to control hemostasis, while the arterial source of intrathoracic bleeding was detected in 6 cases. Selective (4 observations) and non-selective (2 observations) embolization of damaged arterial branches was performed (Table 6).

A correlation between the nature of the pelvic ring fracture and the diagnosed damaged vessels of the basin of the internal iliac artery (VPA) was not detected due to the small number of observations. In most cases, only one damaged artery was determined.

Types of operations	Group the main (n_1 = 93)	Group comparisons (n_2 = 75)
Fixation of the front structures of the AVF pelvis	47 (50,5)	67 (89,3)
Fixation of the posterior structures of the pelvis by the Ganz frame	6 (6,4)	4 (5,3)
Simultaneous fixation of the anterior and posterior pelvic structures	29 (31,1)	4 (5,3)
Combined fixation (AVF + immersion osteosynthesis)	11 (11,8)	-
Extraperitoneal pelvic tamponade (VTT)	26 (27,9)	-
Peritoneal Tamponade of the Pelvis (CTT)	11 (11,8)	-
Combined pelvic tamponade (CTT)	4 (4,3)	
Diagnostic Pelvic Angiography (AH) Isolated Of which with embolization After tamponade of the pelvis Of which with embolization	16 (17,2) 7 (7,5) 4 (4,3) 9 (9,8) 6 (6,5)	-
Endovascular balloon aortic occlusion (EVBOA)	12(12,9)	-

Table 6: *Methods of surgical hemostasis used, n (%).*

During the period of relative stabilization of the victim's condition (from 12 hours 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 AVF was left as the final version treatment in the comparison group.

The total mortality of victims in the comparison group was 53 (70.7%), of which 34 (45.3%) people died on the first day. In the main group, the total mortality rate was 39 (41.9%), of which 18 (19.3%) people died on the first day. One of the main causes of death of 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 developing complications), almost the same frequency of visceral and generalized infectious complications was observed (Table 7).

Parameters	Group the main (n_1 = 93)	Group comparisons (n_2 = 75)	P < 0,05
General mortality	39 (41,9)	53 (70,7)	+
Mortality up to 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 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 Thromboembolism (PE)	1 (1,1)	1 (1,3)	–
Fat embolism	2 (2,1)	1 (1,3)	–
Survived	54 (58,0)	22 (29,3)	+
Ultimate 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, day	1,4 ± 0,6	2,5 ± 3,7	+
The term of inpatient treatment, day	37,4 ± 35,1	52,5 ± 29,8	+

Table 7: *The results of treatment, n (%), M ± m.*

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

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 needed 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 in days.

The use of a modern diagnostic and treatment algorithm to achieve surgical hemostasis in patients with severe concomitant 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, including due to irreversible blood loss - 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.

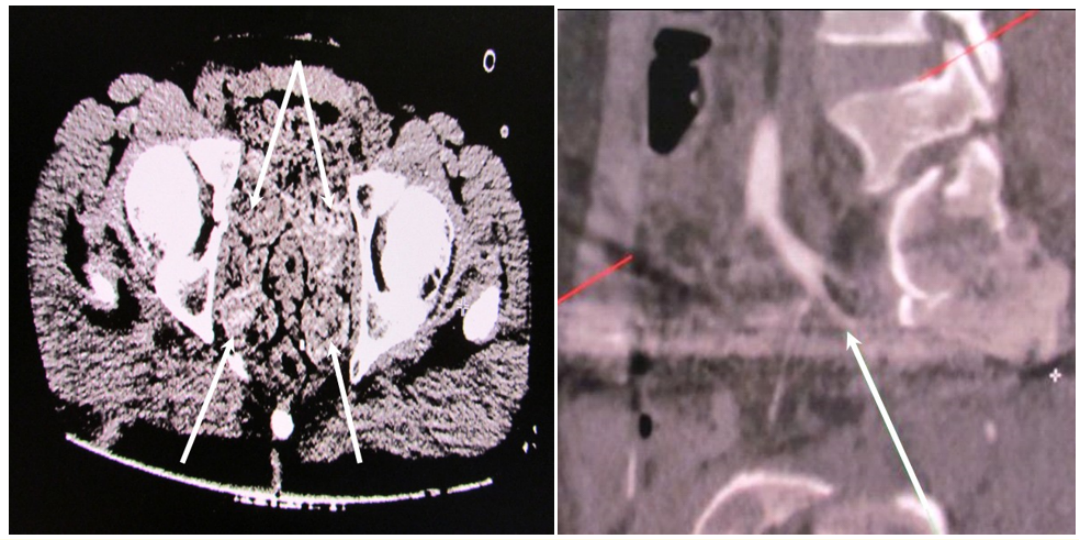
A treatment option for a victim with severe combined pelvic trauma is presented as a clinical observation.

Clinical observation

Injured Z., 33 years old, received a severe combined trauma to the head, neck, chest, abdomen, pelvis, limbs. An open head injury. A brain injury of moderate severity. Torn-bruised wound of the right frontoparietal region. Closed chest injury with a fracture of the left clavicle, body of the left shoulder blade. Closed abdominal injury with rupture of the spleen 3 tbsp. Continuing abdominal bleeding. Hemoperitoneum (800 ml). Multiple pelvic trauma. Closed rotationally unstable pelvic ring damage: fractures of the right pubic and ischial 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. Torn-bruised wound of the lower third of the right thigh. Acute massive blood loss. Traumatic shock III Art. Upon admission to the anti-shock operating blood pressure 70 and 35 mm Hg Art., heart rate 127 beats. in minutes the severity of injuries on the ISS scale is 29 points, VPH-P (MT) - 10.8 points, the severity of the condition on the VPH-SP scale is 43 points, the severity of a head injury on the Glasgow com scale is 10 points.

The victim according to the severity of the condition is assigned to the clinical class of unstable. Emergency specialized surgical care was provided according to the proposed treatment and diagnostic algorithm. During the examination, the pelvic ring is fixed with an antishock pelvic girdle. Given the persistent unstable hemodynamics, the extensive retroperitoneal pelvic hematoma (up to the diaphragm level) detected during laparotomy with splenectomy, an extraperitoneal pelvic tamponade was performed after fixing the unstable pelvic ring of the AVF. An epicystostomy is imposed. Relative stabilization of hemodynamic parameters was noted against a background of reduced to minimal levels of vasopressor and inotropic support. Next, the primary surgical treatment of head wounds and an open fracture of the left femur with extra focal fixation of AVF was performed. In order to monitor the effectiveness of VTT and to clarify the nature of damage to the pelvic ring, the patient underwent SCT with intravenous contrasting (Figure 2). Signs of damage to the arterial vessel of the pelvic cavity were revealed.

In order to verify the arterial source of intra-pelvic bleeding, a diagnostic AH was performed. Stop contrast was revealed at the level of the anterior trunk of the right internal iliac artery (Figure 3), which indirectly indicated it as a possible main source of intra-pelvic bleeding. The selective embolization of the damaged arterial vessel with the Terumo spirals, Japan was performed.



a) ***b)***

Figure 2: *CT of the pelvis with intravenous contrast: a - axial section at the level of the acetabulum (arrows indicate tampons); b - a break in contrast at the level of the anterior trunk of the right internal iliac artery (indicated by an arrow).*

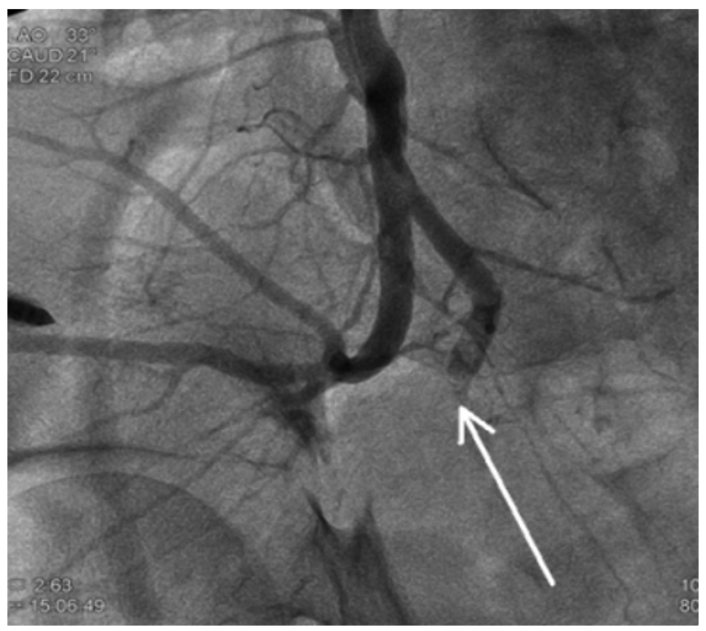


Figure 3: *Diagnostic pelvic angiography after VTT (the arrow indicates the break in contrast at the level of the anterior trunk of the right internal iliac artery).*

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

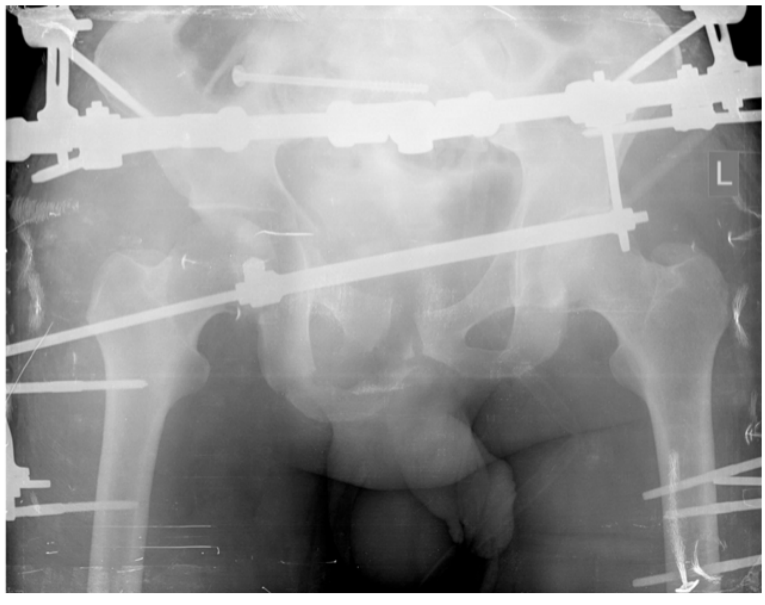


Figure 4: *X-ray of the pelvis (anteroposterior projection) after fixation of AVF and osteosynthesis with the sacroiliac screw.*

Tampons from the pelvic cavity were removed on the 3rd day, the urethral continuity was restored according to the Albaran-Vishnevsky method on the urinary catheter by means of counter-bugging, the pelvic cavity and paravesical tissue were drained according to Buyalsky-Mac-Worther. On the 15th day, a fracture of the femur is fixed with an intramedullary shaft with blocking. Postoperative course without features. Early rehabilitation treatment started. AVF from the pelvis was dismantled on the 30th day, discharged on the 39th day after the injury. When assessing long-term results of treatment, the quantitative value of the final index on the S.A. scale. Majeed [14] amounted to 89 points, which corresponds to good functional treatment results.

Discussion

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

EVBOA helps to increase systemic blood pressure and stop internal bleeding, including intra-pelvic. 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 disadvantages of the method are the risks of complications such as: damage to the femoral artery, improper positioning of the balloon in the aorta, accidental inappropriate catheterization and damage to the vessel, displacement of the balloon due to lack of sufficient support, severe reperfusion due to prolonged standing of the balloon, bleeding from the vascular access zone [15,16].

In the literature, the issue of indications for VPA ligation on the damage side continues to be discussed in the absence of a positive effect of hemostatic therapy, including the application of AVF. There are also opposing points of view. So, J. DuBose believes that even bilateral

wound dressing of the VPA, as a rule, cannot stop deadly 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 VPA ligation is not effective due to the fact that the 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 internal iliac arteries and subsequent pelvic tamponade through the abdominal cavity leads to disastrous consequences [18,19]. Another point of view is held by K.P. Mineev, who promotes this method as a life-saving method for ongoing arterial and venous pelvic bleeding and believes that the ligation of the VPA and their branches is anatomically and functionally permissible and effective, having successful experience of dressing in 12 patients [20].

Information on the frequency of arterial bleeding was obtained by analyzing 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 parenchymal organs of the abdomen. In 90% of cases, it is possible to embolize a damaged vessel and stop ongoing bleeding, which reduces the need for additional surgical interventions. However, there are several drawbacks, one of which is that, despite performing AH and embolization and 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 haemostatic embolization is 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" measure in cases of intracranial hemorrhage that is resistant to replacement blood transfusion therapy, which has a significant effect on hemodynamics and which 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 with the help of AH, while the percentage of such bleeding during pelvic injuries is only 10.0 - 20.0%. The remaining 80.0% of bleeding with damage to the pelvis is of venous origin or bleeding from the fracture surface. In some cases, due to heavy blood loss, selective embolization is not possible. For those affected, it's best to try to stop pelvic bleeding using blind embolization. For this, two millimetre Gelfoam cubes are inserted into the internal iliac artery. The gel spreads and clogs most of the arterial vessels in the bed of the internal iliac artery. Such a volume of gel is enough to prevent it from entering the pelvic capillary network and maintain the movement of blood through it, thereby avoiding ischemic complications.

It should be emphasized that sometimes repeated pelvic hypertension is required, especially in those cases when the patient still needs to undergo hem transfusion replacement therapy, which indirectly indicates persistent intracranial bleeding. Repeated pelvic hypertension is performed with a frequency of 6.7 to 40.0% [22]. D. Gourley showed that about 7.5% of patients with pelvic trauma who initially underwent embolization underwent repeated pelvic hypertension, according to the results of which pelvic bleeding was determined in 80% of cases, of which 68% from another damaged artery, initially embolized artery in 18%, from both arterial sources in 14% of cases [24]. GC Velmahos reported a temporary embolization of both internal iliac arteries in patients with damage to the pelvic arteries, while bleeding could not be stopped by selective embolization.

There are articles comparing two groups of victims who underwent pelvic tamponade and diagnostic angiography with embolization [25]. The authors noted that in the group where hypertension was primarily used and embolization, the need for blood transfusion therapy was higher than after pelvic tamponade. On the contrary, in the group with VTT, the time from the moment of receipt to the operation and the time of the operation itself is much shorter and it is also possible to simultaneously perform urgent operations to eliminate the life-threatening consequences of injuries on other areas of the body in the form of laparotomy, etc. However, a detailed study of the literary

material shows that after pelvic tamponade the frequency of diagnostic hypertension 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 and without signs of hypo coagulation, are subject to stable or transiently changing infusion-transfusion therapy. Also, to carry out 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 systolic blood pressure, therefore, direct surgical hemostasis in the form of pelvic tamponade, which acts as a kind of "bridge" to subsequent angiography with temporary stabilization of hemodynamics, should be preferred. In order to reduce mortality among patients with severe concomitant pelvic trauma, mechanical fixation of the pelvic ring bones in combination with surgical hemostasis should be performed to successfully stop pelvic bleeding. But given the organizational problems associated with creating the conditions for performing angiography, the most rational is the implementation of extraperitoneal pelvic tamponade.

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 VTT technique cannot provide a enough 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 intra-pelvic bleeding [19]. With extraperitoneal access, the intact side cannot be open enough to install tampons and this surgical procedure can be recommended if there is no need to perform emergency laparotomy [9]. However, we believe that BTT has obvious advantages and provides minimal intraoperative blood loss, reduces the risk of developing abdominal compartment syndrome and repeated life-threatening uncontrolled intrathoracic bleeding and it is possible to remove tampons more than 72 hours after surgery without performing relaparotomy. When performing peritoneal tamponade, the following disadvantages were noted: high risk of developing abdominal compartment syndrome; additional intraoperative blood loss; the need to remove tampons in a period of 24 to 48 hours from laparotomy access; there is a high risk of developing repeated life-threatening uncontrolled intra-pelvic and intra-abdominal bleeding. Performing pelvic tamponade by means of peritoneal access is only possible when performing laparotomy for concomitant damage to the abdominal organs and detecting an increased in volume or opened retroperitoneal pelvic hematoma with the loss of the "biological tamponade" effect combined pelvic tamponade was not completely ruled out.

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 stopping of bleeding from the cancellous bone occurs with the full combination of wound surfaces and adequate inter-fragment compression, which is achieved by stabilization of the pelvic ring of AVF. Optimum conditions are created for the development of biological (physiological) tamponade of the pelvic cavity and antishock effect by 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 - Advanced Trauma Life Support (ATLS) and others [12,27,28]. According to these algorithms, stabilization of a damaged pelvis is performed during 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]. Several authors believe that this immersion osteosynthesis is difficult to recommend for use within the framework of Damage Control Orthopedics tactics, due to the long duration of this intervention, exceeding all reasonable terms necessary to stop bleeding in hemodynamically unstable patients. Also according to Rare N.S. algorithm (2010), developed to organize the provision of specialized trauma care to victims of injuries of the musculoskeletal system with varying severity, the conditions of the victims of the studied groups belong to the category that should be treated in accordance with the Damage Control Orthopedics

tactics, providing for extra focal fixation of shockogenic body segments , including the pelvis. However, in the main group in the classes of victims, "borderline" and "unstable" while maintaining a general positive tendency to stabilize hemodynamics after performing surgical hemostasis (tamponade, hypertension and embolization), immersion minimally invasive osteosynthesis of the damaged posterior pelvic ring with iliac-sacral screws was used. This surgery was performed on a background of a fixed pelvic ring AVF with anterior frame.

Surgical allowance was carried out on average in no more than 30 minutes, while there were no intraoperative restrictions or time delays. The iliac-sacral screws created a reliable compression in the damaged posterior structures of the pelvis and provided the final stable fixation. For those victims who initially had the back of the pelvis fixed with the Ganz frame, immersion osteosynthesis with the sacroiliac screws was performed 2 days after the injury, after dismantling the frame. Critical class victims do not need final immersion fixation of the posterior part of the pelvis by the iliac-sacral screws in the acute period of injury, since their condition is so unstable that they need to be continued intensive therapy and all surgical aids are sharply limited in time and volume, not only on the pelvis and on other areas of the body. The ability to fulfill this benefit up to 2 days after the injury is taken individually and should be justified.

Various diagnostic and treatment algorithms are proposed for severe pelvic trauma. The structure of the algorithms is diverse. It includes the sequence of therapeutic and diagnostic measures taking into account certain periods, as is accepted in modern literature - the "golden hour", considers a different sequence of diagnostic measures (ultrasound, laparocentesis, CT with contrast enhancement, diagnostic pelvic hypertension), various approaches to the organization of delivery specialized medical care 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 of the pelvis, the sequence of emergency operations is discussed: the fixation of multiple pelvic fractures (AVF, Ganz frame, pelvic fixator), the use of pelvic tamponade, hypertension with selective or non-selective embolization, minimally invasive technologies for submersible osteosynthesis of the iliac-sacral screws or transpedicular systems [29-34].

Conclusion

All proposed diagnostic and treatment algorithms have their advantages and disadvantages. Basically, they are recommended for victims of political trauma in peacetime and with a limited flow of admission to the trauma center. However, with massive sanitary losses in armed conflicts and in various emergency situations, these algorithms are not entirely 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 and also the material and technical support of the units of the trauma center, which receives a specific victim with severe a crippled pelvic injury. None of the ways to stop pelvic bleeding in isolation will provide final hemostasis and only their use in combination will contribute to success in the treatment of this category of seriously injured with polytrauma.

- 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 stop of the ongoing bleeding can be achieved in ¾ victims.

- 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 injuries to other areas of the body, the effectiveness of the previously applied method for stopping intra-pelvic bleeding and also on the availability of the necessary forces and means of emergency duty.

- The introduction of a modern diagnostic and treatment algorithm aimed at achieving the final surgical hemostasis in patients with severe combined pelvic trauma reduced the overall mortality rate by 1.7 times and the daily mortality rate by 2.3 times, including 2 times due to irreversible blood loss , 6 times, as well as 1.8 times reduce the duration and volume of replacement blood transfusion therapy.

Source of funding

The study was conducted without sponsorship.

Conflict of Interest

Not declared.

Bibliography

1. Biffl WL., *et al*. "Evolution of a multidisciplinary clinical pathway for the management of unstable patients with pelvic fractures". *Annals of Surgery* 233.6 (2001): 843-850.

2. Sarin E.L., *et al*. "Pelvic fracture pattern does not always predict the need for urgent embolization". The *Journal of Trauma* 58.5 (2005): 973-977.

3. Hagiwara A., *et al*. "Predictors of death in patients with life-threatening pelvic hemorrhage after successful transcatheter arterial embolization". *Journal of Trauma and Acute Care Surgery* 55.4 (2003): 696-703.

4. Balogh Z., *et al*. "The epidemiology of pelvic ring fractures: a population-based study". *Journal of Trauma and Acute Care Surgery* 63. 5 (2007):1066-1073.

5. Chiara O., *et al*. "Efficacy of extra-peritoneal pelvic packing in hemodynamically unstable pelvic fractures, a Propensity Score Analysis". *World Journal of Emergency Surgery* 11 (2016): 22.

6. Gruen RL., *et al*. "Patterns of errors contributing to trauma mortality: lessons learned from 2,594 deaths". *Annals of Surgery* 244.3 (2006): 371-380.

7. Pohlemann T., *et al*. "The Hannover experience in management of pelvic fractures". *Clinical Orthopaedics and Related Research* 305 (1994): 69-80.

8. Tesoriero R., *et al*. "Angiographic embolization for hemorrhage following pelvic fracture: is it "time" for a paradigm shift?" *The Journal of Trauma and Acute Care Surgery* 82.1 (2017): 18-26.

9. Tile M., *et al*. "Fractures of the pelvis and acetabulum". 4th edition New York: Thieme (2015): 2234.

10. Gumanenko EK and Samokhvalov IM. "Field surgery of local wars and armed conflicts: a guide for doctors". GOETAR-media (2011): 464.

11. Tsibin YuN., *et al*. "Prediction of the outcome of severe injury complicated by shock Traumatic shock". *Medicine* 6 (1975): 29-34.

12. Pape HC., *et al*. "Timing of fixation of major fractures in blunt polytrauma: role of conventional indicators in clinical decision making". *Journal of Orthopaedic Trauma* 19.8 (2005): 551-562.

13. Kozlov I., *et al*. "Abdominal injuries". *Medicine* (1988): 224.

14. Majeed SA. "Grading the outcome of pelvic fractures". *Journal of Bone and Joint Surgery* 71 (1989): 304-306.

15. Brenner ML., *et al*. "A clinical series of resuscitative endovascular ball occlusion of the aorta for hemorrhage control and resuscitation". *Journal Trauma Acute Care Surgery* 75.3 (2013): 506-511.

16. Martinelli T., *et al*. "Intra-aortic balloon occlusion to salvage patients with life-threatening hemorrhagic shocks from pelvic fractures". *The Journal of Trauma* 68.4 (2010): 942-948.

17. DuBose J., *et al*. "Bilateral internal iliac artery ligation as a damage control approach in massive retroperitoneal bleeding after pelvic fracture". *The Journal of Trauma* 69 (2010): 1507-1514.

18. Horton RE and Hamilton GI. "Ligature of the internal iliac artery for massive haemorrhage complicating fracture of the pelvis". *Journal of Bone and Joint Surgery* 50 (1968): 376-379.

19. Ravitch MM. "Hypogastric artery ligation in acute pelvic trauma". *Surgery* 56 (1964): 601-602.

20. Mineev KP and Stelmakh KK. "Treatment of multiple and combined pelvic trauma Modern technologies in traumatology and orthopaedics". (1999): 101-103.

21. Totterman A., *et al*. "Extraperitoneal pelvic packing: a salvage procedure to control massive traumatic pelvic haemorrhage". *The Journal of Trauma* 62 (2007): 843-852.

22. Velmahos GC., *et al*. "Angiographic embolization of bilateral internal iliac arteries to control life-threatening hemorrhage after blunt trauma to the pelvis". *The American Journal of Surgery* 66.9 (2000): 858-862.

23. Burlew CC., *et al*. "Preperitoneal pelvic packing / external fixation with secondary angioembolization: optimal care for life-threatening hemorrhage from unstable pelvic fractures". *The Journal of the American College of Surgeons* 212.4 (2011): 628-635.

24. Gourlay D., *et al*. "Pelvic angiography for recurrent traumatic pelvic arterial haemorrhage". *The Journal of Trauma* 59.5 (2005): 1168-1173.

25. Tai DK., *et al*. "Retroperitoneal pelvic packing in the management of hemodynamically unstable pelvic fractures: a level I trauma center experience". *The Journal of Trauma* 71.4 (2011): E79-E86.

26. Fu CY., *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". *American Journal of Emergency Medicine* 27.7 (2008): 792-796.

27. Miller PR., *et al*. "External fixation or arteriogram in bleeding pelvic fracture: initial therapy guided by markers of arterial haemorrhage". *The Journal of Trauma* 54.3 (2003): 437-443.

28. Tan EC., *et al*. "Effect of a new pelvic stabilizer (T-POD®) on reduction of pelvic volume and haemodynamic stability in unstable pelvic fractures". *Injury* 41.12 (2010): 1239-1243.

29. Routt ML., *et al*. "Circumferential pelvic antishock sheeting: a temporary resuscitation aid". *Journal of Orthopaedic Trauma* 16.1 (2002): 45-48.

30. Durkin A., *et al*. "Contemporary management of pelvic fractures". *The American Journal of Surgery* 192. 2 (2006): 211-223.

31. Fangio P., *et al*. "Early angiography and embolization have been useful in controlling pelvic". *The Journal of Trauma* 58.5 (2005): 978-984.

32. Hak DJ., *et al*. "Management of hemorrhage in life-threatening pelvic fractures". *The Journal of the American Academy of Orthopaedic Surgeons* 17.7 (2009): 447-457.

33. Karadimas EJ., *et al*. "Angiographic embolisation of pelvic ring injuries. Treatment algorithm and review of the literature". *International Orthopaedics* 35.9 (2011): 1381-1390.

34. Li Q., *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* 47.2 (2016): 395-401.

Volume 11 Issue 4 April 2020