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A New Approach to Surgical Treatment of Victims with Pelvic and Femoral Fracture Injuries, Taking into Account the Severity of the Condition and the Severity of the Injury

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Abstract---*Fractures of the pelvis are the most severe musculoskeletal injury, with an average mortality rate of 40-80% according to the literature. The mortality rate depends on the combination of injuries, with mortality determined more by complications than by the pelvic fracture itself. The structure and function of the hip and pelvis cannot be restored without surgical treatment of fractures in the majority of trauma victims with concomitant injuries. The principle is that all unstable pelvic injuries must be stabilized early in the traumatic illness (if objective conditions exist) before complications develop.*
Keywords---*combined fracture, hip fracture, musculoskeletal system, pelvic injury, stabilization*

Introduction

Hip fractures with pelvic bone damage are one of the most severe combined musculoskeletal injuries. This article presents the results in 130 patients, demonstrating that an active tactic of minimally invasive treatment of fractures of the femur combined with pelvic fractures is reasonable. There are strong arguments in favour of early stabilisation of fractures, such as the possibility of early activation of the patient and the prevention of dangerous hypostatic complications. The combination of consolidation and rehabilitation timing contributed to positive functional results, which significantly reduced the number of patients with severe consequences of musculoskeletal injuries (Mavlyanov et al., 2020; Tilyakov, 2020).

High mortality in unstable pelvic bone fractures is due to the development of traumatic shock, which occurs in 58.9% of patients with concomitant pelvic injuries. Massive intrapelvic haemorrhage is due to the spongy structure of the pelvic bones, non-successive vessels in the bone substance and coagulopathy in patients with concomitant trauma in the acute period (Abrassart et al., 2013). Given the severity of the patient's condition, there are several challenges to be addressed when determining treatment tactics, on which the immediate outcome, likelihood of complications, length of hospital stay and long-term outcomes all depend. Thus, one of the key tasks of inpatient treatment is the speed and accuracy of decision-making in the acute period of traumatic illness (Yacenko, 2019). To solve this problem, a clear algorithm for the diagnostic and treatment process is needed, including the determination of indications for the surgical treatment depending on the severity of the patient's condition, the category of combined injury, and the type of pelvic injury (Nightingale et al., 2001; Kanis et al., 2003).

The best-known algorithm in foreign practice is Damage Control, which replaced the Early Total Care treatment concept adopted in the 1980s (Ismoilov, 2021; Radvinsky et al., 2012). Fixation of the pelvic ring and hip in unstable injuries is one of the basic elements of the Advanced Trauma Life Support (ATLS) algorithm for the treatment of severe injuries (Zhigunov, 2006). Due to the development of severe haemodynamic disturbances, pelvic and hip fractures are considered to be life-threatening for the patient, the mortality rate for this type of injury reaches 50% (Krylov et al., 2000; Radvinsky et al., 2012). The objective of the study: To improve the treatment outcomes of injured patients with combined pelvic and femoral injuries, taking into account the severity of the condition and the severity of the injury (Yin et al., 2019; Alam et al., 2014).

Material and Methods

Results of treatment of 130 patients with concomitant injuries of the pelvis with hip fractures were studied, which was 15.4% of all patients with concomitant injuries. Male patients predominated among the injured. 6% of the patients were aged 20-55 years. Road traffic accidents were the cause of injury in 89 (68.4%) patients, falls from height in 33 (25.3%), and accidents at home in 8 (6.1%). Fractures of pelvic and limb bones in 81 (62.3%) patients, with internal organ injuries in 39 (30%). On admission, depending on the severity of their condition, patients were necessarily admitted to the emergency room, where antishock measures were administered. The intensive care unit prevented and treated possible life-threatening complications of respiratory distress syndrome, DIC syndrome, multiple organ failure and primary infectious complications (Mavlyanov et al., 2020). The tactics of treatment of victims with combined trauma at this stage were to remove patients from shock and maintain the vital functions of the body - breathing and circulation. A comprehensive examination was carried out, and the victim was examined by specialists. Depending on the localization and severity of the injuries, urgent surgical treatment was carried out only on vital signs. X-ray examination of the skull, thorax, pelvic bones and injured limb segments was mandatory for all victims. An ultrasound of the thorax organs was always performed if there was suspicion of trauma to these areas. In cases of severe craniocerebral trauma and complicated spinal fractures, computed tomography was always performed. Angiography was performed in the case of suspected main vessel damage. All examinations were performed against the background of full intensive therapy, which aimed to increase the oxygen content in the blood, replenish energy expenditure, maintain breathing, restore the volume of circulating blood, maintain the tone of the cardiovascular system with inotropic and vasodilator-active drugs (Yuldashevich et al., 2020).

One of the indicators that determined treatment tactics was the severity of the condition of the victims, expressed in degrees of shock. From the data presented, it follows that all victims were admitted to the hospital in a state of shock. Depending on this criterion, they were distributed as follows. Most patients were delivered with first and second-degree shock: 78 (60,8%). Third- and fourth-degree shock was diagnosed in 51 (39.2%) of all patients. When patients were admitted in traumatic shock and unstable injuries of the pelvic ring, the primary treatment was the stabilization of the pelvic ring, stopping bleeding and compensating blood loss from pelvic vessels. A prime example is osteosynthesis of the anterior pelvic ring with an external fixation device, which is an antishock operation and helps to stop bleeding in the first hours after injury. The examination was carried out according to the clinical diagnostic standards developed by the authors. Considering the overall severe condition of the vast majority of patients, the main goal of treatment was to preserve life (Sokolov, 2010). We have developed a computer program "Software for assessing the severity of condition and severity of concomitant injuries of the pelvis and femur fractures", patent No. DGU 08846 of 27.07.2020. The program is designed to determine the severity of injuries, criteria of their stage of development, identifying the intensity and duration of intrapelvic bleeding. The data obtained are indicators that play one of the leading roles in the choice of treatment tactics, as well as in the evaluation of the results of surgical treatment of concomitant injuries of the pelvis and femur fractures (Figure 1).

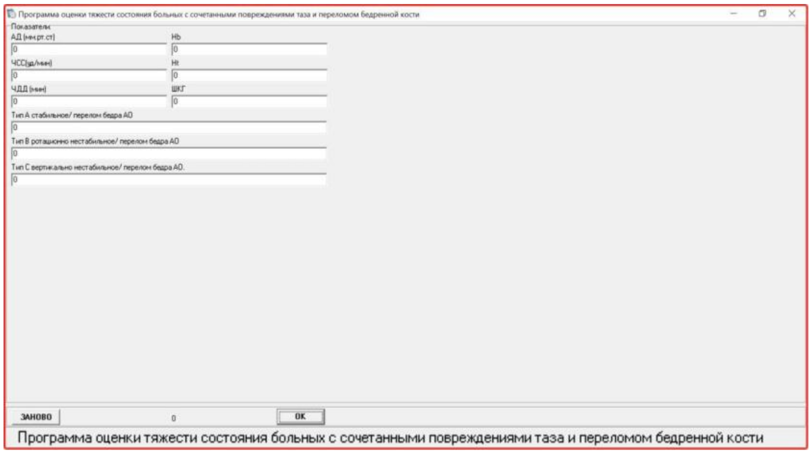

Figure 1. View of "Program for assessment of the severity of condition and severity of concomitant pelvic and femoral fracture injuries".

The functionality of the programme: preparation of patient records, collection, input and storage of laboratory data. The software allows the most informative methods of mathematical analysis based on the Glasgow scale (GCS), heart rate (HR), blood pressure (BP), respiratory rate (BFR), haemoglobin (Hb) and haematocrit (Ht) data, as well as the intensity and duration of intrapulmonary bleeding (IPBV), to reliably determine the severity of condition and severity of the injury of the patient (Table 1).

Table 1
Diagnostic and assessment programme for the severity and gravity of combined pelvic and femoral fracture injuries

Severity States	Score	Clinical and laboratory indicators						Bleeding intensity indicator*			Factor
		BP (mmHg)	HR (beats per minute)	BFD (min)	Hb	Ht (%)	SCG	A	B	C	
Stable	1	>100	<100	<24	>100	>35	15	>100 ml/hr	100-200 ml/hr	200-250 ml/hr	1
Frontier	2	80-100	100-120	24-30	90-100	28-35	11-15	>300 ml/hr	300-500 ml/hr	500-800 ml/hr	2
Unstable	3	60-79	>120	30	60-90	18-27	7-10	>1000 ml/hr	1500-2000 ml/hr	1500-2500 ml/hr	3
Critical	4	<60	>120	Dyspnea	<60	<18	<7	>3000 ml/hr	2000-3000 ml/hr	2500-3500 ml/hr	4

*Bleeding intensity index (source) - I.V (Yacenko, 2019).
X= K x S
Where: X - severity index; K - coefficient; S - the sum of scores (clinical and laboratory parameters of the patient)
Note: The maximum severity score was 96; the minimum was 6.

Distribution of severity of condition and injury scores: 6-24 points - stable condition; 25-49 points - borderline; 50-74 - unstable and 75-96 - critical.

Table 2
Tactics and treatment methods * (A). (A,B). (B,C1). (B,C2)

Tactics and treatments*	
A 75-96 point	Performing only emergency (vital signs) surgical interventions for the head, chest, abdominal injuries and stopping external bleeding; Use of non-invasive external pelvic compression, as an early means of stabilizing the pelvic ring, use of a pelvic bandage that will reduce pelvic bleeding in the initial phase of intensive care; For hip fractures, conservative treatment methods (immobilisation of the limb with splints or plaster casts).
B 50-74 point	Performing surgical interventions for urgent indications; Skeletal traction with longitudinal traction or double traction. Hammock pelvic girdle traction or transverse cross traction with spokes with thrust pads by the wings of the iliac bones; Angioembolisation is an effective way to stop retroperitoneal arterial pelvic bleeding. Angioembolisation should be considered if haemodynamic instability persists or bleeding continues despite the stabilisation of the pelvic bone, aggressive haemostatic therapy and no other sudden sources of bleeding; Hip fracture - conservative treatment (immobilization with splints or plaster casts), until haemodynamics are fully stabilised.
C1 25-49 point	Performing surgical interventions for urgent indications; Pelvic fixation with external fixation apparatus (external fixation of the pelvis provides rigid temporary stability of the pelvic ring and creates conditions for the early stop of intrapelvic bleeding in hemodynamically unstable pelvic ring injuries); Unstable posterior pelvic injuries are an indication of repositioning and stable internal fixation. Rotationally unstable or vertically unstable injuries are standard indications for surgical fracture fixation. Fixation of the pubic symphysis with plates is the method used for "open book" anterior fixation of fractures when the diastasis between the pubic bones exceeds 2.5 cm. The stabilisation of a femoral fracture with external fixation devices can be achieved with intramedullary osteosynthesis of the femur without drilling the medullary canal if the conditions allow.
C2 6-24 point	The entire spectrum of delayed surgical interventions is performed; In case of pelvic injuries, stabilization with external fixation apparatus, if technical and professional conditions are available, immersion osteosynthesis is performed for injuries to the anterior, posterior pelvis and acetabulum region; Intramedullary osteosynthesis of the femur, supraosseous plate osteosynthesis, blocked intramedullary osteosynthesis if technically possible.

Emergency surgical interventions and manipulations aimed to restore vital functions of the organism were performed in patients with concomitant trauma against the background of intensive care without preoperative preparation and patients with severity of state according to the scale (Table 2 A 75-96 points):

1) Laparotomy - for injuries of parenchymatous organs, accompanied by bleeding and decompensated shock (final stop bleeding, suture and ligation of vessels, suturing wounds of the liver, spleen, kidney and pancreas, splenectomy and nephrectomy).
2) Thoracotomy - for injuries accompanied by massive intrapleural haemorrhage.
3) Thoracoscopy, pleural cavity drainage - for pneumo- and haemothorax.
4) Tracheostomy - for injuries to the facial skeleton, neck, accompanied by asphyxia.
5) Primary surgical treatment - for wounds in various anatomical areas with damage to major vessels and massive external bleeding, including open fractures, crush injuries and severed limb segments (final stopping of bleeding - suture and ligature of vessels, amputation).

Urgent surgical interventions and manipulations were performed on victims with combined trauma to prevent life-threatening complications, including sub compensation of central hemodynamics and external respiration, achieved by inotropic support and AVL, and patients with condition severity (Table 2 B, C1 50-25 points):

1) Diagnostic laparoscopy; Laparotomy - for injuries of parenchymatous and hollow organs, diaphragm, retroperitoneal organs, bladder and urethra, not accompanied by massive intra-abdominal bleeding and decompensated shock (suturing wounds of the liver, The procedure is based on the following principles: liver, spleen, kidney, bladder, pancreas, mesentery, intestine, diaphragm, epicystostomy, liver and intestinal resection, splenectomy, nephrectomy; suture and vessel ligation to permanently stop the bleeding.
2) Thoracoscopy, pleural cavity drainage for non-life-threatening haemothorax and pneumothorax; Thoracotomy - for injuries of the chest wall vessels, lung, not accompanied by massive intrapleural haemorrhage and compensated shock (with a blood loss of more than 300 ml/hour during 3-4 hours of observation) and for lung ruptures accompanied by pneumo-, haemothorax, which cannot be treated by active drainage of the pleural cavity.
3) Decompressive craniotomy and elimination of cerebral compression.
4) Laminectomy with spinal cord decompression and subsequent stabilisation of the damaged vertebrae;
5) Restoration of the main blood flow in the arteries when they are injured (without external bleeding), accompanied by an increase in limb ischaemia.
6) Primary surgical treatment of wounds in various anatomical areas, amputation of limb segments if they are severed, crushed, irreversibly ischaemic and without massive haemorrhage.
7) Pelvic bone repositioning and stabilization, primary osteosynthesis of open limb fractures and use of external fixation devices.

Delayed surgical interventions were performed after compensation of vital body functions and when the condition was severe (Table 2 C1, 2 6-25 points):

1) Stabilisation of the pelvic ring and acetabulum with a clinic rod apparatus for unstable injuries.
2) Intramedullary osteosynthesis with pins.
3) Extramedullary osteosynthesis with plates.
4) EKDO with external fixation devices.
5) Stabilizing surgeries for spinal injuries.
6) Thoracotomy - for ineffective drainage of the pleural cavity for pneumothorax (persistent collapse of the lung);
7) Tracheostomy for prolonged evi to prevent purulent pulmonary complications.
8) Operations for injuries to the face of the skull - splinting of the lower and upper jaws, osteosynthesis.
9) Relaparotomy - in case of peritonitis, euentricity, adhesive intestinal obstruction, etc.
10) Secondary surgical treatment of wounds, neurectomy, and the opening and drainage of abscesses and phlegmon.

The extent of care was in direct correlation with the presence of concomitant internal injuries and the severity of the condition at the time of admission. After elimination of the dominant injury to the abdominal and thoracic organs and skull, and stabilization of hemodynamic parameters, we decided on stabilization of the pelvic and femoral injuries. With regard to unstable pelvic bone fractures in the early period of the traumatic disease, we follow active surgical tactics using minimally invasive osteosynthesis techniques. We use rod devices of external fixation with one-stage stabilization and repositioning of bone fragments of the pelvis and femur. It should be noted that the use of rod apparatuses in the treatment of this contingent of patients made important adjustments to the complex of antishock measures and contributed to the prevention of complications.

Appliance application technique

The appliance is applied as follows. In the prone position under general anaesthesia, a closed method is used to form channels in the anterior superior spine (supravertebral area) of the iliac wing and introduce bone screws into the left and right iliac bones (Figure 2). The bone screws are inserted to the depth of the thread. Place the pre-assembled construction on the bone rods. The bone screws are inserted into the grooves of the bars and secured with nuts. The vertical and diagonal displacement of the pelvic halves is eliminated by traction along the axis of the lower extremities under the control of an E-optic transducer. By holding the pelvic supports, the pelvic bones are moved in the desired direction, the pelvic supports can be rotated relative to the beams and the threaded rods can change their position due to the axial hinges.

Figure 2. Formation of the canal in the anterior superior ostium (supravertebral area) and insertion of bone screws into the left and right iliac bone

This is used intraoperatively to correct dislocations of damaged structures and dislocated articulations. The angle between the beams is adjusted using axial joints. The uniaxial joint that connects the threaded rod is equipped with a serrated lock. Moving spring-loaded spike, used to prevent unintentional rotation of the threaded rod joint, rotate the threaded rods by the required angle and release the moving spring-loaded spike; it blocks the final rotation of the threaded rod. Bone screws are inserted into the pubic bones, securing them to the threaded rod of the pubic unit on which the two bone screws are attached. This eliminates angular deflections and deviations of the pelvic bones from the anatomically correct position and corrects dislocations of the articulations. When the desired position of the pelvic bones is achieved, the bolts, nuts and joints are tightened and the position is stabilised. Using the telescopic distraction traction, the position of the femoral module in relation to the pelvic support is changed to give the desired position to the femur. Once the desired position is achieved, the spherical joint is tightened.

Then the bone fragments of the femur are repositioned. To move the bone fixators and the fixated fragments, a frame is used, which is installed with the possibility of dosed movement relative to the rings and the pelvic support, allowing for compression or distraction. The frame contains a strain gauge and a control unit for remote control, and reading the signal from the control unit and determining the magnitude of forces allows control of compression and distraction. The femoral model is stabilised by tightening the hinge nuts and the brackets fixing the traction. Lateral compression is created by means of the threaded rods, which ensures stable fixation of the bone fragments and pelvic halves in the position of anatomical repositioning. If one-stage complete repositioning was not possible due to the severity of the patient's general condition, correction of the fracture position was performed gradually in the postoperative period by moving the pelvic supports of the device relative to each other, moving the femoral module relative to the pelvic supports, and moving the frame and bone fixators. The period of immobilization in the apparatus averaged 6 to 8 weeks (Malaka et al., 2021; Chang et al., 2020).

Discussion

Given the severe general condition in most patients due to traumatic shock, acute blood loss, damage to internal organs and pelvic organs, development of such life-threatening complications of the acute period of traumatic disease as fat embolism, respiratory distress syndrome, pneumonia, etc., the main goal of treatment in this period of traumatic disease was to preserve life (Figure 2). After elimination of predominant injuries of abdominal and thoracic cavities and skull and normalisation of haemodynamic parameters, there was a question of stabilisation of injuries of pelvis and femur. With regard to unstable fractures of the gas bones in the early period of the traumatic disease, we followed an active surgical tactic using minimally invasive osteosynthesis techniques and used rod devices of external fixation of two modifications developed in the clinic (Demetriades et al., 2002; Gänsslen et al., 1996). For stabilization of type B and C pelvic ring fractures, we suggested a pelvic bar apparatus and a spike-rod apparatus for osteosynthesis of unstable pelvic and femoral bone fractures. 75 (57,7%) patients within 3 to 12 hours after admission were able to accomplish operative stabilization of pelvic ring injuries, and as a final treatment, this method was carried out in 19 (14,6%) patients with type B injuries and in 36 (27,7%) - with severe unstable type C fractures.

Figure 3. View of a patient in intensive care (day 1 after surgery)

It should be noted that the use of a pelvic spike apparatus in the treatment of pelvic bone fractures made important adjustments in the complex of antishock measures and the prevention of complications, and its simplicity and accessibility allowed for its wider implementation in practice.We also developed treatment tactics for femoral bone injuries combined with pelvic bone fractures, based on the severity of the condition (especially) and the severity of damage to the femoral segment. As a matter of principle, all hip fractures should be stabilised in the early period of traumatic illness before complications develop if objective conditions exist. The method of fixation depends on the severity of the injury. Hip fractures were observed in all our patients; there were 137 fractures in all. Fractures of both femurs were observed in 7 patients (Iyer & Ananthanarayan, 2008; Diener et al., 1984).

Surgical intervention was performed after elimination of the dominant pathology, immediately after surgical intervention on abdominal and thoracic organs, the skull, or after stabilisation of the haemodynamics. The intramedullary pin osteosynthesis method was used in 82 (63.1%) patients, 13 (10%) of them had closed intramedullary osteosynthesis without medullary canal opening under EOP control. In 24 (18,5%) patients with closed fractures of the femur at the level of the lower third, a bone plate osteosynthesis was performed. In 28 (21,5%) patients with severe injuries of bone tissue the method of transosseous osteosynthesis with an external fixation device, developed by us, was applied. The patients were divided into two groups depending on the timing of osteosynthesis of the femur. In 75 (57.7%) patients of the 1st group, early osteosynthesis was carried out for up to 3 days. In 55 (42.3%) group 2 patients, surgical intervention was performed at a later date (Voloshin et al., 1998; Vincent et al., 2012).

Results

Studying the results of treatment of multiple fractures of the pelvis and femur showed that recovery came to 123 (94,6%) patients. There were 7 (5.4%) patients who died. Analysis of lethal outcomes revealed that the cause of death in 3 (2.3%) patients were the massive trauma of three or more bone segments combined with damage to internal organs (liver, spleen, intestines, etc.). In 2 (1.5%) patients, the cause of death was traumatic shock caused by multiple fractures and blood loss. In 2 (1.5%) patients the fatal outcome was due to severe head injury. The immediate results of treatment were examined at follow-up examination after 2, 4, 6 and 12 months in 87 (66,9%) patients. Recovery occurred in 80 (96.5%) patients with concomitant injuries of the pelvis and femur. Fragment fusion was recorded in 64 (61.5%) patients. Long-term results of treatment were traced in 43 (33,1%) patients within 2 to 5 years. The results were evaluated as good, satisfactory and unsatisfactory.

The results were considered good in case of complete anatomical-functional recovery of the injured limbs, absence of complaints and return to the previous work capacity or preservation of the previous quality of life in incapacitated elderly patients. Satisfactory results were characterized by fracture healing in the average terms, moderate restriction of movements in the adjacent joints, reduction of professional work capacity of physical labourers (up to changing their profession for the lighter one) and absence of permanent disability. Unsatisfactory results included such signs as the absence of consolidation (even of one of the operated sockets) or its sudden delay, healed fractures with severe deformation and functional disorders, permanent disability caused by injuries of the musculoskeletal system.

Conclusion

The structure and function of the hip and pelvis cannot be restored without surgical treatment of fractures in the majority of trauma victims with concomitant injuries. The principle is that all unstable pelvic injuries must be stabilised early in the traumatic illness (if objective conditions exist) before complications develop. The question of performing osteosynthesis of hip fractures should be decided after elimination of the dominant pathology and stabilization, taking into account the severity (type) of the fracture.

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