

Our experience with the results of surgical treatment of victims with concomitant injuries of the pelvis and femur

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Abstract

Hip fractures with damage to the pelvic bones are one of the most severe combined injuries of the musculoskeletal system. This article presents the results of our studies in 130 patients, which demonstrated that the active tactics of minimally invasive methods of treatment of femoral fractures combined with pelvic bone fractures looks quite reasonable. In favor of early stabilization of fractures, such strong arguments are put forward as the possibility of early activation of the patient, the prevention of threatening hypostatic complications. Combining the terms of consolidation and rehabilitation contributed to obtaining positive functional results, which significantly reduced the number of patients with severe consequences of injuries to the musculoskeletal system.

Keywords

Hip fracture, Combined fracture, Stabilization, Musculoskeletal system, Pelvic injury, "Damage control" tactics

Imprint

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Introduction

Fractures of the pelvis as part of a combined trauma are the most severe musculoskeletal system injuries: the mortality rate, according to the literature, averages 40-80% [10; 13]. This rate depends on the combination of injuries in the combined trauma, and mortality is more determined by the development of complications than by the fracture of the pelvic bones [1,3,5].

The high mortality rate in unstable pelvic bone fractures is due to the development of traumatic shock, which is observed in 58.9% of patients with concomitant pelvic injuries. Massive intrapelvic bleeding is caused by the spongy structure of the pelvic bones, non-collapsing vessels in the bone substance, and coagulopathy in patients with concomitant trauma in the acute period [8].

Given the severity of the patients' condition, when determining the treatment tactics, it is necessary to solve a number of tasks, on which the immediate outcome, the probability of complications, the duration of the patient's hospital stay, and the long-term results depend. Thus, one of the key tasks in patient treatment is speed and accuracy of decision making in the acute period of traumatic disease [7]. To solve this problem, we need a clear algorithm for the diagnostic and treatment process, including determination of indications for surgical treatment depending on the severity of the patient's condition, the category of concomitant trauma, and the type of pelvic injuries.

The most well-known in foreign practice is «Damage Control» algorithm for treatment of patients with concomitant injuries, which replaced the «Early Total Care» treatment concept adopted in the 1980s [5,6].

Fixation of the pelvic ring and femur in case of their unstable injuries is one of the basic elements of Advanced Trauma Life Support (ATLS) algorithm for treatment of severe injuries [2]. Due to the development of marked hemodynamic disorders, pelvic and femoral fractures are considered to be life-threatening for the patient, the mortality rate in this type of injury reaches 50% [3,6].

Objective

To improve the results of treatment of patients with combined pelvic and femoral injuries taking into ac-

count the assessment of the severity of the condition and the severity of the injury.

Material and methods of examination

We studied the results of treatment of 130 patients with concomitant injuries of the pelvis with hip fractures, which made up 15.4% of all patients with concomitant trauma. 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%). Bone fractures of the pelvis and extremities in 81 (62,3%) cases, with injuries of internal organs revealed in 39 (30%) victims. Upon admission, depending on the severity of the condition, the patients were mandatorily hospitalized in an antishock ward of the admission department, where antishock measures were carried out. The intensive care unit prevented and treated possible life-threatening complications of respiratory distress syndrome, DIC syndrome, multiple organ failure and primary infectious complications. The tactics of treatment of patients with combined trauma at this stage consisted in removing the patients from shock and maintaining the vital functions of the body - breathing and circulation. A comprehensive examination was carried out, and the injured were examined by specialists. Depending on the localization and severity of the injuries, emergency surgical treatment was performed only on vital signs. X-ray examination of the cranial bones, thorax, pelvic bones and the injured limb segments was mandatory for all patients. Ultrasound of the thoracic cage organs was necessarily performed if there was suspicion of trauma in these areas. In case of severe craniocerebral trauma and complicated fractures of the spine, computed tomography was necessarily performed. Angiography was performed in case of suspected injury of great vessels. All examinations were performed against the background of complete intensive therapy aimed at increasing oxygen content in blood, replenishing energy expenditures, maintaining breathing, restoring the volume of circulating blood, and maintaining the tone of the cardiovascular system with inotropic and vasoactive drugs. One of the indicators that determined the tactics of treatment was the severity of the condition of the victims, expressed in degrees of shock.

It follows from the data presented that all the victims were delivered 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%) out of the total number of patients.

When patients were admitted in traumatic shock and unstable injuries of the pelvic ring, the primary treatment was stabilization of the pelvic ring, stopping bleeding and compensation of blood loss from the pelvic vessels. A striking example is osteosynthesis of the anterior pelvic ring with external fixation apparatus, which is an antishock operation and helps to stop bleeding in the first hours after injury.

The examination was performed according to the clinical and diagnostic standards developed by the authors. Given the overall severe condition of the vast majority of patients, the main goal of treatment was life preservation.

We developed a computer program, «Software for estimating the severity of state and severity of concomitant injuries of the pelvis and fractures of the femur»; patent number DGU 08846, 27.07.2020, was received.

The program is designed to determine the severity of injuries, criteria of their stage of development, revealing the intensity and duration of intrapelvic bleeding. The obtained data 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.

Functionality of the program: registration of the card of the examined patient, collection, input, storage of data on the indicators of laboratory research. The program allows the most informative methods of mathematical analysis based on the Glasgow scale (GCS), heart rate (HR), blood pressure index (BP), respiratory rate (BFR), data on hemoglobin (Hb) and hematocrit (Ht), as well as the intensity and duration of intrapelvic bleeding (IPBH) to reliably determine the severity of condition and severity of the patient.

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

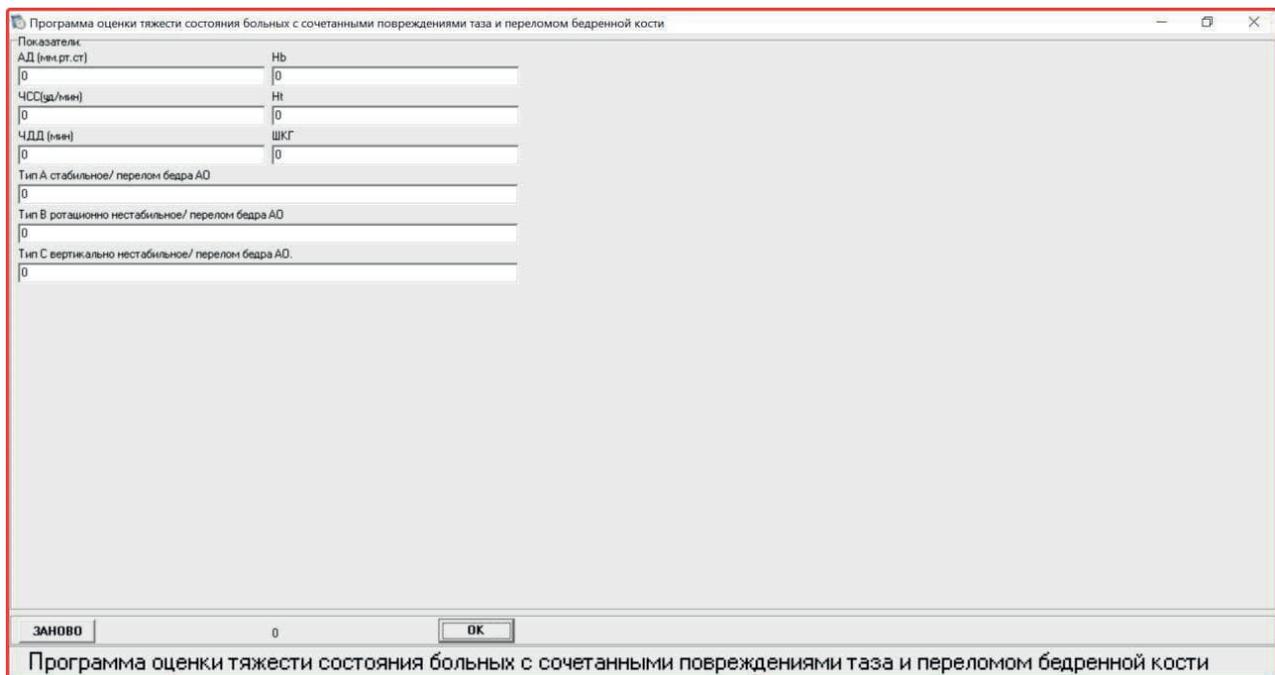


Figure 1. View of the "Program for Assessing the Severity of Condition and Severity of Combined Pelvic and Femoral Fracture Injuries".

Diagnostic and assessment program for the severity and severity of combined injuries of the pelvis and femur fractures

Severity States	Score	Clinical and laboratory parameters						Bleeding intensity index*			Coefficient
		BP (mm Hg)	HR (bpm)	BFD (min)	Hb	Ht (%)	SCG	A	B	C	
Stable	1	> 100	< 100	< 24	> 100	> 35	15	> 100 ml/h	100-200 ml/h	200-250 ml/h	1
Frontier	2	80-100	100-120	24-30	90-100	28-35	11-15	> 300 ml/h	300-500 ml/h	500-800 ml/h	2
Unstable	3	60-79	> 120	30	60-90	18-27	7-10	> 1000 ml/h	1500-2000 ml/h	1500-2500 ml/h	3
Critical	4	< 60	> 120	Dys-pnea	< 60	< 18	< 7	> 3000 ml/h	2000-3000 ml/h	2500-3500 ml/h	4

* Bleeding intensity index (source) - I.V. Borozda et al. «Blood loss in pelvic bone fractures»; Amur Medical Journal No.2 (26) 2019 P.50.60.

$$X = K \times S$$

where: X - condition severity index; K - coefficient; S - sum of points (clinical and laboratory indices of the patient)

Note: The maximum severity score was 96; the minimum was 6.

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

Tactics and treatment methods *	
A 75-96 point	<p>Performing only urgent (vital signs) surgical interventions for injuries to the head, chest, abdomen and stopping external bleeding;</p> <p>Use of non-invasive external pelvic compression, as an early means of stabilizing the pelvic ring, the use of a pelvic bandage, which will reduce the volume of pelvic bleeding in the initial phase of intensive care;</p> <p>For hip fractures - conservative methods of treatment (immobilization of the limb with splints or plaster casts).</p>
B 50-74 point	<p>Performing surgical interventions on urgent indications;</p> <p>Skeletal traction with longitudinal traction or with double traction. Hammock pelvic girdle traction or transverse cross traction with spokes with thrust pads by the wings of the iliac bones;</p> <p>Angioembolization is an effective way to stop retroperitoneal arterial pelvic bleeding. Angioembolization should be considered if hemodynamic instability persists or bleeding continues despite pelvic bone stabilization, aggressive hemostatic therapy and no other sudden sources of bleeding;</p> <p>Hip fracture - conservative methods of treatment (immobilization of the limb with splints or plaster casts), until full stabilization of hemodynamics.</p>

<p>C1 25-49 балл</p>	<p>Surgical interventions for urgent indications; Pelvic fixation using external fixation apparatus (external fixation of the pelvis provides rigid temporary stability of the pelvic ring and creates conditions for early stop of intrapelvic bleeding in hemodynamically unstable pelvic ring injuries); Unstable posterior pelvic injuries are an indication for 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. Stabilization of a hip fracture with external fixation devices, if conditions allow, can be performed using intramedullary osteosynthesis of the femur without drilling the medullary canal.</p>
<p>C2 6-24 балл</p>	<p>Performance of the whole range of delayed surgical interventions; In case of pelvic injuries, taking into account indications - stabilization with external fixation apparatus, if there are technical and professional conditions, immersion osteosynthesis is performed for injuries of anterior, posterior parts of pelvis and acetabulum area; Intramedullary osteosynthesis of the femur, osteosynthesis with supraosseous plates, blocked intramedullary osteosynthesis if technically possible.</p>

Emergency surgical interventions and manipulations aimed at restoring vital functions of the body were performed in patients with combined trauma against the background of intensive care without pre-operative preparation and in patients with severity of state according to the scale (A 75-96 points):

- 1) laparotomy - for injuries of parenchymatous organs accompanied by bleeding and decompensated shock (final stopping of bleeding, suture and ligation of vessels, suturing of wounds of the liver, spleen, kidney and pancreas, splenectomy and nephrectomy);
- 2) thoracotomy - for injuries accompanied by massive intrapleural bleeding;
- 3) thoracoscopy, pleural cavity drainage - for pneumo- and hemothorax;
- 4) tracheostomy - in injuries of facial skeleton, neck, accompanied by asphyxia;
- 5) primary surgical treatment - for wounds of 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 ligation of vessels, amputation).

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

- 1) diagnostic laparoscopy;
- 2) 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 liver, The following are also necessary to stop bleeding: suture and vascular ligation for the final stopping of bleeding;

- 3) thoracoscopy, pleural cavity drainage - for non-life threatening hemothorax and pneumothorax;
- 4) thoracotomy - for injuries of the chest wall vessels, lung, not accompanied by massive intrapleural hemorrhage and compensated shock (with a blood loss rate of more than 300 ml/hour during 3-4 hours of observation), and for lung ruptures accompanied by pneumo- or hemothorax, which cannot be treated by active drainage of the pleural cavity;
- 5) decompressive cranial trepanation and elimination of brain compression;
- 6) laminectomy with decompression of the spinal cord and subsequent stabilization of the damaged vertebrae;
- 7) restoration of the main blood flow in the arteries at their injuries (without external bleeding), accompanied by increasing ischemia of the limb;
- 8) primary surgical treatment of wounds in various anatomical areas, amputation of limb segments in case of their detachment, crush, irreversible ischemia and absence of massive hemorrhage;

Repositioning and stabilization of pelvic bones, primary osteosynthesis of open limb fractures and use of external fixation devices.

Delayed surgical interventions were performed after compensation of vital body functions and severity of condition (C1, 2 6-25 points):

- 1) stabilization of the pelvic ring and acetabulum with the clinic's rod apparatus for unstable injuries;
- 2) intramedullary osteosynthesis with pins;
- 3) extramedullary osteosynthesis with plates;
- 4) VKDO with external fixation devices;

- 5) Stabilizing operations for spinal injuries;
- 6) thoracotomy - for ineffective drainage of the pleural cavity for pneumothorax (persistent collapse of the lung);
- 7) tracheostomy in case of prolonged AV to prevent purulent pulmonary complications;
- 8) operations for injuries of the facial skull - splinting the lower and upper jaws, osteosynthesis;
- 9) Relaparotomy - in the development of peritonitis, euentricity, adhesive intestinal obstruction, etc;
- 10) secondary surgical treatment of wounds, necrectomy, opening and drainage of abscesses and phlegmon.

The scope of care was in direct correlation with the presence of concomitant injuries of internal organs and the severity of the condition at the time of admission.

After elimination of the dominant damage from the organs of the abdominal and thoracic cavity and skull, stabilization of hemodynamic indicators, the question of stabilization of injuries of the pelvis and femur was solved. With regard to unstable pelvic bone fractures in the early period of traumatic disease, we adhere to 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 in the complex of antishock measures and contributed to the prevention of complications.

Technique of applying the apparatus. The apparatus is used as follows. In the patient's back position under general anesthesia, closed method, channels are formed in the anterior superior ostium (in the supra-vertebral area) of the iliac wing and bone screws are inserted into the left and right iliac bones.

Bone screws are inserted to the depth of the thread. The pre-assembled structure is placed on the bone rods. The bone screws are inserted into the grooves of the bars and fixed 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 image converter. By holding the pelvic supports, the pelvic bones are displaced in the required direction; the pelvic supports can be rotated relative to the beams and the threaded rods can change their position due to the axial hinges.

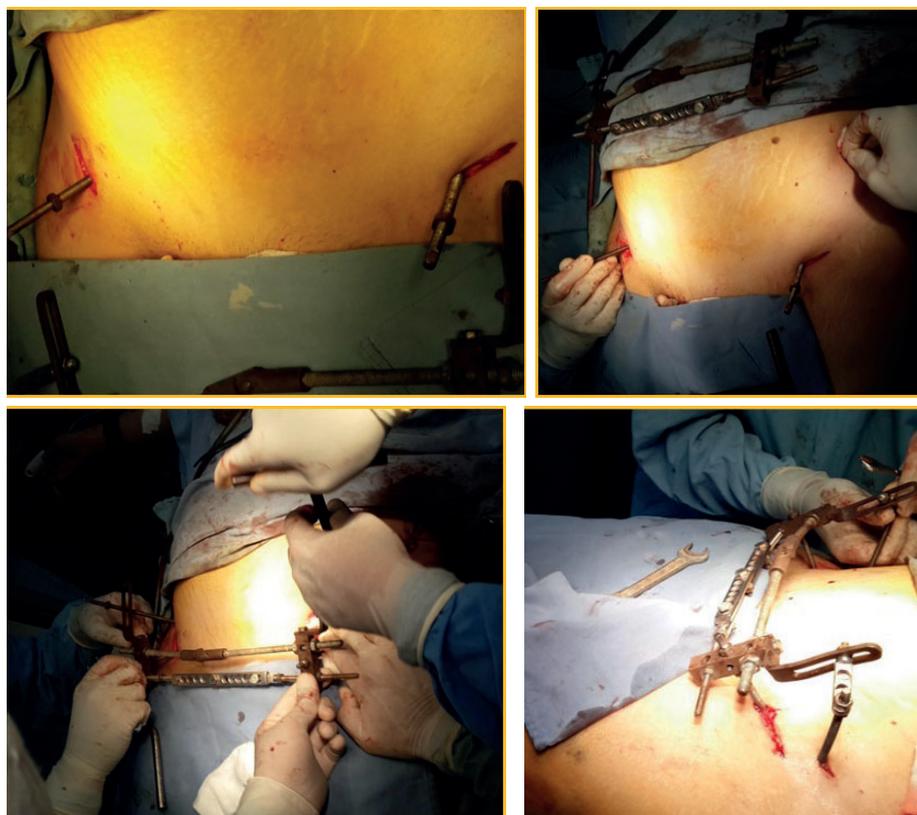


Figure 2. Formation of the canal in the anterior superior ostium (supravertebral area) and insertion of bone screws into the left and right iliac bone.

This allows intraoperative elimination of dislocations of the damaged structures and correction of articular dislocations. The angle between the beams is adjusted using axial joints. The uniaxial joint that connects the threaded rod is equipped with a serrated retainer. The movable spring-loaded spike designed to prevent spontaneous rotation of the threaded rod joint is moved aside, the threaded rods are rotated to the desired angle and the movable spring-loaded spike is released, 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 assembly, on which the two bone screws are attached. Thus eliminate angular displacements and deviations of the pelvic bones from the anatomically correct position, set dislocations in the joints. Having achieved the desired position of the pelvic bones, the bolts and nuts are tightened, and the joints are fixed, stabilizing the position. Using the telescopic distraction rod, the position of the femoral module relative to the pelvic support is changed, giving the desired position to the femur. Once the desired position is achieved, the spherical joint is tightened. Then we proceed to repositioning the bone fragments of the femur. To move the bone fixators and the fragments fixed in them, a frame in-

stalled with the possibility of dosed movement relative to the rings and the pelvic support is used, which allows 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 amount of force allows control of compression and distraction.

The femoral model is stabilized by tightening the hinge nuts and traction brackets. 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.

In those cases where a one-stage complete repositioning was impossible due to the severity of the patient's general condition, correction of the position of the fragments was performed gradually in the post-operative period by moving the pelvic supports of the apparatus relative to each other, moving the femoral module relative to the pelvic supports, and moving the frame and bone fixators. Immobilization period in the apparatus averaged 6 to 8 weeks.

Taking into account the severe general state in the majority of patients caused by traumatic shock, acute blood loss, injuries of internal organs and pelvic organs, development of such life-threatening compli-

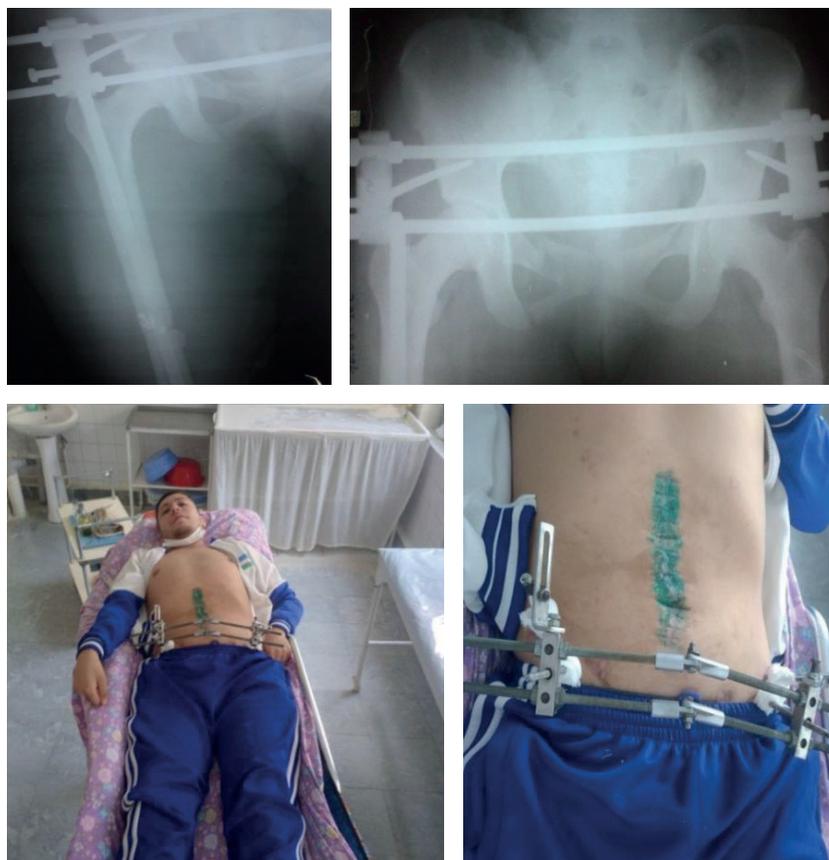


Fig.3. View of the patient in the intensive care unit (1 day after surgery).

cations of the acute period of traumatic disease as fat embolism, respiratory distress syndrome, pneumonia, etc., the main objective of treatment of this period of traumatic disease was life saving. After elimination of the dominant damage from the abdominal and thoracic cavity organs and skull, and normalization of hemodynamic indices, the issue of stabilization of pelvic and femoral injuries was raised. As for unstable fractures of gas bones in the early period of traumatic disease, we followed active surgical tactics with the use of minimally invasive osteosynthesis methods; we used rod devices of external fixation of two modifications developed in the clinic. To stabilize type B and C pelvic fractures a pelvic rod apparatus and a spoke rod apparatus for osteosynthesis of unstable pelvic and femoral bone fractures were suggested. 75 (57, We were able to perform operative stabilization of the pelvic ring injuries in the time period from 3 to 12 hours after the patient's arrival. As the final method of treatment was realized in 19 (14,6%) patients with type B injuries and in 36 (27,7%) patients with severe unstable type C fractures.

It should be noted that the use of a spoke-rod apparatus in the treatment of pelvic bone fractures made important adjustments in the complex of antishock measures and prevention of complications, and its simplicity and accessibility allowed us to introduce it into practice more widely.

We also developed the tactics of femoral bone injuries treatment in combination with pelvic bone fractures, which was based on the severity of the condition (especially) and the severity of femoral segment damage. It is fundamental that all fractures of the femur should be stabilized in the early period of traumatic illness before complications develop, if there are objective conditions. The method of fixation depends on the severity of the patients' condition. All our patients had 137 fractures of the femur. Fractures of both femurs were observed in 7 patients.

Surgical interventions were carried out after the elimination of the dominating pathology, immediately after surgical interventions on the organs of the abdominal and thoracic cavities, the skull or after hemodynamics stabilization. Intramedullary osteosynthesis with pins was used in 82 (63.1%) patients with 13 (10%) of them under EOP control; the closed intramedullary osteosynthesis without bone marrow channel opening was performed. 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 bone tissue injuries we used transosseous osteosynthesis with the external fixation apparatus designed by us.

The patients were divided into two groups depending on the period of osteosynthesis of the hips. Early osteosynthesis up to 3 days was performed in 75 (57.7%) patients of the 1st group. In 55 (42.3%) patients of Group 2, surgical intervention was performed at a later date.

Results

Studying the results of treatment of multiple fractures of the pelvis and femur bones showed that the recovery occurred in 123 (94,6%) patients. Seven (5,4%) patients died. Analysis of the causes of treatment outcomes showed that massive trauma of three and more bone segments combined with the damage of internal organs (liver, spleen, intestines, etc.) was the immediate cause of death in 3 (2.3%) patients. In 2 patients (1.5%) the cause of death was traumatic shock caused by multiple fractures and blood loss. In 2 (1.5%) patients lethal outcome was related to severe craniocerebral trauma.

The immediate results of treatment were studied by follow-up examination in 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 registered in 64 (61,5%) patients.

The long-term results of treatment were followed in 43 (33,1%) patients within the period from 2 to 5 years. The results were evaluated as good, satisfactory and unsatisfactory.

The results were considered good if the injured limbs were restored completely anatomically and functionally, no complaints, return to the previous work capacity and preservation of the previous quality of life in the incapacitated elderly patients. Satisfactory results were characterized by the middle-term healing of fracture(s), a moderate restriction of movements in the adjacent joints, reduction of professional ability to work (down to changing a profession to the lighter one) and absence of permanent disability.

Unsatisfactory results included such signs as absence of consolidation (even of one of the operated sets) or its sharp delay, incorrectly healed fractures with expressed deformity and functional impairment, permanent disability related to injuries of musculoskeletal system.

Discussion

On the basis of our multiyear work experience with a heavy contingent of patients with concomitant traumas of the pelvis and femur in polytrauma, we have singled out the priorities of the main scientific directions in providing aid to the injured - the organization of therapeutic and diagnostic process at all stages of care, and its technical support in the course of treatment.

In order to realize organizational and tactical aspects of care for the injured with pelvic and hip injuries as well as to prevent various complications of the traumatic disease course at all stages of introduction of patients with polytrauma, we proposed a number of scientifically grounded developments; the latter have played a positive role in practical application on a large clinical material.

The most effective of them was the "Program of evaluation of severity of patients with concomitant injuries of the pelvis and fracture of the femur", (№ DGU 2020 1300); and others.

Taking into account the severe contingent of patients, difficulties and sometimes impossibility to perform stabilization of OA injuries by traditional methods in the acute period of traumatic disease, we developed constructions for minimally invasive osteosynthesis of fractures, the most common in concomitant injuries. These are a universal bar apparatus for osteosynthesis of osteosynthesis of OMD injuries in patients with polytrauma, RF patent (№ 2758023); apparatus for treatment of combined fractures of pelvis and femur bones, RF patent (№ 2749897); and so on. Implementation of organizational and tactical developments in practical healthcare of the Center and its branches, as well as tools for minimally invasive osteosynthesis of injuries of the pelvis and femur, allowed to revise the tactics of treatment in this category of patients, to improve the quality of care, treatment results and reduce mortality rates.

Conclusions

Treatment and diagnostic process in patients with concomitant trauma of the pelvis and femur should begin with determining the dominant pathology. Patients with combined craniocerebral trauma and injuries of the musculoskeletal system (68.2%) take the first place, followed by combined injuries of internal organs and the musculoskeletal system (19.2%) and multiple injuries of the musculoskeletal system

(12.6%). The diagnosis of injuries at concomitant trauma of the pelvis and femur should include clinical and instrumental methods of investigation. The application of the developed algorithm allows us to avoid diagnostic errors and reduce the time of pathology detection. The choice of treatment methods for fractures of the pelvis and femur bones in the acute and early period of traumatic disease depends on the condition of the victim, localization, and nature of the fracture. Operative interventions are performed sequentially after eliminating the dominant pathology in the abdominal, thoracic cavities and skull. Our developed constructions for osteosynthesis of injuries of the long bones of the limbs and pelvis on the spike and rod basis decrease the volume of surgical aggression and reduce the duration of osteosynthesis by 3 times.

The complex treatment of concomitant injuries of the pelvis and femur bones should be performed in the first three days from the moment of injury. It is advisable to perform simultaneous (by two teams) osteosynthesis of all injuries, especially of the femur, tibia and shoulder. The most effective osteosynthesis is immersion osteosynthesis when the condition of the injured is stable; when hemodynamics is unstable and complications develop, minimally invasive methods of osteosynthesis are preferred. Early osteosynthesis promotes normalization of hemodynamic indices. Severe unstable injuries of the pelvic bones, regardless of the severity of the condition of the injured, should be stabilized within the first day after injury with rod and spoke-rod apparatuses. The frequency of complications (general and local purulent-septic, microcirculatory, trophic) was found to depend directly on the tactics and timing of traumatological care in patients with combined trauma. After early osteosynthesis the number of complications was 1.6 times lower than after late intervention.

We found that 57% of patients died in the first three days after injury, and 43% died in the early and late periods of traumatic illness. The most frequent causes of death were brain damage, blood loss, and shock. The developed algorithms for the organization and surgical tactics of treatment of patients with combined pelvic and femoral trauma proved to be effective.

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