MINIMALLY INVASIVE LUMBOPELVIC FIXATION FOR STABILIZATION OF THE POSTERIOR PELVIC RING IN VICTIMS WITH POLYTRAUMA

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Objective. To evaluate the use of minimally invasive lumbopelvic fixation (LPF) in the acute period of traumatic disease in patients with vertically unstable pelvic injuries.
Material and Methods. Three patients with vertically unstable injuries of the pelvic ring were operated on using LPF technique. Fixation of pelvic fractures was performed by a minimally invasive procedure with a system of transpedicular and iliosacral screws. The choice of the lumbopelvic system configuration depended on the sacral injury morphology.
Results. The average length of hospital stay was 22.7 ± 7.5 days. Assessment of the functional status of the pelvis using Majeed scale was 92.0 ± 5.3 points. Before surgery, the neurological status was assessed by Gibbons scale, all victims received 1 point: decompression of sacral neural structures was not indicated. All the victims returned to the previous level of physical and professional activity in the period from 6 to 18 months. At the same time, control SCT of the pelvis was performed, which confirmed the union of pelvic fractures and the stability of instrumentation.
Conclusion. Successful restoration of the pelvic ring anatomy with subsequent stable fixation using minimally invasive internal osteosynthesis in the acute period of traumatic disease including lumbopelvic transpedicular stabilization allowed obtaining good anatomical and functional outcomes in patients with vertically unstable injuries of the pelvic ring.
Key Words: unstable pelvic ring injury, minimally invasive lumbopelvic fixation, traumatic disease.

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One of the most important criteria of the pelvic ring stability is the integrity of its posterior compartment. The posterior hemi-ring of the pelvis includes the sacrum, the ligaments in the area of sacroiliac joints, and the posterior parts of iliac wings. These structures are affected in pelvic injuries in 37–60 % of cases [26]. Currently, unsatisfactory treatment outcomes of victims with unstable pelvic injuries account for 52–70 % of cases [2, 8].

Restoration of the pelvic ring anatomy and stable fixation using internal constructs improve the anatomical and functional outcomes. Definitive internal fixation of pelvic fractures, particularly in patients with severe concomitant injury, is often performed at the fourth period of traumatic disease (when the vital body functions are fully normalized). The reduction and restoration of the pelvic ring correct anatomy are challenging in this period. A surgical intervention implies a wide approach associated with the significant blood loss and the high likelihood of infectious complications.

The need for single complete reconstructive and restorative surgeries on the injured pelvic ring in the acute period of traumatic disease before the onset of complications appeared with the implementation of minimally invasive pelvic osteosynthesis procedures, which include percutaneous lumbopelvic fixation (LPF). The literature includes sporadic reports on small samples of victims, who were treated with this technique [24].

The aim of this study is to assess the use of minimally invasive LPF in the acute period of traumatic disease in patients with vertically unstable pelvic injuries.

Material and Methods

An analysis of treating three victims with vertically unstable pelvic ring injuries admitted to the I.I. Dzhanelidze Research Institute of Emergency Medicine (St. Petersburg) has been performed. The nature of unstable pelvic ring injury and the configuration of definitive stabilization for each particular clinical case is presented in Table. Reconstructive and restorative surgical interventions on the injured pelvic ring were performed to all the victims in the early stages, which corresponded to the acute period of traumatic disease [2].

The victims were a part of employable population. The mean age was

38.0 ± 15.7 years. The overall severity of injuries according to the ISS scale was 22.3 ± 5.5 scores. Circumstances of injury: falling from a height – 2 (66.7 %), road traffic accident – 1 (33.3 %). Upon admission to the Emergency Room, all the victims underwent HCT of the pelvis and other regions of the body. The tomograms were used to identify the nature of pelvic ring injury, the degree of anteroposterior, vertical, external, and internal rotational displacement, and whether L5–S1 articular facets were injured.

Upon admission to the Shock Room, the victims were divided into three groups: stable – 1, transient – 1, and unstable – 1. For this, we used certain criteria proposed by Pape et al. [18] allowing the rough assessment of severity of patient's condition and classify the patients into clinical groups. Temporary fixation of the pelvis was performed using a pelvic belt. The decision on the method of definitive pelvic ring stabilization was taken after the patient underwent the entire range of diagnostic and treatment procedures. Depending on the clinical group, we planned the further treatment algorithm, which consisted in single complete reconstructive and restorative surgical intervention on the pelvic ring or implementing the Damage Control Orthopedics protocols. The definitive internal fixation of the pelvic ring was performed through minimally invasive approaches using transpedicular screw systems alone or in combination with other metal constructs (cannulated screws, plates).

Pelvic bone reduction and osteosynthesis were performed under the surgical imaging by multiple view radiography with digital motorized mobile C-arm OEC 9900 Elite system. The long-term outcomes were assessed in the period from 6 to 18 months according to the Majeed scale [16].

Results

Minimally invasive LPF with transpedicular screws alone or in combination with iliosacral screws was used for fixation of the injured posterior pelvic structures. Osteosynthesis of the anterior hemi-ring was performed using cannulated screws or reconstruction plate. The mean hospital stay was 22.7 ± 7.5 days. The score of the functional status of the pelvis assessed using Majeed scale [16] was 92.0 ± 5.3. The preoperative neurological status was evaluated using the scale of Gibbons et al. [10] and all the victims received a score of 1: decompression of neural sacral structures was not indicated. The detailed treatment algorithm of the victims is described in clinical cases.

Clinical case 1. Patient K., 45 years old, was admitted to the Traumatology Center in 1 h after injury. On admission: blood pressure was 120 and 75 mm Hg, the heart rate was 84 beats/min and consciousness on the Glasgow Coma Scale (GCS) scale – a score of 15. HCT of the pelvis revealed vertical transforaminal sacral fracture on the right with the anteroposterior and vertical displacement, with ruptured anterior ligaments of the right sacroiliac junction and the symphysis pubis (Fig. 1). Sacral injury was classified as Isler type 1 [13]. The overall injury severity according to ISS was 27. The victim was related to the stable clinical group. Single definitive pelvic fixation was performed on the day of admission. Closed reduction and temporary fixation of the symphysis pubis with bone fixator were conducted, the left hemi-pelvis was pulled down using traction at the ipsilateral lower extremity. Osteosynthesis of fracture through the sacral lateral mass with two iliosacral cannulated screws, the fixation of the right sacroiliac junc-

Table
The nature of injury and stabilization options

Patients	Nature of unstable injury to the pelvic ring	The type of osteosynthesis of the anterior pelvic hemi-ring	The type of osteosynthesis of the posterior pelvic hemi-ring
1st	Vertical rotational injury to the pelvic ring: zone 2 Denis unilateral sacral fracture, the fracture line extends externally to the L5—S1 articular facet	Osteosynthesis of the symphysis pubis using a plate	Ipsilateral LPF at L4—L5/iliac wing, iliosacral fixation with two cannulated screws at the S1 and S2 level
2nd	Vertical rotational pelvic ring injury: zone 2 Denis unilateral sacral fracture, the fracture line extends internally of the L5—S1 facet, transverse component at the S3 level	Osteosynthesis of pubic bones fractures with cannulated screws	Bilateral LPF at L4—L5/iliac wing, iliosacral fixation with cannulated screw at the S1 level
3rd	Vertical rotational pelvic ring injury: H-pattern sacral fracture	Without injury	Bilateral LPF at L4—L5/iliac wing

LPF — lumbopelvic fixation.

Fig. 1
Preoperative HCT of the pelvis of a patient K., 45 years old: 3D-reconstruction

Fig. 2
Minimally invasive fixation of the pelvic ring in a patient K., 45 years old: 3D-reconstruction

tion with cannulated screw, and osteosynthesis of the symphysis pubis using reconstructive plate were performed. On the third day, LPF was conducted using a system of transpedicular screws (Fig. 2). On the tenth day, the victim was verticalized and allowed to walk using a walker, with partial 10 % load of body weight on the right lower extremity. The patient was discharged on the 23rd day after admission. In 9 months after discharge, the total score on the Majeed scale was 96 and the anatomical and functional outcomes were perfect.

Clinical case 2. Female patient B., 20 years old, was admitted in 35 min after injury. On admission: blood pressure 80 and 60 mm Hg, the heart rate was 110 beats/min and consciousness score on the Glasgow Coma Scale – 15. HCT of the pelvis revealed the fractures of the both pubic bones, the left ischial bone, vertical transforaminal sacral fracture on the left with the anteroposterior and vertical displacement (Fig. 3). Sacral fracture was classified as type 2 according to Isler [13]. The overall injury severity score on ISS was 34. The victim was classified to the unstable clinical group. The Damage Control Orthopedics treatment algorithm was implemented. Fixation of the pelvic bones with rod external fixation system, osteosynthesis of fracture through the sacral lateral mass with iliosacral cannulated screw were performed. In 2 days, external fixation system was disassembled, the fixation of fractures of the anterior hemi-ring of the pelvis with two cannulated screws and bilateral LPF using a system of transpedicular screws were performed (Fig. 4). On the 15th day, the victim was verticalized and was allowed to walk using a walker, with partial 10 % load of body weight on the left lower extremity. The patient was discharged in satisfactory condition on the 28th day. In 6 months after discharge, the total score on the Majeed scale was 86, the anatomical and functional outcomes were perfect.

Clinical case 3. Patient G., 49 years old, was admitted to the Traumatology Center in 45 min after the injury. On admission: blood pressure was 100 and 75 mm Hg, the heart rate was 94 beats/min and consciousness score on the Glasgow Coma Scale – 15. HCT of the pelvis revealed a vertical H-pattern sacral fracture with a transverse component at the S3 vertebral level (Fig. 5). Sacral fracture – type 2 according to Isler [13]. The overall injury severity score according to ISS was 19. The victim was related to the transient clinical group. Bilateral minimally invasive LPF was performed using a system of transpedicular screws (Fig. 6). On the tenth day, the patient was allowed to walk using a walker. The patient was discharged in satisfactory condition on the 16th day. In 18 months after discharge, the total score on the Majeed scale was 94; the anatomical functional outcomes were perfect.

All the victims returned to their previous level of physical and professional activities in a period of 6 to 18 months. At this period, control HCT of the pelvis was performed, which confirmed the union of pelvic fractures and the stability of metal constructs.

Discussion

Vertically unstable pelvic injuries represent a severe trauma to the locomotor apparatus. The need for functionally stable fixation of the posterior pelvic structures in these injuries is not in doubt. Various methods of internal fixation in the treatment of unstable pelvic injuries are becoming more and more important, but are mostly traumatic and accompanied by significant blood loss and infectious complications. Iliosacral fixation of the posterior pelvic hemi-ring with cannulated screws is an effective technique, but its application has some limitations.

The clinical case 3 shows that it is not possible to completely stabilize the H-pattern sacral fracture using iliosacral screws as there is no a "safe" surgical corridor in the body of S1 vertebra for iliosacral screw placement. In vertically unstable pelvic injuries after iliosacral screw fixation, one needs the long-term limiting of axial loads to prevent secondary displacements [8, 12, 13]. In two of the victims with vertical sacral fracture we used iliosacral cannulated screws for fixation of the posterior pelvic structures. An additional minimally invasive LPF using a system of transpedicular screws was performed for early verticalization of patients and ensuring pelvic tolerance to axial loading. Either unilateral or bilateral configuration of LPF in the presented cases was chosen based on HCT findings, depending on the location of the vertical fracture line of the sacrum in relation to the L5–S1 articular facet [11, 26].

The technique of the lumbopelvic distraction fusion for the fixation of sacral fractures was first described in 1994 [14]. This technique of osteosynthesis did not guarantee tolerance of the posterior pelvic structures to rotational loads. A technique of triangular posterior osteosynthesis was later proposed, which combined vertical lumbopelvic transpedicular stabilization and transverse iliosacral fixation

using cannulated screws. Experimental studies showed that triangular posterior osteosynthesis of vertically unstable sacral fractures provides greater stability compared with iliosacral fixation alone. Tolerance of this combination of metal constructs to vertical and rotational loads was proved empirically using biomechanical tests; hence, this method of osteosynthesis of the posterior pelvic compartment has been biomechanically validated [9, 22].

The growing numbers of reports on using LPF at the posterior pelvic structures for the treatment of victims with unstable pelvic ring injuries have been published in the literature [1, 3, 4, 6, 7, 15, 17, 19, 21, 23, 25, 26].

The following LPF complications in vertically unstable injuries of the posterior structures to the pelvic ring have been described: delayed union and false joint, metal construct fracture, pain syndrome in the projection of metal construct, incorrect fusion, iatrogenic injury to the L5 nerve root, evident L5 vertebral body tilt resulting from distraction at the L5–S1 junction on the fixation side (in unilateral LPF configuration) [7, 11, 15, 20, 25]. These complications were not observed in our clinical cases.

We believe that the successful application of a minimally invasive LPF technique in vertically unstable pelvic injuries is associated with the fact that operations were performed in early periods after injury. The minimal surgical invasiveness allows reduced intraoperative trauma (Fig. 7), shorter treatment time and early rehabilitation of the victims [5].

A characteristic feature of minimally invasive LPF technique is the failures of distractor installation on the elements of proper metal construct with subsequent pulling down the injured hemi-pelvis. Therefore, traction over lower extremities with counter weight was used for reduction of the posterior pelvic ring.

The presented clinical cases revealed no significant neurological deficit. For this reason, decompression of the nerve roots using an open laminectomy of the posterior cortical wall of the sacral canal or focal foraminotomy were not required [10].

In bilateral LPF, it is recommended to implant a transverse connector between the parallel support rods connected to the heads of transpedicular screws. We did not use this additional connection in our clinical cases because the installation would require widening an operative approach and formation of additional tunnel in the horizontal plane between the spinous processes of the lower lumbar vertebrae. We believe that the option without the transverse connector provides conditions for stable fixation. Additionally, implanted iliosacral cannulated screws ensure tolerance to rotational loads, which agrees with the concepts of triangular posterior osteosynthesis described in the foreign literature [20, 21].

Fig. 3
Preoperative HCT of the pelvis of a female patient B., 20 years old: 3D-reconstruction

Fig. 5
Preoperative HCT of the pelvis of a patient G., 49 years old: 3D-reconstruction

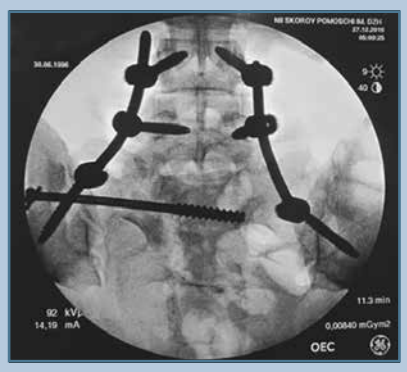

Fig. 4
Minimally invasive fixation of the pelvic ring in a female patient B., 20 years old

Fig. 6
Postoperative HCT of the pelvis of a patient G., 49 years old

Conclusions

1. The successful recovery of the pelvic ring anatomy with its further stable fixation using minimally invasive internal osteosynthesis in the acute period of traumatic disease, including lumbopelvic stabilization with transpedicular systems, allowed us to obtain good anatomical and functional treatment outcomes in victims with vertically unstable pelvic ring injuries.

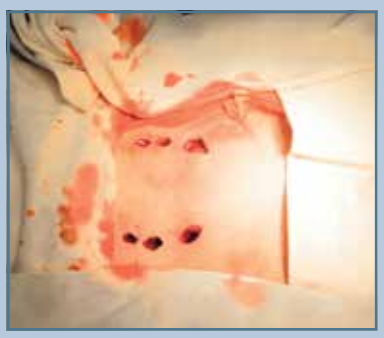

Fig. 7
The external view of a surgical approach in minimally invasive lumbopelvic fixation using a system of transpedicular screws

2. A detailed description of the pelvic ring injuries and a modern internal osteosynthesis technique through minimally invasive LPF as a surgical method to treat the injured posterior pelvic compartment are given for the clinical cases studied. The choice of LPF configuration depends on the sacral fracture morphology, more specifically, on whether the articular L5–S1 facets are involved in the fracture area.

3. At the moment, the number of clinical cases is not enough for the complete statistical analysis of the efficacy of approved minimally invasive percutaneous lumbopelvic technique for the posterior pelvic structures stabilization. However, the successful application of the technique in our practice permits us to recommend the study of this method within interdisciplinary pathology, fracture surgery, and traumatology in relation to pelvic surgery.

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