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Optimization of treatment tactics for patients with combined unstable injuries of the pelvis and long bones of the lower limbs

O. A. Buryanov, V. P. Kvasha, V. M. Domin, V. M. Lianskorunskyi, B. R. Vashkevych

Bogomolets National Medical University, Kyiv. Ukraine

Treatment of polytrauma patients with multiple fractures in general and «pelvis + lower extremities» in particular is a complex, topical and debatable problem today. Combined injury of the pelvis and TBI is observed in 16.9–58.7 % of cases, pelvis and lower limbs — in 49.2 %, pelvis and upper limbs — in 32.2 %, pelvis and chest organs — in 21.2–45.7 %, pelvis and abdominal organs — in 31.5–43.9 %, pelvis and spine — in 9 %. Objective. To improve treatment outcomes in patients with combined pelvic and lower extremity injuries by optimizing treatment tactics. Methods. The clinical study is based on the examination and treatment of 38 patients with combined injuries of the pelvis and lower extremities between 2014 and 2023. The average age of the patients was (41.4 ± 16.3) years. Typing of fractures of the pelvis and long bones of the lower extremity was carried out according to the AO classification, and the condition of patients was assessed according to the TS scale. Results. Guided by the provisions of the "damage control" concept, the nature of surgical interventions for victims with multiple and combined pelvic injuries can be presented in the following sequence: stabilizing, restorative, reconstructive, or reconstructive-restorative. Stabilizing surgical interventions are part of the resuscitation complex, the purpose of which is to preserve life by reducing pain reactions and blood loss. Conclusions. Unstable combined pelvic ring injuries require initial multidisciplinary treatment aimed at stopping or limiting life-threatening bleeding. The use of compressive devices (pelvic belt, Seattle technique) is a mandatory component of staged treatment. Individual treatment tactics and their extent depend on the overall condition of the patient, however, the basic principle of the first stage is to ensure the stability of the pelvis: in type B damage, of the anterior semi-ring, in type C damage, of both semi-rings, which has a positive effect on the anatomical and functional result and allows to avoid dangerous prognosis for life.

Лікування пацієнтів із політравмою з множинними переломами загалом і «таз + нижні кінцівки» зокрема, є складною, актуальною та дискусійною проблемою сьогодення. Спостерігаються поєднані ушкодження таза та таких ділянок: черепно-мозкової травми (ЧМТ) — у 16,9–58,7 % випадків; нижніх кінцівок — в 49,2 %; верхніх кінцівок — в 32,2 %; грудної клітки — в 21,2–45,7 %; живота — в 31,5–43,9 %; хребта — в 9 %. Мета. Покращити результати лікування пацієнтів із поєднаними ушкодженнями таза та нижніх кінцівок шляхом оптимізації тактики лікування. Методи. Клінічне дослідження базується на обстеженні та лікуванні 38 постраждалих із поєднаними травмами таза та нижніх кінцівок за період з 2014 по 2023 роки. Середній вік складав (41,4 ± 16,3) року. Типування переломів таза та довгих кісток нижньої кінцівки проводилось за класифікацією АО, оцінка стану пацієнтів — за шкалою Trauma Score (TS). Результати. Керуючись положеннями концепції «demage control» у постраждалих із множинними і поєднаними ушкодженнями таза характер втручань можна подати в наступній послідовності: стабілізуючі, відновні, реконструктивні або реконструктивно-відновні. Стабілізуючі є частиною реанімаційного комплексу, його мета — зберегти життя шляхом зменшення больових реакцій і крововтрати. Висновки. Нестабільні поєднані ушкодження тазового кільця вимагають початкового мультидисциплінарного лікування, яке полягає в зупинці або обмеженні небезпечної для життя кровотечі. Використання компресуючих засобів (тазовий пояс, техніка Сіетла) є обов'язковою складовою під час етапного лікування. Застосування індивідуального підходу та його обсяг залежать від загального стану пацієнта, проте базисним принципом першого етапу є забезпечення стабільності таза: в разі ушкоджень типу В — переднього, типу С — обох напівкілець, що позитивно впливає на анатомо-функціональний результат і дозволяє уникнути небезпечного прогнозу для життя. Ключові слова. Поєднані нестабільні ушкодження таза, переломи довгих кісток нижніх кінцівок, лікування.

Keywords. Combined unstable injuries of the pelvis, fractures of long bones of the lower limbs, treatment

Introduction

Trauma is the leading cause of death and disability worldwide. An important aspect of this problem at the present stage is the tendency to reduce the proportion of patients with isolated trauma and a significant increase (by 10–15 %) of severe multiple, combined and combined injuries [1].

Combined injuries are a consequence of the impact of a high-energy mechanical factor (road accident, catatrauma). This condition is most characterized by such terms as "polytrauma", "multiple trauma", "severe trauma" and "major trauma", which are used interchangeably and describe the condition of patients with a high score on the Injury Severity Score (ISS) scale [2].

Patients with multiple fractures from 10 to 20 % are those with pelvic fractures, predominantly men (76.5 %) with a mean age of (41 ± 21) years and characterized by a high degree of severity according to the ISS scale and a mortality rate of 8 to 15 % [3].

Combined injuries of the pelvis and craniocerebral trauma are observed in 16.9–58.7 % of cases, pelvis and lower extremities — in 49.2 %, pelvis and upper extremities — in 32.2 %, pelvis and chest organs — in 21.2–45.7 %, pelvis and abdominal organs — in 31.5–43.9 %, pelvis and spine — in 9 % [4].

Treatment of patients with polytrauma with multiple fractures in general and "pelvis + lower extremities" in particular, is a complex, relevant and debatable problem of today. In recent years, much effort has been made to develop methods and principles for the treatment of this category of patients, but there is still no single defined approach to the timing and method of surgical treatment. There are some disputes between the treatment tactics: Early Total Care (ETC) and Damage Control Orthopedics (DCO) [5].

Thus, combined injuries of the pelvis and lower extremities in patients with polytrauma require further study to resolve current issues regarding tactics and means of fixation.

Purpose: to improve the results of treatment of patients with combined unstable injuries of the pelvis and lower extremities by developing and implementing treatment algorithms in subjects with stable/unstable hemodynamics.

Material and methods

The clinical study is based on the examination and treatment of 38 patients with combined injuries of the pelvis and lower extremities for the period from 2014 to 2023. Their average age was (41.4 ± 16.3) years.

Inclusion criteria: patients with combined types B, C injuries of the pelvis and lower extremities. Exclusion criteria: patients with combined type A injuries of the pelvis, lower extremities and other organs and systems.

The typing of fractures of the pelvis and long bones of the lower extremities was carried out according to the AO classification [6, 7], the assessment of the patient's condition was carried out according to the ISS and Trauma Score (TS) scales [8, 9].

The clinical study was performed in compliance with the requirements and provisions of the Helsinki Declaration on Human Rights (2000), including the EC-GCP revision, the Constitution and Fundamentals of Ukrainian Legislation on Health Care (1992), and all ethical norms for conducting clinical studies. Protocol of the Commission on Bioethical Expertise and Ethics of Scientific Research at O. O. Bogomolets National Medical University on the topic "Unstable combined pelvic injuries (modern diagnostic and treatment strategy) within the framework of which this research was performed (Protocol No. 134 dated 21.11.2023). All patients signed an informed consent to participate in the study.

All patients underwent a targeted clinical, laboratory and instrumental examination (FAST protocol, pelvic examination radiography and examination of lower limb lesions, and CT, MRI if necessary).

To assess the results of treatment, clinical and functional tests were used, which made it possible to determine the condition, anatomical and functional capacity of the pelvic ring: Majeed S. A. Pelvic Score scale [10], Tegner activity level scale [11], visual analog pain (VAS) scale [12].

Contemporary literature on the treatment of patients with polytrauma, which included injuries to the pelvis and lower extremities for the period from 2015 to 2023 was analyzed in three databases (PubMed, Scopus and Web of Science) using the keywords: polytrauma, multiple trauma, severe trauma, fracture pelvis, bone legs.

Results

Among the 38 patients included in the study, there were 28 (73.7 %) men, who predominated by gender. and 10 women (26.3 %). The average age of the patients was (41.4 ± 16.3) years.

The general structure of injuries of anatomical and functional areas combined with multiple fractures of the long bones of the lower extremities is given in Table 1.

Thus, in the general structure of patients with polytrauma, combined injuries of the pelvis and long bones of the lower extremities make up 10.6 %, which statistically corresponds to global indicators.

Table 1

General structure of injuries of anatomical and functional areas associated with multiple fractures of the long bones of the lower extremities

Injury location	n / %
Head, cervical spine	109 / 30.4
Chest and thoracic spine	111 / 31.0
Abdomen, lumbar spine	54 / 15.1
Pelvis and lower extremities	38 / 10.6
Facial bones of the skull	24 / 6.7
Other	22 / 6.2
Total	358 / 100

Table 2

Characteristics of patients by type of injury and gender

Injury	n / %	
	male	female
Traffic accident	23 / 82.1	3 / 30.0
Catatrauma	4 / 14.3	6 / 60.0
Other	1 / 2.6	1 / 10.0
Total	28 / 73.7	10 / 26.3

Table 3

Type of injuries to the pelvis, long bones of the lower extremities and characteristics of the general condition of patients

Fracture (AO / ASIF)		TS M ± m
type, pelvis (n / %)	lower extremity (n %)	
B (26 / 68.4 %)	Femoral (14 / 53.8 %)	9 ± 1.1
	Tibial (12 / 46.2 %)	10 ± 1.5
C (12 / 31.6 %)	Femoral (7 / 58.3 %)	6 ± 1.2
	Tibial (5 / 41.7 %)	7 ± 0.9

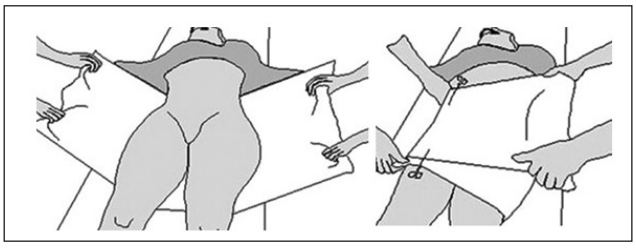

Fig. 1. Stabilization of the pelvic ring using the Seattle technique

Characteristics of individuals with combined injuries of the pelvis and long bones of the lower extremities by type of injury and gender are presented in Table 2.

Male patients predominantly had road traffic injuries — 82.1 % of cases, while female patients had catatrauma — 60 %.

The combination of types of injuries of the pelvis, long bones of the lower extremities and the characteristics of the general condition of the patients are presented in Table 3.

From the comparative analysis of the type of fractures of the pelvis, long bones of the lower extremities and the characteristics of the general condition of the patients, it can be concluded that in such combinations of injuries, the primary influence on the general condition is the type of pelvic injury, which is the main one in the priority of providing orthopedic and traumatological care.

In the presence of clinical data of unstable injury of the pelvic ring against the background of intensive therapy, temporary stabilization was performed using a pelvic belt or wrapping using the Seattle method (Fig. 1) [13].

Analyzing laboratory and instrumental methods of examination, the general condition of the patient, the type of fracture of the pelvis and long bones of the lower extremities were assessed. To determine the priority of orthopedic care “pelvis + long bones of the lower extremities”, we were guided by the generally accepted concept — all injuries of the pelvic ring are potential causes of hemorrhagic shock.

Tactics of treatment of type B injuries of the pelvis and long bones of the lower extremities. Type 2 pelvic fractures (Fig. 2) are characterized by rotational instability and vertical stability, resulting from the action of lateral compressive or rotational forces on the pelvis. In all cases of such injuries, the posterior group of pelvic ligaments and the pelvic floor remain intact, only rotational instability is possible.

The combination of type B pelvic injuries and the location of fractures of the long bones of the lower limb is given in Table 4.

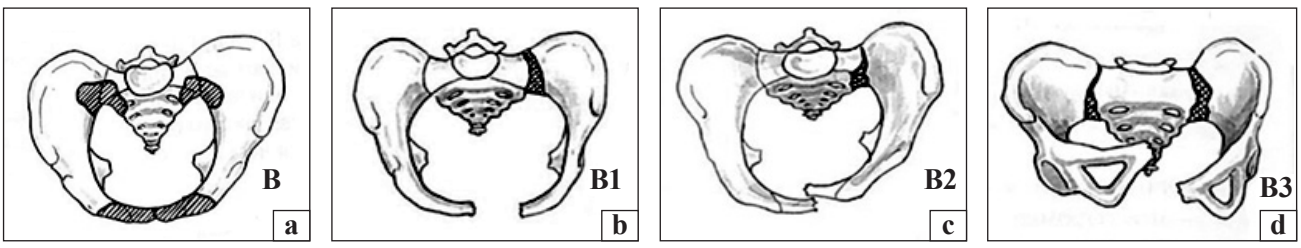

Fig. 2. Type B pelvic injury (a), where b) B1, “open book” type; c) B2, lateral compression; d) B3, ventral pelvis and anterior sacroiliac joint

The obtained data show that among type B pelvic fractures, group B1 prevails (80.8 % of cases), and regarding the location of the femoral and tibial injuries, the diaphyseal part is up to 75 and 55.6 % of cases, respectively.

The treatment tactics for type B pelvic injuries and long bones of the lower limbs in the case of stable hemodynamics of patients are presented in Figure 3.

Thus, in the case of such injuries, treatment can be implemented according to the principles of Early Total Care (ETC), even considering the phenomenon of "second impact".

Table 4

Characteristics of combined type B injuries of the pelvis and localization of fractures of the long bones of the lower extremities

Pelvic injury, AO type (n / %)	Bone fracture, AO type	
	femoral (n / %)	tibial (n / %)
B1 (21 / 80.8)	3.1 (1 / 8.3); 3.2 (9 / 75); 3.3 (2 / 16.7)	4.1 (1 / 11.1); 3.2 (5 / 55.6); 3.3 (3 / 33.3)
B2 (1 / 3.9)	3.1 (0 / 0); 3.2 (1 / 100); 3.3 (0 / 0)	3.1 (0 / 0); 3.2 (0 / 0); 3.3 (0 / 0)
B3 (4 / 15.3)	3.1 (0 / 0); 3.2 (2 / 66.7); 3.3 (1 / 33.3)	3.1 (0 / 0); 3.2 (1 / 100); 3.3 (0 / 0)

The treatment tactics for type B injuries of the pelvis and long bones of the lower extremities in unstable hemodynamics of patients are shown in Figure 4.

A clinical example of treatment tactics for type B injuries of the pelvis is shown in Figure 5.

Tactical treatment of type C injuries of the pelvis and long bones of the lower extremities. Type C fractures (Fig. 6) are characterized by rotational and vertical instability, accompanied by complete injury to the pelvic ring, which includes both the anterior and posterior sacroiliac complex, including lig. sacrospinosum and sacrotuberosum. Variations of type C injuries can be a combination of the following injuries: symphysis and sacroiliac complex; symphysis and fracture of the iliac bones; symphysis and fracture in the area of the sacroiliac joint; fracture of the anterior pelvis and sacroiliac complex (Malgaigne fracture); fracture of the anterior segment and fracture of the sacrum through the holes or its lateral part.

Characteristics of combined type C injuries of the pelvis and localization of fractures of the long bones of the lower limb are given in Table 5.

Statistical indicators revealed that group C1 prevails (58.3 %) among type C injuries of the pelvis,

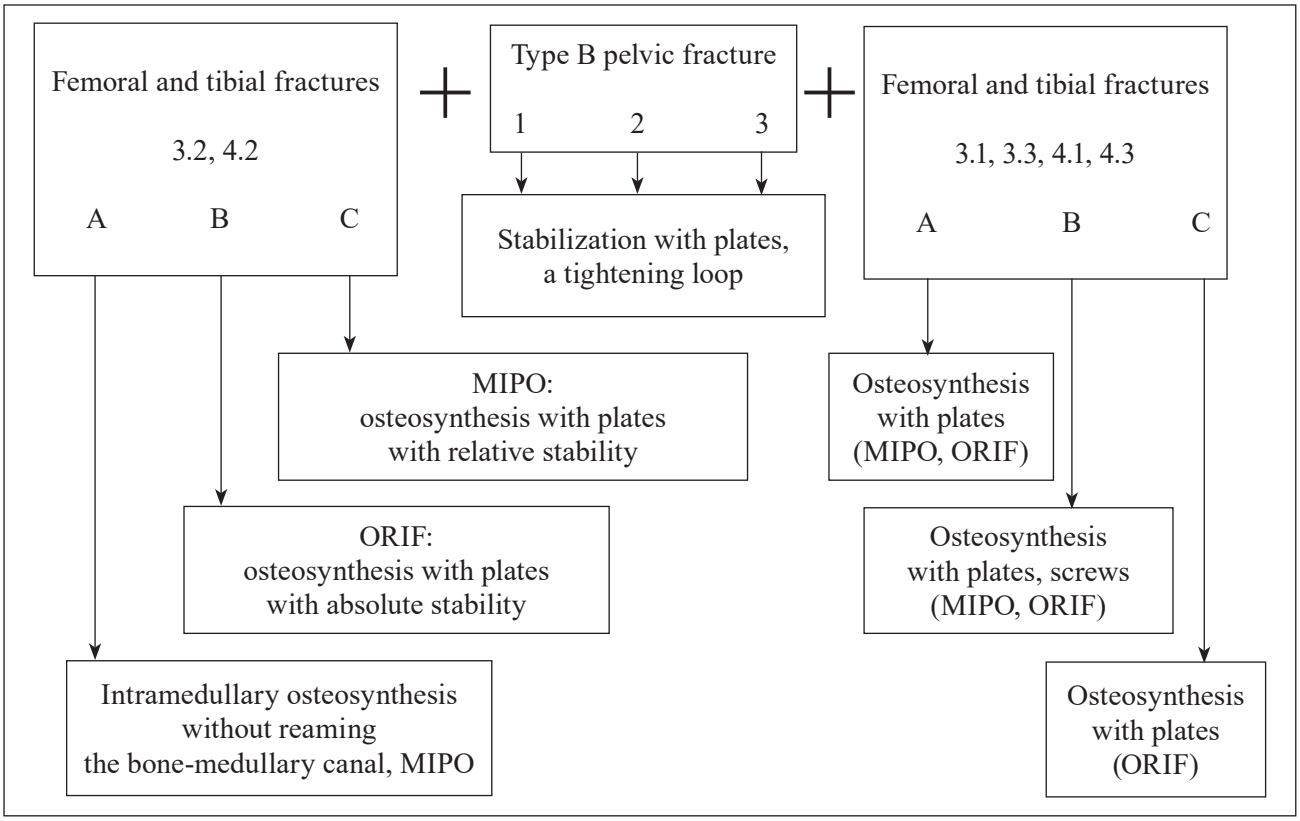

Fig. 3. Treatment tactics for type B injuries of the pelvis and long bones of the lower extremities with stable hemodynamics: especially for fractures 4.1, 4.3. If it is necessary to fill the bone defect, in these cases, preference is given to bioactive materials

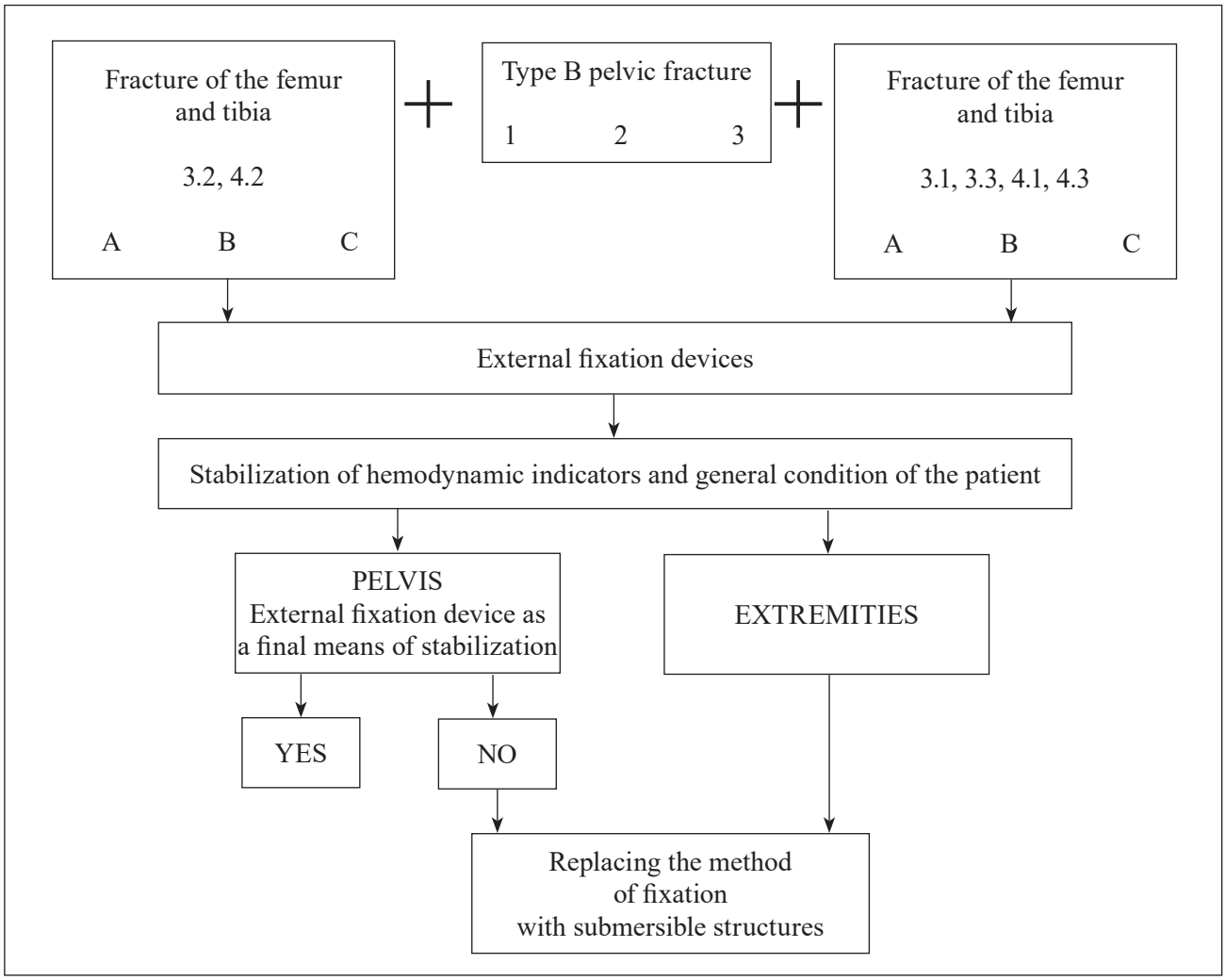

Fig. 4. Treatment tactics for type B injuries of the pelvis and long bones of the lower extremities with unstable hemodynamics

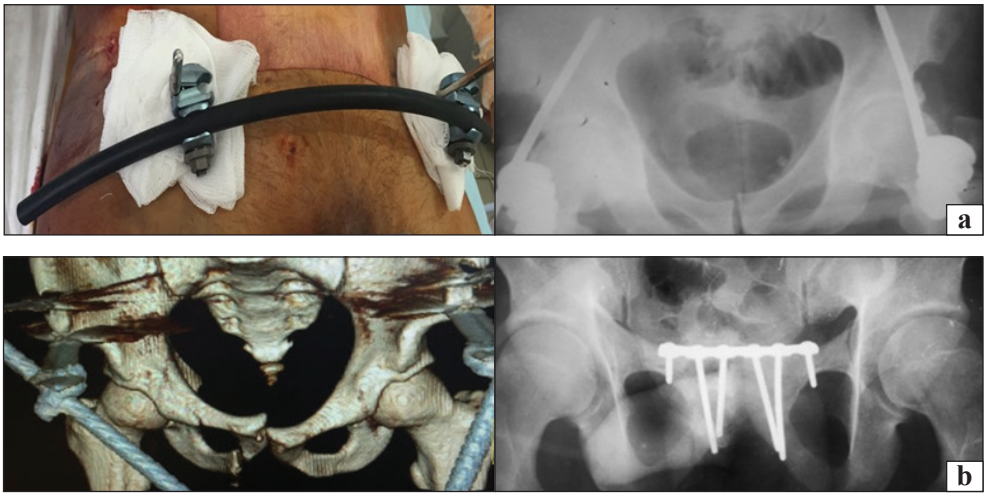

Fig. 5. Application of an external fixation device in type B pelvic injuries, where a — final method of fixation; b — temporary fixation of an external fixation device, insufficient reduction, conversion of the method of fixation

with diaphyseal part, femoral — 75 % and tibial — 66.7 % among the locations of injuries of long tubular bones.

The general condition of patients in this group is characterized as severe or extremely severe, which determines the appropriate treatment tactics. Along with this, the nature of the injury of the pelvic ring requires stabilization of both the anterior and posterior half-rings. To fix the fracture of the posterior half-ring around the sacroiliac joint, based on the MIPO

concept, standardized screws and a counter-compression screw of our proprietary design were used [14].

The treatment tactics for type C injuries of the pelvis and long bones of the lower extremities in the first period are presented in Figure 7.

After stabilization of the general condition, a decision is made to convert the fixation method.

A clinical example of treatment tactics in type C injuries of the pelvis is presented in Figure 8.

The results of treatment of unstable injuries of the pelvis 6 months after the injury according to the above tactics are presented in Table 6.

Discussion

Unstable injuries of the pelvis are accompanied by injuries of the retroperitoneal muscles (spiral-lumbar, gluteal and their fasciae), which leads to the so-called "chimney effect" and increased intrapelvic bleeding, which spreads cranially and causes the development of pelvic and abdominal compartment syndrome [15].

Experimental studies have proven that for every centimeter of diastasis in the symphysis area, the volume of the pelvis increases by almost 5 %, and in the sacroiliac joint area by 3 %, 5 cm of diastasis up to 20 %, which is objective confirmation of the need for its rapid reduction by mechanical means, to minimize blood loss and ensure the tamponade effect [16].

In order to stop bleeding at the resuscitation stage during the implementation of the conservative method, various types of pelvic belts are used, which provide compression of the pelvic ring without limiting access to the patient. The feasibility of using such devices at the prehospital and resuscitation stages has been confirmed by anatomical and biomechanical studies, which indicate a sufficient degree of ensuring the stability of the fragments [17].

However, 3D modeling has revealed that the pelvis is a semi-elliptical sphere and its volume does not change significantly with changes in radius and diameter, which gives grounds to conclude that the pelvic loop affects the stabilization of hemodynamics only by reducing the mobility of the fragments [18].

The modern concept of treatment of patients with unstable pelvic injuries in the first 48 hours requires immediate stabilization, mainly extra-focal: external fixation device, C-forceps or Ganz forceps, and immersion osteosynthesis if possible. The last type of surgical intervention is recommended for urgent indications on pelvic or intra-abdominal organs (rupture of the bladder, urethra), when bone fragments protrude into the wound, and the fixation itself will

Table 5

Characteristics of combined type C pelvic injuries and localization of fractures of the long bones of the lower extremities

Pelvic injury, AO type (n / %)	Bone fracture, AO type	
	femoral (n / %)	tibial (n / %)
C1 (7 / 58.3)	3.1 (0 / 0); 3.2 (3 / 75); 3.3 (1 / 25)	4.1 (1 / 33.3); 3.2 (2 / 66.7); 3.3 (0 / 0)
C2 (3 / 25)	3.1 (0 / 0); 3.2 (2 / 75); 3.3 (0 / 0)	3.1 (0 / 0); 3.2 (1 / 100); 3.3 (0 / 0)
C3 (2 / 16.7)	3.1 (0 / 0); 3.2 (1 / 100); 3.3 (0 / 0)	3.1 (0 / 0); 3.2 (0 / 0); 3.3 (1 / 100)

Table 6

Functional outcomes of treatment of unstable pelvic injuries

AO injury type	Outcome	n / %
B	Excellent	6 / 23.1
	Good	16 / 53.8
	Satisfactory	4 / 15.4
	Unsatisfactory	2 / 7.7
Total		26 / 100.0
C	Excellent	3 / 25.0
	Good	4 / 33.3
	Satisfactory	3 / 25.0
	Unsatisfactory	2 / 16.7
Total		12 / 100.0

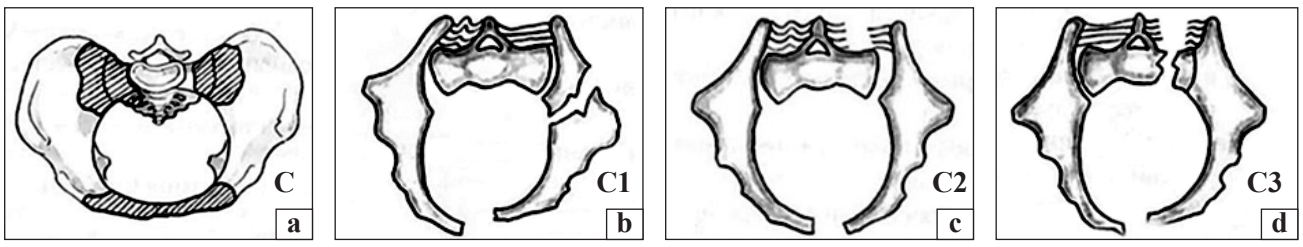

Fig. 6. Type C pelvic injuries (a), where b) C1, fracture of the ilium; c) C2, complete injury of the posterior ligamentous complex; d) C3, fracture of the sacrum

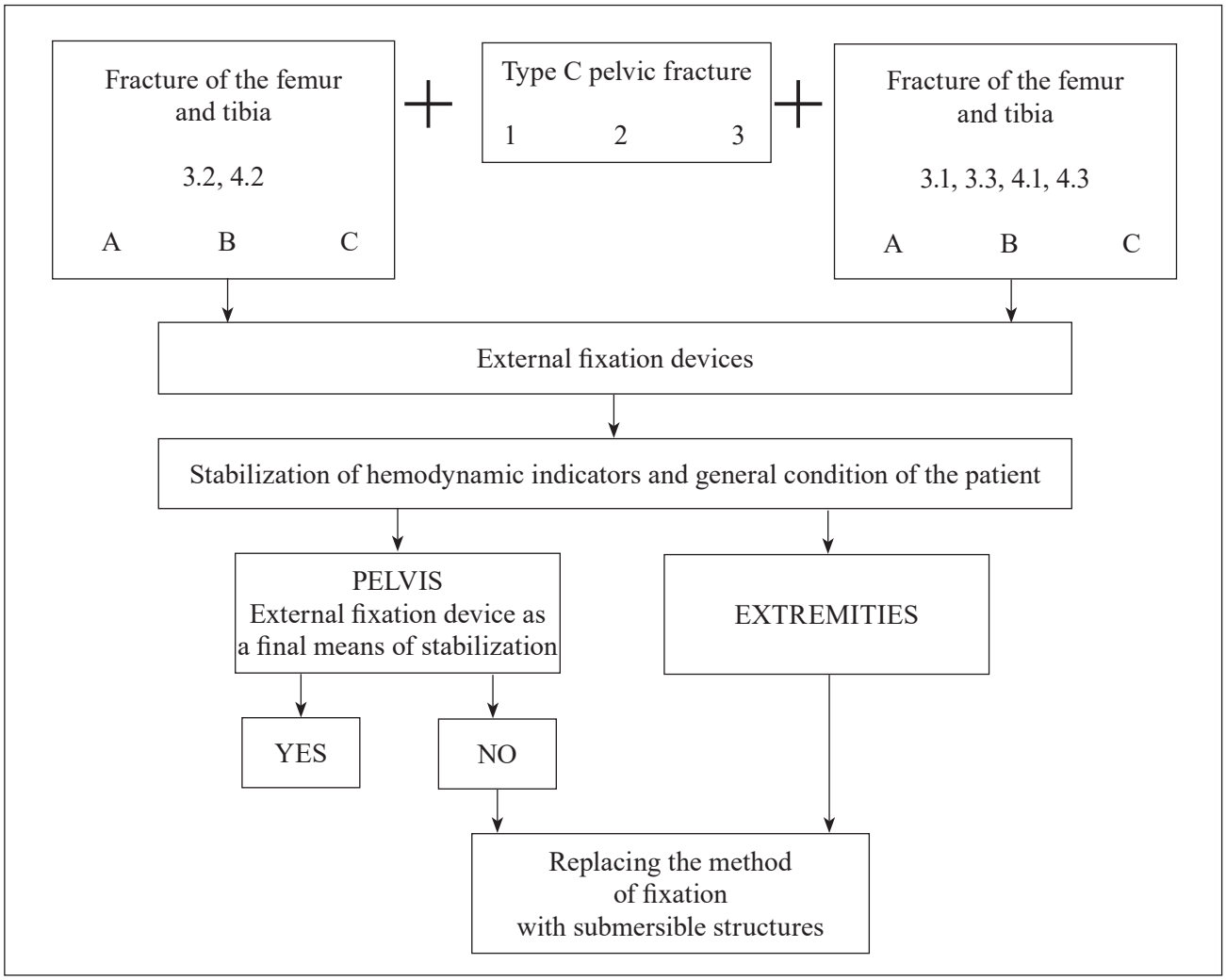

Fig. 7. Treatment tactics for type C injuries of the pelvis and long bones of the lower extremities

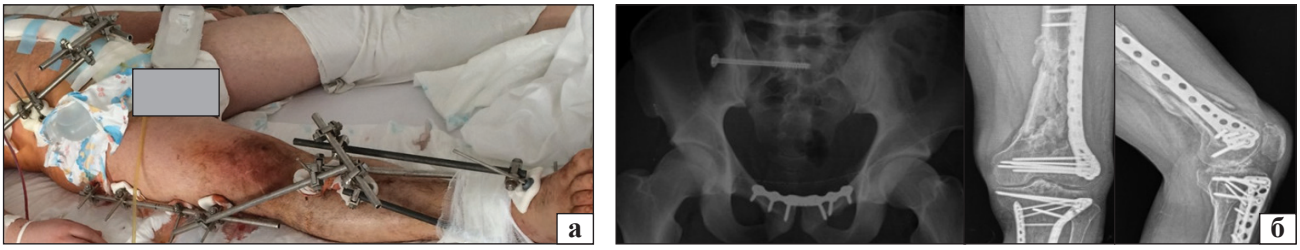

Fig. 8. Clinical examples of implemented treatment tactics for type C1 injuries of the pelvis: a — at the first stage: stabilization of the posterior semi-ring with a screw, the anterior semi-ring, femur and tibia — external fixation device; b — second stage: conversion of the fixation method: immersion osteosynthesis of the anterior semi-ring, fracture of the femur and proximal epimetaphysis of the tibia with metal plates

not be traumatic and long-term. It stands to mention that this mostly applies to injuries of the anterior semi-ring [19]. Following the provisions of the concept of "damage control" in patients with multiple and combined pelvic injuries, the nature of surgical interventions can be listed in the following sequence: stabilizing, restorative, reconstructive or reconstructive-restorative. Stabilizing surgical interventions are part of the resuscitation complex, its goal is to save life by reducing pain reactions and blood loss. During this period, C-forceps or Ganz forceps and external fixation devices of various designs are used, the so-called external emergency surgical hemostasis, which is based on the principle that compression of the pelvic ring significantly reduces or restores the internal volume of the pelvis, limits the formation and spread of intrapelvic and retroperitoneal hematomas [20].

Pelvic ring stabilization at the emergency stage using external fixation devices is the most widely used due to its relatively simple technique and low trauma [21].

However, the effectiveness of its use depends on the type of fracture. Mechanical stability of the pelvic ring due to the external structure is necessary and justified, especially in unstable pelvic injuries, but in this situation it is not able to stop bleeding by tamponade, because fixation of the posterior pelvic ring complex is not ensured [22].

Currently, there are several methods of internal fixation of the sacroiliac joint, including iliosacral screws and plates, which differ in design features and location (anterior, posterior). Percutaneous technique with screws, even despite the debatable issues regarding their number, methods of insertion and possible complications, is a promising direction, which is due to minimal invasiveness and low risk of infection [23].

Thus, the current concept of treatment of unstable pelvic injuries can be formulated as follows: for type B pelvic injuries, which are characterized by anterior, rotational and partially posterior instability, stabilization of the anterior segment is sufficient. Type C injuries, which involve anterior and posterior instability, require fixation of the anterior and posterior semi-rings. Along with this, the decision-making is based on the physiological state of the patient. Patients with unstable hemodynamics should not be sent to computed tomography or angiography, but to the operating room for mechanical stabilization and additional surgical measures to control the injuries, if necessary.

Conclusions

Unstable combined pelvic ring injuries require multidisciplinary treatment, the goal of which is to stop or limit life-threatening bleeding. The use of compression devices (pelvic belt, Seattle technique) is an obligatory component during staged treatment.

Individual treatment tactics and its scope depend on the patient's general condition, but the basic principle of the first stage is to ensure pelvic stability: the anterior in case of type B injuries, both semi-rings in type C, which positively affects the anatomical and functional outcome and allows avoiding a life-threatening prognosis.

Conflict of interest. The authors declare the absence of a conflict of interest.

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OPTIMIZATION OF TREATMENT TACTICS FOR PATIENTS WITH COMBINED UNSTABLE INJURIES OF THE PELVIS AND LONG BONES OF THE LOWER LIMBS

O. A. Buryanov, V. P. Kvasha, V. M. Domin, V. M. Lianskorunskyi, B. R. Vashkevych

Bogomolets National Medical University, Kyiv. Ukraine

✉ Olexander Buryanov, MD, Prof. in Orthopaedics and Traumatology: kaftraum@ ukr.net
✉ Volodymyr Kvasha, MD, Prof. in Orthopaedics and Traumatology: vlkvash@ukr.net
✉ Volodymyr Domin: diominc@gmail.com
✉ Volodymyr Lianskorunskyi: kaftraum@ukr.net
✉ Bohdan Vashkevych, MD, PhD: bvashkevich@gmail.com