PRINCIPLES OF PELVIC FRACTURE TREATMENT IN POLYTRAUMA PATIENTS

Uroš Dabetić¹, Danilo Golubović², Jovana Grupković¹, Marko Ilić¹,³, Dejan Aleksandrić⁴, Goran Tulić¹,³

¹ University Clinical Center of Serbia, Clinic for Orthopedic Surgery and Traumatology, Belgrade, Serbia
² City Medical Emergency Department, Belgrade, Serbia
³ University of Belgrade, Faculty of Medicine, Belgrade, Serbia
⁴ Institute for Orthopedic Surgery "Banjica", Belgrade, Serbia

ABSTRACT

Introduction: The treatment of pelvic fractures is one of the biggest challenges in orthopedic surgery and traumatology. Mortality from these injuries can be as high as 21%, which is why recognizing them and providing adequate treatment is of great importance. The most common cause of death in the first 24 hours following injury is bleeding. Pelvic fractures range from simple to complex fractures with consequent hemodynamic instability. The aim of this study is to assess current standards of pelvic fracture care, as well as to indicate a possible strategy to improve the final outcome of treatment.

Results: When there is no established protocol, the on-duty team of doctors is guided by the guidelines available to them. More recently, DCR has been considered a guiding principle in the care of polytraumatized patients. It is of primary importance to establish bleeding control — using PPP, angiographic embolization or the REBOA method. The use of pelvic bandages is recommended in literature as the primary form of care for pelvic injuries by the emergency service or by a trained person in pre-hospital conditions. External fixation of unstable pelvic fractures is one of the key steps in the DCR protocol. ORIF of pelvic fracture is a definite type of fracture fixation, but it is performed only in hemodynamically stable patients.

Conclusion: Due to the anatomical characteristics of the pelvic cavity, pelvic ring injuries represent only a part of the spectrum of polytrauma, therefore the treatment is initially based on the hemodynamic stabilization of the patient (DCR protocol). The treatment of such patients requires a multidisciplinary approach. Placement of an external fixator as part of the DCO protocol has a role in bleeding control and is the method of choice in hemodynamically unstable patients. Definitive pelvic fracture fixation (ORIF) is performed in hemodynamically stable patients, who are not in life-threatening condition.

Key words: pelvic fracture, polytrauma, bleeding, DCO
INTRODUCTION

Treating pelvic fracture is one of the greatest challenges in orthopedic surgery and traumatology. Pelvic fractures occur as the result of powerful force, primarily in traffic accidents (60%), in falls from height (30%), as well as in shooting and industrial accidents [1]. In a small number of elderly patients, pelvic fracture may occur as the result of the patient falling from standing height, due to osteodystrophic changes in the bone joint system. Bearing in mind that mortality in these injuries can be as high as 21% [2], it is of great importance that they should be recognized and treated adequately and on time. Bleeding is the most common cause of death in the first 24 hours following injury.

Pelvic fractures vary from simple fractures to complex multiple fractures with consequent hemodynamic instability. In polytraumatized patients, pelvic fractures are present in as many as 20% of cases [3]. In treating these patients, a multidisciplinary approach is necessary – a team made up of experienced orthopedic and general surgeons, including also an interventional radiologist and anesthesiologist.

In several studies published so far, it has been noted that, in those centers where an algorithm for treating pelvic fracture in hemodynamically unstable patients has been designed and put into use, a significant drop in mortality has occurred [4–7].

The aim of this study is to assess the current standards of pelvic fracture treatment, as well as to indicate the possible strategy for improving the final outcome of treatment.

POLYTRAUMA

According to the new Berlin Definition, polytrauma indicates cases with an Abbreviated Injury Scale (AIS) score ≥ 3, for at least two anatomical regions of the body, and with one of the following five physiological parameters, or with a combination of two or more of these parameters:

1. Hypotension (systolic blood pressure ≤ 90 mmHg)
2. Loss of consciousness (Glasgow Coma Scale ≤ 8)
3. Acidoza
4. Coagulopathy (partial thromboplastin time ≥ 40 s)
5. Patient age (≥ 70 years) [8].

In a polytraumatized patient, at least one of two or more injuries is life-threatening.

FIRST STEP IN TREATING PELVIC FRACTURE

The protocol for treating pelvic fracture varies from hospital to hospital. When there is no established protocol, the on-duty team of doctors are guided by available guidelines. As of late, damage control resuscitation

UVOD

Lečenje preloma karlice predstavlja jedan od najvećih izazova u ortopedskoj hirurgiji i traumatologiji. Ovi prelomi nastaju usled dejstva jake sile, a u saobraćajnim odsustvima (60%), prilikom pada sa visine (30%), kao i pri ustrelnim i industrijskim nezgodama [1]. Kod manjeg broja starijih pacijenata, mogu nastati usled pada sa sopstvene visine, a usled osteodistrofičnih promena koštanog-zglobnog sistema. S obzirom da se radi o povredama čiji mortalitet dostiže i 21% [2], od velike važnosti su, kako prepoznavanje, tako i pravovremeno i adekvatno lečenje. Krvarenje je najčešći uzrok smrtne izgube u prvih 24 sata od povreda.

Prelomi karlice variraju od jednostavnih preloma do kompleksnih višestrukih fraktura sa posledičnom hemodinamskom nestabilnošću. Kod politraumatizovanih pacijenata, prelomi karlice su zastupljeni u čak 20% slučajeva [3]. Kod zbrinjavanja ovakvih pacijenata, neophodan je multidisciplinarni pristup lečenju – tim sastavljen od iskusnih ortopedskih i opštih hirurga, kao i intervencionog radiologa i anesteziologa.

Kod politraumatizovanog pacijenta, barem jedna, iako se radi o povredama čiji mortalitet dostiže i 21%, od velike važnosti su, kako prepoznavanje, tako i pravovremeno i adekvatno lečenje. Krvarenje je najčešći uzrok smrtnog izgoda u prvih 24 sata od povrede.

PRVI KORAK U ZBRINJAVANJU PRELOMA KARLICE

Protokol za zbrinjavanje preloma karlice varira od ustanove do ustanove. Kada protokol ne postoji, dežurni tim se vodi smernicama koje su im dostupne. U novije
vreme, DCR (engl. damage control resuscitation) se smatra vodećim principom u zbrinjavanju politraumatizovanih pacijenata. DCR je strategija koja za cilj ima da zaustavi krvarenje, kao i da spreči ili preokrene razvoj komponenti letalnog traumatskog trijasa – hipotermije, acidoze i kogaulopatije, kroz niz kombinovanih terapijskih protokola [9].

Međutim, primena ove strategije zavisi od mnoštva faktora – kapaciteta same bolnice, opremljenosti, osposobljenosti hirurškog tima za damage control hirurgiju, kao i mogućnosti izvođenja hitne angiografije (embolizacije krvnih sudova).

Nezavisno od izbora strategije, neophodno je uraditi dijagnostiku (klinički pregled, laboratorijske analize, RTG, EHO, MSCT), napraviti procenu težine povreda, procenu potrebe za neinvasivnom/invasivnom stabilizacijom karlice, procenu eventualnih povreda abdomena, te doneti odluku o potrebi za hirurškim lečenjem i angiografijom [10].

IZVORI KRVARENJA

Mogući izvori krvarenja su arterije, vene i spongiozne kosti [11]. Neophodno je utvrditi izvor i uspostaviti kontrolu krvarenja. Vefs i saradnici su u svojoj studiji naveli da je, kod hemodinamski nestabilnih pacijenata sa povredom karlice i hipotenzijom otpornom na reanimaciju, u 70% slučajeva bilo prisutno arterijsko krvarenje [12].

Takođe, određeni tipovi preloma su u korelaciji sa povredom određenih krvnih sudova – prelomi pubičnih kostiju koreliraju sa povredom obturatornih krvnih sudova; dislokacija sakroilijačnog zgloga (povreda po tipu smicanja) korelira sa venskim krvarenjem, a to iz gleutalnih i hipogastričnih grana.

KARLIČNE POVESKE

Primena karličnih poveski se u literaturi preporučuje kao primarni vid zbrinjavanja povreda karlice od strane službe hitne pomoći ili obućenog lica u predbolničkim uslovima. Karlične poveske predstavljaju neinazivnu viskoznu krvarenja; dislokacija sakroilijačnog zgloga (povreda po tipu smicanja) korelira sa venskim krvarenjem, a to iz gleutalnih i hipogastričnih grana.

SPOLJAŠNJA FIKSACIJA PRELOMA KARLICE

Spoljašnja perkutana fiksacija mehanički nestabilne karlice predstavlja jedan od ključnih koraka u sklopu DCR protokola politraumatizovanih pacijenata sa (DCR) has been considered the leading principle in treating polytraumatized patients. DCR is a strategy whose aim is to stop bleeding, as well as to prevent or reverse the development of the components of the trauma triad of death – hypothermia, acidosis, and coagulopathy, through a series of combined therapeutic protocols [9].

However, the implementation of this strategy depends on a number of factors – the capacities of the hospital, equipment, the capability of the surgical team to perform damage control surgery, as well as the possibility of performing urgent angiography (blood vessel embolization).

Regardless of the choice of strategy, it is necessary to perform the following: requisite diagnostics (clinical examination, laboratory analyses, X-ray, ECHO, MSCT), assessment of the severity of the injuries, assessment of the need for noninvasive/invasive pelvic stabilization, assessment of possible abdominal injuries, and then reach a decision on the need for surgical treatment and angiography [10].

SOURCES OF BLEEDING

The possible sources of bleeding are arteries, veins, and cancellous bones [11]. It is necessary to determine the source and establish control of the bleeding. In their study, Wijffels et al. stated that in 70 % of cases of hemodynamically unstable patients with pelvic injury and hypotension resistant to resuscitation, arterial bleeding was present [12].

Also, certain types of fractures correlate with injury of certain blood vessels – pubic bone fractures correlate with injury to obturator blood vessels; dislocation of the sacroiliac joint (shear injury) correlates with venous bleeding, primarily from gleutal and hypogastric branches.

ABDOMINAL-PELVIC TOURNIQUETS

The application of abdominal-pelvic tourniquets is recommended in literature as the primary method of taking care of pelvic injuries by the emergency services or by a trained person, in prehospital care. Abdominal-pelvic tourniquets are a noninvasive form of external compression, which has proven useful in the control of bleeding and for temporarily stabilizing the pelvic ring [10].

Abdominal-pelvic tourniquets should be positioned around the great trochanters and the pubic symphysis, so that the pressure applied would lead to temporary stabilization of pelvic fracture, leg adduction, and a decrease of the internal volume of the pelvic cavity.

EXTERNAL PELVIC FRACTURE FIXATION

External percutaneous fixation of a mechanically unstable pelvis is one of the key steps in the DCR protocol.
preломom karlice. Osim što se stabilizuje karlični prsten, cilj primene ove metode je i smanjenje volumena karlične duplje, kako bi došlo do tamponade venskog krvarenja [13].

U literaturi su opisana dva glavna principa spoljašnje fiksacije, u zavisnosti od vrste preloma karlice. Za rotaciono nestabilne, antero-posteriorne kompresivne i lateralne kompresivne prelome, metodo izbora je prednja spoljašnja fiksacija. Zadnja spoljašnja fiksacija (C clamp) je pristup koji se preporučuje kod vertikalno nestabilnih preloma karlice, kako bi se postigla stabilnost posteriornih segmenta karlice [10,14].

Spoljašnja fiksacija se u najvećem broju slučajeva sprovodi u sklopu DCR protokola i predstavlja privremenu metodu stabilizacije preloma i kontrole krvenja, koja, međutim, u određenom broju slučajeva, može biti i definitivna metoda fiksacije [15]. Tada mobilizacija preloma spoljašnjim fiksatorom traje 6 – 12 nedelja, sve dok se ne pojave klinički i radiografski znaci zarastanja preloma.

Kod primene ove metode, neophodno je da hirurg bude iskusan i upoznat sa principima spoljašnje fiksacije karlice, s obzirom na moguće komplikacije, u smislu povreda neurovaskularnih struktura uzrokovanih klinova, potom popuštanja fiksacije i pojava onovne nestabilnosti, kao i u smislu razvoja infekcija na mestu plasiranih šrafova.

**PREPERITONEALNO TAMPONIRANJE KARLICE (PPP)**

Glavni izvor akutnog retroperitonealnog krvarenja kod hemodinamski nestabilnih pacijenata sa povredama karličnog prstena pripisuje se venskom krvarenju, u 80% – 90% svih slučajeva, a to je posledica venskog krvarenja iz mesnih i venskih krvionih pločica, ali i u 20% slučajeva, uzrokovanih krvarenjem iz presakralne prelome, sacralnih i sakralnih fraktura i prekida sakroilijačnog zgoba, dok je 10% – 20% arte rijskog porušenja [16].

Koncept „direktnog“ preperitonealnog karličnog tamponiranja (engl. preperitoneal pelvic packing – PPP), opisanog u Denveru, predstavlja posebnu hiruršku intervenciju, prilikom koje se pravi suprapubicni pristup, sa ciljem kompliciranja venske i sakralne duplje, na koje se nadovežu direktni retroperitonealni prstupni kompresivi, objašnjava u svrhu tamponiranja [17].

Modifikovana PPP metoda omogućava efikasnije tamponiranje unutar skrivenog retroperitonealnog prostora, pri čemu se tri i četiri sa laparotomiju postavljaju na svaki strane mokraće bešike, tako da budu upakovani ispod oboda karlice a prema ilijskim krvnim sudovima, bez potrebe ekspanziranja retroperitonealnog prostora [10]. Ovom tehnikom, laparotomi je na srednjoj liniji se može izvesti kroz odvojeni rez, proksimalno od suprapubicnog pristupa, ako postoje

for polytraumatized patients with pelvic fracture. In addition to stabilizing the pelvic ring, the goal in applying this method is also to decrease the volume of the pelvic cavity, in order to bring about the tamponade of venous hemorrhage [13].

Two main principles of external fixation, depending on the type of pelvic fracture, have been described in literature. For rotationally unstable, anteroposterior compression fractures and lateral compression fractures, the method of choice is anterior external fixation. Posterior external fixation (C clamp) is the approach recommended in vertically unstable pelvic fractures, in order to achieve stability of posterior pelvic segments [10,14].

In most cases, external fixation is carried out within the DCR protocol and represents a temporary method for stabilizing the fracture and establishing control of the bleeding, which, however, in a certain number of cases, may be the definitive method of fixation [15]. In such cases, immobilization of the fracture with an external fixator lasts 6 – 12 weeks, until clinical and radiographic signs of fracture healing are registered.

In the application of this method, it is necessary that the surgeon is experienced and familiar with the principles of external pelvic fixation, due to the possibility of the development of complications, such as injury to the neurovascular structures caused by inappropriate positioning of the pins, loosening of the fixation and renewed instability, as well as the development of infection at the placement site of the pins.

**PREPERITONEAL PELVIC PACKING (PPP)**

The primary source of acute retroperitoneal bleeding in hemodynamically unstable patients with pelvic ring injury is attributed to venous bleeding, in 80% – 90% of all cases, and it originates from the presacral and para vesical venous plexus, as well as from bleeding from the cancellous bones, due to iliac and sacral fractures and the disruption of the sacroiliac joint, while in 10% – 20% of cases the bleeding is of arterial origin [16].

The concept of ‘direct’ preperitoneal pelvic packing (PPP), as described in Denver, is a special surgical method, wherein a suprapubic incision is made, enabling direct retroperitoneal access, upon which packing is performed [17].

The modified PPP method enables more efficient packing within the hidden retroperitoneal space, wherein three laparotomy pads are placed on each side of the urinary bladder, in such a way as to be packed below the rim of the pelvis and towards the iliac blood vessels, without there being any need to expose the retroperitoneal space [10]. Using this technique, midline laparotomy can be executed through a separate incision, proximally to the suprapubic access, if there are

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Angiografska embolizacija

Angiografska embolizacija je tehnika kojom se u arterijski krivni sud kateterom plasiraju sintetički materijali, koji se nazivaju embolički agenci, i na taj način se blokiра tok krvi u datom području tela. Arterijsko krvenje se javlja u oko 10% – 15% svih krvenja kod hemodinamski nestabilnih karličkih povreda, što je obično praćeno hipotenzijom, koja je otporna na reanimaciju i mehaničku stabilizaciju [19]. Arterijske povrede imaju lošu prognozu, posebno kada su zahvaćeni veći krivni sudovi. Unutrašnja ilišna arterija predstavlja glavni izvor arterijskog krvenja u karlici (86%), sa najvećim brojem lezija na njenoj glavnoj grani [11]. Indikacije za angiografiju su sledeće: hemodinamska nestabilnost otporna na reanimaciju, delimično responzivni pacijenti sa kontrastnom ekstravazacijom na CT-u, kao i progresivni pad nivoa hemoglobin, koji zahteva četiri ili više jedinica krvi [11].

Reanimacijska endovaskularna balonska okluzija aorte (REBOA)

Reanimacijska endovaskularna balonska okluzija aorte (engl. resuscitative endovascular balloon occlusion of the aorta – REBOA) predstavlja percutanu transfemoralnu proceduru, koja uključuje postavljanje endovaskularnog balona u aortu, u cilju kontrole arterijskog krvenja i privremenog održavanja krvenog pritiska kod traumatetskog hemoragičnog šoka [11,20]. Visoko je zavisna od funkcionalnog pristupa femoralnoj arteriji, a rano formiranje ovog pristupa je od velikog značaja. Ova metoda je poslednjih godina postala alternativa za urgentnu torakotomiju kod hemodinamski nestabilnih politraumatizovanih pacijenata.

REBOA se može sprovesti u Zoni 1 (supracelijna aorta ili descendentna aorta), Zoni 2 (pararenalna aorta) ili Zoni 3 (infrarenalna aorta). Zona 2 se uglavnom izbegava, zbog moguće ishemije visciernalnih organa. Zona 3 je optimalna kod krvenja u karlici, zato što se prevenira ishemija visciernalnih organa a istovremeno omogućava dugo vreme okluzije (4 – 6 h) [21].

REBOA je samo privremeno rešenje, a definitivna kontrola krvenja se mora postići. Jedan od glavnih nedostataka ove tehnike je pojava ishemijskih oštećenja organa i tkiva koja mogu dovesti i do višestrukog otkazivanja organa (engl. multiple organ dysfunction syndrome associated intraabdominal injuries [18]. This method is recommended along with external fixation in hemodynamically and mechanically unstable patients. The drawbacks of this method are reflected in the following: it requires additional surgery, which is necessary to remove the pads; it is inefficient for arterial bleeding; it may compromise future surgical procedures [11].

Angiografska embolizacija

Angiografska embolizacija je tehnika whereby synthetic materials, called embolic agents, are injected into an artery via catheter, which results in blood flow blocking in the given region of the body. Arterial bleeding occurs in approximately 10% – 15% of all hemorrhages in hemodynamically unstable pelvic injuries, which is usually accompanied by hypotension, resistant to resuscitation or mechanical stabilization [19]. Arterial injuries have an unfavorable prognosis, especially when larger blood vessels are involved. The internal iliac artery is the main source of arterial bleeding in the pelvis (86%), with the greatest number of lesions occurring on its main branch [11]. Indications for angiography are as follows: hemodynamic instability resistant to reanimation, partially responsive patients with CT contrast extravasation, as well as a progressive fall of the hemoglobin level, requiring the transfusion of four or more units of blood [11].

Resuscitative endovascular balloon occlusion of the aorta (REBOA)

Resuscitative endovascular balloon occlusion of the aorta (REBOA) is a percutaneous transfemoral procedure, which includes the placement of an endovascular balloon into the aorta, for the purpose of controlling arterial bleeding and temporarily maintaining blood pressure in traumatic hemorrhagic shock [11,20]. This procedure is highly dependent on a functional approach to the femoral artery, and early implementation of this approach is of the utmost importance. This method has become the alternative for emergency thoracotomy in hemodynamically unstable polytraumatized patients.

REBOA can be performed in Zone 1 (supraceliac aorta or descendant aorta), Zone 2 (pararenal aorta), or Zone 3 (infrarenal aorta). Zone 2 is usually avoided, due to possible visceral organ ischemia. Zone 3 is the optimal approach in pelvic hemorrhage, as it prevents visceral organ ischemia, at the same time enabling a long occlusion time (4 – 6 h) [21].

REBOA is just a temporary solution, while definitive hemorrhage control still needs to be achieved. One of the main limitations of this technique is the occurrence of ischemic organ and tissue damage, which may lead to multiple organ dysfunction syndrome (MODS), due
syndrome – MODS) usled ishemijsko – reperfuzijske reakcije. Ovaj problem se prevenira kratkotrajnom REBOA procedurom, intermitentnom REBOA procedurom (iREBOA), Zona 3 REBOA procedurom i parcijalnom REBOA procedurom [22,23].

**DCO U SKLOPU DCR-A**

Nakon teške traume, razvoj kliničke slike određuju tri glavna faktora:
1. Inicijalni stepen povrede ("first hit" – opterećenje traumom)
2. Individualni biološki odgovor organizma povređenog
3. Vrsta lečenja ("second hit" – opterećenje operacijom) [24].

U sklopu DCR protokola, svoje mesto ima i damage control orthopedics – DCO.

DCO je hirurška strategija koja se fokusira na:
1. postizanje kontrole krvarenja – ABCDE pristup (engl. *airway, breathing, circulation, disability, exposure – AB-CDE approach*), osim u uslovima katastrofalnog krva-
renja kada se primarno zbrinjava komponenta C;
2. sprečavanje kontaminacije mekog tkiva – debrid-
man rane;
3. ranu privremenu stabilizaciju prevaloma – uglavnom

spoljašnjom fiksacijom, što je metoda izbora jer je
ekspektivina i minimalno invazivna, ali i jednostav-
nijim procedurama, kao što su trakcija i gips;
4. stabilizaciju pacijenta – zahteva dobru komunika-
ciju hirurškog tima sa anesteziologom, s obzirom

da anesteziolog ima najbolju sliku o opštem sta-
nju pacijenta; sve terapijske procedure su usme-
rene na dostizanje željenih vrednosti – srednji ar-
terijski pritisak > 60 mmHg, puls < 100, diureza =
0,5 – 1,0 ml/kg/h, serumski laktati < 2,5 i normalan

bazni deficit (-2 do +2);
5. izbegavanje ”second hit” i letalne trijade [9].

Ovakav pristup minimalizuje operativno vreme i
gubitak krvi, a istovremeno olakšava negu bolesnika

i omogućava raniju i bolju pokretljivost pacijenta [25].

Smatra se da je to najkorisniji pristup za pacijente sa
udruženom traumom glave i grudnog koša, visokim
skorom ozbiljnosti povrede (engl. *injury severity sco-
re – ISS*), predispozicijama za razvoj postoperativnih
komplikacija, kao i za ”*borderline*” pacijente [16]. Kod

ovakvih politraumatizovanih pacijenata, izlaganje hi-
rurškoj intervenciji povećava rizik od postoperativnih
komplikacija [26]. Ovaj pristup je proizašao iz primera
zbrinjavanja pacijenata sa abdominálnom i karličnom

traumom, gde se pokazalo da primarno zaustavljanje

krvarenja i sekundarna revizija, u cilju definitivnog

zbrinjavanja pacijenta, poboljšava postoperativni tok i

oporavak [27].

**DCO AS A PART OF DCR**

After severe trauma, the following three major factors determine the development of clinical presentation:
1. Initial degree of injury (“first hit” – burden of trauma)
2. Individual biological response of the injured pa-

cient’s body
3. Type of treatment (“second hit” – burden of sur-

gery) [24].

Within the DCR protocol, damage control orthoped-

ics (DCO) also has its place.

DCO is a surgical strategy focused on the following:
1. establishing control of the bleeding – the ABCDE (air-

way, breathing, circulation, disability, exposure – AB-

CDE approach), osim u uslovima katastrofalnog krva-

renja kada se primarno zbrinjava komponenta C;
2. prevention of soft tissue contamination – wound debrid-

ment;
3. early temporary stabilization of the fracture – pri-

marly with external fixation, which is the method of

choice as it is expedient and minimally invasive,

but also with simpler procedures, such as traction and plaster;
4. stabilization of the patient – requires good com-

munication between the surgical team and the

anesthesiologist, as it is the anesthesiologist who

has the best understanding of the general status

of the patient; all treatment procedures are aimed

at achieving the desired values – median arterial

pressure > 60 mmHg, pulse < 100, urine output =
0.5 – 1.0 ml/kg/h, serum lactates < 2.5, and normal base
deficit (-2 to +2);
5. avoiding ‘second hit’ and the trauma triad of death [9].

Such an approach minimalizes the duration of the

procedure and blood loss; at the same time, it makes

patient care easier and provides earlier and better mo-

bility of the patient [25]. It is believed to be the most

useful approach for patients with associated head and

chest trauma, patients with a high injury severity score

(ISS), patients with a predisposition for the develop-

ment of postoperative complications, as well as for

‘borderline’ patients [16]. In such polytraumatized pa-

tients, undergoing surgery increases the risk of postop-

erative complications [26]. This approach stems from

examples of patient care in cases with abdominal and

pelvic trauma, where it has transpired that the strate-

gy of primary bleeding control and secondary revision

surgery, with the aim of definitive patient treatment,

improves the course of postoperative recovery [27].
Kod primene DCO-a, umesto rane potpune fiksacije (< 24 – 36 časa posle povrede), ortoped privilemno stabilizuje prelom pomoću trakcije ili eksterne fiksacije, kod „borderline“ visokorizičnih pacijenata [28]. Za pacijente sa teškim povredama, koagulopatijom, hipotermijom, kao i pacijente koji su u šoku, ovo je metoda prvog izbora.

Kada se lečenje sprovodi po principima DCO-a, važno pitanje jeste u kom je trenutku optimalno izvesti sekundarnu hiruršku intervenciju.

Smatra se da period od 2 – 4 dana nakon povrede nije pogodan za sekundarnu intervenciju. U ovo vreme, imunološke promene su još uvek u toku [29], a generalizovani edem tkiva se još nije povukao [30]. Rezultati velikog istraživanja, kojim je obuhvaćeno 4.314 pacijenata, pokazali su da tajming sekundarne operacije, koja traje duže od tri sata, može biti povezan sa razvojem organske disfunkcije. Pacijenti su podeljeni u odnosu na prisustvo ili odsustvo sindroma disfunkcije više organa – MODS. Kod pacijenata koji su operisani 2 – 4 dana nakon trauma, došlo je do otkazivanja organa, dok kod pacijenata koji su sekundarno operisani između 6. i 8. dana, nije došlo do razvoja disfunkcije organa (p < 0,0001) [31]. Takođe, istraživanje je pokazalo da je, kod pacijenata koji su ranije operisani, došlo do razvoja jače inflamacije, u odnosu na pacijente koji su operisani kasnije. Stoga, nakon DCO-a, trebalo bi da postoji period čekanja od nekoliko dana pre sekundarne definitivne operacije.

**OTVORENA REPOZICIJA I UNUTRAŠNJA FIJACIJA (ORIF)**

Otvorena repozicija i unutrašnja fiksacija (engl. *open reduction and internal fixation – ORIF*) preloma karlice jeste jedna od najkompleksnijih ortopedskih operacija i predstavlja definitivan tip fiksacije preloma. Kod politraumatizovanih pacijenata, otvorena repozicija i unutrašnja fiksacija preloma realizuje se najčešće u drugom aktu, nakon potpune stabilizacije pacijenta, a u cilju omogućavanja najboljefunkcionalnog oporavka i minimalizovanja poremećaja kvaliteta života i potencijalne stope invaliditeta, u slučaju nelećenog preloma karlice [32,33]. Za vreme stabilizacije pacijenta od strane intenzivista, prelom karlice ostaje stabilizovan spojajšnim fiksatorom.

U odnosu na vrstu preloma, adekvatnim pristupom se dolazi do nesta preloma, te se učini otvorena repozicija prelomnih fragmenta, koji se potom fiksiraju odgovarajućim implantacionim materijalom – u najvećem broju slučajeva, kompresivnim vzrtnjima, anatomskom pločicom i pripadajućim vzrtnjima. U poređenju sa spojajšnjom fiksacijom, ORIF obezbeđuje anatomsku repoziciju prelomnih fragmenta i superiorniju biomehaničku stabilnost, kao i brži oporavak.

In DCO, instead of early complete fixation (< 24 – 36 hours after injury), the orthopedic surgeon temporarily stabilizes the fracture by means of traction or external fixation, in ‘borderline’ high-risk patients [28]. For patients with severe injuries, coagulopathy, hypothermia, as well as patients in a state of shock, this is the method of first choice.

When treatment is carried out according to the principles of DCO, an important issue to consider is the optimal moment for carrying out the secondary procedure.

It is believed that the period of 2 – 4 days following injury is not favorable for the second procedure. In this period, immunological changes are still ongoing [29] and generalized edema has as yet not subsided [30]. The results of a large study, which included 4,314 patients, showed that the timing of the secondary operation, which normally lasts more than three hours, may be associated with the development of organ dysfunction. Patients were divided according to the presence or absence of MODS. In patients surgically treated 2 – 4 days following trauma, organ failure did occur, while in patients which had a secondary operation between day 6 and day 8, organ dysfunction did not develop (p < 0,0001) [31]. Also, the study showed that, in patients who were operated on earlier, more severe inflammation developed, as compared to patients who were operated on later. Therefore, after DCO, there should be a waiting period of several days before secondary definitive surgery.

**OPEN REDUCTION AND INTERNAL FIXATION (ORIF)**

Open reduction and internal fixation (ORIF) of pelvic fracture is one of the most complex orthopedic surgical procedures and represents a definitive type of fracture fixation. In polytraumatized patients, open reduction and internal fracture fixation is most often carried out as a second step, after the patient has been completely stabilized, with the aim of providing the best possible functional recovery and minimizing the disruption in the quality of life, as well as minimizing potential invalidity, in case of untreated pelvic fracture [32,33]. While the patient is being stabilized in intensive care, the pelvic fracture remains stabilized with an external fixator.

Depending on the type of fracture, the site of the fracture is accessed using the appropriate approach, open reduction of the fractured fragments is performed, and the fractures are then fixed with the appropriate implantation material – in most cases, with lag screws and with plates. As compared to external fixation, ORIF provides anatomical reduction of fractured fragments and more superior biomechanical stability, as well as faster recovery.
ZAKLJUČAK

Pelvic ring injuries mainly occur as the result of powerful force, resulting in injury, not only to the skeletal, but to other body systems as well. These are rarely isolated injuries (in elderly patients, low-energy injuries), and, in most cases, associated injuries of the bone joint system, thorax, abdomen, and/or head are also present. This means that timely and appropriate treatment of these injuries is of vital importance, both at the site of first aid and at trauma centers. Bearing in mind the anatomical features of the pelvic cavity, injuries to the pelvic ring are only one segment of polytrauma, which is why treatment is initially focused on hemodynamic stabilization of the patient (DCR protocol). The treatment of such patients requires a multidisciplinary approach (hemodynamic stabilization, PPP, REBOA). Only when vital functions are stabilized, can doctors proceed to treat other medical issues, which do not primarily threaten the life of the patient.

Placement of an external fixator, within the DCO protocol, has a role in bleeding control, which makes it the method of choice in hemodynamically unstable patients.

Definitive fixation of pelvic fracture (ORIF) is carried out initially in stable patients, whose life is not in danger, or in polytraumatized patients, upon their stabilization. It is an indispensable method of treatment with respect to functional recovery and decreasing the rate of invalidity.

Although the mortality rate in these patients is still high, timely medical assistance and the correct choice and application of treatment methods, reduce the said rate effectively.

CONCLUSION

Pelvic ring injuries:

- Majority are due to powerful forces, resulting in injury not only to the skeletal but other body systems as well.
- Rarely isolated, especially in the elderly and low-energy injuries.
- Associated injuries are common, particularly involving bone joints, thorax, abdomen, and head.
- Timely appropriate treatment is crucial, both at the site of first aid and trauma centers.

DCR protocol focuses on initial hemodynamic stabilization (Damage Control Orthopedics, PPP, REBOA).

External fixator placement within the DCO protocol plays a vital role in bleeding control.

Definitive fixation (ORIF) follows in stable patients, or upon stabilization of polytrauma patients.

These interventions aim to reduce mortality rates effectively, through timely medical assistance and appropriate choice of treatment methods.
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