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Open pelvic fractures – results of a multi-institutional study

Otvoreni prelomi karlice – rezultati multi-institucionalne studije

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Abstract

Background/Aim. Open pelvic fractures are devastating, rare injuries with high mortality. Leading causes of mortality are the following: hemorrhage, infection, and associated injuries. The aim of this study was to point out methods of treating these injuries and a great number of prognostic mortality factors. **Methods.** In the period from January 2011 to December 2015, 221 patients with pelvis ring fractures were treated at three large clinical centers in Serbia, of which 13 (5%) patients had an open fracture type. We have classified pelvic ring fractures according to the Young-Burgess classification. We have classified injuries according to Gustilo at I, II, and III degrees, and the location of the wound according to Faringer classification was distributed in zone I, II, and III. Urogenital and intra-abdominal injuries were monitored, and the severity of injuries was determined according to Severity Score Injury (ISS) and Trauma Score (TS). **Results**. There were 6 (46%) women and 7 (54%) men with an average age of 41 year (13–76). Injuries from traffic trauma were dominant. The most common causes of pelvic ring fracture were antero-posterior compression – 6 (46%), lateral compression – 4 (31%), and vertical force in 3 (23%) patients. Dominant injuries were types I and II according to Gustilo and zone I according to the Faringer classification. There were 6 (46%) patients with urogenital injuries and the same number with intra-abdominal injuries, of which 3 (23%) patients had been treated with colon resection and diversion. Due to abundant hemorrhage and hypovolemic shock, two patients died, and another one died after three days due to sepsis and multisystem organ failure. **Conclusion.** Open pelvic fractures have a high mortality rate due to: hemorrhage, infection, associated abdominal and genitourinary tract injuries, ISS > 25, TS < 8, and the age of patients > 65 years.

Key words:
fractures, open; injury severity score; mortality; orthopedic procedures; pelvis; risk factors.

Apstrakt

Uvod/Cilj. Otvoreni prelomi karličnog prstena su retke razorne povrede, sa velikom smrtnošću. Vodeći razlozi smrtnosti su: krvarenje, infekcija i udružene povrede. Cilj rada bio je da se ukaže na metode zbrinjavanja tih povreda i veliki broj prognostičkih faktora smrtnosti. **Metode.** U periodu od 2011. do 2015. godine, lečen je 221 pacijent sa prelomom karličnog prstena u tri velika klinička centra Srbije, a 13 (5%) pacijenata imalo je otvoreni tip preloma. Prelomi karličnog prstena su klasifikovani prema Young-Burgess klasifikaciji. Povrede smo podelili prema Gustilo klasifikaciji na povrede I, II i III stepena, a lokalizacija im je određena prema Faringer kalsifikaciji u zone I, II i III. Praćene su urogenitalne i intraabdominalne povrede, a težina povreda određivana je prema *Severity score injury (ISS)* i Trauma skoru (TS). **Rezultati.** Istraživanjem je obuhvaćeno 6 (46%) žena i 7 (54%) muškaraca prosečne starosti od 41 godine (13–76). Dominirale su povrede zadobijene u saobraćajnim udesima. Najčešći načini nastajanja preloma karličnog prstena bili su antero-posteriorna kompresija – 6 (46%), lateralna kompresija – 4 (31%) i vertikalana sila kod 3 (23%) bolesnika. Dominirale su povrede tipa I i II po Gustilo klasifikaciji i zona I po Faringer klasifikaciji. Bilo je 6 (46%) pacijenata sa urogenitalnim povredama, a isti broj i sa intra-abdominalnim povredama, od kojih je kod njih 3 (23%) urađena resekcija kolona. Zbog obilne hemoragije i hipovolemijskog šoka umrla su 2 pacijenta, a još jedan posle tri dana, zbog sepse i multisistemskog organskog poremećaja. **Zaključak**. Otvoreni prelomi karlice imaju veliku stopu smrtnosti, a tome doprinose: krvarenje, infekcija, prateće povrede abdomena i genitourinarnog trakta, ISS > 25, TS < 8 i starost > 65 godina.

Ključne reči:
prelomi, otvoreni; povrede, indeksi težine; mortalitet; ortopedske procedure; karlica; faktori rizika.

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Introduction

Open pelvic fractures (OPFs) represent one of the most devastating injuries in orthopedic trauma. OPF is defined by communication to the lesion of integument, gastrointestinal or urogenital tracts, i.e., direct communication between fracture and the external environment (through the rectum, vagina, or skin) [1, 2]. They are usually the result of extensive force trauma and are associated with multiple injuries. Most often, they occur in traffic accidents, motorcycle drivers, and as a consequence of falling from height.

Fractures of the pelvis are reported to represent 3% of all fractures, with an associated mortality rate from 10 to 16% [3]. OPFs occur in 2–4% of all pelvic fractures, and mortality is high – until 1980, it was up to 50% due to early hemorrhage and late sepsis [3–5]. Today, there are standard resuscitation protocols (Advanced Trauma Life Support – ATLS), which include permanent airway and cervical spine control, good ventilation, and circulation [6, 7]. With this procedure, mortality is reduced to 5–25%. Mortality is not the result of pelvic fractures but of joint injuries – urogenital injuries (23% to 57%), intra-abdominal injuries (up to 50%), and head injuries (up to 35%) [8, 9]. There is a high risk of pelvic sepsis and hemorrhage in these injuries.

Determining whether hemorrhage arises from abdominal trauma, fractured bone surfaces, or ruptured pelvic vessels can be difficult. Hemorrhagic shock is the most common cause of death in the first 24 hrs [2].

Treatment of OPFs conventionally has four critical elements: control of hemorrhage, treatment of soft tissue wound, prevention and treatment of subsequent sepsis, recognition and treatment of associated injuries, and treatment of the fracture itself. Soft tissue injuries should be adequately treated with extensive debridement and rinsing, along with antibiotic therapy, while performing open reduction and stable fixation at the same time, thus preventing infection development and hemorrhage [10, 11].

The aim of this study was to present characteristics, modality of treating these injuries and examine prognostic factors for mortality of patients with OPFs.

Methods

The study included patients treated and monitored in three different centers: the Clinic for Orthopedics and Traumatology in Niš, the Clinic for Orthopedics and Traumatology at the Military Medical Academy in Belgrade, and the Clinic for Orthopedics and Traumatology in Novi Sad. From January 2011 to December 2015, 221 patients with pelvic fractures were directed to our trauma centers, while 13 (5%) of them had an open fracture type. The following data were observed: patient age, sex, injuries, type of pelvic bones fracture, extent and location of soft tissue injuries, orthopedic treatment of fractures and wounds, joint urogenital and abdominal injuries, long bones fractures, Injury Severity Score (ISS), Trauma Score (TS), number of transfusions in the first 24 hrs, and mortality.

Patients were treated in trauma rooms according to Advanced Trauma Life Support (ATLS) guidelines which means permanent airway and cervical spine control, good ventilation, and adequate circulatory support. When patients were in severe hemorrhagic shock, principles of damage control resuscitation were applied. Systolic blood pressure, presence of shock on arrival, and base deficit were all significant predictors of hemodynamic instability. Hemodynamic stability was achieved first by aggressive resuscitation with intravenous fluids and blood products, including clotting factors. Pelvic fracture instability increases hemodynamic instability, so we immediately checked initial stability – positioning and leg rotation, traction, or connecting pelvic ring. If these methods and measures of resuscitation do not achieve hemodynamic stability, it is necessary to gain early stability of the pelvis – provisional stabilization of the pelvic ring that can be achieved either by the application of an external fixator frame or the pelvic C-clamp.

In order to determine the type of pelvic ring fracture, we initially applied an antero-posterior pelvic radiograph. If the patient is in stable hemodynamic condition, additional inlet and outlet pelvic radiographs will help identify pelvic ring disruption and associated displacement. If a patient with OPF is stable, computed tomography (CT) is applied to exclude abdomen injuries and show the spatial position of pelvic fragments.

When it comes to injury mechanism, pelvic ring fractures were classified according to Young-Burgess classification [12]. For the classification of OPFs in relation to stability and rectal injuries, we used the Jones classification [13, 14]. For pelvic fracture stabilization, the method of external, internal, or combined fixation was used. Hospitalization to surgery time differs and depends on patient stability, localization, and condition of injury; surgery was performed in 10–12 hrs to 14 days, and on average, after four days. In extremities fractures, stabilization was applied at the same time, and sometimes even later, depending on the general condition of the patient.

The extent of injury in OPFs was classified according to Gustilo et al. [15]. Surgical treatment of open pelvic wounds included extensive irrigation and debridement of traumatized and devitalized soft tissues. If the condition of the wound allows, delayed secondary wound closure may follow. If there is a great loss of soft tissue, infection, and great soft tissue necrosis when the wound is treated, a delayed skin graft should be applied.

Due to the massive forces applied to cause this injury, most fractures were grade I and II open fractures. All patients with open fractures received tetanus prophylaxis and antibiotics. Furthermore, the location of soft tissue injury in OPFs can be classified as zone I (perineum, anterior pubis, medial buttock, posterior sacrum), zone II (medial thigh, groin crease), or zone III (postero-lateral buttock, iliac crest) Faringer's classification [16] (Figure 1).

Urogenital injuries in OPFs were detected by inspection of external genitalia (labia, penis, scrotum). We monitored bleeding of the external urethral meatus, the

Fig. 1 – Soft tissue injuries associated with open pelvic fracture (Faringer zone injuries I and II).

ability to urinate, and the color of the urine; we examined the perineum, vagina, and prostate. If there is a large displacement of the anterior part of the pelvis ring, there is a suspicion of partial or complete rupture of the urethra, and if possible, a catheter should be introduced. If there is a large intestine injury and perianal wound, colon resection and derivation should be applied, and the wound irrigated periodically, devitalized, and necrotic tissue removed until conditions are met for secondary suture.

During the monitoring period, an ultrasound study of the abdomen was performed in order to detect intra-abdominal bleeding. Hypotensive patients with a positive ultrasound study were indicated for diagnostic peritoneal lavage (DPL). It was applied via a supraventile entry point in order to minimize the possibility of piercing pelvic hematoma and producing a false positive result. If the DPL were grossly positive (> 8 mL of blood aspirated on entry into the peritoneum), operative exploration was indicated [17].

Determining the severity of polytrauma is one of the crucial factors for determining priority in managing injured patients, whether at the injury site or trauma centers. Nowadays, in order to successfully resolve this difficult problem, we have several scoring systems available – anatomical, physiological, or combined. We used the ISS in our study; it gives a numerical description of injuries within the polytrauma and is a type of anatomical scoring system. According to this scale, the body is divided into 6 regions, and with the increase in points, mortality [18] increases. We also used TS, a physiological scoring system. It consists of the Glasgow Coma Scale (GCS), which is reduced by one-third of the value, and an assessment of cardiopulmonary functions. It is composed of 5 parameters, and the number of points is 1 to 16; the higher the score, the greater the possibility of the polytraumatized patient's survival [19].

Statistical analysis

Kolmogorov-Smirnov test for small samples with a marginal value of $p < 0.05$, D = 7, was used for statistical data processing on a small sample of 13 subjects.

Results

In the period from January 2011 to December 2015, 221 patients with a pelvic ring fracture were monitored in these three orthopedic traumatology clinics, of which 13 (5%) patients had an open fracture type. Demographic data of patients, trauma scoring, and mechanism of injury are listed in Table 1.

Table 1

Demographic data, trauma scoring, and mechanism of injury

Characteristics	Value
Age (years), mean (range)	41 (13–76)
Sex, n (%)	
male	7 (54)
female	6 (46)
ISS, mean (range)	30.7 (10–69)
TS, mean (range)	10.8 (4–16)
PRBCs (first 24 hrs), mean (range)	7 (0–18)
Mechanism of injury, patients n (%)	
pedestrian struck by a car	5 (39)
motorcycle collision	3 (23)
fall	3 (23)
tractor driver	2 (15)

ISS – Injury Severity Score; TS – Trauma Score; PRBCs – Packed Red Blood Cells.

The most common cause of pelvic fracture was antero-posterior compression (APC) in a total of 6 (46%) patients.

Lateral compression (LC) as a mechanical fracture factor was noted in 4 (31%) and vertical force (VS) in 3 (23%) patients.

The radiographic findings of patients with open pelvic fractures are shown in Figure 2.

The number of patients in the first open pelvic ring fractures group (stable OPFs) of patients, the second (unstable OPFs without rectal injury), and the third group (unstable OPFs in combination with rectal injury) is presented in Table 2.

The magnitude of the injury was classified using the Gustilo classification. There were 4 (31%) patients with type I, 7 (53%) with type II, and 2 (16%) with type III.

The location of soft-tissue injury was classified according to the Faringer system. In 9 (68%) patients, the wound was located in zone I, in zone II in 2 (16%) patients, and in zone III in 2 (16%) patients.

Hemodynamic instability at reception was registered in 9 (69%) patients. The average transfusion requirement for the first 24 hrs was three units of packed red blood cells.

In 6 (46%) patients, urogenital injuries were registered, of which 4 were women and 2 were men. In one girl, vaginal laceration and uterine amputations were found, as well as intraperitoneal bladder rupture. The other three women had lacerations of the vagina – one had intraperitoneal bladder rupture, the second one had extraperitoneal, and the third one had urethra rupture. In two men, a rupture of the urethra was found. Three women were immediately operated on when reconstruction of the vagina and urinary tract was performed, and the fourth died 8 hrs after admission. Both male patients with urethral disruption required suprapubic drainage and subsequent delayed repair. The mortality rate of patients with associated urogenital injuries was 33% (1 of 3 patients).

In this series, 6 (46%) patients were diagnosed with intra-abdominal injuries. They all had laparotomy performed for various reasons: intraperitoneal bladder rupture was found in two women, and besides that, in one of them, a colon serosal tear requiring a sigmoid colon resection and diversion was also present, and the other one had a small bowel injury requiring surgical repair; 2 patients required a sigmoid colon resection and diversion, one had liver laceration requiring surgical repair, and one was with splenic laceration requiring splenectomy. The mortality rate of patients with associated intra-abdominal injuries was 33% (1 of 3 patients).

Orthopedic stabilization of OPFs was performed in 11 (85%) patients, and 2 (15%) patients died in the initial resuscitation phase. External fixation was applied in 7 (54%) patients, of which 1 vertically and 6 rotationally

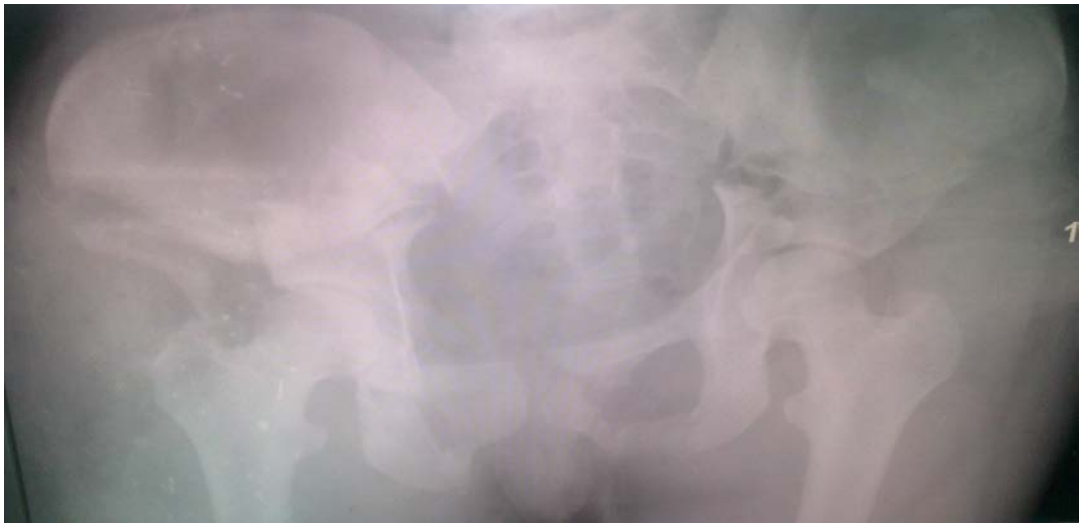

Fig. 2 – Antero-posterior radiograph showing an open pelvic fracture.

Table 2

Type and magnitude of pelvic fractures

Classification	Magnitude	Patients (number)	Toral (percentage)
Young-Burgess			
APC	I	2	46
	II	3	
	III	1	
LC	I	1	31
	II	2	
	III	1	
VS		3	23
Jones			
Group I	I	4	31
Group II	II	4	31
Group III	III	5	38

APC – antero-posterior compression; LC – lateral compression; VS – vertical shear.

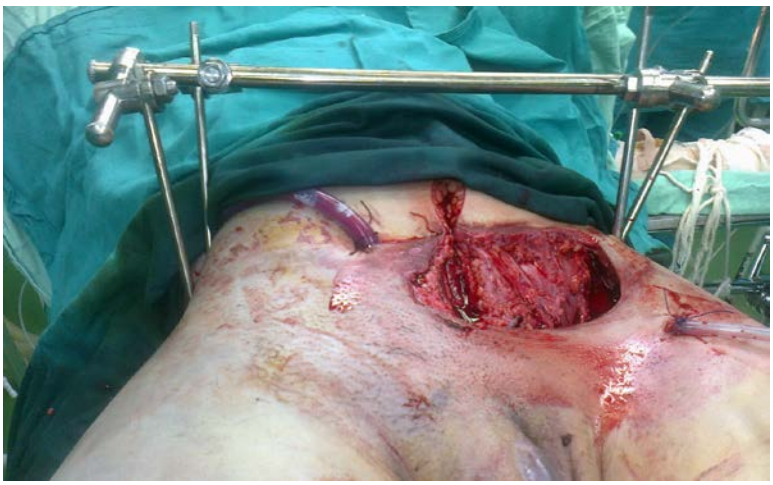

Fig. 3 – An open pelvic fracture stabilized with an external fixator.

unstable fractures. In 3 (23%) patients, internal fracture stabilization was performed, and one had a combination of internal and external fixation – internal femur fracture fixation was applied (Figure 3). After managing wounds in the pelvic region – 15 days on average, a delayed internal fixation was performed in two patients – one vertically and one rotationally unstable fracture and the frontal bow of the pelvic ring was stabilized. Seven patients were treated using the external fixation method, and the apparatus was fixed for seven weeks on average. In 3 (41%) patients, there was a minor infection around pegs – five pegs in total, and it was treated with periodic bandaging. We replaced two pegs of the external fixator in series, i.e., pegs were reinserted in *crista iliaca* because of constant moisture and looseness.

We found no significant correlation between fracture pattern and wound type or location. In 2 (17%) patients, wounds have healed *per primam* – they were located in zone III, in 9 (66%) patients, the wounds have healed *per secundam* with a prolonged period of bandaging and antibiotic therapy, and in 2 (17%) patients, skin graft by Tiersch was applied.

Associated injuries are commonly found with pelvic fractures. The most common joined injuries were fractured extremities – there were five femur fractures – external femur fixation was applied in two patients in the same act when the pelvic ring was fixated, and in three, internal femur fixation was applied with delay after nine days on average**,** and six *cruris* fractures found – external fixator stabilization was applied in four, and in two patients, a lower leg amputation was performed. There were three closed head injuries, one ruptured diaphragm, two pneumothorax, one liver laceration, one small intestine injury, three colon lesions, four perineal and vaginal tears, three urethral injuries, and three bladder ruptures.

Three of 13 patients died (mortality rate 23%), two died in the first 24 hrs due to abundant hemorrhage and hypovolemic shock, and one died after three days due to pelvic sepsis and multisystem organ failure (MSOF). Risk factors for overall mortality are shown in Table 3.

Table 3

Risk factors for overall mortality

Variable	Death		K-S test (D-value)	*p*-values
	yes	no		
Pedestrian struck by a car	2	3		
Motorcycle collision	0	3	D = 7	< 0.05
Fall	0	3		
Tractor driver	1	1		
Young-Burgess class				
APC	2	4		
LC	0	4	D = 7	< 0.05
VS	1	2		
Jones class				
group I	0	4		
group II	1	3	D = 7	< 0.05
group III	2	3		
Gustilo-Anderson grade				
I	0	4		
II	1	6	D = 0	< 0.05
III	2	0		
Faringer class				
zone I	2	7		
zone II	1	1	D = 7	< 0.05
zone III	0	2		
Urogenital injury				
yes	1	5	D = 7	< 0.05
no	2	5		
Intra-abdominal injury				
yes	1	5	D = 7	< 0.05
no	2	5		
Gender				
male	2	4	D = 7	< 0.05
female	1	6		
Age, years				
< 30	1	4	D = 7	< 0.05
> 30	2	6		
ISS				
< 25	0	8	D = 8	< 0.05
> 25	3	2		
TS				
< 8	3	3	D = 7	< 0.05
> 8	0	7		

ISS – Injury Severity Score; TS – Trauma Score; APC – antero-posterior compression; LC – lateral compression; VS – vertical shear.

The results showed there was a statistically significant difference in our material compared to expected values, so there was a greater number of deaths present.

Discussion

OPFs are usually the result of a high energy transfer and are most often seen as part of a trauma mechanism. They most commonly occur in traffic traumatism and are less frequent in case of falling from a height or industrial traumatism [5, 7].

Pelvic fractures are a marker of excessive force applied to the human body and are associated with hemorrhage. Hemorrhage from the cancellous bone surface, the presacral venous plexus, and/or iliac arterial or venous branches can cause hypotension. Hemodynamically unstable pelvic fracture represents a difficult diagnostic and therapeutic challenge for the trauma team. Bleeding is often also extrapelvic due to following injuries (chest 15%, intra-abdominal 32%, long bones 40%). This bleeding is the cause of high mortality in the first 24 hrs – more than 40% [11, 20, 21]. One of the potential causes of late mortality is most likely to be a direct result of the "bloodless vicious cycle" of continuing hemorrhage and transfusion since blood transfusion is an indispensable risk factor for the development of MSOF and death [22, 23]. In our series, 2 (67%) patients died in the first 24 hrs due to hemorrhage, and 1 (33%) died after three days due to MSOF.

Grotz et al. [5] and Bircher and Hargrove [24] have reviewed management priorities in patients with OPFs, including control of hemorrhage, aggressive assessment and management of the wound, stabilizing pelvic ring, early diagnosis of rectal and/or urogenital injuries, and selective use of fecal diversion. That is a protocol for successful OPFs management, which we have also adhered to.

Pelvic ring stabilization is one of the conditions for stopping bleeding and hemodynamic restoration. Biomechanical instability causes hemodynamic instability, i.e., there is a direct correlation. Traditionally, only external fixation techniques were used in OPFs patients [25, 26]. These tools, via external compression, reduce intrapelvic volume and create a tamponade effect against ongoing bleeding. They also restore stability and bone contact to posterior elements of the pelvis and contribute to blood clotting. The pubic symphysis is the weakest link of the structure, representing only about 15% of its stability. Posterior elements – sacroiliac, sacrospinous, and sacrotuberous ligaments – are the strongest, contributing to vertical and antero-posterior stability of the pelvis [27].

In our series, an external fixator was used in 7 (54%) patients. Many authors recommend internal fixation of the pelvic ring in order to achieve both rotational and vertical stability [28]. In 3 (23%) patients, we performed internal fixation of the frontal pelvis ring while performing laparotomy, and in 2 (17%) patients, external fixation was replaced by the inner one, and only after treating wounds and local infection, after 15 days on average.

Hemorrhagic shock is the most common cause of death in the first 24 hrs. In order to eliminate hemorrhage, many authors recommend pelvic packing, i.e., preperitoneal pelvic packing has been suggested to be ineffective for hemorrhage control in OPFs [2, 4, 20, 29]. In our series, this was applied to 4 (31%) patients.

Urogenital injuries are common in OPFs and are a possible cause of developing infection and death. Vaginal lacerations are the result of either penetration of a bony fragment or indirect forces from diastasis of symphysis pubis or bilateral pubic rami fractures [30]. Primary treatment of these injuries is indicated in order to prevent abscess formation. We had 4 (31%) women with vaginal lacerations, of which two had complete uterus amputation up to the cervix. One died 8 hrs after injury, and in 3 patients, revision and bone fragment removal from the vagina were performed. Urethral lesions were conservatively treated by placing a suprapubic catheter. Intraperitoneal urinary bladder ruptures have been operated on, and extraperitoneal have been treated with urethral catheters.

Rectal lacerations with OPF are rare, causing infection, sepsis, and death. Opinions on the method of treatment are opposed. Maull et al. [31], Birolini et al. [32], and Song et al. [14] have operated on all patients and performed total diverting colostomy. The incidence of pelvic infection was lower in patients with early colostomy. Woods et al. [33] and Pell et al. [34] treated fewer patients with this method, treated more patients inoperatively, and found no differences in frequency of infection. In our series, there were 3 (23%) patients with rectal injury, and diverting colostomy was performed on all of them; extensive irrigation and debridement of traumatized and devitalized soft tissues and a secondary seam were applied.

There were 6 (46%) patients with urogenital injuries, 4 women and 2 men. One woman died in the first 24 hrs, and 5 patients were regularly monitored. All three women had dyspareunia (painful sexual intercourse), and the youngest (18 years old) had gynecological surgery in order to apply vagina dilatation and remove the scars; at the time of injury, she had cervix amputation in relation to the vagina. The causes of dyspareunia were: vagina laceration and formation of scar tissue that narrows its lumen, impingement of visceral pelvic organs due to deformation of pelvic ring, as a result of poor treatment of rotational and vertical unstable fractures, and residual displacement of the fracture – more than 5 mm. One male patient was registered with erectile dysfunction of medium level, and the result was pubic diastasis and urethral rupture [35, 36].

The mortality rate in our series of OPFs was 23% (3 deaths out of 13 patients). The mortality rate from closed pelvic fractures was 7% (15 deaths out of 221 patients). Using Fischer's exact test, the difference in mortality was statistically significant for $p < 0.005$. In the study by Hermans et al. [2], no significant difference in survival rate between open and closed pelvic fractures was found. The question was whether the modern improvements in injury treatment, early management, intensive care therapy, damage control, and definitive fracture stabilization techniques would decrease the mortality rate due to pelvic fractures.

Risk factors for OPFs increased mortality include the following: increased ISS, > 25; decreased TS, < 8; age > 65 years; initial systolic blood pressure < 100 mmHg; blood transfusion of > 10 units in 24 hrs; mortality was higher in larger soft-tissue injuries (Gustilo III); location of wounds (Faringer zone I or II); type of bone injury (vertical shear and antero-posterior type); intra-abdominal injury; urogenital injury; pelvic sepsis [37–40]. In our series, the results indicated the same risk factors for mortality in OPFs. A strategic, multidisciplinary response is a critical component in managing these complex and difficult injuries [7, 8, 37].

Conclusion

We presented experiences in the treatment of patients with OPFs in our listed institutions. Vascular damage and bone bleeding associated with pelvic fracture can lead to a very significant, potentially fatal, hemorrhagic shock. OPFs have high mortality due to hemorrhage, infection, and intra-abdominal and urogenital injury. Based on our results, we suggest that ISS > 25, TS < 8, and patients age > 65 years have a poor prognosis on the outcome of treatment.

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