



Original Article

Epidemiology of pelvic ring fractures and injuries[☆]

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ABSTRACT

Objective: This study evaluated the pelvic ring fractures and injuries in patients admitted to and treated at this ward between August, 2012 and January, 2014.

Methods: 66 patients were submitted to treatment protocols according to their age, gender, skin color, injury mechanism, location of the trauma, classification of their injuries, emergency intervention, associated injuries, injured side of the body, treatment, and mortality. The most relevant data were classified according to statistic procedures, such as Goodman's association test. Measures were compared with Student's t-test and analysis of variance associated with Tukey's multiple comparison test.

Results: The mean age was 47 years; white race and male gender were most common. Car or truck accident was the most common cause of injuries, which occurred mainly in urban sites. Type A injuries were the most frequent. 16.6% of the cases were submitted to emergency surgery. 42.4% displayed associated injuries. The right side of the body was the most commonly affected side. Non-invasive treatment was most commonly used. Death was the outcome in 3% of the cases, associated to high-energy trauma.

Conclusions: Pelvic ring fractures and injuries are more often verified among males. In general and among younger individuals, traffic accidents are the most common cause of the injury, while among the elderly, ordinary falls are the most commonly verified cause. The majority of those injuries are suffered in urban areas. Type A fractures are more frequent. The majority of cases do not require emergency intervention nor do they feature associated injuries. Non-invasive treatment is most common and death outcomes are associated to high-energy traumas with severe injuries.

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Estudo epidemiológico das fraturas e lesões do anel pélvico

R E S U M O

Palavras-chave:

Fraturas ósseas/epidemiologia

Ossos pélvicos/lesões

Estudos epidemiológicos

Objetivo: Estudo das fraturas/lesões do anel pélvico atendidas e tratadas neste serviço de agosto de 2012 a janeiro de 2014.

Métodos: Elaborou-se um protocolo para os 66 pacientes, consideraram-se os dados: idade, sexo, cor, mecanismo da lesão, local do trauma, classificação das lesões, intervenção de urgência, lesões associadas, lado acometido, tratamento e óbito. Para os dados de maior interesse foram usados os procedimentos estatísticos que envolveram o teste de associação de Goodman e as técnicas de comparações de medidas por meio do teste t de Student e da análise de variância complementada com as comparações múltiplas de Tukey.

Resultados: A idade média foi de 47 anos; pacientes do sexo masculino e brancos foram mais frequentes. A causa mais comum das lesões foi acidente carro/caminhão e a zona urbana foi o local onde elas mais ocorreram. Fraturas tipo A foram as mais frequentes. Em 16,6% dos pacientes, foi necessária cirurgia de urgência e 42,4% apresentaram lesão associada. O lado direito foi mais acometido. O tratamento incruento foi o mais usado e o óbito ocorreu em 3%, em casos de trauma de alta energia.

Conclusões: As fraturas/lesões do anel pélvico são mais frequentes no sexo masculino. De modo geral e em jovens, o acidente de trânsito é o mecanismo mais frequente, já em idosos é queda banal. A maioria das lesões ocorre na zona urbana. Fraturas do tipo A são as mais frequentes. A maioria não necessita de intervenção de urgência e não apresenta lesões associadas. O tratamento incruento é o mais usado e os óbitos estão associados a trauma de alta energia com graves lesões associadas.

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Introduction

Fractures and injuries of the pelvic ring, which may or may not be associated with severe trauma, are generally not considered to be frequent, accounting for only 2–8% of all fractures. However, in polytraumatized patients the occurrence of this type of injury is much higher, being observed in 20–25% of cases.¹ Fractures of the pelvic ring in young individuals most often occur as a consequence of high-energy trauma such as car and motorcycle accidents and falls from great heights. In the elderly, they are usually caused by low-energy trauma, most commonly fall from own height, mainly due to bone porosity.¹ Young patients with pelvic ring fractures or injuries due to high-energy trauma should be initially assessed by a multidisciplinary team, because they often have multiple injuries and are subject to major bleeding. Bleeding in this type of injury is more severe when associated with unstable pelvic fractures, which, although infrequent, present a high mortality rate of 19–31%.^{2–4} In turn, elderly patients with fractures due to minor trauma generally do not present complications. In recent years, a considerable number of studies related to the care and immediate or late complications of this type of injury have been published, which is undoubtedly praiseworthy, since they increasingly inform and guide the professionals involved in such care, characterizing the importance and severity of the injury, especially in polytrauma

cases.^{5–9} However, a much smaller proportion of publications are related to epidemiological data, regional or otherwise, about fractures and injuries of the pelvic ring, which also have very important information, especially regarding the characterization and appropriateness of care for such an injury.^{3,10,11} Therefore, this study sought to analyze and compare various data, such as age, mechanism and site of injury, type of fracture, emergency interventions, and definitive treatment, among others, referring to the cases of fractures and injuries of the pelvic ring that occurred in this region and were treated in this service.

Material and methods

The study included 66 patients with pelvic ring fractures and injuries treated at this service from August 2012 to January 2014, who agreed to participate in the study.

A protocol was elaborated with data obtained from patients/relatives and medical records, which included the following items: age, sex, color, mechanism of injury (motor vehicle/truck accident (one), motorcycle accident (two), fall from own height (three), fall from height greater than 1 m (four), horse accident/fall or saddle trauma (five), tractor accident (six), and being run over (seven)). Place of occurrence of accident or fall: urban area, rural area, highway, home/institution. Emergency intervention: C-clamp (one),

anterior external fixator (two), no intervention (three), laparotomy (four). Associated injuries: no associated injury (one), urethral/bladder injury (two), paraplegia (three), other fractures/dislocations (four), abdominal organ injuries/cranial trauma (five). Affected ring side: right (one), left (two), both (three), pubic symphysis diastasis (four). Pelvic ring fracture/injury classification (Tile classification): type A,¹² type B, type C, and their subdivisions. Definitive treatment: non-surgical (one), iliosacral screw (two), iliosacral screw and plate (three), iliosacral screw and external fixator (four), plates (five), plates and external fixator (six), external fixator (seven). Occurrence of death: no (one), yes (one).

In the statistical analysis of the present study, the association among the variables of interest was assessed through the Goodman¹³ test for contrasts among and within multinomial populations. When the contingency table presented a large number of null cells, the results were only descriptive. In the case of the Goodman test, results were presented regarding their significance ($p < 0.05$) by lower case letters (comparison of rows by column) and upper case letters (comparison of columns by row). These data should be interpreted as follows: two responses with the same letter do not differ from each other.

Regarding the association of age and sex, injury mechanism, and classification of the pelvic ring fracture/injury mechanism (Tile), Student's t-test was used for sex, and multivariate analysis of variance supplemented by the Tukey test was used for the variables injury mechanism and pelvic ring fracture/injury classification (Tile).

The study was approved by the Institutional Review Board of this service (CEP 4296/2012).

Results

The results were presented in a descriptive manner, as well as in tables with a comparison of some data that the authors considered important.

The age of the individuals analyzed ranged from 3 to 86 years (mean of 47). Mean age in relation to sex was 55.3 years for females and 41.9 years for males. As for sex, there was predominance of males (57.5% of the sample). Regarding ethnicity, the highest percentage (69.6%) was white, followed by blacks (16.6%).

The following injury mechanisms were observed:

Car/truck accident	17 (25.7%)
Motorcycle accident	13 (19.6%)
Fall from own height	17 (25.7%)
Fall from height >1 m	4 (6%)
Horse fall/saddle trauma	5 (7.5%)
Tractor accident	2 (3%)
Being run over (8.8%)	8 (12%)

Observation: In the mechanism fall from own height, 81% of the individuals were female.

The injury mechanism was compared with the age of the patients (Table 1).

Injuries occurred in the following places:

Urban area	22 (33.3%)
Highway	19 (28.7%)
Rural area	8 (12.1%)
Home/organization	17 (25.7%)

Table 2 shows an association between the place of occurrence of trauma and injury mechanism.

Regarding the classification of pelvic ring fractures/injuries (Tile), the following were observed:

Type A (stable)	36 (54.5%)
(the most frequent type was A2.3, observed in 61% of cases).	
Type B (rotationally unstable and vertically stable)	19 (28.7%)
Type C (rotationally and vertically unstable)	11 (16.6%)

Table 3 presents a comparison between the classification of fractures/injuries (Tile) and age of patients.

Table 4 describes the association between pelvic ring fracture/injury mechanism and patients' gender.

Regarding the presence or absence of associated (concomitant) injuries, the following was observed:

Table 1 – Injury mechanism × age.

Injury mechanism	Descriptive measure					p-value
	Mean	Standard deviation	Minimum	Median	Maximum	
1	34.3	18.4	3.0	31.0	71.0	p < 0.001
2	30.5	16.2	14.0	22.0	60.0	
3	76.6 ^a	7.8	59.0	79.0	86.0	
4	43.5	12.8	26.0	47.0	54.0	
5	43.6	13.1	30.0	38.0	59.0	
6	47.0	15.6	36.0	47.0	58.0	
7	44.8	30.8	10.0	42.5	86.0	

^a ($p < 0.05$) in relation to the other mechanisms.

Table 2 – Place of trauma × injury mechanism.

Injury mechanism	Place				Total
	Urban area	Rural area	Highway	Home/organization	
1	3 (17.7)	1 (5.9)	13 (76.4)	0 (0.0)	17
2	9 (69.2)	0 (0.0)	4 (30.8)	0 (0.0)	13
3	0 (0.0)	0 (0.0)	0 (0.0)	17 (100.0)	17
4	4 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	4
5	0 (0.0)	5 (100.0)	0 (0.0)	0 (0.0)	5
6	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	2
7	6 (75.0)	0 (0.0)	2 (25.0)	0 (0.0)	8

Table 3 – Tile classification × age.

Classification	Descriptive measure					p-value
	Mean	Standard deviation	Minimum	Median	Maximum	
A	55.6 ^a	27.3	3.0	65.5	86.0	p < 0.01
B	43.4	16.8	10.0	41.0	71.0	
C	27.4	8.4	15.0	27.0	40.0	

^a (p < 0.05) classification A versus classification C.

Table 4 – Injury mechanism × sex.

Sex	Mechanism							Total
	1	2	3	4	5	6	7	
F	6 (22.2)aAB	5 (18.5)aAB	12 (44.5)bB	0 (0.0)aA	0 (0.0)aA	0 (0.0)aA	4 (14.8)aAB	27
M	11 (28.2)aA	8 (20.5)aA	5 (12.8)aA	4 (10.3)aA	5 (12.8)aA	2 (5.1)aA	4 (10.3)aA	39

Table 5 – Associated injuries × sex.

Sex	Associated injuries					Total
	1	2	3	4	5	
F	16 (59.3)aB	1 (3.7)aA	0 (0.0)aA	10 (37.0)aB	0 (0.0)aA	27
M	22 (56.5)aB	2 (5.1)aA	2 (5.1)aA	11 (28.2)aAB	2 (5.1)aA	39

No associated injury	38 (57.5%)
Associated injury	28 (42.4%)

Observation: Fractures/dislocations (single or multiple) were the most frequently associated injuries, present in 75% of the cases with associated injuries.

The other associated injuries observed were those of the urethra/bladder, abdominal organs, and cranial trauma.

Table 5 presents the association between the presence or absence of associated (concomitant) injury to the pelvic ring injury and the patients' sex.

Regarding the need for emergency intervention, the following was observed:

No emergency intervention	55 (83.3%)
Emergency intervention	11 (16.6%)

Type of intervention:

- Anterior external fixator – six.
- C-clamp – five.
- Laparotomy (associated with clamp) – one.

Table 6 – Urgency intervention status (type of fixation) × injury mechanism.

Mechanism	Interventions			Total
	Clamp	Fixator	No	
1	2 (11.8)aA	4 (23.5)aAB	11 (64.7)bB	17
2	0 (0.0)aA	2 (15.4)aA	11 (84.6)bB	13
3	0 (0.0)aA	0 (0.0) aA	17 (100.0)bB	17
4	1 (25.0)aAB	0 (0.0) aA	3 (75.0)bB	4
5	0 (0.0)aA	0 (0.0) aA	5 (100.0)bB	5
6	2 (100.0)bB	0 (0.0) aA	0 (0.0)aA	2
7	0 (0.0)aA	0 (0.0) aA	8 (100.0)bB	8

- Reduction of hip dislocation (associated with ring fixator) – one.
- Linear external fixator (associated with ring clamp/fixator) – three.
- Bladder/urethra intervention (associated with ring fixator) – two.

Table 6 presents the association between presence or absence of emergency intervention (type of ring fixation) and the mechanism of ring injury.

Table 7 – Classification of the injury × trauma mechanism.

Mechanism	Classification			Total
	A	B	C	
1	7 (41.2)aA	5 (29.4)abA	5 (29.4)aA	17
2	6 (46.2)aA	4 (30.8)abA	3 (23.0)aA	13
3	17 (100.0)bb	0 (0.0)aA	0 (0.0)aA	17
4	1 (25.0)aAB	3 (75.0)bb	0 (0.0)aA	4
5	1 (20.0)aAB	4 (80.0)bb	0 (0.0)aA	5
6	0 (0.0)aA	1 (50.0)abA	1 (50.0)aA	2
7	4 (50.0)abA	2 (25.0)abA	2 (25.0)aA	8

Table 7 shows the relationship between the pelvic ring fractures/injuries classification (Tile) and trauma mechanism.

Table 8 presents a comparison between the mechanism of pelvic ring fractures/injuries with presence or absence of associated injury.

Regarding side of the ring that was affected (local), the following was observed:

Right	30 (45.4%)
Left	23 (34.8%)
Both	9 (13.6%)
Pubic symphysis diastasis	4 (6%)

Table 9 shows an association between affected side and injury mechanism.

Regarding definitive treatment, the following was observed:

Non-surgical	42 (63.6%)
Surgical	24 (36.4%)

Materials used

- Plate (pubic symphysis/iliosacral) – 13.
- Iliosacral screw + plate (pubic symphysis) – five.
- Iliosacral screw – three.
- Anterior external fixator – two.
- Anterior external fixator + plate – one.

Regarding the occurrence or not of death, the following was observed:

No	64 (96.9%)
Yes	2 (3%)

Observation: Deaths occurred in cases of high-energy trauma (traffic accident) with type B or C pelvic ring injuries, in addition to severe associated injuries.

Discussion

The data on age (mean 41.9 years), sex (more frequently males), and ethnicity (predominantly whites) observed in the present sample, in general, were very close to those presented in the literature. Kobbe et al.¹⁴ reported a mean age of 47.3 years in their cases of pelvic ring injury. Jezek and Dzupa,¹⁵ in an epidemiological study on age and mechanism of pelvic ring

injury, reported a slightly higher mean age (51 years); stratified by sex, mean age of female patients was 53 while male patients was 49. Gansslen et al.,³ in a similar epidemiological study, also reported a higher incidence of pelvic ring injuries in males, in a proportion (56.7%) very close to that observed in the present sample (57.5%). Chueire et al.,⁹ in an epidemiological study, reported a larger number of males with ring injuries (67%); white subjects also represented a higher percentage of their sample. Only the mean age of their cases (37 years) was lower than that observed in the present study. Devarinos et al.¹¹ reported their experience in pelvic ring injuries in Ireland, having also observed a much higher percentage of males (76%), with a mean age of 36.5 years.

It was observed that, generally speaking, the literature also presents a higher incidence of male sex in this type of trauma, except in specific cases, as reported by Alnaib et al.,¹⁶ who assessed only pelvic ring injuries due to low-energy trauma (osteoporotic bones) and found a higher incidence in females. In relationship to mean age, the authors consider that the value observed in the present study was slightly higher than those observed in some other studies, as the present sample included numerous elderly individuals.

Regarding the mechanism of the pelvic ring injuries, we observed that, in general, accidents involving transportation vehicles (cars/trucks and motorcycles) were the most frequent causes of injuries, accounting for 45.3% of the total. When including the mechanism “being run over” (also caused by the same type of vehicle), total of injuries caused by traffic accidents was 57.5%, which reinforces the fact that these injuries were caused, for the most part, by motor vehicles. Devarinos et al.,¹¹ in a long follow-up of pelvic ring injuries (10 years), indicated that the most frequent injury mechanism was traffic accidents (74%). Freitas et al.,¹⁰ in a literature review of studies on pelvic ring fractures in recent decades, observed that the most prevalent trauma mechanisms were those related to traffic. Chueire et al.⁹ reported a very similar percentage to that observed in the present study; in their study, pelvic ring injuries were caused by car accidents in 23% of cases (25.7% in the present study) and by motorcycle accidents in 19% (19.6% in the present study).

In the comparison of the mechanism of injury with the age of the patients, an expected but important finding was observed: the significant predominance of the elderly in cases in which the injury was caused by a fall from own height (mechanism 3). Furthermore, it was also observed that the main trauma mechanism in adolescents or young adults was traffic accidents (mechanisms 1 and 2), with individuals inside the vehicle. Jezek and Dzupa,¹⁵ in their study on the influence of age on the mechanism of ring fractures, reported that common fall was the most frequent cause of this type of injury in the elderly and, of those, females were the most affected, a result similar to that observed in the present study. Those authors also noted that men were significantly more involved in fractures resulting from motorcycle accidents and falls from stairs. Krappinger et al.,⁴ in their study on pelvic fractures restricted to patients with osteoporosis, indicated that this type of fracture is typically the result of simple falls and that high-energy trauma are infrequent causes in these patients. Those authors also indicated that the proportion of pelvic

Table 8 – Injury mechanism × associated injury.

Mechanism	Associated injury, n (%)					Total
	1	2	3	4	5	
1	9 (52.9)	0 (0.0)	2 (11.8)	6 (35.3)	0 (0.0)	17
2	5 (38.4)	2 (15.4)	0 (0.0)	6 (46.2)	0 (0.0)	13
3	13 (76.5)	0 (0.0)	0 (0.0)	4 (23.5)	0 (0.0)	17
4	3 (75.0)	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	4
5	5 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5
6	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	1 (50.0)	2
7	3 (37.5)	0 (0.0)	0 (0.0)	4 (50.0)	1 (12.5)	8

Table 9 – Affected side × injury mechanism.

Mechanism	Affected side				Total
	1	2	3	4	
1	5 (29.4)	8 (47.1)	4 (23.5)	0 (0.0)	17
2	4 (30.8)	4 (30.8)	3 (23.0)	2 (15.4)	13
3	11 (64.7)	6 (35.3)	0 (0.0)	0 (0.0)	17
4	2 (50.0)	1 (25.0)	0 (0.0)	1 (25.0)	4
5	1 (20.0)	0 (0.0)	0 (0.0)	4 (80.0)	5
6	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	2
7	4 (50.0)	2 (25.0)	1 (12.5)	1 (12.5)	8

fractures due to common traumas increases with age; the incidence in the general population is 2–37/100,000 individuals, increasing to 92/100,000 in individuals aged over 60 years and to 446/100,000 in those aged over 85 years. Balogh et al.,¹⁷ in an epidemiological study on the same type of injury, reported that low-energy trauma fracture mechanism was fall from height of less than 1 m in all cases.

As previously mentioned, a relationship between adolescents/young adults and traffic accidents was also observed in the present study (Table 1). Freitas et al.,¹⁰ in an analysis of the literature on the subject, commented that traffic accidents are generally among the most frequent causes and present a higher risk in the young male population. Devarinos et al.¹¹ also mentioned traffic accidents in pelvic ring injuries; in their work, the typical patient was male and aged around 30 years.

In relationship to the place where the injuries of the pelvic ring occurred, the urban zone was the most frequent place in the present study. In the comparison of the place of occurrence with the injury mechanism (Table 2), motorcycle accidents (mechanism 2) in the urban area stood out. The same Table also indicates that mechanisms 5 and 6, accidents with animals (horses) and tractors, stand out in the rural area, car/truck and motorcycle accidents (mechanisms 1 and 2) on the highway; at homes/institutions, 100% of the cases were of fall from own height (mechanism 3). The authors believe that these results are compatible with type of trauma and place of occurrence. Nonetheless, no references in the literature regarding these parameters were retrieved.

Regarding the classification of pelvic ring injuries, the authors emphasize that in the present study, of all fractures/injuries, type A (stable) was the most frequent and, among these, subtype A_{2,3} (isolated fracture of the anterior region of the ring – one or four branches) was the most

common. These were followed by types B (rotationally unstable and vertically stable) and C (rotationally and vertically unstable). Table 3 (classification by age) presents a predominance of type A (stable) fractures in the elderly and of type C (rotationally and vertically unstable) in younger individuals, i.e., the latter had the most severe injuries. Grotz et al.¹⁸ also associated the severity of ring injuries with age and reported that the most serious injuries (including bone exposure) usually affect young adult males as a result of traffic accidents. Gansslen et al.,³ in epidemiological study on pelvic ring injuries with a large sample, also found that type A fractures (stable) were the most frequent, accounting for 54.8% of the cases (including higher involvement of the ischiopubic bones). Moreover, in their study the order was similar to that observed in the present study: type B (rotationally unstable and vertically stable) was the second most common, followed by type C (rotationally and vertically unstable). Chueire et al.⁹ reported that type A injuries were the most common, occurring in 55% of the sample, and were also related to the elderly, with involvement of ischiopubic branches; in that study, the subtype A_{2,2} was the most common. Those authors also observed type B (30%) as the second most common, followed by type C (15%). It was observed that regarding the order and the frequency of fracture types, as well as percentage and the place of involvement, the results were very close to those observed in the present study. Freitas et al.,¹⁰ in a literature review from indexed databases, sought to analyze the evolution of pelvic ring fractures in the past decades; these authors also observed type A as the most frequent, followed by types B and C.

Table 4 shows the relationship between the mechanism of fracture/injury of the ring and the sex of the patients; a significant association between the mechanism fall from own height (mechanism 3) and sex was observed, with a predominance

of females. Thus, in males, the distribution of mechanism of injury was homogeneous, whereas in females, fall from own height was noteworthy. Jazek and Dzupa¹⁵ commented on the mechanism of pelvic ring injuries and also reported that fractures due to simple trauma were significantly more common in older women; the women in this age group were eight years older than the men. Alnaib et al.,¹⁶ in a study on pelvic ring fractures in the elderly caused by low energy trauma, also reported a much higher percentage of involvement in females, 80.4% of the cases.

Regarding the presence of injuries/fractures associated with pelvic ring injuries, the literature presents a certain variation. Chueire et al.⁹ reported a higher percentage of cases of other injuries associated with pelvic ring fractures than of isolated fractures; 54% of their cases showed some type associated involvement. Regarding the type of concomitant injury, the authors also observed, as in the present study, a prevalence of fractures/dislocations in other places. Richard and Tornetta,¹⁹ in a study on the emergency treatment on pelvic injuries ring with the C-clamp, reported that 37.5% of cases had other fractures associated with the pelvic ring injury. Sagi et al.,²⁰ in a study of serious injuries of the pelvic ring (vertical instability), observed concomitant injuries in 36.2% of patients and found bladder rupture as the most common injury associated with this type of ring injury. In the present study, bladder injury was much less frequent, but it is noteworthy that all types of ring fractures/injuries were included, not only the more severe cases. In turn, Gansslen et al.,³ in an epidemiological study with a large sample of pelvic ring injuries including all types, observed that most had some kind of associated injury; only 30.2% of the cases were isolated injuries. In the present study, injuries associated with those of the pelvic ring, although occurring in a considerable percentage (42.44% – Table 9), were not as high as those observed in the literature. The authors believe that the considerable number of less severe fractures (Type A) in this sample and the lesser involvement of other areas or organs has influenced the finding that the general percentage of associated injuries was not elevated. Also in relation to associated injuries, gender of patients (Table 5) were compared in order to assess a possible predominance. However, no significant correlation was observed. Regarding the need for emergency intervention in patients who suffered pelvic ring fracture/injury, it was observed that in the great majority (83.3%) of cases there was no need for urgent intervention. In cases where these interventions were made, orthopedic interventions were the most frequent, with a balance between the use of C-clamp and anterior external fixator. The other emergency interventions were recorded and numbered, but not considered separately, since they were performed (concomitantly) in the same patients who underwent orthopedic interventions. Chueire et al.⁹ reported an emergency intervention rate of 32% in their cases of pelvic ring fractures; orthopedic interventions and laparotomy were the most frequent, but the authors did not specify whether the procedures were done separately or in the same patients. Balogh et al.,¹⁷ in an epidemiological study of ring injuries, indicated that 15% of the cases of high-energy trauma required emergency ring fixation. In turn, Pisanis et al.,¹ assessing a large sample of patients with pelvic ring injuries to compare the stabilizing ring methods in the emergency treatment,

indicated that only 3.4% of patients underwent emergency orthopedic procedures; of these, the C-clamp was one of the most often used.

Table 6 compares the need for emergency intervention with the mechanism of the injury; a significant association was observed, notably between the mechanisms car/truck and motorcycle accidents, together with tractor accidents (high-energy trauma) and need for emergency intervention, especially with the anterior external fixator and C-clamp. Pisanis et al.¹ also reported that the pelvic ring injuries in their sample that required urgent intervention for stabilization resulted from high-energy trauma, and that the C-clamp was the most used method. Abrassart et al.,²¹ in a study on emergency treatment in unstable pelvic ring injuries associated with hemodynamic instability, reported that all cases were high-energy trauma, such as motor vehicle accidents or falls from great heights. The authors emphasize that, of these, the vast majority (80%) required ring fixation with external fixator or C-clamp. Brum et al.,²² in a study on serious injuries to the pelvic ring that included only polytrauma patients, reported that emergency ring fixation, whether with C-clamp or another method, was necessary in 35% of the sample. Grotz et al.,¹⁸ in a study on the treatment of open fractures of the ring, did not discuss percentages, but reported that in cases requiring emergency intervention to stabilize the ring, the use of C-clamp or anterior external fixator is recommended.

Mechanism of trauma was compared with the classification of the injuries (Table 7). We observed that in type A (stable fracture) injuries, the mechanism of fall from own height, i.e., a low-energy trauma, is noteworthy; in type B (rotational instability and vertical stability), the most prevalent mechanisms were fall from more than 1 m and horse accident, which are considered moderate or high-energy traumas. In type C (rotational and vertical instability) there was a predominance of car/truck and motorcycle accidents, i.e., only high-energy traumas. Krappinger et al.⁴ examined cases of pelvic ring fractures in osteoporotic bones and reported that the typical fractures of this segment are stable and that the mechanism of injury is trivial trauma, such as fall from own height. Loon et al.,²³ in a study on the treatment of type B pelvic ring injuries, observed that the most common mechanism in this type of injury was falling from a height greater than ordinary, as well as traffic accidents; Jezek and Dzupa,¹⁵ in a study on the mechanism of ring fracture/injury and the age of patients, reported that simple fractures (AO type A) are common in elderly individuals and those considered more severe (type C) are predominant in young males. The authors also point out that the most serious fractures are related to high-energy traumas, with significant involvement of motorcycle accidents and falls from great heights. Balogh et al.¹⁷ observed that Tile type B and C fractures resulted from high-energy trauma with a predominance of accidents with cars and motorcycles.

In the present study, the fracture/injury mechanisms were compared with the presence of associated injuries (Table 8). It was observed that in cases without associated injury (item 1 – associated injury), the mechanism fall from own height was more prevalent (item 3 – mechanism of the injury), i.e., in cases of low-energy trauma there was no associated injury. In cases with concomitant fractures (item 4 – associated injury), the mechanisms related to high-energy traumas (car/truck

accidents and motorcycles items 1 and 2 – mechanism) were noteworthy. Balogh et al.,¹⁷ in an epidemiological study on pelvic ring injuries, compared the injuries caused by low- and high-energy trauma, having also reported a much higher and more severe incidence of concomitant injuries in cases of high-energy trauma.

We observed that the right side of the ring was the most affected, but no elements to justify this finding were found. Comparing the mechanism of injury with affected side (Table 9), we observed that on the right side (item 1) the mechanism fall from own height (item 3 – mechanism) was more prevalent. On the left side (item 2) and on both sides (item 3), car/truck and motorcycle accident mechanisms (items 1 and 2 – mechanism) stood out. In the cases of pubic symphysis diastasis (item 4 – affected side), the main mechanism was horse accident (fall or trauma in the saddle – item 5 of the mechanism). In relation to these parameters, pubic symphysis diastasis was only associated with the mechanism of injury “direct trauma in the saddle of the horse.” It was not possible to associate injury side with mechanism of trauma; furthermore, no references in the literature were retrieved.

Regarding the definitive treatment used, most of the present cases (63.6%) underwent non-surgical treatment. Gansslen et al.,³ in a study of pelvic ring injuries, also reported a high percentage of cases (78%) treated non-surgically. In the present study, the authors believe that the high percentage of type A fractures (54.5%) in the sample influenced this result, since these are stable injuries and almost all are treated in a non-invasive manner. Among the cases submitted to surgical treatment, the plate (pubic symphysis/iliosacral) was the most used material in the present study (isolated or associated), followed by iliosacral screw (isolated or associated). Dimitriou and Giannoudis²⁴ also highlighted the use of plate in the pubic symphysis associated with iliosacral screw or iliosacral fixation with plates (anterior or posterior). These authors also commented on the recent trend of increased use of percutaneous fixation with iliosacral screw in cases of ring injury.

Regarding the type of fixation used in the present study, internal fixation was much more frequent (87.5%); external fixation (single or associated) accounted for only 12.5% of the cases. Chueire et al.,⁹ in their series of pelvic ring injuries, presented a slightly smaller percentage of patients who underwent surgical treatment (29%) when compared with the present study; however, the type of fixation used was quite different, as those authors used external fixation in 75% of their cases and internal fixation in 25%. In the present study, iliosacral fixation (isolated or associated) was used. The authors believe that there is a trend of greater use of this method in this service, since it is considered efficient in the reduction and stabilization of the iliosacral joint, as well as less invasive. Tosounidis et al.,²⁵ assessing data from German centers of treatment of pelvic ring injuries, also reported an increase tendency of iliosacral screw use in the treatment of this type of trauma. Strobl et al.,²⁶ in a recent study on the treatment of unstable injuries of the posterior region of the pelvic ring, reported that in many centers the iliosacral screw is already established as the most used treatment in posterior fixation of the ring. In turn, Trikha and Gupta²⁷ report the use

of iliosacral screw in pelvic injuries, but also recommend transiliac plates in the posterior region of the ring. Muller et al.,²⁸ in a study on unstable ring injuries (type C) recommend a combination of types of syntheses, i.e., anterior internal fixator (subcutaneous) and posterior stabilization (iliosacral screw or spinopelvic and iliolumbar support); these authors remarked upon the wide variety of technical options for fixation in ring injuries. It was observed that although there is a tendency in the literature for less invasive internal fixations, a variety of ring osteosynthesis materials are still advocated.

In relation to mortality in pelvic ring injuries, the literature presents indexes with wide variation, and the authors always emphasize the association of these rates with concomitant injuries and the severity of the ring injury itself.^{1,29,30} In the present study, this association was also observed, as the cases of death were ring injuries types B or C with severe associated injuries. Gansslen et al.,³ in an epidemiological study on this type of injury, reported an overall mortality rate of 13.4%, but indicated that this rate was directly associated with extrapelvic trauma. Mortality observed in the literature^{17,21,22,29,30} ranges from 2% to 46%, and the percentage is always dependent on severity of the ring injury, on whether trauma was of high energy, and on the presence of associated injuries. Pohlemann et al.,²⁹ in a study on predictors of mortality in ring injuries, commented that in recent years the rate still remains high when considering only cases of complex injuries of the ring, but when all types of ring fractures/injuries are included, a general trend toward a decrease in the mortality rate is observed (5%, in these cases). The fact is attributed to the inclusion of less serious injuries and improved treatment both in the pre-hospital phase and in the emergency care. Chueire et al.,⁹ in their study of pelvic ring fractures, reported a 7% mortality rate; these authors also highlighted the significant relationship with this extrapelvic trauma. Richard and Tornetta,¹⁹ in a study on serious injuries of the pelvic ring, reported a mortality rate of 6.8%.

The authors considered that the most important factor in the low mortality rate observed in the present study (3%) was the high number of type A cases, which are usually associated with low-energy traumas and do not have associated injuries or complications. Furthermore, the small percentage of severe type C injuries (16.6%) also influenced this rate, as these are due to much more severe trauma. The authors highlight that the two cases of death in the present study were unstable injuries and had serious and multiple associated lesions. In addition to these factors, it is also noteworthy that in recent years there has been an improvement in the overall care for polytrauma patients in this service, as well as greater training and experience of the orthopedic staff, both in emergency procedures and in the definitive treatment of pelvic ring injuries; the authors believe that these elements also contributed to the low mortality rate observed in the present work.

Conclusions

Under the conditions of this study, the following can be concluded regarding pelvic ring fractures/injuries:

- They are more frequent in males.
- In general, most common mechanism of injury is traffic accident.
- In the elderly, the most common mechanism of injury is low-energy trauma (fall from own height), there is a prevalence of the female sex, and the most common place of injury is at home/institution.
- In adolescents/young adults, the most common mechanism of injury is high-energy trauma (traffic accident) and the most common place of injury is the urban area and highway.
- In general, type A fractures are the most frequent, followed by types B and C.
- Type A fractures are the most common in the elderly and type C, in adolescents/young adults.
- Most injuries do not need emergency intervention and, when necessary, orthopedic interventions are the most frequent.
- Emergency interventions are associated with high-energy trauma.
- Among associated injuries, fractures/dislocations in other sites are the most common and are associated with high-energy trauma.
- Non-surgical treatment is the most common; in cases treated surgically, external fixation is the most used method.
- Deaths occur in unstable fractures and severe associated injuries.

Conflicts of interest

The authors declare no conflicts of interest.

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