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Original article

Epidemiology of high-energy blunt pelvic ring injuries: A three-year retrospective case series in a level-I trauma center

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ABSTRACT

Background. – High-energy pelvic ring injuries (PRI) represent a heavy burden for institutions treating severely injured patients. Epidemiological data knowledge may help to provide them appropriate management. Only two epidemiologic studies about high-energy PRI were published during last decade. This study aimed to determine the gender-specific and global incidences of high-energy blunt AO/OTA type B or C PRI and their frequency among high-energy blunt trauma. It further reports the spectrum of these injuries and compares their characteristics and outcomes to high-energy blunt trauma without type B or C PRI.

Hypothesis. – Type B or C PRI incidence isn't gender specific and approximates 5/100,000/year.

Patients and methods. – A prospective database of a level-I trauma center serving approximately 500,000 inhabitants was retrospectively queried for all high-energy trauma patients injured between 01.01.2014 and 12.31.2016. Inclusion criteria were: alive emergency department delivery; entire acute treatment at the authors' institution; age >16. Exclusion criteria were: penetrating, blast, burn and electrical injuries; drownings; low-energy trauma; patients living outside the institution's catchment area. Three authors performed PRI classifications. Clinical data were extracted from the database.

Results. – We analyzed 434 patients. High-energy blunt type B or C PRI incidence was 3.8/100,000/year without gender disparity ($p = 0.6697$). High-energy blunt trauma incidence was lower in women than in men (20.5 vs. 51.6/100,000/year, $p < 0.001$). Type B or C PRI frequency during high-energy blunt trauma was higher in women than in men (17.6% vs. 7.9%, $p = 0.003$). Type B or C PRI patients were more severely injured and needed more treatment resources than other high-energy blunt trauma patients but didn't present higher complication or death rates.

Discussion. – The incidence of high-energy blunt type B or C PRI was comparable to previously published data. Women were less likely to sustain a high-energy blunt trauma, but when they sustained one, they were more likely to have a type B or C PRI. Despite higher injury severity score and resource requirements, complication and death rates weren't different between type B or C PRI patients and other high-energy blunt trauma patients.

Level of evidence. – Level III, retrospective cohort study.

Abbreviations: AIS :, abbreviated injury scale
ED :, emergency department
ICU :, intensive care unit
ISS :, injury severity score
PRBC :, packed red blood cells
PRI :, pelvic ring injuries.

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1. Introduction

High-energy pelvic ring injuries (PRI) represent a heavy burden for institutions treating severely injured patients as they require the involvement of multiple teams, including pre-hospital rescue teams, in-hospital emergency teams, surgical teams, intensive care unit (ICU) teams and radiology teams [1,2]. Training and preparedness are key elements to provide them optimal care and outcome [3]. Epidemiological data knowledge can help in this process. Commonly used PRI classifications are the Young-Burgess and the AO/OTA classifications [4–6]. The first considers the mechanism of injury and classifies PRI depending on the vector of force applied to the bone. The latter integrates anatomical bony lesions and fracture stability [7,8]. The AO/OTA type A fractures are usually treated conservatively while some type B and all type C fractures usually need surgical stabilization [7].

Pelvic fractures represent 1.5% of all fractures [9]. Reported high-energy PRI incidence ranges from 0.8 to 10 cases/100,000/year, while their frequency is about 10% among high-energy trauma cases [10–12]. High-energy PRI, like acetabular fractures, may be associated to hemodynamic instability and require packed red blood cells (PRBC) transfusions [4,11–15]. About 40% of PRI need surgical stabilization [11]. Related death rate may reach 50%, while reported long-term functional outcome varies considerably [16–19]. These results were published between 1992 and 2016 and high-energy trauma incidence increased concomitantly with survival rates' improvements [19,20]. Only two epidemiologic studies concerning high-energy PRI were published during last decade [10,11].

This study's aim was first to determine the gender specific and global incidence of high-energy blunt AO/OTA type B or C PRI in a defined urban population, and type B or C PRI frequency among high-energy blunt trauma cases. We hypothesized that high-energy blunt type B or C PRI incidence is similar in both genders and approximates 5/100,000/year. Secondly, this study aimed to compare the characteristics and outcomes of high-energy blunt trauma cases with and without type B or C PRI.

2. Patients and methods

Institutional research ethics board approval was obtained before study initiation.

2.1. Patients

This retrospective study was performed in an academic level-I trauma center serving approximately 500,000 inhabitants. All high-energy trauma patients admitted between 01.01.2014 and 12.31.2016 were identified using the institutional severely injured patients' registry. This prospective database lists every patient admitted to the shock room and encompasses around 300 items for each patient, including Abbreviated Injury Scale (AIS) codes and Injury Severity Score (ISS) [21–24]. Inclusion criteria were: alive emergency department (ED) delivery; entire acute treatment at the authors' institution; age > 16 at injury time. Exclusion criteria were: penetrating, blast, burn and electrical injuries; drownings; low-energy trauma; patients living outside the defined institutions' catchment area.

2.2. Methods

The outcome was PRI presence, as defined by the AO/OTA (2018 version) classification, which has been shown to be reliable up to the fracture type level [5,6]. Corresponding AIS codes (856100.2, 856101.3, 856151.2, 856152.3, 856161.3, 856162.4, 856163.4, 856164.5, 856171.4, 858172.4, 856173.5, 856174.5) were looked for in the severely injured patients' registry for each study patient [23]. Three authors completely reviewed the pelvic radiological images and consensual detailed Young-Burgess and AO/OTA (2018 version) classifications were determined [4,5]. The study population was divided into two groups for comparison: patients with, respectively without an AO/OTA type B or C PRI.

Table 1
Population exclusively served by the authors' institution.

Year	Total population ≥ 16 yo, *n* (%)	Females ≥ 16 yo, *n* (%)	Males ≥ 16 yo, *n* (%)
2014	403,045 (100)	210,120 (52)	192,925 (48)
2015	409,722 (100)	213,228 (52)	196,494 (48)
2016	412,429 (100)	214,612 (52)	197,817 (48)

Values are expressed as *n* (%). yo: years old.

2.3. Methods of assessment

Demographic and clinical data, AIS codes and ISS were extracted from the severely injured patients' registry. Complications were defined as any serious secondary condition appearing during hospital stay and worsening the outcome (cardiopulmonary arrest, myocardial infarction, stroke, organ failure, thrombo-embolic event, pressure sore, infection, compartment syndrome and surgical wound complication). Hemodynamic instability was defined as prehospital systolic blood pressure < 90 mmHg or prehospital heart rate > 100 bpm or need for PRBC in the ED. An accredited study nurse calculated AIS codes and ISS [21–23]. Pelvic surgery type and timing were extracted from patients' charts. Description of the population exclusively served by the authors' institution was obtained from the government's Statistics Office (Table 1) [25].

2.4. Statistical analysis

Continuous variables were described by their means ± standard deviation, and range; categorical variables by their frequencies and relative percentages. High-energy blunt type B or C PRI incidence and high-energy blunt trauma incidence were calculated among at-risk populations by gender and year (2014, 2015, 2016) and 95% confidence intervals (95%CI) were reported. High-energy blunt type B or C PRI incidence and high-energy blunt trauma incidence were compared between women and men using Mid-P exact test (two-sided). Patients' characteristics were compared between those with and without type B or C PRI: continuous variables were compared using Student *t* or Mann-Whitney non-parametric tests, depending on the application criteria; categorical variables were compared using Chi^2 or Fisher's exact tests. All analyses were performed using Stata 16.0 IC (Stata Corporation, College Station, TX, USA). Statistical significance was defined as $p < 0.05$ (two-sided).

3. Results

Nine hundred patients were recorded in the database between 01.01.2014 and 12.31.2016, 832 met the inclusion criteria and 434 were finally analyzed (Fig. 1). The mean incidence of high-energy blunt type B or C PRI was 3.8/100,000/year without gender disparity (3.6 in women, 4.1 in men) (Table 2). The mean incidence of high-energy blunt trauma was significantly lower in women than in men (20.5 vs. 51.6/100,000/year), but the proportion of type B or C PRI among them was significantly higher in women than in men (17.6% vs. 7.9%) (Table 2).

Fig. 2 depicts the PRI spectrum. Among the 47 type B or C PRI patients, 23 (48.9%) had pelvic ring surgery. Fifteen (38.5%) of the 39 type B PRI patients had surgery: three (7.7%) emergent fixations (pelvic C-clamp or anterior external fixation) and 14 (35.9%)

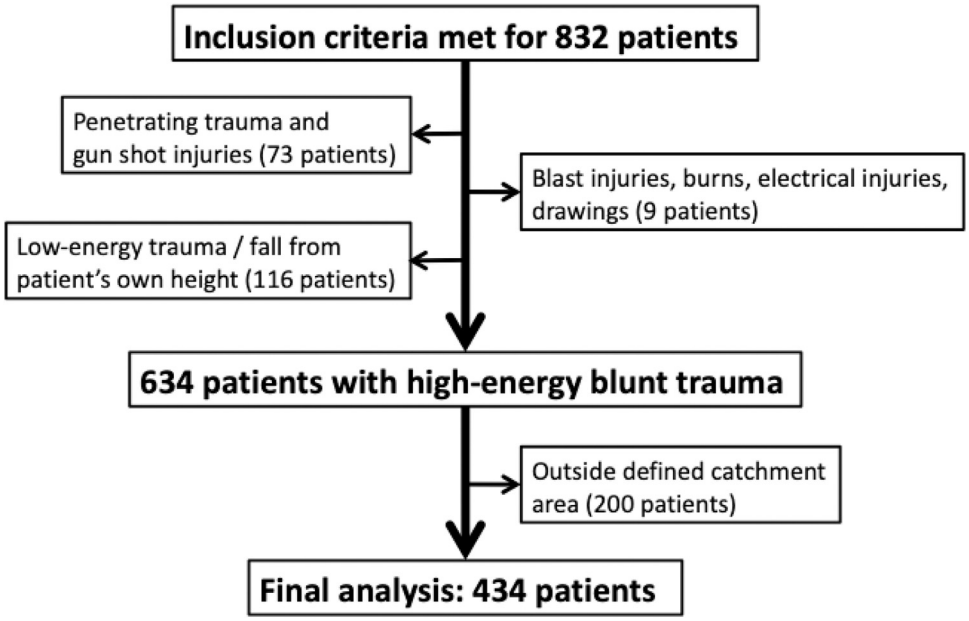

Fig. 1. Flowchart depicting number of patients meeting inclusion and exclusion criteria.

Table 2
High-energy blunt trauma and high-energy blunt AO/OTA type B or C pelvic ring injuries (PRI) mean incidences, and type B or C PRI proportion among high-energy blunt trauma between 2014 and 2016.

	Total population	Females	Males	*p*-value*
Mean incidence/100,000 persons/year				
High-energy blunt trauma	35.4 (32.2–38.9)	20.5 (17.2–24.4)	51.6 (46.0–57.8)	< 0.001
Type A PRI	0.9 (0.4–1.6)	0.6 (0.2–1.6)	1.2 (0.5–2.5)	0.3185
Type B or C PRI	3.8 (2.8–5.1)	3.6 (2.3–5.4)	4.1 (2.6–6.1)	0.6697
Type B or C PRI, *n* (%)	47 (10.8)	23 (17.6)	24 (7.9)	0.003

* *p*-values were obtained to compare incidence (Mid-*p* exact test) and proportion (Chi^2 test) among female and male populations.

delayed definitive fixations (6 anterior only and 8 anterior and posterior); type B1 fractures were never fixed, type B2.1 and B2.2 fractures sometimes fixed, and type B2.3 and B3 fractures always fixed, except for four cases. All eight type C PRI patients had surgery: five emergent fixations and six delayed definitive fixations (4 anterior and posterior, 1 anterior only and 1 posterior only; two patients died before definitive fixation). Table 3 compares patients with, respectively without type B or C PRI.

4. Discussion

Few recent epidemiological studies evaluated the incidence and spectrum of high-energy blunt PRI. In the present study, this incidence was 4.7/100,000/year, approximating the expected result (5/100,000/year). Among the 434 patients having sustained a high-energy blunt trauma, 58 (13.4%) had a PRI of which 47 (10.8%) were classified as type B or C. Type B or C PRI incidence was 3.8/100,000/year.

A stable 4.6/100,000/year incidence of high-energy blunt PRI was reported in Ontario, Canada, between 2005 and 2011; PRI types weren't specified [11]. A constant 0.82/100,000/year incidence of high-energy blunt type B or C PRI was found in the USA between 2000 and 2009 [10]. This much lower incidence might have been influenced by some recruitment, coding and reporting biases, as patients pronounced dead in the trauma room after ED admission weren't included and data were extracted from an administrative database composed of a 20% stratified sample of all community hospitals in the USA. In a retrospective trauma registry study from the Los Angeles County, a PRI proportion similar to the present study of 9.3% among 1545 high-energy blunt trauma patients was reported between 1993 and 2000; PRI types weren't specified [12].

Despite a higher incidence of high-energy blunt trauma in men than in women, type B or C PRI incidence was, as hypothesized, similar in both genders; women were more likely to have a type B or C PRI when they sustained a high-energy blunt trauma. This finding is in contrast with previous publications reporting a higher proportion of men among high-energy PRI cases [11,13]. No scientific explanation can be provided concerning this finding, as data collected didn't allow fine exploration of all potentially associated factors.

The PRI spectrum was 19% type A, 67.2% type B and 13.8% type C fractures. Other studies reported a higher proportion of type A injuries (up to 41%) [13,16]. Differences in reported PRI spectrum might be influenced by the inclusion of low-energy PRI cases in some studies, and by disparate professional occupations, outdoor activities and transport means.

For comparison of injury characteristics and outcomes of high-energy trauma cases with and without PRI, type A PRI cases were assimilated to those without PRI. The rationale for this grouping was that type A fractures don't imply pelvic ring instability, are rarely associated to hemodynamic instability and usually don't require surgical fixation, in contrast to type B and C injuries [4,7,8,11]. Age was similar in both groups, more men were in the high-energy blunt trauma group without type B or C PRI and the trauma mechanism spectrum differed in both groups (Table 3). Despite a higher ISS and hemodynamic instability rate, a higher PRBC transfusion rate and longer ICU and hospital length of stay, type B or C blunt PRI patients had similar complication and death rates than other high-energy blunt trauma patients. This might

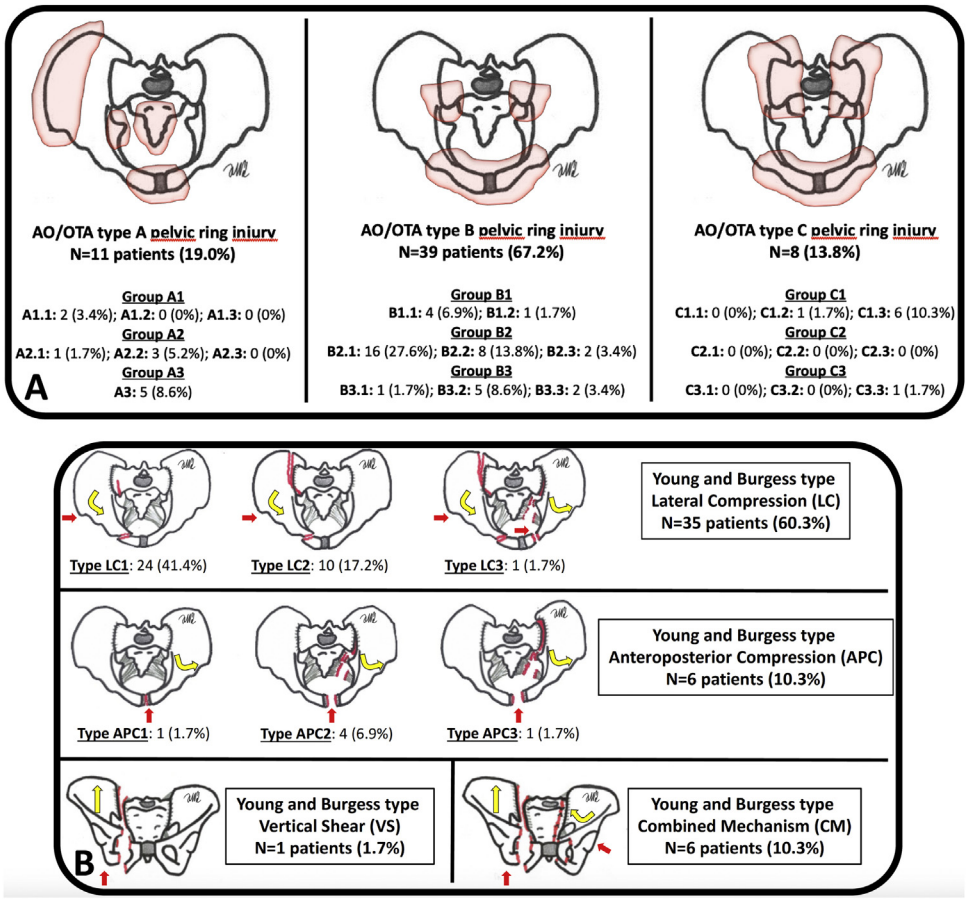

Fig. 2. Presentation of PRI ($n = 58$) according to their classifications. A. AO/OTA classification: schemes represent type A, B and C fractures respectively. Red areas represent fracture localization and zones of instability. Fracture numbers and relative percentages are given up to the subgroup level. B. Young-Burgess classification: schemes represent lateral compression type injuries (3 levels), anteroposterior compression type injuries (3 levels), vertical shear and combined mechanism type injuries. Red arrows represent vectors of force applied to the pelvis during injury. Yellow arrows represent fracture fragments' displacement. Fracture numbers and relative percentages are given for each type. Ten fractures (17.2%) implying pelvic apophyses, or a sacral or coccygeal horizontal line were not classifiable.

Table 3
Injury characteristics and outcomes comparison among high-energy blunt trauma patients with, respectively without AO/OTA type B or C PRI.

Variables	PRI B or C present $n = 47$ (10.8%)	PRI B or C absent $n = 387$ (89.2%)	p-value
Mean age ± SD (years)	44.5 ± 19.1	45.6 ± 20.1	0.798[c]
Males, n (%)	24 (51.1%)	279 (72.1%)	0.003[a]
Injury mechanism (9 missing), n (%)			0.007[b]
Road traffic accident	19 (40.4%)	225 (59.5%)	
Fall from height > 1 m	26 (55.3%)	122 (32.3%)	
Crush, farm and industrial accident	2 (4.3%)	8 (2.1%)	
Sports injury	0 (0)	3 (0.8%)	
Aggression	0 (0)	20 (5.3%)	
Mean ISS ± SD (3 missing)	26.1 ± 10.7	15.6 (± 12.0)	< 0.001[d]
Hemodynamic instability (43 missing), n (%)	10 (23.3%)	20 (5.7%)	< 0.001[a]
PRBC need in ED (6 missing), n (%)	9 (19.2%)	16 (4.2%)	< 0.001[a]
Mean PRBC number in ED ± SD	0.66 ± 1.5	0.14 ± 0.80	< 0.001[b]
PRBC need during first 24 hrs (4 missing), n (%)	18 (38.3%)	53 (13.9%)	< 0.001[a]
Mean PRBC number during first 24 h ± SD	2.53 ± 6.22	0.63 (± 2.16)	< 0.001[b]
ICU stay need (2 missing), n (%)	27 (57.5%)	173 (44.9%)	0.104[a]
Mean ICU length of stay ± SD (days)	6.11 ± 10.05	2.83 (± 6.10)	0.017[c]
Mean total hospital length of stay[#] ± SD (days)	23.5 ± 23.2	13.4 (± 18.9)	< 0.001[c]
Complication during hospital stay[i], n (%)	13 (27.7%)	95 (24.5%)	0.641[a]
Death rate during first 30 days, n (%)	6 (12.8%)	29 (7.5%)	0.250[b]

PRI: pelvic ring injury; ISS: Injury Severity Score; PRBC: packed red blood cells; ED: emergency department; ICU: intensive care unit.
[a] p-values were calculated using: Chi^2 test.
[b] p-values were calculated using: Fischer's exact test.
[c] p-values were calculated using: Mann-Whitney test.
[d] p-values were calculated using: Student t test.

be due to the aggressive management of PRI implemented in the authors' institution with emergent mechanical stabilization to control low-pressure venous and osseous bleeding and within-an-hour angiography and embolization if needed to control persisting hemodynamic instability due to high-pressure arterial bleeding.

This study suffers limitations: (1) its retrospective design; (2) some residents of the institution's catchment area may have sustained a high-energy trauma outside the catchment area and may have been treated elsewhere (estimated annual number < 10); (3) the study population size might be underestimated by not considering non-declared residents; (4) the resources needed might have been slightly underestimated as patients living outside the institutions' catchment area were excluded; (5) the included PRI number didn't allow for a detailed analysis within the type B or C PRI group. This study also has strengths: (1) its population-based design which was possible to achieve as the authors' institution is the only level-I trauma center serving the defined population; (2) data come from a prospective and comprehensive database; (3) we evaluated and ruled out a potential selection bias by comparing the excluded subpopulation ($n = 200$) living outside the institutions' catchment area to the analyzed cases ($n = 434$) and found similar ISS, PRI spectrum and death rate.

5. Conclusion

High-energy blunt type B or C PRI incidence was similar in men and women and comparable to previous publications. Women were less likely to sustain a high-energy blunt trauma than men, but when they sustained one, they were more likely to have a type B or C PRI. Despite being more severely injured and needing more treatment resources, type B or C PRI patients had similar complication and death rates as other high-energy blunt trauma patients.

Disclosure of interest

The authors declare that they have no competing interest.

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Contributions

A.A. & A.G.: study conception, data acquisition/analysis, manuscript writing/critical revision. M.d.F.: data acquisition/analysis, manuscript critical revision. A.G.A.: statistical analysis, manuscript critical revision. E.A.: data acquisition, manuscript critical revision.

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