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ORIGINAL ARTICLE • PELVIS - FRACTURES

Pelvic fractures in the Netherlands: epidemiology, characteristics and risk factors for in-hospital mortality in the older and younger population

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Abstract
Purpose To examine nationwide epidemiology of pelvic fractures in the Netherlands and to compare characteristics and outcome of older versus younger patients as well as predictors for in-hospital mortality.
Methods Retrospective review of pelvic fracture patients admitted to all Dutch hospitals (2008–2012) utilizing National Trauma Registry. Average annual incidence of (minor and major) pelvic fractures was calculated for the population. Older (≥ 65 years) and younger (< 65 years) patients were compared. Multivariate regression analysis was performed to identify independent predictors for in-hospital mortality.
Results Of 11,879 pelvic fracture patients (61.8%, ≥ 65 years), annual incidence of pelvic fractures in older versus younger population was 57.9 versus 6.4 per 100,000 persons. Older patients had lower ISS (7.1 (SD 6.9) vs 15.4 (SD 13.4)) and less frequently had severe associated injuries (15.6 vs 43.5%), an admission systolic blood pressure (SBP) ≤ 90 mmHg (1.6 vs 4.1%) or Glasgow Coma Score (GCS) ≤ 12 (2.0 vs 13.3%) (all, $p < 0.01$). In-hospital mortality was equal in older and younger patients (5.3 vs 4.8%: $p = 0.28$). In both subgroups, greatest independent predictors for in-hospital mortality were GCS ≤ 12, ISS ≥ 16, and SBP ≤ 90 mmHg and in all patients age ≥ 65 (OR 6.59 (5.12–8.48): $p < 0.01$).
Conclusion The annual incidence of (both minor and major) pelvic fractures in the older population was substantially higher than in the younger population. Elderly patients had a disproportionately high in-hospital mortality rate considering they were less severely injured. Among other factors, age was the greatest independent predictor for in-hospital mortality in all pelvic fracture patients.

Keywords Pelvic fractures · Epidemiology · Incidence · Elderly patients · Mortality

Introduction

Pelvic fractures range from major disruptions to minor breaks of the pelvic ring. Major pelvic fractures are typically a result from high-energy trauma and have been the focus of extensive research [1–3]. Minor or isolated breaks of the

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pelvic ring are typically found in the elderly population after a low-impact fall and have previously received much less attention [4]. In recent years, however, it is increasingly recognized that these low-energy (osteoporotic) pelvic fractures may be associated with poor clinical outcome in elderly patients [5–7]. Furthermore, several studies have suggested that the incidence of pelvic fractures in the elderly is increasing at an alarming rate [8–10].

Reliable epidemiological data on (particularly minor) pelvic fractures is scarce and often limited to particular regions within a country or based on administrative (non-scientific) databases [4, 8, 11, 12]. Likewise, in the Netherlands the comprehensive epidemiology of pelvic fractures is largely unknown. As a result, the full extent of this urgent healthcare concern in the older as well as the younger population remains to be further defined.

The Dutch National Trauma Registry records all acute admissions due to traumatic injury in the Netherlands including those resulting from less severe fractures. Every hospital providing trauma care provides data for this comprehensive database.

The primary objective of this study was to examine the nationwide epidemiology of older and younger patients with a (minor or major) pelvic fracture in the Netherlands. Our secondary objective was to compare the characteristics and outcome (hospital and intensive care unit (ICU) length of stay and in-hospital mortality) in both age groups and to determine independent predictors for in-hospital mortality.

Methods

Dutch National Trauma Registry

The Netherlands is a densely populated country which recently reached a population of 17 million [13]. Hospitals in the Netherlands are designated Level I, II or III trauma centers based on criteria similar to those formulated by the American College of Surgeons [14]. The Dutch National Trauma Registry (*Landelijke Traumaregistratie*) was instituted by the National Network of Acute Care (*Landelijk Netwerk Acute Zorg*) in 2007 to monitor the quality of trauma care in the Netherlands. Through the years, hospital participation increased and currently all trauma patients who present at a Dutch Emergency Department (ED) within 48 h from injury and are admitted to hospital or expired in the ED are captured in the National Trauma Registry. In addition to multiple injured patients, patients with isolated injuries and/or a short hospital stay are included in this nationwide registry. Data entry is performed by trained data managers in each individual hospital and is collected by the coordinating hospitals of the 11 trauma regions. These coordinating (Level I) major trauma hospitals are joined in the National Network of Acute Care.

During the 5-year study period, the rate of participating hospitals increased from 74 to 94%. All 11 Dutch Level I major trauma centers participated during the complete study period.

Patients

A retrospective review of the Dutch National Trauma Registry was performed from January 1, 2008, to December 31, 2012. All patients with an abbreviated injury score (AIS) of the pelvic bones were included in this study [15]. The following AIS pelvis codes were used for patient identification: 852600.2, 852602.2, 852604.3, 852606.4, 852608.4, 852610.5, 852800.3 and 853000.3 (AIS version 1998). Collected data included age, gender, admitting hospital (Level I vs II/III), injury severity score (ISS), associated injuries ((AIS) per body region), admission systolic blood pressure (SBP) and Glasgow Coma Score (GCS) on arrival [15, 16]. In addition, the following outcome parameters were collected: hospital and ICU length of stay and in-hospital (or emergency department (ED)) mortality.

Definitions

Older patients were defined as aged ≥ 65 years, major pelvic fracture as AIS pelvis ≥ 3 (vs minor pelvic fractures AIS pelvis < 3), major trauma center as Level I (vs Level II/III), severe associated injury as AIS ≥ 3, multiple injured patients as ISS ≥ 16, hypotension as SBP ≤ 90 mmHg and decreased level of consciousness as GCS ≤ 12.

Statistical analysis

The average annual incidence of patients hospitalized for a pelvic fracture in the Netherlands in the 5-year study period was calculated based on an average Dutch population between 2008 and 2012 of 16,655,799 with 2,538,328 older and 14,117,471 younger persons [13].

Contingency tables were constructed to compare the baseline characteristics and outcome of older and younger patients. Furthermore, ISS and in-hospital mortality were compared in a sub-analysis according to the presence of a minor or a major pelvic fracture.

Continuous variables are presented as mean values with standard deviations (SD) and compared with the independent *t* test. Categorical values were calculated as percentage of frequency of occurrence and compared using Pearson Chi-square test. Univariate and multivariate analyses were performed to identify dependent and independent risk factors for in-hospital mortality in all patients as well as in the older and younger subgroups. The following variables

were entered for analysis: age ≥ 65 years (in all patients), male gender, ISS ≥ 16, major pelvic fracture (AIS pelvis ≥ 3), presence of a severe associated injury (AIS ≥ 3), SBP ≤ 90 mmHg, GCS ≤ 12 and admission to a major trauma center. All listed variables were entered into the multivariate model considering the clinical significance of each factor and the large patient cohort. Results are presented as odds ratio (OR) along with the corresponding 95% confidence intervals (CI).

Statistical significance was declared at the 0.05 level. Multiple imputations were used to manage missing SBP and GCS values [17]. This statistical technique assigns multiple plausible alternative values for each missing values. Each imputed dataset is subsequently analyzed separately, and the results are averaged out. Standard errors are calculated by using Rubin's rules which takes into account the variability in the results between the imputed datasets.

Statistical analysis was performed by two of the investigators (M.F. and S.A.) using R 3.4.1 for Windows [18].

Results

In the 5-year study period, 334,437 trauma patients were admitted to Dutch hospitals and 11,879 (3.6%) had a pelvic fracture. Pelvic fractures occurred predominantly in patients over the age of 65 (61.8%) and the majority of patients (75.2%) was diagnosed with a minor pelvic fracture (Table 1).

Epidemiology

The average annual incidence of all patients with a pelvic fracture in the Netherlands was 14.3 per 100,000 persons. The incidence was considerably higher in the older than in the younger population (respectively, 57.9 and 6.4 per 100,000 persons). Minor pelvic fractures occurred in 10.7 per 100,000 persons, and major pelvic fractures in 3.5 per 100,000 persons.

For both the older and younger groups, the average annual incidence was greater for minor pelvic fractures (respectively, 48.3 and 4.0 per 100,000 persons) as opposed to major pelvic fractures (respectively, 9.6 and 2.5 per 100,000 persons).

Older versus younger patients

Older pelvic fracture patients (mean age 82.2 years, SD 7.8) compared to younger pelvic fracture patients (mean age 40.9 years, SD 16.5) were more likely to be female (76.3 vs 37.3%: $p < 0.01$) and were predominately admitted to Level II/III trauma centers (82.1 vs 50.9%: $p < 0.01$) (Table 1). Compared to younger patients, more older patients sustained a minor pelvic fracture (83.4 vs 61.7%: $p < 0.01$).

The ISS in older patients was lower (mean 7.1, SD 6.9 vs 15.4, SD 13.4: $p < 0.01$), and a smaller number was multiple injured (ISS ≥ 16; 6.9 vs 36.2%: $p < 0.01$).

Severe associated injuries occurred less frequently in older patients (15.6 vs 43.5%: $p < 0.01$). In particular, severe head, chest and abdominal injuries were less common in older patients compared to their younger counterparts (respectively, 3.6 vs 12.8%, 3.7 vs 23.3 and 1.2 vs 9.0%: $p < 0.01$). Systolic blood pressure on arrival was higher in older patients (mean 142.1 mmHg, SD 29.6 vs 128.3 mmHg, SD 24.9: $p < 0.01$) and an SBP ≤ 90 mmHg was uncommon, particularly in older patients (1.6 vs 4.1%: $p < 0.01$). Lastly, a GCS ≤ 12 was also found less frequently in older patients (2.0 vs 13.2%: $p < 0.01$).

Outcome

Older pelvic fracture patients had a shorter hospital stay (mean 11.3 days, SD 11.4 vs 14.4 days, SD 17.8: $p < 0.01$) and were less frequently admitted to the ICU (4.0 vs 20.6%: $p < 0.01$) (Table 2). The ICU length of stay in the older group was also shorter compared to the younger group (mean 6.4 days, SD 3.8 vs 8.2 days, SD 16.1: $p < 0.01$).

The overall in-hospital mortality rate in older pelvic fracture patients was equal to younger patients (5.3 vs 4.8%: $p = 0.28$). Few patients in both the older and the younger groups died in the ED (0.5 vs 1.0%: $p = 0.23$).

When only patients with a minor pelvic fracture were considered, the hospital mortality was equal between the older and younger groups (4.0% (247/6130) vs 3.2% (90/2798): $p = 0.07$) despite older patients with a minor pelvic fracture having a lower ISS (5.8 (5.2) vs 11.7 (11.5): $p < 0.01$). When only patients with a major pelvic fracture were considered, the hospital mortality in older patients was higher than in younger patients (11.3% (138/1216) vs 7.2% (126/1735): $p < 0.01$) despite the older group having a lower ISS (13.7 (9.9) vs 21.3 (14.1): $p < 0.01$).

Predictors for in-hospital mortality

Dependent and independent predictors for in-hospital mortality in pelvic fracture patients are presented in Tables 3 and 4. In all patients, age ≥ 65 was the greatest independent predictor for in-hospital mortality (OR 6.59 (5.12–8.48): $p < 0.01$).

In the older as well as the younger patient groups, the 3 greatest predictors for in-hospital mortality were GCS ≤ 12, ISS ≥ 16 and SBP ≤ 90 mmHg. The presence of a major pelvic fracture was also an independent predictor for in-hospital mortality in all pelvic fracture patients (OR 1.26 (1.02–1.56): $p = 0.03$) and in the older patient group (1.35

Table 1 Baseline characteristics in older (≥ 65 years) and younger (< 65 years) pelvic fracture patients

	All	Older	Younger	*p* value
Patients; *n* (%)	11,879 (100.0)	7346 (61.8)	4533 (38.2)	
Age; mean (SD)	66.4 (23.3)	82.2 (7.8)	40.9 (16.5)	**< 0.01**
Missing; *n* (%)	0 (0.0)	0 (0.0)	0 (0.0)	
Gender; *n* (%)				
Male	4578 (38.5)	1739 (23.7)	2839 (62.7)	**< 0.01**
Female	7292 (61.4)	5603 (76.3)	1689 (37.3)	
Missing; *n* (%)	9 (0.1)	4 (0.1)	5 (0.1)	
Admitting hospital; *n* (%)				
Major trauma center	3542 (29.8)	1317 (17.9)	2225 (49.1)	**< 0.01**
Non-major trauma center	8337 (70.2)	6029 (82.1)	2308 (50.9)	
Missing; *n* (%)	0 (0.0)	0 (0.0)	0 (0.0)	
Abbreviated injury score (AIS) pelvis; *n* (%)				
2	8928 (75.2)	6130 (83.4)	2798 (61.7)	**< 0.01**
3	2473 (20.8)	1116 (15.2)	1357 (30.0)	**< 0.01**
4	361 (3.0)	66 (1.0)	295 (6.5)	**< 0.01**
5	117 (1.0)	34 (0.5)	83 (1.8)	**< 0.01**
Missing; *n* (%)	0 (0.0)	0 (0.0)	0 (0.0)	
Injury severity score; mean (SD)	10.3 (10.7)	7.1 (6.9)	15.4 (13.4)	**< 0.01**
Missing; *n* (%)	0 (0.0)	0 (0.0)	0 (0.0)	
Injury severity score; *n* (%)				
1–3	0 (0.0)	0 (0.0)	0 (0.0)	**< 0.01**
4–8	6765 (57)	5166 (70.3)	1599 (35.3)	**< 0.01**
9–15	2968 (25)	1676 (22.8)	1292 (28.5)	**< 0.01**
16–24	897 (7.6)	227 (3.1)	670 (14.8)	**< 0.01**
25–49	1051 (8.9)	240 (3.3)	811 (17.9)	**< 0.01**
50–66	185 (1.6)	35 (0.5)	150 (3.3)	**0.013**
75	13 (0.1)	2 (0.03)	11 (0.2)	
Missing; *n* (%)	0 (0.0)	0 (0.0)	0 (0.0)	
Any severe associated injury;[a] *n* (%)	3124 (26.3)	1148 (15.6)	1973 (43.5)	**< 0.01**
Missing; *n* (%)	0 (0.0)	0 (0.0)	0 (0.0)	
Severe associated injuries; *n* (%)[b]				
Head	842 (7.1)	262 (3.6)	580 (12.8)	**< 0.01**
Face	72 (0.6)	12 (0.2)	60 (1.3)	**< 0.01**
Neck	9 (0.1)	1 (0.0)	8 (0.2)	**0.04**
Chest	1329 (11.2)	275 (3.7)	1054 (23.3)	**< 0.01**
Abdomen	501 (4.2)	91 (1.2)	410 (9.0)	**< 0.01**
Spine	348 (2.9)	63 (0.9)	285 (6.3)	**< 0.01**
Upper extremity	899 (7.6)	384 (5.2)	515 (11.4)	**< 0.01**
Lower extremity	1080 (9.1)	406 (5.5)	674 (14.9)	**< 0.01**
External	14 (0.1)	2 (0.0)	12 (0.3)	**0.01**
Missing; *n* (%)	0 (0.0)	0 (0.0)	0 (0.0)	
Systolic blood pressure (SBP)				
Mean mmHg (SD)	136.6 (28.6)	142.1 (29.6)	128.3 (24.9)	**< 0.01**
SBP ≤ 90 mmHg; *n* (%)	305 (2.6)	119 (1.6)	186 (4.1)	**< 0.01**
Missing; *n* (%)	1950 (16.5)	1370 (18.6)	580 (12.8)	
Glasgow Coma Score (GCS)				
Mean (SD)	14.1 (2.9)	14.7 (1.6)	13.2 (4.0)	**< 0.01**
GCS ≤ 12; *n* (%)	745 (6.3)	146 (2.0)	599 (13.2)	**< 0.01**
Missing; *n* (%)	3148 (26.5)	2262 (30.8)	886 (19.5)	

Table 1 (continued)

Significant values are indicated in bold

[a]AIS ≥ 3

[b]Patients can have more than one severe associated injury (AIS ≥ 3)

Table 2 Outcome in older (≥ 65 years) and younger (< 65 years) pelvic fracture patients

	All	Older	Younger	*p* value
Patients; *n* (%)	11,879 (100)	7346 (61.8)	4533 (38.2)	
Length of hospital stay; mean (SD)	12.5 (14.3)	11.3 (11.4)	14.4 (17.8)	**< 0.01**
Missing; *n* (%)	313 (2.6)	173 (2.4)	140 (3.1)	
ICU stay; *n* (%)	1224 (10.3)	291 (4.0)	933 (20.6)	**< 0.01**
Length of ICU stay; mean (SD)	7.8 (14.8)	6.4 (3.8)	8.2 (16.1)	**< 0.01**
Missing; *n* (%)	59 (4.8)	25 (8.6)	34 (3.6)	
Mortality; *n* (%)				
Emergency department; *n* (%)	78 (0.7)	33 (0.5)	45 (1.0)	0.23
In-hospital; *n* (%)	601 (5.1)	385 (5.3)	216 (4.8)	0.28
Missing; *n* (%)	42 (0.4)	22 (0.3)	20 (0.4)	

Significant values are indicated in bold

Table 3 Univariate analysis for predictors for in-hospital mortality in older (≥ 65 years) and younger (< 65 years) pelvic fracture patients (odds ratio (OR) 95% confidence interval (CI)))

	All		Older		Younger	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Age ≥ 65 years	1.11 (0.93–1.31)	0.25	NA	NA	NA	NA
Male gender	1.72 (1.46–2.03)	**< 0.01**	2.38 (1.93–2.94)	**< 0.01**	1.37 (1.02–1.85)	**0.04**
ISS ≥ 16	8.77 (7.37–10.43)	**< 0.01**	16.27 (12.92–20.49)	**< 0.01**	26.10 (15.36–44.22)	**< 0.01**
Major pelvic fracture[a]	2.49 (2.11–2.94)	**< 0.01**	3.01 (2.43–3.75)	**< 0.01**	2.38 (1.79–3.15)	**< 0.01**
Severe associated injury	6.38 (5.35–7.61)	**< 0.01**	6.90 (5.58–8.54)	**< 0.01**	20.28 (11.76–34.97)	**< 0.01**
SBP ≤ 90 mmHg	9.99 (7.99–12.49)	**< 0.01**	11.35 (7.89–16.31)	**< 0.01**	10.33 (7.44–14.34)	**< 0.01**
GCS ≤ 12	12.70 (10.58–15.25)	**< 0.01**	23.17 (17.32–31.00)	**< 0.01**	21.97 (15.26–31.65)	**< 0.01**
Trauma center admission	3.79 (3.20–4.49)	**< 0.01**	4.00 (3.22–4.91)	**< 0.01**	8.65 (5.64–13.29)	**< 0.01**

Significant values are indicated in bold

ISS injury severity score, *SBP* systolic blood pressure, *GCS* Glasgow Coma Score, *NA* Not applicable

[a]AIS ≥ 3

(1.02–1.77): $p = 0.03$) but not in younger patients (OR 1.15 (0.83–1.60): $p = 0.40$).

Lastly, admission to a major trauma center was associated with a trend toward higher in-hospital mortality in all patients (OR 1.28 (1.00–1.63): $p = 0.05$) but was unrelated to this outcome in the older and younger subgroups (respectively, OR 1.20 (0.90–1.60): $p = 0.21$ and OR 1.55 (0.94–2.53): $p = 0.08$).

Discussion

In concurrence with trends from other industrialized nations, the elderly population in the Netherlands is projected to grow from 2.7 million in 2012 to 4.7 million in 2041 (16–26% of the population) [19]. As a consequence, the overall admission rate of elderly pelvic fracture patients is expected to continue to rise [8–10]. Our current findings are clearly reflective of this growing healthcare concern given that the majority (61.8%) of pelvic fracture patients in this large cohort was over the age of 65.

Epidemiology

Over the 5-years study period, we found an average annual incidence of all pelvic fractures in the Netherlands of 14.3 per 100,000 persons. Though literature on the subject is sparse and populations dissimilar, this overall incidence of pelvic fractures is markedly lower than has been reported earlier in pelvic fracture patients (20–37 per 100,000

Table 4 Multivariate analysis for independent predictors for in-hospital mortality in older (≥ 65 years) and younger (< 65 years) pelvic fracture patients (odds ratio (OR) 95% confidence interval (CI)))

	All		Older		Younger	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Age ≥ 65 years	6.59 (5.12–8.48)	**< 0.01**	NA	NA	NA	NA
Male gender	1.25 (1.02–1.54)	**0.03**	1.48 (1.15–1.90)	**< 0.01**	0.94 (0.67–1.30)	0.69
ISS ≥ 16	3.74 (2.61–5.36)	**< 0.01**	3.45 (2.25–5.28)	**< 0.01**	4.51 (2.12–9.64)	**< 0.01**
Major pelvic fracture[a]	1.26 (1.02–1.56)	**0.03**	1.35 (1.02–1.77)	**0.03**	1.15 (0.83–1.60)	0.40
Severe associated injury	1.76 (1.29–2.41)	**< 0.01**	1.83 (1.30–2.58)	**< 0.01**	1.70 (0.78–3.73)	0.18
SBP ≤ 90 mmHg	3.09 (2.33–4.09)	**< 0.01**	3.58 (2.31–5.54)	**< 0.01**	2.74 (1.88–3.99)	**< 0.01**
GCS ≤ 12	5.19 (3.92–6.87)	**< 0.01**	4.45 (3.00–6.59)	**< 0.01**	5.94 (3.83–9.20)	**< 0.01**
Trauma center admission	1.28 (1.00–1.63)	0.05	1.20 (0.90–1.60)	0.21	1.55 (0.94–2.53)	0.08

Significant values are indicated in bold

ISS injury severity score, *SBP* systolic blood pressure, *GCS* Glasgow Coma Score, *NA* Not applicable

[a]AIS ≥ 3

persons) [4, 11, 12]. A possible explanation for this finding appears to be the lower occurrence of major pelvic fractures. In a 1-year prospective population-based study in a region in Australia, an occurrence of 20 high- and low-energy pelvic ring fractures (excluding isolated acetabular fractures) per 100,000 persons were found in a cohort of hospitalized patients [4]. The incidence of low-energy pelvic fractures was similar to the rate of minor pelvic fractures found in our study (10 vs 11 per 100,000), but the incidence of high-energy pelvic fractures was considerably higher (10 vs 4 per 100,000). The incidence of all pelvic fractures found in the Australian study is equal to the rate of 20 per 100,000 found in a prior report from a Swedish County [12]. An American study from Rochester (MI), however, found an even higher occurrence for pelvic fractures of 37 per 100,000 persons [11]. Of note is that a range of other studies have described large cohorts of pelvic fracture patients using a variety of (non-scientific) databases and inclusion criteria, but these reports are neither all-inclusive nor do they indicate the specific incidence in the general population [1, 2, 20]. The discrepancy between the nationwide incidence of pelvic fractures found in our study and the regional occurrences reported previously can in part be explained by differences in demographics. Although there is no definitive data to support this claim, it could also be speculated that it may be a result of variances in vehicle and road safety (affecting speed and compartment intrusion) and modes of transportation (more bikes) [21]. The majority of pelvic fractures are a result from motor vehicle collisions and less frequently from bicycle (and motorbike) accidents [20]. Indeed, aspects that impact direction and amount of energy transfer on the human body may also have a direct influence on the proportion of major as opposed to minor pelvic fractures in the Dutch population [21]. Furthermore, the overall shorter road travel distances in densely populated countries such as the Netherlands may have played an important role.

Older versus younger patients

In older individuals, the overall incidence of pelvic fractures was 9 times higher than in younger individuals (57.9 vs 6.4 per 100,000 persons) mostly as a result of a much higher occurrence of minor pelvic fractures in this age group (48.3 vs 4.0 per 100,000 persons). More strikingly, we found that the incidence of major pelvic fractures in older individuals was roughly threefold of that in younger individuals (9.6 vs 2.5 per 100,000 persons) suggesting that older persons are at risk for more severe pelvic fractures despite generally sustaining lower energy trauma [22]. To our knowledge, no earlier population-based studies have reported epidemiology of pelvic fractures in older and younger subgroups separately.

Elderly pelvic fracture patients present a uniquely different patient cohort compared to their younger counterparts. In older patients, pelvic fractures are more likely a result from low-energy falls as opposed to high-energy road traffic accidents in younger patients [5, 10, 23, 24]. This was reflected in our study by a greater proportion of minor pelvic fractures, less severe injuries and a higher rate of admission to a non-major trauma center in older patients. In contrast, younger patients generally sustained a major pelvic fracture as well as severe associated injuries and were more likely to be admitted to a major trauma center. These aspects most likely resulted in a shorter length of hospital and ICU stay for the older group although the absolute difference in days was discrete. Our findings are corroborated by another large study in which older and younger pelvic fracture patients were directly compared. In this National Trauma Data Bank study, the older subgroup also had a larger percentage of

minor pelvic fractures, a lower proportion of severe injuries and a lower ICU length of stay [24].

The results of this study further show a similar in-hospital mortality rate for older and younger patients (5.3 vs 4.8%; $p = 0.28$). However, given the aforementioned differences between groups we conclude that older patients with a minor or major pelvic fracture had a disproportionately high mortality rate. Indeed, in the cohort of major pelvic fractures, older patients had a significantly higher in-hospital mortality rate than younger patients despite having a significantly lower ISS.

In contrast to our findings, data from approximately 12,000 elderly pelvic fracture patients extracted from the American National Trauma Data Bank indicated that the mortality rate in this group was significantly higher than in the younger group (13.3 vs 8.8%) [24]. Furthermore, a number of markedly smaller previous studies from single Level I trauma centers reported a 10–21% mortality rate in elderly pelvic fracture patients [5, 23, 25–27]. It should be noted, however, that the patients admitted to these major trauma facilities as well as the patients described in the National Trauma Data Bank study were more severely injured (mean ISS 12-21) than those reported in our more comprehensive nationwide review (mean ISS 7). The significantly higher mortality rate for elderly patients found in these prior studies does appear to support our similar finding in the subgroup of more severely injured major pelvic fracture patients.

Predictors for in-hospital mortality

The overall in-hospital mortality rate (5.1%) for all pelvic fracture patients found in our study is at the lower end of rates reported previously in large database studies [1, 2, 20, 28]. These prior studies found a mortality rate that ranged from 3 to 14% depending on the specific characteristics of the pelvic fracture patients (and participating institutions) included for review.

Few studies with a large enough population have examined independent predictors for in-hospital mortality in pelvic fracture patients [2, 20, 28]. In the present large cohort of pelvic fracture patients, the single greatest risk factor for in-hospital mortality was age over 65 years, followed by a decreased level of consciousness, the presence of multiple injuries and hypotension. The latter three factors were also highly predictive for in-hospital mortality in the older and younger subgroups.

Results in the current study are supported by a study from the United Kingdom that included over 11,000 patients [20]. Age, physiologic derangement with hypotension and the presence of associated injuries were factors that independently predicted mortality. A further study from the National Trauma Data Bank included more than 30,000 (initially stable) pelvic trauma patients [28]. In this subgroup of pelvic fracture patients advanced age, a higher severity of injury and a lower Glasgow Coma Score were among other factors most predictive for in-hospital mortality. Finally, in a study from the German Pelvic Trauma Registry with roughly 5000 patients, age and ISS were significant risk factors for mortality as well as a variety of variables that indicated signs of significant bleeding (the Glasgow Coma Score was not considered in this study) [2].

Although not a significant independent risk factor, an unexpected finding in our study was that there was a trend toward higher in-hospital mortality in (all) patients admitted to a major trauma center (OR 1.28 (1.00–1.63): $p = 0.05$). Admission to a major trauma center was not independently associated with this outcome in the individual subgroups of older and younger patients. Earlier studies that have investigated this particular matter have found mixed results but most have indicated that predominantly patients with more severe pelvic fractures would likely benefit from specialized (Level I) trauma care [28]. To our knowledge, older pelvic fracture patients as a separate subgroup have not been addressed previously in this context. In the National Trauma Data Bank study, it was found that transport of stable pelvic trauma patients to a Level I or II Trauma facility was independently associated with lower mortality [20, 28]. Furthermore, pelvic fracture patients admitted or transferred to a hospital with pelvic reconstruction facilities in the United Kingdom had significantly lower mortality rates [20]. This was particularly evident for the higher AIS pelvic classifications but not so much for lower AIS classifications. A secondary analysis from data from the American National Study on Costs and Outcomes of Trauma found mixed results (at various time points) for a number of subgroups of pelvic and acetabular fracture patients [29]. In-hospital mortality was not independently associated with admission to a Level I trauma facility (vs a large non-trauma center) in all pelvic fracture patients. However, outcome (in terms of survival and physical function) at 1 year was superior in patients with unstable pelvic and severe acetabular fractures that were admitted to these more advanced trauma facilities. Ultimately, it could be speculated that perhaps differences between Level I and II trauma centers in the Netherlands are more discrete than in other countries and that a comparison between Dutch Level I/II and Level III facilities would have yielded different results.

The present study underscores that elderly pelvic fracture patients present a growing patient cohort that demands urgent attention. In treating these challenging patients, it should be recognized early that the elderly are at increased risk for death even in the presence of less severe pelvic fractures. Aggressive management of comorbid conditions as well as treatment directed at immediate pain relief and early restoration of function are particularly crucial in this high-risk patient group. Future studies will have to evaluate which

fracture specific treatment strategies are most successful in decreasing morbidity and mortality. A more detailed (pelvic trauma) registry may be an important first step to advance such efforts. Also, further research is needed to identify effective fracture prevention strategies such as programs aimed at decreasing falls in the elderly and osteoporosis treatment.

Strengths and limitations

This study represents the first scientific report based on data from the Dutch National Trauma Registry. While previous studies have generally reported selected pelvic fracture patients from certain regions within a country and/or have been based on non-scientific databases [4, 8, 11, 12], we were able to describe a near all-inclusive nationwide cohort of almost 12,000 pelvic fracture patients admitted to Dutch hospitals. This included patients with less severe fractures and admissions to smaller (non-major trauma) hospitals. More than 7000 patients over the age of 65 years were included, one of the largest cohorts of elderly pelvic fracture patients reported to date [24].

This study has several limitations inherent to large database reviews such as potential issues related to the accuracy and quality of the data entered. Miscoding of pelvic ring injuries has been found to be a significant problem in the American National Trauma Data Bank [30]. It is unknown if the current Dutch National Trauma Registry suffers from the same shortcoming. Furthermore, a number of potentially important variables such as Revised Trauma Score, packed red blood cell requirement, (surgical) interventions and cause of death were not recorded. Also, similar to other studies, the Dutch registry only collects AIS pelvic codes to classify pelvic fractures these codes did not allow us to further classify the various pelvic fracture types other than in minor and major fractures. We encountered a considerable volume of missing values for some variables (particularly the GCS). To deal with this important issue, we employed the method of multiple imputation [17]. This statistical technique represents a superior alternative to simple (stepwise) deletion of patients with missing values which risks introducing a selection bias and decreases the effective sample size (and power) of the analysis. Results in the current study may have been influenced by (unknown) confounders that were not entered (or missing) in the multiple regression analysis. Lastly, it should be noted that while hospital participation currently approaches 100%, during the 5-year study period an average of 84% of hospitals participated in the Dutch National Trauma Registry. It is unlikely, however, that this had a significant impact on our findings as all (Level I) major trauma centers and the majority of other large hospitals participated in the registry during the entirety of the study period.

Conclusion

In this review of a near all-inclusive nationwide cohort of trauma patients in the Netherlands, the annual incidence of (both minor and major) pelvic fractures in the older population was substantially higher than in the younger population. However, overall, the incidence of (particularly major) pelvic fractures appeared to be lower than estimates from other industrialized countries.

Compared to younger pelvic fracture patients, elderly patients presented a uniquely different patient cohort with overall less severe injuries but with a disproportionately high in-hospital mortality rate. Among other factors, age was the single largest independent predictor for in-hospital mortality. Admission to a Level I major trauma center was not predictive for lower in-hospital mortality.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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