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Research Article

Underestimation Posterior Ring Involvement in Fragility Pelvic Fractures with Anterior Ring Compromise

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Abstract

Fragility pelvic fractures (FPF) are an increasing issue in our aging population. Radiography is the most commonly used examination for initial diagnosis, however, it may underestimate posterior ring injuries.

Objective: to evaluate radiographic underestimation of posterior ring fractures in patients with FPF and isolated anterior ring fracture.

Materials and Methods: a prospective study was conducted at two trauma centers with patients diagnosed with FPF from 2019 to 2022. We Included individuals over 60 years old with isolated anterior ring fracture confirmed radiographically and attributed to low-energy mechanisms. Bedridden patients and pelvic fractures in tumoral bone were excluded. Selected individuals underwent a pelvic computed tomography (CT) to search for hidden posterior ring fractures. Results were compared and associated with demographic and clinical data through statistical model analysis, hypothesis testing, and machine learning models.

Results: out of 264 diagnosed with FPF, 58 met inclusion and exclusion criteria. In pelvic CT, hidden posterior ring fracture was found in 65% of cases. Average age was 81.7 years (SD = 9.49 years), and 87.9% of cases were women. Of recorded patients, 32% presented with posterior sacral pain, and 48% retained the ability to walk at the time of their first emergency consultation. The most common initial classification of FPF by Rommens was Ia, followed by Ib. After CT, predominant classification was 2b (39.6%) followed by Ia (29.3%). On statistical analysis, no significant association was found between hidden posterior ring involvement and age, sex, sacral pain, walking ability, or time from onset at first consultation.

Conclusion: Every patient with FPF with isolated anterior ring involvement needs a pelvic CT in their initial evaluation, given the low diagnostic accuracy of radiography for diagnosing posterior ring fractures. This practice should be maintained independent of findings in the medical interview and physical examination.

Keywords: Pelvic Fracture; Rami Fractures; Fragility Fracture; Osteoporosis

Introduction

Fragility pelvic fracture (FPF) is an increasingly significant problem due to the sustained rise in life expectancy of our population [1]. The World Health Organization defines it as a fracture resulting from a mechanism insufficient to break normal bone [2]. It is more common in women and the most frequent underlying cause is osteoporosis, although it is also associated with vitamin D deficiency, prolonged immobilization, corticosteroid, and rheumatoid arthritis [3-5]. In the United States, pelvic fractures account for 7% of all osteoporotic fractures among individuals over 50 years old, encompassing 5% of associated costs [6]. In Finland, adjusted incidence of FPF in individuals aged 80 or older increased from 73 to 364 per 100,000 inhabitants between 1970 and 2013, with projections suggesting 87% increase in new cases by 2030, which would result in a population 2.4 times the current number of FPF cases [1].

Studies have shown that in elderly individuals, initial radiographic examination of the anterior pelvic ring often correlates with involvement of the posterior ring, with computed tomography (CT) detecting up to 60% and magnetic resonance imaging (MRI) up to 90% of such cases [7-10]. This has significant clinical implications, as an additional fracture of the posterior ring increases medical complications from 18% to 44% and is notably associated with a higher rate of infections and cardiovascular events, as well as extended hospital stays [11].

Given the distinct nature of FPF compared to high-energy fractures, it was necessary to develop a specific pelvic fracture classification. In 2013, Rommens and Hofmann introduced a new system based on instability of the pelvis [10]. This classification helps identify the most common fracture sites and suggests appropriate management strategies based on severity of findings. Rommens I are fractures involving only the anterior ring: Ia includes unilateral fractures and Ib bilateral fractures. Rommens II, characterized by moderate instability and involving a non-displaced posterior component, accounting for 50% of cases. IIa fractures do not involve anterior ring, IIb include a comminuted area in sacral wing with anterior ring involvement, and IIc involve fractures of sacrum, sacroiliac or iliac with anterior ring involvement. Rommens III, which make up 10% of cases, are characterized by unilateral displacement of the posterior pelvis with an anterior ring fracture, rendering them unstable. IIIa occurs through iliac bone, IIIb through sacroiliac joint, and IIIc through sacrum. The most severe instability occurs in type IV fractures, which constitute 20% of FPF cases and are described as bilateral posterior displacement with or without anterior involvement. IVa are fractures involving bilateral iliac bone, IVb are "H" type sacral fractures, and IVc include combinations not described in previous categories. This system has demonstrated good intra and inter-observer reliability [12].

Due to lack of local data, the aim of this work is to assess radiographic underestimation of posterior ring involvement in fragility pelvic fractures with isolated anterior ring involvement.

Materials and Methods

This study was a prospective analysis conducted at two centers in Chile: a central trauma hospital and a regional base hospital. It included patients diagnosed with FPF at the emergency department from November 2019 to June 2022. Participants were individuals over 60 years old with isolated anterior ring fractures confirmed by radiography, attributed to low-energy mechanisms. Exclusion criteria encompassed patients in a bedridden state, tumoral bone fractures, high-energy mechanism injuries, and patients who could not be followed up. Data collected from clinical care included demographic details (age, gender), medical history, time elapsed since the accident, mobility status, and presence of posterior sacral pain. Each patient was required to undergo a standardized set of pelvic radiographs (anteroposterior, inlet, and outlet views), facilitating classification of fracture according to Rommens system. A non-contrast pelvic CT scan was subsequently performed, and images were reviewed by two specialists in hip and pelvis surgery, each with over 20 years of experience, aiming to reassess the classification and determine presence or absence of hidden fractures.

The analysis of results was performed using a) Hypothesis testing: a.1: Student's t-test for continuous variables, a.2: Chi-squared test for categorical variables, b) Statistical models: b.1: Correlation matrix to measure strength and direction of relationships between variables, b.2: Assumption for ANOVA (Shapiro-Wilk, Kruskal-Wallis) for continuous variables, b.3: Logistic regression and c) Machine learning model: Decision tree model (Classification and Regression Trees, CART).

Results

Of 264 patients evaluated for FPF between November 2019 and June 2022, 58 met inclusion criteria and agreed to participate in study. Average age of these participants was 81.8 years with standard deviation of 9.49 years and ranging from 60 to 99 years. Median age was 83 years, as depicted in figure 1. Of these patients, 51 were female (87.9%) and 7 were male (12.1%). Medical histories indicated that 34% had type 2 diabetes mellitus and 46% suffered from hypertension. Average time from accident to first consultation was 3.55 days.

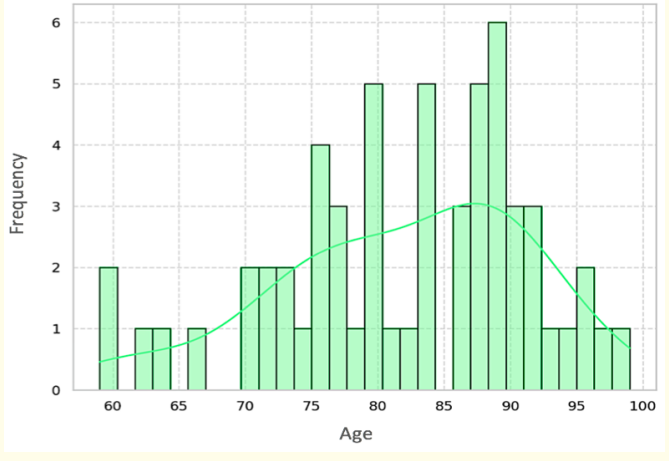

Figure 1: Age distribution and density curve of patients.

At their initial emergency consultation, 28 patients (48.2%) retained their ability to walk. Regarding posterior sacral pain, documented in 43.1% of the cases, only 9 patients (36%) reported pain during their initial evaluation.

Prior to CT, the most common Rommens classification was Ia (87.9%), followed by Ib (12.1%). After CT scans, classification most frequently changed to 2b (39.6%), then Ia (29.3%) and 2c (20.6%) as shown in figure 2. This indicated that 40 patients had classification changed due to hidden fractures, suggesting that presence of more unstable fractures was underestimated in 65.5% of cases initially diagnosed via radiography alone, as exemplified in figure 3.

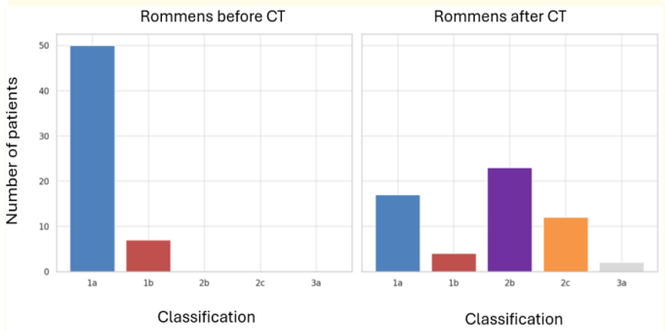

Figure 2: Distribution of patients according Rommens pelvic fragility fracture classification, before and after CT.

Figure 3: Underestimation posterior ring involvement in fragility pelvic fractures with anterior ring compromise. On the left, a pelvic x-ray set (anteroposterior, inlet and outlet) shows an ischiopubic ramus fracture. On the right CT scan of the same patient, where an associated sacral fracture is also observed.

Statistical analysis revealed no significant associations between underestimation of posterior ring involvement and variables such as gender (X^2 p = 0.965), diabetes mellitus type 2 (X^2 p = 0.417), hypertension (X^2 p = 0.887), ability to walk at the time of emergency (X^2 p = 0.374), and posterior sacral pain (X^2 p = 0.129).

Age did not significantly correlate with presence of additional fracture (Student's t p = 0.324). Similarly, when age was segmented into intervals of 10 or 20 years, no significant associations emerged (X^2 p = 0.489 and 0.201, respectively). Time interval between occurrence of FPF and emergency service consultation also did not predict the presence of a hidden fracture (Student's t p = 0.409).

Logistic regression analysis was conducted to explore the strength and direction of relationships between studied variables. Although no significant associations were found within a 95% confidence interval, there was a trend indicating a positive relationship between Ia classification (OR = 2.42) and presence of posterior sacral pain (OR = 1.90) with presence of hidden fracture. Conversely, female patients exhibited a lower trend of having undiagnosed posterior ring fracture (OR = 0.65).

No significant correlations were found when final fracture classification was associated with variables such as age (ANOVA p = 0.824), time between accident and consultation (ANOVA p = 0.159) or posterior sacral pain (X^2 p = 0.129).

Correlation matrix analysis revealed only mild correlations with outcomes, and no significant findings were obtained from training a decision tree model (Classification and Regression Trees, CART), where overall accuracy was 37.7%, indicating a limited capability to correctly distinguish between patients with and without hidden fractures.

Discussion

Pelvic Fragility Fractures (PFF) have become an issue of increasing relevance due to continuous rise in life expectancy in our population. This study assessed the presence of hidden fractures in patients with PFF and factors that may be related to this diagnosis.

Our results in the Chilean population are similar to previous research, finding a hidden fracture of the posterior ring in 65% of cases when there is a PFF of the anterior ring. Transition is more clearly shown in figure 4, where it is observed that most changes in classification were from Rommens Ia to 2b and from Rommens Ia to 2c. Clinical significance of these findings is relevant, as a failure to identify them can lead to inadequate management by underestimating instability of the fracture. This is what Böhme J., *et al.* [13] demonstrate, they assessed 252 patients over 65 years old with PFF and, although they used another classification, showed that after CT scans, management approach shifted from conservative to sur-

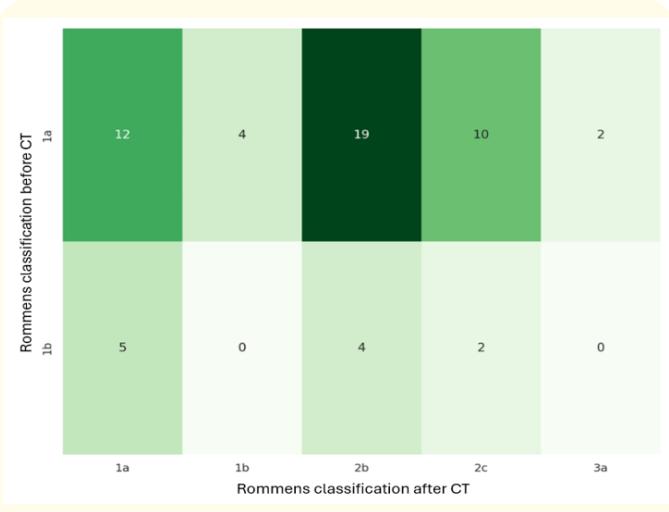

Figure 4: Transition of Rommens classifications from before to after CT.

gical in type B fractures (Tile classification) from 33% to 43% and up to 71% in isolated sacral fractures. Lau T-W., *et al*. in their work with 37 cases of PFF, found 59% hidden sacral fractures, requiring intervention in 7 of the 9 patients presenting with Type II lateral compression pelvic fractures according to the Young-Burgess classification [8]. Additionally, as mentioned, an additional fracture of the posterior ring can increase complications from 18% to 44%. Loggers., *et al*. [11] reviewed 117 fragile patients with branch fractures and found that those with hidden fractures had higher rates of infection and cardiovascular events, as well as longer hospital stays. It is noteworthy that no significant difference in mortality has been established in these groups, being approximately 14% with or without a fracture of the posterior ring [14]. We did not find current publications that evaluate the persistence of pain, prostration, or the ability to walk long-term when finding a hidden PFF, which could be interesting to analyze, considering the new techniques of minimally invasive surgery that are less aggressive and have allowed surgeries on increasingly older patients.

In 1996 Berg E., *et al*. [15] and in 2012 Scheyerer MJ., *et al*. [16] reported underdiagnosis of 47% and 96.8%, respectively. For their part, Schicho A., *et al*. [17], assessed PFF in patients over 75 years old and found that the sensitivity of radiography to detect sacral fractures was only 10.5%. The problem of identification can be for various reasons. Intestinal gas in an unprepared radiograph prevents seeing sacrum in its entirety. Additionally, decreased bone density can conceal fracture line. There are also errors in the image acquisition technique that can hide the posterior injury. Lastly, the advanced age of these patients may imply difficulty in obtaining radiograph correctly, due to limited joint ranges, deviations from spinal axis, alterations in pelvic tilt, problems following instructions, etc.

We did not find a significant association between studied variables and presence of hidden fractures, so pending further research, approach should be to request CT scans for all PFFs with isolated involvement of the anterior ring, regardless of age, presence of posterior sacral pain, fracture evolution time, comorbidities, or ability to ambulate.

Our weaknesses are lack of data collection for some variables and low number of participants compared to other publications. Strength is that it is a prospective study conducted in two trauma centers, which gives greater heterogeneity and fidelity to the sample.

Conclusion

Our work supports that every patient with PFF with isolated involvement of the anterior ring requires an initial pelvic CT scan, given a high percentage of radiographic underestimation of posterior ring involvement. This must be independent of findings in the medical interview and physical examination.

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