Original Article

Determination of Clinical Signs and Symptoms Predicting No Pelvic Fracture in Patients with Multiple Trauma

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Abstract

Background: Pelvic fracture (PF) is the second-most prevalent cause of mortality after brain trauma among multiple trauma patients. Our aim was to examine the reliability of suggestive criteria for having no PF (NPF) according to the common reported clinical signs and symptoms (CSSs). **Materials and Methods:** In the current prospective study, 3527 patients with multiple trauma were recruited according to the guideline of emergency medicine. Information on age, gender, pelvic pain or tenderness, sacrum and coccyx pain or tenderness, the ability to active straight leg raising (SLR), and distracting injury was collected, and PF was examined by either X-ray or computed tomography (CT) scan. **Results:** The CSS sensitivity of NPF was 39.75% and the specificity was 100%. The no distracting injury was not significantly different according to the CSS criteria and results of X-ray and CT scan ($P = 0.269$); however, the difference of other criteria was significant ($P < 0.0001$). No pelvic pain or tenderness and the ability to active SLR considerably affected the prediction of NPF ($P < 0.0001$). No distracting injury can be omitted from the criteria without any effect on specificity, but with increased sensitivity (60.8% with three criteria vs. 39.7% with four criteria). **Conclusion:** According to our results, it can be said that due to the high predictive value of our suggestive criteria, it could be applicable as the important criteria for defecting NPF among patients with the possibility of PF. This approach can reduce the necessity of imaging in these patients which helps to reduce the health cost and hazards of X-ray used for imaging and exhaustion of medical devices.

Keywords: *Computed tomography scan, clinical signs, multiple trauma, pelvic fracture, symptoms, X-ray*

Introduction

Trauma has become one of the three main reasons of death worldwide. It allocates the highest ratio of morbidity in people aged between 1 and 44 years. Trauma may cause damage to various sites of the body in which fractures are the most noticeable problem.[1] Pelvic fracture (PF) is the most prevalent cause of death after brain trauma among patients with multiple trauma. Furthermore, trauma is the most common cause of pelvic injuries, in which 81% of the reported reasons consist of crashes and road accidents. Although in recent years due to advances in medical science and the prompt and timely transfer and treatment of patients with PFs and also the role of radiological intervention (artery embolization) in the mortality and morbidity rates have been reported. Mortality remains high and the treatment of patients with PF and perineal injury still remains a problem. Death among these patients has reported up to 50% and the number of injuries such as damage to the rectum and the urinary tract is likely to initiate further complications and to provide complex treatment.[2]

PFs are the most problematic diagnostic injuries in which clinicians are still uncertain of which type needs which kind of treatment approach. Inability to identify the kind of fracture and source of hematoma and bleeding site is the main reason for performing the diagnostic radiography. During past decades, many clinical methods were established in order to access the best efficacy in terms of inhibition of pelvic hemorrhage and pelvic fixation; however, due to insufficient consideration for anatomic changes during PFs, all the patients had to undergo radiography in the first treatment step in order to identify the

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kind and place of fracture to receive the appropriate clinical aids.[3]

In fact, for a surgeon who wants to evaluate the operation setting and management, the priorities for those patients with multiple trauma, especially because of PFs, the mechanisms of injury and physical examination, and also psychologic data are demanded and, without a primary imaging from the possible site of fracture, it is hard to distinguish the right points of fractures.[4] On the other hand, the considerable expenses which impose pressure on the patients' shoulder demonstrated the importance of reliable initial assessment tools for the diagnosis of PF. And also, to obtain normal graphic results in the noticeable ratio of patients with primary signs of PFs,[5] a pivotal cost-free approach with high diagnostic accuracy is needed to reduce the X-ray hazards in patients, especially in children and pregnant women.

Hence, our aim was to evaluate the accuracy of the suggestive criteria according to the clinical guideline of emergency medicine for PF, which consists of seven criteria for the pediatric fractures.[6] Regarding this issue that there are no reliable criteria for adults in terms of PF, we tried to find the best criteria in which no PF (NPF) could be confirmed on the arrival of patients with multiple trauma of PF to the hospital.

Materials and Methods

This cross-sectional diagnostic study has been conducted to detect clinical signs and symptoms (CSS) as predictors of NPF in patients with multiple traumas referred to Al-Zahra and Kashani hospitals in Isfahan and Amiral-Momenin in Shahreza during December 2014–February 2016.

According to the previous study which considered 90% of sensitivity containing the proportion of patients do not need to X-ray of 0.50[7] and regarding our sample size formula, 3527 patients were assigned. We applied simple randomization and 7–10 patients assigned daily.

We excluded patients who suffered blunt trauma caused by collision, falls, etc., could walk four steps without feeling any pelvic pain (based on scientific evidences), or who suffered penetrating trauma, an injury that occurs when an object pierces the skin and enters a tissue of the body, creating an open wound, or have a depressed level of consciousness (Glasgow Coma Scale [GCS] <15), or who used psychedelic or have signs of alcohol intoxication, and who are <5 years old or >65 years old, since patients with intoxication and depressed level of consciousness and those aged <5 years cannot recognize signs and symptoms well and also patients aged >65 years with osteoporosis and comorbidities such as diabetes and Alzheimer's disease show high risk of fractures, and their signs and symptoms, including pain, are not reliable.

We recorded patients' age and gender at baseline. Then, for all patients after the initial diagnosis and treatment according to the emergency department guidelines, pelvic X-ray or, if required, computed tomography (CT) scan was performed to diagnose whether fracture is presence and definitive or not.

Then, for each patient, the following proposed CSSs were recorded by someone else who was blinded to the imaging results:[6]

1. No pelvic pain or tenderness
2. No sacrum and coccyx pain or tenderness
3. The ability to active straight leg raising (SLR)
4. Distracting injury.

Pain or tenderness is the common sign and symptom in any fracture, and lack of pain or tenderness at pelvis can indicate NPF. Distracting injury is known as the severe injury elsewhere in the body and it can distract the patient's attention from pelvic pain or tenderness (with pain score >7). In addition, given undertaking the muscles in pelvic and femoral areas to perform active SLR, it is likely to insert many involved muscles in pelvic area and ability to detect active SLR is disturbed. These were the reasons why we had chosen these four CSSs.

Therefore, when patient expresses "no pelvic pain or tenderness," "no sacrum and coccyx pain or tenderness," and "no distracting injury" and can involve active SLR, it indicates as NPF and, if the above-mentioned criteria were not seen in patients, it is found as a probability of PF.

Statistical analysis

Finally, we entered the collected data into SPSS (version 20; SPSS Inc., Chicago, Ill., USA) software, and descriptive statistics such as frequency, frequency percentage, mean, and standard deviation were undertaken. In addition, inferential statistics were used to evaluate the association between CSS and PF or NPF through Fisher's exact test. In order to ascertain demographic characteristics (age and sex), CSS as the indicator of PF and NPF, and depending on using X-ray or CT scan, we used step-wise logistic regression. To evaluate sensitivity, specificity, positive predictive value, and negative predictive value of CSS comparing X-ray or CT scan, we used receiver operating characteristic (ROC) analysis. The significance level in all analyses was considered at <0.05.

Results

A total of 3527 patients with multiple trauma were included in this study (men = 2686 [76.2%], women = 841 [23.8%], and mean age = 31.74 ± 13.98 years [range; 5–65 years]). The demographic data, baseline characteristics, and patients' clinical symptoms are summarized in Table 1.

Of 3303 NPF patients, 2532 (76.7%) patients were female and 771 (23.3%) were male and also their age frequency distribution ranged as follows: ≤10 years old, 11–20 years old, 21–30 years old, 31–40 years old, and >40 years

Table 1: Basic characteristics and clinical symptoms

Characteristics and symptoms	Frequency (%)
Sex	
Male	2686 (76.2)
Female	841 (23.8)
Age (years)	
Mean±SD	31.74±13.98
≤10	112 (3.2)
11-20	664 (18.8)
21-30	1214 (34.4)
31-40	658 (18.7)
>40	879 (24.9)
Pelvic pain or tenderness	
No	3047 (86.4)
Yes	480 (13.6)
Sacrum and coccyx pain or tenderness	
No	2927 (83)
Yes	600 (17)
The ability to active straight leg raising	
No	1119 (31.7)
Yes	2408 (68.3)
Distracting injury	
No	1752 (49.7)
Yes	1775 (50.3)
Pelvic fracture	
No	3303 (93.6)
Yes	224 (6.4)

SD: Standard deviation

old included 107 (3.2%), 636 (19.3%), 1155 (35%), 615 (18.6%), and 790 (23.9%) patients, respectively.

Detecting NPF based on four CSSs including "no pelvic pain and tenderness," "no sacrum and coccyx pain or tenderness," "the ability to active SLR," and "no distracting injury" indicated that according to X-ray or CT scan results (to detect true PF), 224 patients (6.4%) with PF and 3303 patients (93.6%) with NPF were detected, while based on CSS, 1313 patients (37.2%) with NPF and 2214 patients (62.8%) with PF were diagnosed. The sensitivity of CSS to detect NPF was 39.75% (1313/3303), while its specificity was 100% (224/224). In addition, its positive and negative predictive values were 100% (1313/1313) and 10% (224/2214), respectively (area under the ROC curve [AUC] = 0.699, $P < 0.0001$) [Table 2].

However, out of the four criteria of CSSs, the only criterion identified by X-ray or CT scan that showed no significant difference between NPF and PF was "no distracting injury" ($P = 0.269$); but in contrast, "no pelvic and sacrum pain and tenderness" among patients with PF and "the ability to active SLR" among patients with NPF are the most frequent criteria identified ($P < 0.0001$).

Furthermore, according to the results of logistic regression analysis with adjusted sex and age, among three out of four CSS criteria, only two criteria including "no pelvic pain or tenderness" and "the ability to active SLR" were recognized as the indicators of NPF with odds ratio of 8.186 (6.365–15.861) and 0.107 (0.062–0.185), respectively ($P < 0.0002$).

Table 2: Comparison of clinical signs and symptoms with X-ray or computed tomography scan for diagnosis of no pelvic fracture

NPF, according to CSS	True NPF		Total
	Positive	Negative	
Four criteria of CSS*			
Positive	1313	0	1313
Negative	1990	224	2214
Total	3303	224	3527
AUC=0.699, $P<0.0001$, sensitivity=39.75%, specificity=100%, positive predictive value=100%, negative predictive value=10%			
Three criteria of CSS**			
Positive	2010	0	2010
Negative	1293	224	1517
Total	3303	224	3527
AUC=0.804, $P<0.0001$, sensitivity=60.85%, specificity=100%, positive predictive value=100%, negative predictive value=14.7%			
Two criteria of CSS***			
Positive	2281	6	2287
Negative	1022	218	1240
Total	3303	224	3527
AUC=0.832, $P<0.0001$, sensitivity=69.1%, specificity=97.3%, positive predictive value=99.7%, negative predictive value=17.5%			
No pelvic pain or tenderness			
Positive	3034	13	3047
Negative	269	211	480
Total	3303	224	3527
AUC=0.930, $P<0.0001$, sensitivity=91.86%, specificity=94.20%, positive predictive value=99.6%, negative predictive value=43.9%			
The ability to active straight leg raising			
Positive	2388	20	2408
Negative	915	204	1119
Total	3303	224	3527
AUC=0.817, $P<0.0001$, sensitivity=72.30%, specificity=91.07%, positive predictive value=99.2%, negative predictive value=18.2%			

*The presence of all four CSSs altogether, **Removed distracting injury, ***Removed no sacrum and coccyx pain or tenderness. NPF: No pelvic fracture, CSS: Clinical signs and symptoms, AUC: Area under the ROC curve, ROC: Receiver operating characteristic

Hence, once again to evaluate the diagnostic value of NPF based on the CSS, any less important factors were removed. Results indicated that by elimination of "no distracting injury," the sensitivity and specificity altered to 60.8% (2010/3303) and 100% (224/224), respectively, in which positive and negative predictive values were 100% (2010/2010) and 14.7% (224/1517), respectively. In addition, by eliminating one or more criteria (sacrum and coccyx pain or tenderness), sensitivity and specificity turned into 69.1% (2281/3303) and 97.3% (218/224), respectively, in which positive and negative predictive

values were 99.7% (2281/2287) and 17.5% (218/1240), respectively [Table 2].

Finally, according to the results of ROC analysis, it was found that one of the most important and powerful criterion to detect NPF could be "no presence of pelvic pain or tenderness" (sensitivity = 91.8%, specificity = 94.2%, AUC = 0.930, $P < 0.0001$). However, by adding "ability to perform active SLR (sensitivity = 69.1%, specificity = 97.3%, AUC = 0.832, $P < 0.001$)," followed by adding "no pain or tenderness in the sacrum and coccyx (sensitivity = 60.8%, specificity = 100%, AUC = 0.804, $P < 0.0001$)" and finally adding "no presence of distracting injury (sensitivity = 39.7%, specificity = 100%, AUC = 0.699, $P < 0.0001$)," the sensitivity decreased, while the specificity in detecting NPF increased, but positive predictive value decreased; hence, statistically it showed significant differences when comparing diagnostic factors in pairs ($P < 0.01$) [Table 2].

Ultimately, diagnostic value of CSS in terms of different age ranges is shown in Figure 1. As illustrated, the diagnostic value of CSS in identifying NPF showed no significant differences at different ages statistically and in fact the AUC for different ages shows no considerable differences ($P > 0.05$). Therefore, it may be stated that the mentioned CSS can be undertaken for all ages (in this study 5–65 years), while its diagnostic value is retained.

Discussion

In the current study, our aim was to evaluate the accuracy of the suggestive criteria, which were composed of four most commonly observed CSSs according to recent studies and the guideline of PF.[6] We examined the diagnostic accuracy of suggestive criteria for NPF in different age groups in the relatively large population. Our results demonstrated high specificity and also positive predictive value in predicting NPF.

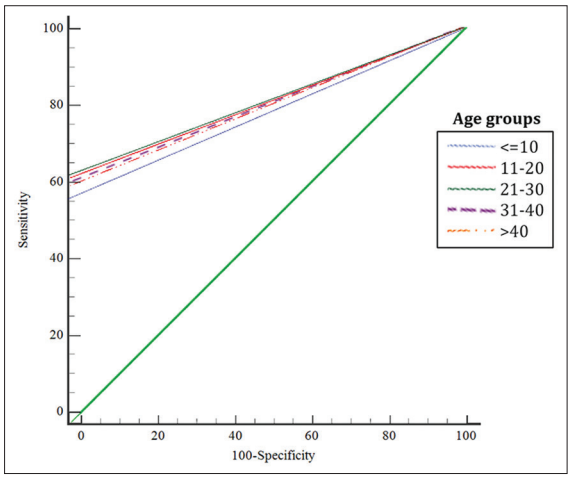

Figure 1: Comparison of diagnostic value of clinical signs and symptom in detecting no pelvic fracture in terms of different ages

For detecting and identifying the criteria of NPF precisely and preventing hazards and complications caused by various rays on patients and also reducing the exhaustion of instruments, 3527 patients with multiple trauma were recruited, of which 76.2% were male and 23.8% were female, with an average age of 31.74 ± 13.98 years. The first noteworthy point was that it might be said that most of the traumatic events occurred in middle-aged males. Likewise, in different studies on PF, it has been stated that in middle age, especially in men, the rate of PF is relatively higher than that in women,[8-11] although other investigations have declined any difference in gender distribution.[12]

Considering the main objective of the current study, common CSSs such as no pain or tenderness in the pelvis, no pain or tenderness in sacrum and the coccyx, having the ability to perform active SLR, and no distracting injuries for identifying NPF were taken. It should be noted that in our opinion, patients who had all these symptoms together definitely did not have PFs. The results of this claim showed that based on CSS, we did not encounter any error in identification of PF as NPF; in other words, with our suggestive criteria, the PF can fully stablish. However, given that the main objective of this study was to identify PF, it was observed that although the number of registered cases as having NPF was 3303, based on our CSS diagnostic criteria, 1313 people were identified. In fact, it can be said that the specificity of our criteria was 100% and positive predictive value was also 100%. However, in PF recognition, more than half of our patients were referred to CT scan or X-ray. With this approach, clinicians will have trust more to its discretion and will make sure that our above-mentioned criteria have no harm or risk to the patients whom imaging is unnecessary and also the population less likely to expose to radiation radiography devices. In this regard, Duane *et al*. examined the reliability of some rules compared with CT. They found the sensitivity of the Canadian Cervical Spine Rule, and the observed clinical symptom was 100%; however, their specificity was 0.60% and also the positive predictive value was 6.03%; nevertheless, the negative predictive value was 100%.[12] Junkins *et al*. in their retrospective analysis about the clinical presentation of PF in children reported that positive predictive value of pelvic examination was 84%, whereas the negative predictive value was 89%. They found that most of the PF patients had abnormal PF in the physical examination, and they concluded that although pelvic examination was specific and sensitive for pediatric PF, it was not suggested to eliminate radiography for severe PF.[13] Although it should be kept in mind that our main objective was to diagnose NPF, they were investigating about PF predicting within their population.

In the diagnostic value evaluation of the CSS, according to different age categories, we found that the value of our suggestive criteria was equal ($P > 0.05$). Our strong point in our evaluation was recruiting of various ages in the

study population; however, one study before us worked on diagnostic criteria of PF and they performed only in children.[13] It seems that our study is more comprehensive, because regarding the guideline of PF,[6] the limitation for NPF has been reported the age above 3 years. Another study introduced age as an important factor increase the incidence of PF, regardless of diagnostic value of PF.[14] Therefore, although our study has shown nonsignificant diagnostic value of NPF among different age categories, and, in the mentioned guideline, the attention was only paid toward children, perhaps, the separation of different age classifications and evaluation of diagnosis in each age group in the larger population can reach the beneficial meticulous diagnostic criteria.

At the next stage, we tried to remove the less important signs and symptoms, in order to reach the strict criteria in identifying NPF. The results showed that removal of distracting injury criterion increased the sensitivity and the specificity of NPF detection and the positive predictive value of 100% still retained. Despite increase the sensitivity of NPF detection, remove 'no pain' or 'tenderness sacrum and coccyx' from our criteria, reduced specificity and positive predictive value, which was contrary to our aim. Junkins *et al*. stated that distracting injuries may affect pelvic examination outcome with regard to both sensitivity and specificity.[13] Duane *et al*. declared that tenderness in cervical spine is a strong predictor of PF (odds ratio = 3.699, confidence interval: 2.652–5.076, $P < 0.0001$).[12] Furthermore, pain or tenderness in the sacrum and coccyx and pelvis is pivotal in the diagnosis of PF.[15]

Considering that the purpose of this study was detection of NPF, and our intent was not to report any NPF mistakenly instead of PF, despite lower AUC, after omitting the distracting injuries criterion, we still observe that our specificity was 100%, thus this element can be omitted if necessary, especially in severe multiple trauma. The most important diagnostic criterion for NPF was no pain or tenderness of pelvis. At the end, we opine that the report value with these simple criteria is that at least one-third of our population did not need to take an imaging, and that would be an important issue to reduce unnecessary imaging in patients with NPF with evaluating three or four simple criteria. It can also reduce the high costs of imaging in many unnecessary conditions. Using our criteria in different populations in further studies is highly recommended to reduce the complications of imaging.

Conclusion

According to the outcome of our mentioned criteria, we suggest that graphy is better to be taken only from the patients who have not meet our criteria. Furthermore, it is suggested to perform further investigations with not including distracting injury in the criteria and also being done in patients with age over than 65 years. The selected CSS was desirable in the diagnosis of NPF for various age groups (5–65 years). In addition, regarding our result, in patients with multiple trauma, if the following are observed: GCS = 15, no distracting injury, no intoxication, no pain and tenderness in pelvis and sacrum and coccyx, able to active SLR, and 5≤ age ≤65 years, there is no need to take a pelvic image.

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Conflicts of interest

There are no conflicts of interest.

References

1. Townsend CM Jr., Beauchamp RD, Evers BM, Mattox KL. Sabiston Textbook of Surgery E-book. Elsevier Health Sciences; 2016.
2. Scalea TM, Burgess AR. Pelvic fractures. Trauma. 4th ed. New York: McGraw-Hill; 2000. p. 807-37.
3. Flint L, Cryer HG. Pelvic fracture: The last 50 years. J Trauma 2010;69:483-8.
4. Evers BM, Cryer HM, Miller FB. Pelvic fracture hemorrhage. Priorities in management. Arch Surg 1989;124:422-4.
5. Sauerland S, Bouillon B, Rixen D, Raum MR, Koy T, Neugebauer EA, *et al.* The reliability of clinical examination in detecting pelvic fractures in blunt trauma patients: A meta-analysis. Arch Orthop Trauma Surg 2004;124:123-8.
6. Marx J, Walls R, Hockberger R. Rosen's Emergency Medicine-Concepts and Clinical Practice E-book. Elsevier Health Sciences; 2013.
7. Yugueros P, Sarmiento JM, Garcia AF, Ferrada R. Unnecessary use of pelvic x-ray in blunt trauma. J Trauma 1995;39:722-5.
8. Yoshihara H, Yoneoka D. Demographic epidemiology of unstable pelvic fracture in the United States from 2000 to 2009: Trends and in-hospital mortality. J Trauma Acute Care Surg 2014;76:380-5.
9. Al Balushi AA, Malik KA. Role of pelvic X-ray in blunt trauma patients – A university hospital experience in Oman. J Pak Med Assoc 2015;65:910-2.
10. Wang H, Phillips JL, Robinson RD, Duane TM, Buca S, Campbell-Furtick MB, *et al.* Predictors of mortality among initially stable adult pelvic trauma patients in the US: Data analysis from the national trauma data bank. Injury 2015;46:2113-7.
11. Giannoudis PV, Grotz MR, Tzioupis C, Dinopoulos H, Wells GE, Bouamra O, *et al.* Prevalence of pelvic fractures, associated injuries, and mortality: The United Kingdom perspective. J Trauma 2007;63:875-83.
12. Duane TM, Wilson SP, Mayglothling J, Wolfe LG, Aboutanos MB, Whelan JF, *et al.* Canadian cervical spine rule compared with computed tomography: A prospective analysis. J Trauma 2011;71:352-5.
13. Junkins EP, Furnival RA, Bolte RG. The clinical presentation of pediatric pelvic fractures. Pediatr Emerg Care 2001;17:15-8.
14. Breuil V, Roux CH, Carle GF. Pelvic fractures: Epidemiology, consequences, and medical management. Curr Opin Rheumatol 2016;28:442-7.
15. Coppola PT, Coppola M. Emergency department evaluation and treatment of pelvic fractures. Emerg Med Clin North Am 2000;18:1-27, v.