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Original Article

Anatomical Dimensions of the Anterior Column of the Acetabulum with Imaging Criteria in Patients with Surgical Acetabular Fractures

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Abstract

Introduction: This study was conducted to determine the imaging criteria of anterior pelvis fractures.

Methods: The present study was done as a cross-sectional study in the orthopedic clinic of Taleghani Hospital, Theran, Iran, from 2018 to 2020. All hospitalized patients with a diagnosis of pelvic fracture (unstable acetabular fracture) were included in the study. For sampling, the census method was used, which according to the inclusion criteria, 102 record were included.

Results: The angle of coronal cut and sagittal cut at variable levels, the dimensions of the anterior pelvis in three areas of stenosis at variable levels and BMI, the distance from the bladder to the posterior border at the variable levels of BMI, the posterior border at the anterior column to venous at variable levels of BMI, the posterior border distance in the anterior column to the artery at variable levels of age and BMI, and lateral ileum to three narrowing zones at varying levels of gender, age, and BMI are significantly different. The age had a significant negative correlation with posterior border distance in the anterior column with artery, vein, and BMI index had a significant positive correlation with pelvic anterior column dimensions and lateral ileum distance.

Conclusion: To determine the imaging criteria of the anterior pelvic column, variables such as age, gender, and body mass index must be considered.

Keywords: Anterior Pelvis, Imaging, Acetabular Fractures.

Introduction

Pelvic fractures usually occur in people over 60 years old and are commonly caused by osteoporosis [1, 2]; which accounts for 2 to 8% of all skeletal fractures [3, 4]. According to the World Health Organization (WHO), the number of pelvic fractures will triple by 2050 compared to 1990 and reach 3.6 million annually. 75% of these fractures will be relevant to the developing countries [4]. Various studies have indicated that in high-energy pelvic ring fractures, often 12% to 62% soft tissue injury and other organs damages, or fractures of the upper and lower limbs are associated with acetabular fractures, as well as the rate of mortality due to these fractures is estimated from 10% to 60% [4-7]. The results of various studies show that more than 90% of stable fractures are due to high-energy trauma caused by accidents and falls from heights [8]. Recent data show that approximately a quarter of stable fractures occur in patients older than 60 years and the elderly [9-11]. In these patients, the most common mechanism of fracture was a fall on the larger trochanter, which directs the femoral head into the acetabulum and causes a fracture of the anterior column with a posterior transverse fracture,

with an internal displacement of the quadrilateral plate and damage to the articular cartilage of the femur head [10-12]. Determining acetabular fractures due to their unique anatomical structure is very complicated [13]. Therefore, to describe the stable fractures, several classification methods have been proposed, including the judet-letourned and OTA / AO methods [14, 15].

The sacrum is a curved bone located behind the pelvis, it is often difficult to diagnose a fracture on plain radiographs, especially in LC I fractures where only the anterior sacrum cortex is fractured regularly without displacement or slight displacement; however, the use of CT scans can be helpful in diagnostically complicated cases [16]. Treating acetabular fractures include surgical and non-surgical treatment [17]. Physicians' treatment method for hip fractures is based on the rapid diagnosis of fractures and rapid bone fixation in patients [18]. Currently, pelvic fixation through percutaneous sacroiliac screw fixation is used as the surgical method in the treatment of posterior pelvic fractures due to fewer complications [19]. Long et al. (2019) showed that pelvic fixation through percutaneous screwing with the help of TiRobot in posterior ring fracture surgery has advantages such as shorter surgery time, less bleeding and trauma. Therefore, this surgical method has high safety and accuracy with special clinical importance [20]. Measuring the size (dimensions) of the anterior pelvic column is an important point to selecting the surgical method of pelvic anterior column fracture through percutaneous fixation. The studies showed that significantly measurements of the average dimensions of the anterior pelvic column and the dimensions of the screw is helpful to fix them between the gender and racial groups in different populations [21-23]. The average of this size in Iranian patients has not been studied so far. Thus, this study aimed to investigate and measure the dimensions of the anterior pelvis in the Iranian population according to age, gender and body mass index (BMI). Therefore, it is possible to identify patients who are eligible for screwing through the skin.

Methods

This study was performed as a retrospective cross-sectional study in the orthopedic clinic of Taleghani Hospital in Tehran, Iran, from 2018 to 2020. All hospitalized patients with a diagnosis of pelvic fracture (unstable acetabular fracture) were included in the study. For sampling, the method of counting the records in the archives and HIS system was employed. Inclusion criteria were Iranian origin, age over 18 years, completeness of patient records related to patients with anterior pelvic spine trauma, candidate for surgery, and having a digital CT scan that can be evaluated in terms of diameter. According to the inclusion criteria,102 complete records were included in the study. The persuader of assessment the imaging criteria was as follows: orthopedic specialist using pelvic CT scan in the patient record (all images were digital) and with the cooperation of radiologist, the imaging criteria and dimensions of the anterior pelvis (Figure 1) were determined.

A two-part checklist was used in the study; the first part is related to demographic variables parameters including age, sex, and BMI, and the second part was about disease information, including anterior pelvic column dimensions in three areas of stenosis, coronal and sagittal cut angle, and bladder distance from Parasmphysterial posterior border. The pubis in the axilla was considered as the distance between the posterior border in the anterior pelvis from the iliac vein and artery in the axilla and the lateral distance of the ileum to three areas of stenosis.

To report information about qualitative variables the number and percentage indices were applied, and the mean and standard deviation (SD) indices were used for quantitative variables. Due to the normality of data distribution, which was evaluated by Shapiro-Wilk test before data analysis, parametric tests, including Independent Sample T-Test, One-Way ANOVA, and Pearson correlation test were employed. All statistical analyses were done with SPSS software version 22 (the statistical significance level was considered as 0.05 in this study).

Figure 1. Patients with anterior pelvic spinal trauma candidates for surgery (Dimensions of the anterior pelvis in three areas of stenosis, angle coronary and sagittal incision, bladder distance from the posterior border of parasympathetic bursa of the pubis in the axial cut, distance of the posterior border in the anterior pelvis with the vein and iliac artery in the axial cut, lateral distance of the ileum to three areas of stenosis)

Results

50 men (49.0%) and 52 (51.0%) women were participated in this study from 2018 to 2020. The overall mean age of participants was 45.43 ± 15.43 years, 25.49% in the age range of 35 to 45 years, and 21.57% in the age range of 55 to 65 years. The overall average BMI was 25.85 ± 4.05, so that, 42.16% of their BMI was in the range of 25 to 30, and 36.27% in the range of 20 to 25 (Table 1).

The results were showed that the angle of coronal cut and sagittal cut screw in sex variable levels had a significant difference (P <0.05) so that the angle of corona cut and sagittal cut screw was higher in women compared to men (Table 2).

The dimensions of the anterior pelvic column in the area of stenosis I, II, and III showed significant differences in the levels of gender and BMI (P <0.05). The dimensions of the anterior pelvis with all three types of stenosis I, II, and III were larger in men than women. Patients with a BMI of less than 20 had fewer anterior column dimensions in all types of stenosis I, II, and III. Patients with a BMI of more than 30 had more anterior column dimensions in the type I stenosis, but there was no significant difference between patients with a BMI of 20 to 30. Patient with a BMI of 25 to 30 and more than 30 had more anterior column dimensions in type II and III stenosis and there was no significant difference between them (Table 2).

The distance of the bladder from the posterior border was significantly different in the variable levels of BMI (P<0.05), so that patients with a BMI less than 20 showed more distance from the bladder to the posterior border, but there was no significant difference between patients with other BMI categories (Table 2).

The distance between the posterior border in the anterior column and the vein showed a significant difference in the variable levels of BMI (P<0.05). Therefore, patients with a BMI of less than 20 had the longest distance between the posterior border in the anterior column and the vein. There was no significant difference between the distance posterior border in the anterior column and the vein in individuals with other BMI classifications. The distance of the posterior border in the anterior column from the artery in the levels of age and BMI variables showed a significant difference (P<0.05). Hence, patients in the age range of 18 to 25 years had the longest distance and the others with the age range of 55 to 65 years and more had the shortest distance. This distance was almost the similar in patients in the age range of 25 to 35, 35 to 45, and 45 to 55 years. Patients with a BMI of less than 20 had the longest distance between the posterior border in the anterior column and the artery. There was no significant difference between distance posterior border of the anterior column and the artery in individuals with a BMI rage 20 to 25, 25 to 30, and greater than 30 (Table 2).

The distance of the lateral ileum to the three stenosis zones I, II, and III was showed a significant difference in the levels of variables of gender, age, and BMI (P<0.05). The distance between the lateral ileum and the three stenoses was shorter in women compared to men. The distance between the lateral ileum to three narrowing zones was the lowest in patients aged 18 to 25 and over 65, and there was a

significant difference with other ages. The maximum distance in type I stenosis was in the age range of 55 to 65, in type II stenosis in the age range of 45 to 55 and type III stenosis in the age range of 55 to 65 years. The distance from the lateral ileum to the three stenosis zones in patients with a BMI of less than 20 had the least distance. It was significantly different between patient with a BMI of 20 to 25, 25 to 30 and more than 30. The highest distance between type I and II stenosis was seen in people with a BMI of more than 30 and type III stenosis in patient with a BMI of 25 to 30 (Table 2).

The results showed that the angle of coronal cut and sagittal cut screw were significantly different in the age and BMI, anterior pelvis in stenosis I, II, and III in age levels, bladder distance from Posterior border in gender and age, posterior border of the anterior column with vein at gender and age, the distance of posterior border in the anterior column with the artery at the variable levels were not significantly different ($P<0.05$).

The results showed that the age variable had a significant negative correlation with the posterior border distance in the anterior column with arteries and veins ($P<0.05$).

In other words, by aging, the posterior border of the anterior column to the artery and vein decreases. The results also showed that the BMI index had a positive and significant correlation with the dimensions of the anterior pelvic column in all three areas of stenosis I, II and III and with the lateral distance of the ileum to the stenosis area of type II and III ($P <0.05$). In other words, by increasing BMI, the dimensions of the anterior column increase in all three areas of stenosis I, II, and III and the lateral distance of the ileum to the stenosis area of type II and III (Table 3).

Table 1. Demographic information of the participants.

Items		Number	Percent
Gender	Male	50	49.00
	Female	52	51.00
Age	18-25	10	9.80
	25-35	19	18.63
	35-45	26	25.49
	45-55	15	14.71
	55-65	22	21.57
	Over 65	10	9.80
BMI	Under 20	7	6.86
	20-25	37	36.27
	25-30	43	42.16
	Over 30	15	14.71

Table 2. Summary of the results of statistical tests of study indicators with gender, age, and BMI

		Screw angle		**Dimensions of the anterior pelvis in the area of stenosis**			**Bladder distance from Poserio border**	**Posterior border distance in the anterior column with**		**Lateral ileum distance to three areas of stenosis**		
		Coronal cut	sagittal cut	I	II	III		Vein	Artery	I	II	III
Gender	Male	53.54± 1.86	64.92± 2.23	14.23 ±1.96	13.28 ± 1.36	14.8 ± 1.34	3.81± 1.29	5.42± 2.97	9.60± 0.57	42.61±2.97	13.28±1.36	14.8 ±1.34
	Female	56.0 ± 1.34	67.54 ± 1.47	9.82± 1.76	11.89 ± 2.23	11.69 ± 1.82	2.88 ± 0.28	5.76± 2.63	9.97± 0.46	40.01±2.76	11.89±2.23	11.69±1.82
Significant P1		0.001	0.001	0.001	0.001	0.001	0.477	0.543	0.620	0.001	0.001	0.001
Age	18-25	55.00±1.56	66.90±1.96	10.75 ± 3.40	11.37 ± 1.81	11.48 ± 2.40	3.65 ± 1.64	7.29±2.30	12.14±2.53	10.75±3.40	11.37±1.81	11.48±2.40
	25-35	55.27± 1.67	66.44 ± 2.03	12.17 ± 2.85	12.95 ± 2.50	13.07 ± 2.12	2.88 ± 2.23	5.96±3.01	10.49±4.09	12.17±2.85	12.95±2.51	13.07±2.12
	35-45	54.69 ± 2.18	65.84 ± 2.14	12.40 ± 3.34	12.73 ±1.69	13.52 ± 2.25	2.75 ± 2.07	5.65±3.13	9.95±4.07	12.40±3.34	12.73±1.69	13.52±2.25
	45-55	54.86 ± 1.68	66.60 ± 1.45	12.23 ± 2.24	13.05 ±1.93	13.38 ±2.04	3.16 ± 2.12	6.10±1.96	10.74±3.08	12.23±2.24	13.05±1.93	13.38±2.04
	55-65	54.36 ± 2.30	65.86 ± 3.10	12.44 ± 2.64	12.6 ± 1.75	14.04 ± 1.84	1.80 ± 1.13	4.38±1.76	7.7±2.56	12.44±2.64	12.6 ±1.75	14.04±1.84
	Over 65	54.70 ± 2.66	66.60 ± 2.59	10.41 ± 2.2	11.92 ± 1.99	12.39 ± 2.54	3.09 ± 2.72	4.94±3.98	8.87±4.09	10.41±2.24	11.92±1.99	12.39±2.52
Significant P2		0.827	0.720	0.299	0.256	0.045	0.163	0.097	0.016	0.005	0.005	0.017
BMI	Under 20	55.71± 1.38	67.42 ± 1.51	8.41 ± 0.45	10.04 ± 0.57	9.82 ± 2.11	4.82 ±2.74	8.78±2.74	13.1±2.84	8.41 ±0.45	10.04±.57	9.82 ±2.11
	20-25	54.54 ± 1.95	66.21 ± 1.93	11.28 ± 2.67	11.92 ± 1.73	12.92 ± 2.17	2.84 ± 1.87	5.86±2.58	10.2±3.53	11.28±2.67	11.92±1.73	12.92±2.17
	25-30	54.45 ± 2.12	65.85 ± 2.61	12.45 ± 2.70	13.75 ± 1.85	13.85 ± 2.0	2.26 ± 1.73	4.83±2.67	8.88±3.70	12.45±2.70	13.15±1.85	13.85±2.00
	Over 30	55.86± 1.88	66.86 ± 2.35	14.06 ± 2.57	13.70 ± 1.81	13.70 ± 1.53	2.98 ± 2.25	5.61±2.75	9.85±3.66	14.06±2.59	13.73±1.81	13.71±1.53
Significant P2		0.058	0.247	0.001	0.001	0.001	0.014	0.004	0.032	0.001	0.001	0.006

1. Independent Sample T-Test 2. One-Way ANOVA

Table 3. Summary of the results of the correlation between age and BMI with the study variables

Items	Screw angle		Anterior pelvic column in the stenosis area			Bladder distance from Posterior border	The distance of the posterior border in the front column with		Lateral ileum distance to three areas of stenosis		
	Coronal cut	Sagittal cut	I	II	III		Vain	Artery	I	II	III
Age	-0.121	-0.080	-0.007	0.022	0.152	-0.008	-0.270 **	-0.320 **	-0.144	-0.073	-0.162
BMI	0.022	0.041	0.493 ***	0.430 ***	0.410 ***	0.033	-0.130	-0.114	0.320 ***	0.311 **	0.200

* P<0.05 , ** P<0.01 , *** P<0.001

Discussion

The selective treatment method for orthopedic surgeons in pelvic and acetabular fractures, in addition to open surgery, is the use of pelvic fixation through percutaneous sacroiliac screw fixation [20, 24]. The pelvis has a specific anatomical shape and consists of bones such as the ilium, ischium, pubis, and sacrum that are connected at the sacroiliac and symphysis joints of the pubis [25]. Accurate diagnosis of a fracture in the pelvis due to its complex anatomy is very difficult by plain radiography, and physicians often recommend inlet-outlet views radiography, plain CT scans, and in more difficult cases, they perform three-dimensional CT scans [26]. Therefore, the diameter and dimensions of the pelvis in some cases can also help in clinical diagnosis. For example, based on the data obtained from pelvic measurements, its shape is determined, which is not detectable in clinical examination [27]. Thus, the purpose of this retrospective study is to investigate the average dimensions of the anterior pelvis and compare it within age, gender, and BMI groups. Consistent with the findings of the present study, there was a significant difference between the mean dimensions of the anterior pelvic column in stenosis I, stenosis II, and stenosis III with gender. Rajasekhar et al. also studied 206 patients' pelvis (121 males and 85 females) with parameters such as tubercle pubic distance and anterior rim of acetabulum, vertical diameter of the acetabulum, transverse acetabular diameter, the distance between pubic ridge to the highest point along iliopubic ridge. They managed to find a significant difference between male and female femur in the measured variables. In parameters such as the distance between the tubercle pubic and the anterior rim of the acetabulum and the distance between the pubic ridge to the highest point along the iliopubic ridge, the values were higher in women than in men. In the case of the vertical and transverse diameter of the acetabulum, the values were higher in men than women [28], which is consistent with the results of the present study. The results of study showed that the difference between the mean coronal and sagittal cut angle angles among men and women. As it turned out, the angle of coronal and sagittal cut screw in women is greater than men, which is consistent with the findings of the study by Quan et al. [29]. They demonstrated screw insertion as a subpubic angle point with a diameter of 6.3-7.5 mm and a length of 60-70 mm for male patients and a diameter of -4.5-6.5 mm and a length of 70-80 mm for female patients. The angle of about 50 and 8 degrees between the axis and the sagittal and coronal plane was chosen in the surgery for men and women respectively, because it is safe and secure to achieve [29].

The results of the study showed that the mean bladder distance from the posterior border of the parasympathetic bursa of the pubis in the axial cut, the mean distance from the anterior pelvis border to the iliac artery in the axial cut, and the mean distance of the anterior pelvic border in the pelvic vein and the iliac artery in the axial cut had respectively significant differences between different groups of BMI, various age groups and different groups of body mass index. However, there was no significant difference between the gender and various age groups in the mean distance of the anterior pelvic posterior border in the pelvis with the vein and iliac artery in the axial cut and the mean

distance of the anterior pelvic posterior border in the pelvic vein in the axial vein. Meanwhile, there was a significant difference between the mean distance of lateral ileum to the three stenosis areas in the studied patients in stenosis I, stenosis II, and stenosis III and BMI and age.

Conclusion

To determine the imaging criteria of the anterior pelvic column, variables such as age, gender, and body mass index must be considered. The iliac artery in the axilla is different according to the two indices of BMI and age in individuals, and this difference can be easily detected by CT scan data and greatly reduced the need for radiography in this area. Therefore, since the present study was performed on the records of surgical patients in a specific time, it is suggested the extensive research with more samples and the possible impact of variables such as osteoporosis rate and number of deliveries in women, the diameter and dimensions of different pelvic structures.

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Conflict of Interest Disclosures

The authors declare that they have no conflicts of interest.

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None

Authors' Contributions

All authors contributed equally in this study.

Ethical Statement

The protocol was confirmed by research council of Shahid Beheshti University of Medical Sciences, Tehran, Iran

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