Estimation of Inter Iliac Crest Distance by Ulna Length Measurement for Reference in Reduction of Pelvic Fractures

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Objective: *To determine inter iliac crest distance (IICD) by measurement of ulna length (UL) for reference in reduction of pelvic fractures (APC II).*
Materials and Methods: *A cross sectional study was done among 325 healthy participants. They were enrolled and stratified into two groups according to gender. UL and IICD of each participants were measured and recorded in centimeters. R-program was used for the statistical analysis. Pearson correlation was tested. Simple and Multiple linear regression model were estimated to predict dependent factors affecting IICD.*
Results: *The correlation between UL and IICD was 0.31 (P-value=0.001). The univariate equation was IICD=13.66+0.57(UL), R^2 adjusted=0.10. The multivariate equation was IICD=13.51+0.30(UL) + 0.08(BW) + 0.05(Age), R^2 adjusted=0.26, (BW=body weight).*
Conclusion: *This is the first estimation of IICD by measurement of UL for reference in reduction of pelvic fracture (APC II). Because of low correlation, using this numeric assessment should be cautiously applied in clinical practice.*

Keywords: *Pelvic fracture, Ulna length, Inter iliac crest distance, pelvic width*

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Introduction

Pelvic fractures of different types were reported as 2-8 percent of all skeleton fractures[1-3]. Anterior Posterior Compression type II (APC II) fractures, in particular, are characterized by the widening of pubic symphysis greater than 2.5 cm. caused by injuries to the anterior sacroiliac (SI) complex resulting in anterior SI widening while the posterior SI ligaments remain intact (open - book pelvic fractures), according to the Young-Burgess classification[4]. In any case of APC II fractures, both in trauma and pubic symphysis separation after delivery, anterior or posterior external fixations or pelvic circumferential compression devices were employed as an effective instrument to reduce the pelvic ring for achieving nearly anatomic reduction[5-11].

Nonetheless, in clinical practices, physicians performing anterior or posterior external fixation or using other devices simply estimate the width of pubic symphysis after the initial radiographic evaluation. It's inadequate evidence for reduction of pelvic fractures. No numeric data available for assessment the width of reduction. Only clinical experience may induce under or over reduction. Under or over reduction of pelvis would induce inappropriate tamponade effect. Lack of study reported the accuracy of reduction under a simple estimation method. Moreover, the accuracy of pelvis length reduction currently depend on clinician's experience rather than evidence based estimation. The estimation was made by the physicians' experiences of manual feeling and made personal judgment in reducing the pelvic ring to nearly anatomic reduction in the patient who remained haemodynamically unstable and required reducing pelvic volume in open-book pelvic fractures, but numeric assessment for performing to estimate the width of pelvic ring found only one study by use of the foot length[12].

In Anthropology, studies were conducted on the estimation human stature or height by measurement of ulna length[13-17]. Other studies and forensic anthropology were also performed to determine age, sex, and body size[18-20]. Ulna bone is a subcutaneous bone. It is easy to palpate and measure compare with other bony landmarks. Moreover, it has been used to determine age, sex, and stature in previous studies. However, previous studies never demonstrated any relationship with pelvic length.

No previous studies, however, showed relationship of ulna length (UL) and the inter iliac crest distance (IICD). The present study was an attempt to estimate the relationship of ulna length and the inter iliac crest distance for the accuracy in reducing the pelvic ring in cases of pubic

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symphysis separation (APC II) in clinical application. It was expected to be used for estimation in reducing of pelvic fracture, especially in APC II of trauma.

Materials and Methods

***Study design*:** A cross-sectional study.

Sample size calculation

The formula for estimating a correlation was used to calculate the sample size. The alpha and beta was 0.05 and 0.20 respectively. Estimated correlation coefficient was 0.166 (from the pilot study). Consequently the sample size were 283. Then 15% of non-response rate were calculated, the total sample size were 325.

Participants

The inclusion criteria included healthy people aged equal to or greater than 20 years. The exclusion criteria were 1) previous history of pelvic or forearm fractures, 2) systemic metabolic bone diseases, 3) anomaly or deformity of stature or limb. 325 healthy people in south of Thailand who 20-88 years old were voluntary enrolled in the study in the year 2016. They were stratified into 2 groups according to gender. All subjects had no history of trauma. Because the pubic symphysis separation during pregnancy and delivery may be difference among women, female participants were divided into three subgroups; single, married without children, and married with children. On the other hand, because of no differences in pelvic width, male participants were put into only one group.

Data collection

Data collection, completed within three months, was performed in a room specifically arranged in the participating hospital. The IICD, the most widest diameters between two iliac crest points in upper part of iliac crest, was measured manually using a caliber in undress supine position as shown in figure 1. Similarly, the ulna (right side) length of each subject was measured from the ulna styloid process to the tip of olecranon in supine position using a measuring tape. All measuring data were recorded in centimeters with one decimal point. The body weight, however, was recorded in kilograms with one decimal point. Each manual measuring process for IICD and UL were measured twice by 2 separated well-trained nurses. A pilot study was developed and tested on 20 participants (10 males, 10 females). Inter-observer reliability of UL and IICD measurement was 0.93 and 0.89 respectively. The correlation coefficient was 0.166.

Statistical analysis

R-program was used for data analysis. Median and interquartile range (IQR) were used for describing characteristics of participants. Pearson correlation was tested for linear relationship. Simple and multiple regression model (Method: backward stepwise) were used to determine the dependent factors that predict IICD.

Ethical consideration

This study was approved by the Research Ethics Committee of Hatyai Hospital (REC-HY). Protocol number 20/2529.

Fig. 1 Demonstrating the IICD measurement

Results

Table 1 Participants' characteristic

	Male, n = 161 Median (IQR)*	**Female, n = 164 Median (IQR)***
UL (cm)	27.0 (26.0,28.0)	25.0 (24.0,25.5)
IICD (cm)	28.2 (27.0,32.0)	27.5 (25.7,29.0)
Height (cm)	167 (163,172)	157 (153,160)
Body weight (kg)	64.0 (57,72)	55.0 (50,64)
Age (year)	47.0 (37,55)	39.0 (28,51)

*IQR = Interquartile range 25 percentile and 75 percentile

Table 2 Associations between UL and IICD using univariate analysis

***P*-value**	**Constant**	**Crude Coefficient**	**95% CI**
UL < 0.001	13.66	0.57	0.38, 0.76
BW < 0.001	21.96	0.10	0.08, 0.13
Age < 0.001	25.78	0.06	0.04, 0.08
Height < 0.001	11.18	0.11	0.07, 0.14
Female gender < 0.001	29.17	-1.68	-2.32, -1.04

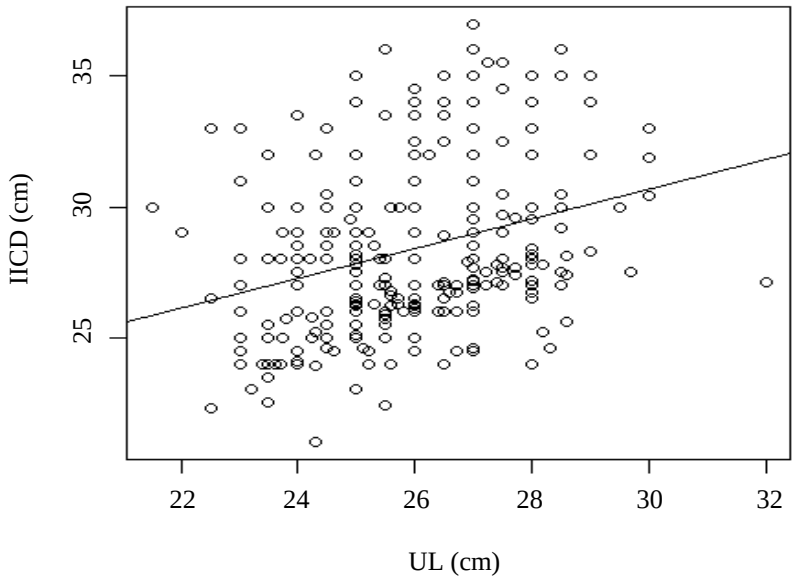

Fig. 2 The correlation between UL and IICD

Table 3 Associations between UL and IICD using backward multivariate stepwise regression analysis

***P*-value**	**Constant**	**Adjusted coefficient**	**95% CI**
UL 0.001	13.51	0.30	0.12, 0.49
BW < 0.001	13.51	0.08	0.06, 0.11
Age < 0.001	13.51	0.05	0.03, 0.07

There were 325 participants; 161 male (49.54%), 164 female (50.46%). Among female, there were three subgroups of marital status; 55 single, 18 married with no children, 91 married with children, the range of IICD were 22.0-30.5 cm, 22.3-30.0 cm, and 22.5-34.0 cm respectively. There was no significant difference of IICD among these three subgroups. Other characteristics were shown in table 1. The correlation between UL and IICD was 0.31 (*P*-value = 0.001) as shown in figure 2.

Univariate analysis

There was a significant linear relationship between UL and IICD (crude coefficient 0.57, 95% CI 0.36, 0.76, *P*-value < 0.001). The univariate equation was

IICD = 13.66+0.57(UL)
R^2 adjusted = 0.10

(IICD = inter iliac crest distance,
UL= ulna length)

The covariate factors such as body weight, age, and height were significantly found associated with IICD (*P* < 0.001). Being female was more likely to have lower IICD (crude coefficient -1.68, 95% CI -2.32, -1.04, *P*-value < 0.001).

Multivariate analysis

The backward stepwise regression model was used to estimate an association between UL and IICD. The final model included only body weight and age. There was a significant linear relationship between UL and IICD after adjusted for body weight and age (adjusted coefficient 0.30, 95% CI 0.12, 0.49, *P*-value < 0.001) The multiple variate equation was

IICD = 13.51+0.30(UL)+0.08(BW) +0.05(Age)

R^2 adjusted = 0.26

(IICD = inter iliac crest distance,
UL= ulnar length, BW = body weight)

Discussion

Previous studies have used ulna length to estimate human stature or height, sex and body size. There were close correlation between ulna length and those factors. A good correlation of stature was observed with UL and it was statistically highly significant[13], sex determination accuracy as high as 96% [18]. Present study found significant low correlation between ulnar and pelvic length.

The present study found that males' ulna length and inter iliac crest distance were longer and wider than females. The reasons could be because of male's anatomy which males usually taller than females. The negatively linear correlation between UL and IICD was found among females gender compared with male. There was no significant difference of IICD among females who were single, married with no children, and married with children. In backward stepwise multivariate analysis, it was found that height was not significantly associated with IICD. The variables effect to predict IICD were body weight and age. Although the coefficient was not so high when compared with ulna length. To predict IICD by UL, the authors found that UL could predict IICD precisely after adjusted for body weight and age. Previous study used foot length to relate the inter anterior superior iliac distance[12]. Nevertheless, in clinical practice, inter anterior superior iliac distance has found difficult to measure compare with inter iliac crest distance. Thus, pelvic length was more preferable than inter anterior superior iliac distance. In clinical observation, ulnar length, which easy to palpate and measure, was observed to have relationship with pelvic length.

However, since the correlation coefficient between UL and IICD was low at 0.31 and R^2 adjusted in multiple variate equation was low at 0.26, aware of using UL for IICD estimation should be concerned. Clinical judgment using simple clinical estimation combine with numeric estimation from the equation would be the solution for applying in clinical practice. The result from larger size of study may be needed for more precise. Also other organs will be found to be more accurate reference for IICD estimation in reduction of pelvic fractures.

Conclusion

This is the first estimation of IICD by measurement of UL for reference in reduction of pelvic fracture (APC II). Because of low correlation, using this numeric assessment should be cautiously applied in clinical practice.

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What is already known on this topic?

Measurement of ulna length could be performed to determine human stature or height, age, and sex.

What this study adds?

This study is the first study to estimate inter iliac crest distance by measurement of ulna length for reduction pelvic fractures.

Potential conflicts of interest

None.

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การประเมินความกว้างของกระดูกเชิงกรานโดยใช้ความยาวของกระดูก ulna เป็นตัวอ้างอิงในการจัดกระดูกเชิงกรานที่หัก

ศตพงษ์ พิสุทธิ์ธนกาญจน์, พบ, จุก สุวรรณโณ, พว, ภัทราวรรณ ทองตาล่วง, พว

วัตถุประสงค์: *เพื่อหาความสัมพันธ์ระหว่างความยาวของกระดูก ulna (UL) และความกว้างของกระดูกเชิงกราน (IICD)*

วัสดุและวิธีการ: *กลุ่มตัวอย่าง 325 คน แบ่งเป็นชาย 161 คน หญิง 164 คน วัดความยาวของกระดูก ulna (จาก ulna styloid process ถึงปลายของ olecranon) และความกว้างของกระดูกเชิงกราน (ส่วนที่กว้างที่สุดของขอบนอกของ iliac crest) วิเคราะห์หาความสัมพันธ์โดยใช้ Pearson correlation test และใช้ multiple กับ simple linear regression model เพื่อหาอิทธิพลของตัวแปรที่มีผลต่อการทำนายความกว้างของกระดูกเชิงกราน*

ผลการศึกษา: *ความสัมพันธ์ระหว่างความยาวของกระดูก ulna และความกว้างของกระดูกเชิงกราน = 0.31 (P-value=0.001) สูตรการทำนายความกว้างของกระดูกเชิงกรานโดยใช้การวิเคราะห์แบบ univariate คือ IICD = 13.66+0.57(UL), R2 adjusted = 0.10 ส่วนการวิเคราะห์แบบ multivariate สูตรที่ได้คือ IICD = 13.51+0.30(UL)+0.08(BW) +0.05(Age), R2 adjusted = 0.26, (BW = body weight)*

สรุป: *เป็นการศึกษาครั้งแรกที่ใช้ความยาวของกระดูก ulna เป็นตัวอ้างอิง ในการทำนายความกว้างของกระดูกเชิงกราน เพื่อจัดกระดูกเชิงกรานหักแบบ APC II แต่มีความสัมพันธ์ต่ำ ควรใช้ด้วยความระมัดระวังในทางปฏิบัติ*