Signature: © Pol J Radiol, 2016; 81: 219-227
DOI: 10.12659/PJR.896380

Polish Journal of Radiology
www.PolRadiol.com
ORIGINAL ARTICLE

Received: 2015.10.21
Accepted: 2015.10.30
Published: 2016.05.08

Pelvimetry by Three-Dimensional Computed Tomography in Non-Pregnant Multiparous Women Who Delivered Vaginally

Authors' Contribution:
- **A** Study Design
- **B** Data Collection
- **C** Statistical Analysis
- **D** Data Interpretation
- **E** Manuscript Preparation
- **F** Literature Search
- **G** Funds Collection

Ismail Salk[1ABCDE], Ali Cetin[2ACEF], Sultan Salk[3CDEF], Meral Cetin[2CDEF]

[1] Department of Radiology, Cumhuriyet University, Faculty of Medicine, Sivas, Turkey
[2] Department of Obstetrics and Gynecology, Cumhuriyet University, Faculty of Medicine, Sivas, Turkey
[3] Department of Obstetrics and Gynecology, Sivas State Hospital, Sivas, Turkey

Author's address: Ismail Salk, Department of Radiology, Cumhuriyet University, Faculty of Medicine, 58140 Sivas, Turkey, e-mail: ismailsalk@gmail.com

Summary

Background: We assessed retrospectively the reference values of pelvic dimensions by 3D CT performed for non-obstetrical indications in non-pregnant multiparous women with a successful vaginal delivery. We further aimed to evaluate the impact of maternal short stature on these parameters.

Material/Methods: The 3D CT pelvimetry was performed retrospectively in 203 non-pregnant women selected consecutively if they had at least one singleton term delivery with head presentation and if there was no history of maternal or fetal birth trauma or cerebral palsy after childbirth. With standard sagittal and reformatted axial-oblique views, anteroposterior including three conjugates of pelvic inlet, transverse, posterior sagittal diameters of pelvic inlet, the plane of greatest diameter, the plane of least diameter, and pelvic outlet were measured. Selected obstetric parameters were collected.

Results: Overall, the pelvises had transverse oval appearance in inlet and size of the female pelvis. The diagonal conjugate was at least 15 mm longer than the obstetric conjugate. Women with short stature had lower maximal birth weight, and this was in accordance with their somewhat lower pelvic diameters.

Conclusions: The findings of this study present the reference values of the main planes of the true pelvis by 3D CT pelvimetry in a relatively large group of multiparous women who passed a trial of labor successfully. Overall, the pelvises had features of female pelvic bony structure although pelvic diameters were somewhat lower in multiparous women with short stature. The 3D pelvimetry with CT applications may be used as an adjunct to clinical and ultrasonographic examinations to rule out cephalopelvic dystocia in selected cases.

MeSH Keywords: **Multidetector Computed Tomography • Pelvimetry • Women's Health**

PDF file: http://www.polradiol.com/abstract/index/idArt/896380

Background

In obstetric practice, pelvimetry refers to measurement of diameters of the pelvis to assess if the pelvic cavity is adequate for the passage of a fetus of average size. During clinical pelvimetry, the examiner does not examine internal bony structures covered with soft tissue of the pelvis; the estimated pelvic size is accepted as approximate. Firstly, pelvimetry has been performed directly in cadavers to determine basic specifications. With the aid of radiological advancements, in living women, it has become possible to determine bony pelvis measurements precisely by using X-ray, computed tomography (CT), magnetic resonance imaging (MRI), and in part ultrasound (US) [1].

For the purpose of pelvimetry, the true pelvis is divided into a series of planes that must be passed by the fetus during labor process. The pelvis can be broadly divided into

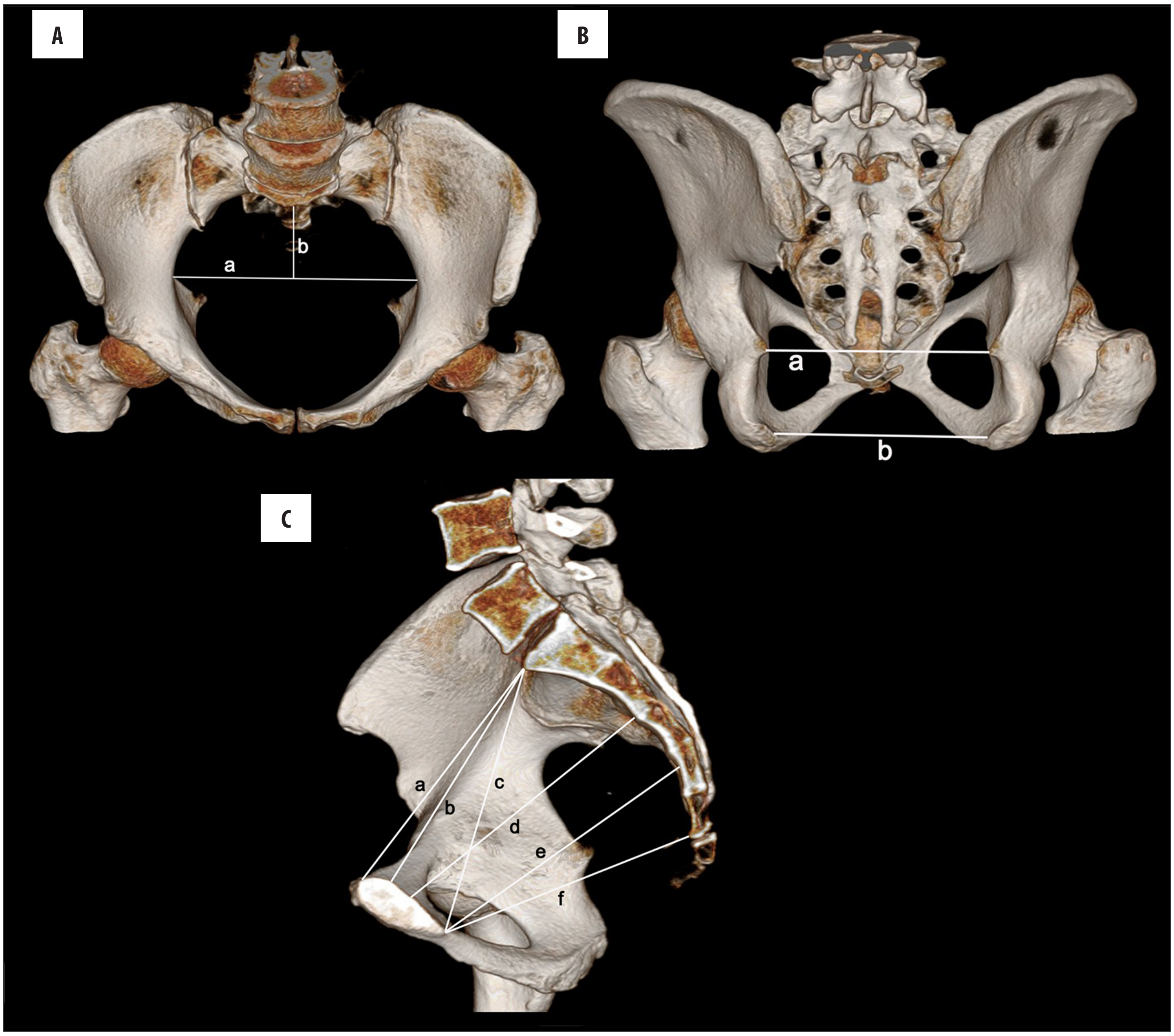

Figure 1. Representative 3D CT images of the pelvis (41-year-old woman, parity 4, with height of >150 cm). (**A**) Measurements of transverse (a) and posterior sagittal (b) diameters of pelvic inlet. (**B**) Measurements of interspinous diameter (a) of the plane of least diameter and intertuberous diameter (b) of the pelvic outlet. (**C**) Measurements of true (a), obstetric (b), and diagonal conjugates (c) of pelvic inlet and anteroposterior diameters of pelvic inlet (a), planes of greatest (d) and least (e) diameters, and pelvic outlet (f) of pelvis.

the pelvic inlet, mid pelvis, and pelvic outlet. X-ray and CT, and MRI with conventional and three-dimensional (3D) capabilities have been used to define average and minimal values for the diameters of the bony pelvis for a successful labor and delivery [2–4]. In an experimental study with foam pelvises with markers [5], the authors demonstrated that measurements obtained from 3D reconstructed images were more accurate than measurements performed manually and provided a high interobserver reliability. The interest in pelvimetry has increased since imaging capabilities of new CT and MRI systems with 3D reformatted images were considerably useful to measure easily several diameters of the true pelvis [6]. Computed tomography (CT) and 3D post-processing capabilities provide considerable advantage to assess the true pelvis by measuring its dimensions. The sizes of the pelvis at the plane of the pelvic inlet, mid pelvis, and outlet alone and in combination determine whether vaginal birth of a fetus of average size is possible and mechanism by which the fetus may pass through the birth canal. In a recent study of serial pelvimetry by MRI [7], the authors determined whether maternal pelvic dimension could change from the third trimester through the postpartum period. They concluded that maternal pelvic measurements by MRI are stable over the course of pregnancy and delivery.

In obstetric practice, labor dystocia remains one of the ill-defined phenomena that have many definitions. Research should be continued to provide improved understanding of this complex problem caused by inappropriate pelvic dimensions in many cases and to improve perinatal care to help laboring woman in safe spontaneous vaginal delivery and to mitigate the need for cesarean delivery. Extensive technological advancement of CT and MRI made them applicable during the diagnostic workup of several difficult conditions. There is a need to increase their reliability in the diagnosis and management of dystocia and in predicting the obstetric outcome. Although there are several studies related to pelvimetry in pregnant and non-pregnant women, the performed pelvic measurements and

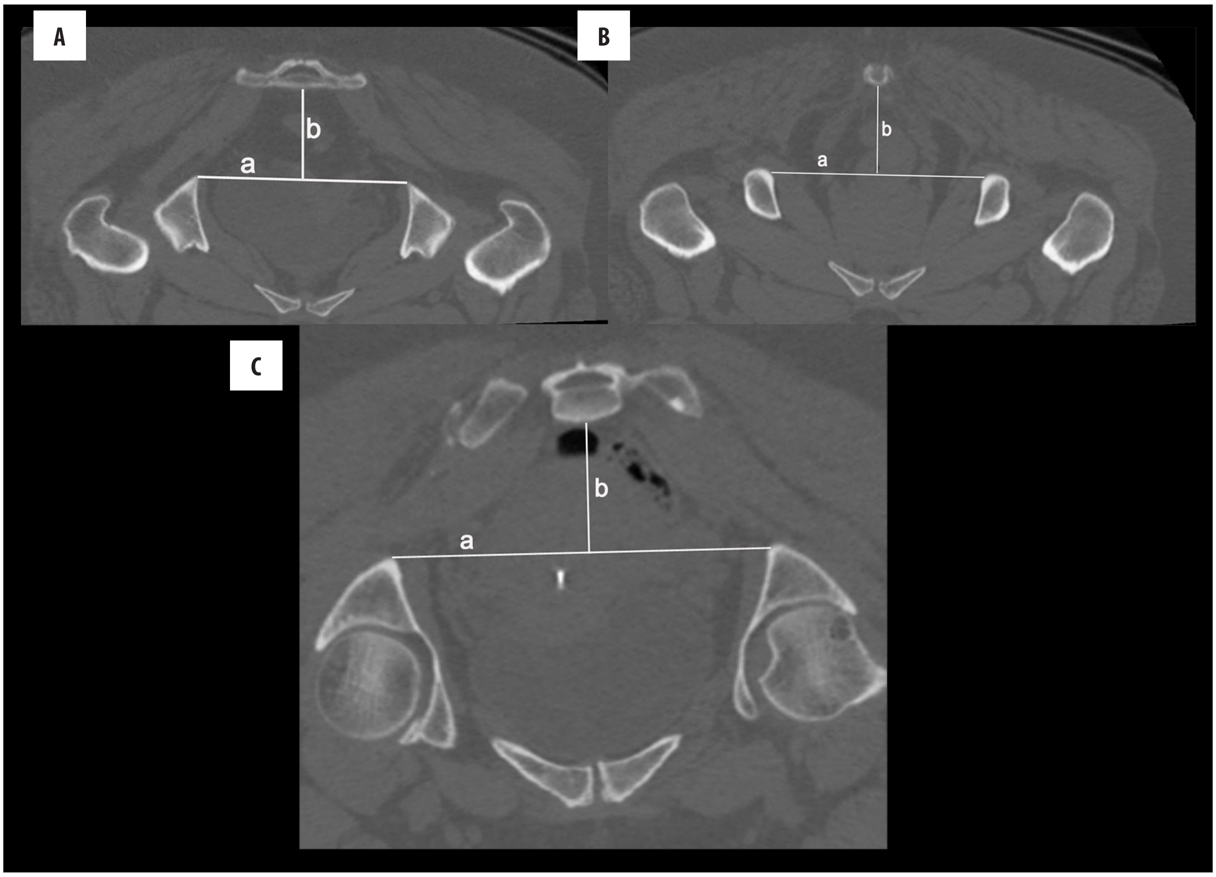

Figure 2. A representative reformatted images of the pelvis (41-year-old woman, parity 4, with height of >150 cm). Measurements of transverse (a) and posterior sagittal (b) diameters of plane of least diameter (**A**), pelvic outlet (**B**), and plane of greatest diameter (**C**) of pelvis.

their clinical settings were considerably different. In this study, during pelvimetry, pelvic measurements that were accepted as important in obstetric textbooks were selected to increase the accordance of obstetric and radiological knowledge. To the best of our knowledge, no prior studies have assessed pelvic dimensions with CT or MRI in women with short stature. We sought to determine retrospectively the reference values of pelvic dimensions by three-dimensional (3D) CT performed for non-obstetrical indications in non-pregnant multiparous women with a successful vaginal delivery. We further aimed to determine the impact of maternal short stature on these pelvic diameters.

Material and Methods

This retrospective evaluation was warranted by the University's Human Research Ethics Committee and conducted according to its standards. The records and picture archiving and communication system (PACS) of our university hospital was screened for abdominal CT scans of women referred from the various clinical departments. Specific inclusion and exclusion criteria were developed to determine study eligibility. Women were eligible if they had at least one singleton term delivery with head presentation; if there was no history of maternal or fetal birth trauma or cerebral palsy after childbirth; if there was no history of prolonged labor, or vacuum- or forceps- assisted delivery, and they shared the same ethnic and cultural background. Exclusion criteria were also maternal pelvic fractures, lumbosacral spondylolisthesis, pelvic bone tumor or anomalies, or any other diseases or trauma that can affect the bony pelvic structure. Two hundred and three women were identified consecutively and included in the analysis. Short stature was accepted as a height of less than or equal to 150 cm during their reproductive age since menopause can affect the height.

Measurements of the true pelvis by 3D CT

All CT examinations were acquired on multidetector CT scanners with routine abdominal protocols with 128-slice CT scanners (Aquilion, Toshiba Medical Systems, Tokyo, Japan); they were generally performed for the differential diagnosis of abdominal pain. Images were reconstructed at 5-mm slice thickness. In the study population, there was no CT examination performed for the purpose of pelvimetry. Pelvimetry was performed retrospectively on a 3D workstation (Aquarius iNtuition Edition ver4.4.6, TeraRecon Inc., San Mateo, CA, USA) using multiplanar or volume rendered images as appropriate by one investigator (I.S.) who was blind to the clinical data. The technique implies measurements performed according to four planes of the true pelvis in standard sagittal, and reformatted axial-oblique views after appropriate and similar zooming (Figures 1, 2). Intra-observer variability was determined for measurements as Kappa coefficient ranged from 0.83 to –0.92.

Table 1. Measurements of pelvic planes [9].

	Pelvic inlet	The plane of greatest diameter	The plane of least diameter (midplane)	Pelvic outlet
Anteroposterior	M*,**	M*	M*	M*
Right or left oblique	M			
Transverse	M*	M*	M*	M*
Anterior sagittal	M			
Posterior sagittal	M*	M*	M*	M*

M presents suggested measurement obstetrically during pelvimetry. * Accepted as significant for the adequacy of the true pelvis obstetrically. ** There are three types in the plane of the pelvic inlet: true, obstetrical, and diagonal conjugates.

Table 2. Selected demographic and clinical parameters of the study population.

Age, mean ±SD, y	54.1±12.5 (min–max: 2–87)
Parity, median (min-max), n	4 (1–14)
Height, n (%)	
≤150 cm	37 (18.2%)
>150 cm	166 (81.8%)
Weight, mean ±SD, kg	76.3±14.9 (min–max: 46–120)
Maximum birth weight, mean ±SD, g	
All cases	3616±488 (min–max: 2500–5100)
Height ≤150 cm*	3379±382 (min–max: 2700–4000)
Height >150 cm	3599±493 (min–max: 2500–5000)

* $P<0.05$ *vs.* height >150 cm.

For the purpose of pelvimetry in accordance with obstetric knowledge, the pelvis was divided into four imaginary planes that extend across the pelvis at different levels for descriptive purposes [8,9].

The pelvic inlet

It is delineated by linea terminalis. Anteroposterior diameters are the distance from the sacral promontory to the upper margin (true conjugate), a short distance from the upper margin (obstetric conjugate), and the lower (diagonal conjugate) margin of symphysis pubis. The transverse diameter of the inlet is the main determinant in defining the pelvic shape as between the widest points on the pelvic brim. The oblique diameter is directed from the sacroiliac joint on one side to the opposite iliopectineal eminence.

The plane of greatest diameter

It is the largest part of the pelvic cavity and bordered by the posterior midpoint of the pubis anteriorly, the upper part of the obturator foramina laterally, and the junction of the second and third sacral vertebrae posteriorly. The anteroposterior diameter extends from the midpoint of the posterior surface of the pubis to the junction of the second and third sacral vertebrae. The transverse diameter is the widest distance between the lateral borders of the plane.

The plane of least diameter (midplane)

It is delineated by the lower edge of the pubis anteriorly, the ischial spines laterally, and the lower sacrum posteriorly. The anteroposterior diameter extends from the lower border of the pubis to the approximately middle of the fourth sacral vertebra. The transverse diameter extends between the ischial spines.

The pelvic outlet

It is formed by two triangular planes with a common base at the level of the ischial tuberosities. The anteroposterior diameter is from the lower margin of the symphysis to the sacrococcygeal joint but not to the tip of the coccyx. The transverse or intertuberous diameter of the outlet is between the inner borders of ischial tuberosities.

For each pelvic plane, there are theoretically six measurements as anteroposterior diameter, right and left oblique diameters, transverse diameter, and anterior and posterior sagittal diameters. However, not all diameters were considered as important in measuring each of the planes for the prediction of obstetric outcome for a fetus of average size. The anterior and posterior sagittal diameters measure the distance from the midpoint of the transverse diameter to the points used in measuring the anteroposterior diameter. Table 1 presents the pelvic diameters that were measured for the 3D CT pelvimetry in this study since they were

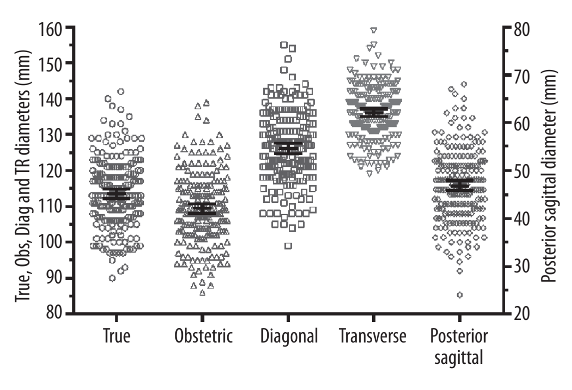

Figure 3. True, obstetric, and diagonal conjugates and transverse and posterior sagittal diameters of pelvic inlet. Obs – obstetric; Diag – diagonal; TR – transverse. Variables were presented as mean with 95% confidence interval.

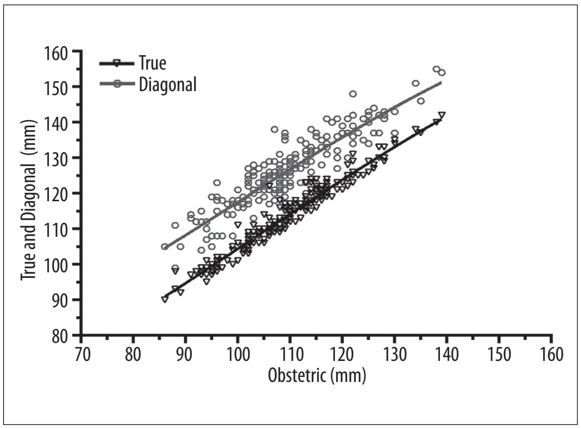

Figure 4. Correlation of obstetric conjugate with true and diagonal conjugates of pelvic inlet.

accepted as significant for the adequacy of the true pelvis for labor and delivery [8,9].

Statistical analysis

We recorded CT data with selected maternal data including age, parity, height, weight, and maximum birth weight. Data analysis was performed using a commercially available software (IBM SPSS Statistics version 21; IBM, Chicago, IL, USA). Variables are expressed as mean ±SD with min-max or 95% confidence interval or percentage as appropriate. Comparison and correlation of variables were conducted with t and Pearson correlation tests. Significance was determined at the p<0.05 level.

Results

Table 2 presents selected demographic and clinical parameters of the study population. In the study population, the maternal age ranged from 25 to 87 years; the ratio of maternal height ≤150 cm was 18.2%; and maternal weight ranged from 46 to 120 kg; parity ranged from 1 to 14; and maximum birth weight ranged from 2700 to 4000 and from 2500 to 5000 g for maternal height ≤150 cm or >150 cm, respectively.

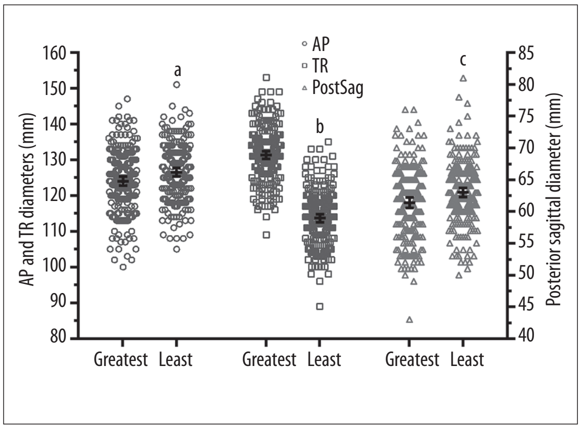

Figure 5. Anteroposterior, transverse and interspinous, and posterior sagittal diameters of planes of greatest and least diameters, respectively. AP – anteroposterior; TR – transverse. Variables were presented as mean with 95% confidence interval.

Figure 3 displays the true, obstetric, and diagonal conjugates and transverse and posterior sagittal diameters of the pelvic inlet. Overall, the pelves had an inlet of slightly transverse oval shape. Delta values were obtained as true conjugate minus obstetric conjugate (TMO) and diagonal conjugate minus obstetric conjugate (DMO). The TMO and DMO were 4.2±2.2 (min–max: 1–16) mm and 16.7±4.6 (min–max: 3–31) mm, respectively. There was a significantly high correlation between the obstetric conjugate with the true and diagonal conjugates of the pelvic inlet (r=0.97 and r=0.90, respectively; p<0.05) (Figure 4). The obstetric conjugate and transverse diameter were 109±10.0 (min–max: 86–139) mm and 136.1±7.6 (min–max: 119–159) mm, respectively. The anterior and posterior sagittal diameters were 66.7±5.4 (min–max: 54–90) and 46.9±7.8 (min–max: 24–68) mm, respectively. Delta value of anterior minus posterior sagittal diameters was 25.3±8.4 (min–max: 7–66) mm, and there were 24 patients with a delta value of more than 30 mm.

Figure 5 presents the anteroposterior, transverse, and posterior sagittal diameters of planes of greatest and least diameters. We found that the anteroposterior and posterior sagittal diameters of the plane of least diameter revealed a small but significant increase compared to those of the plane of greatest diameter (p<0.05); however, the transverse diameter of the plane of least diameter was significantly lower than that of the plane of greatest diameter (p<0.05). The anteroposterior, intertuberous, and posterior sagittal diameters of the pelvic outlet were 115.7±8.3 (min–max: 92–135), 117.1±8.1 (min–max: 93–139), and 56.4±5.6 (min–max: 36–74) cm, respectively.

Figure 6 shows the anteroposterior, transverse, and posterior sagittal diameters of the pelvic inlet and plane of greatest diameter in patients with height of ≤150 cm and >150 cm. The anteroposterior and transverse diameters of the pelvic inlet and plane of greatest diameter in patients with height of >150 cm were higher than those with height of ≤150 cm (p<0.05). Although the posterior sagittal diameters of the pelvic inlet and plane of greatest diameter in patients with height of >150 cm were found

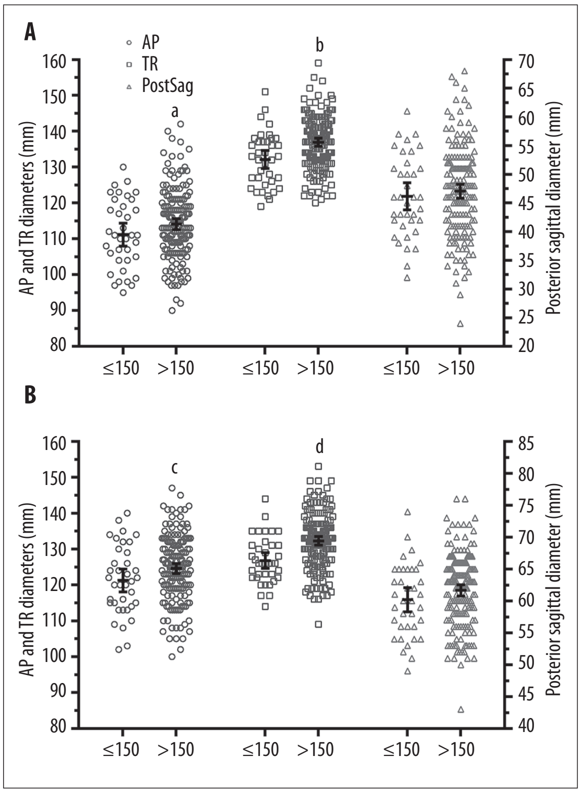

Figure 6. Anteroposterior, transverse, and posterior sagittal diameters of pelvic inlet (**A**) and plane of greatest diameter (**B**) in patients with height of ≤150 cm and >150 cm. AP, anteroposterior; TR, transverse; and postsag, posterior sagittal. Variables were presented as mean with 95% confidence interval. ^{a,b,c,d} P<0.05 *vs.* ≤150 of anteroposterior and transverse.

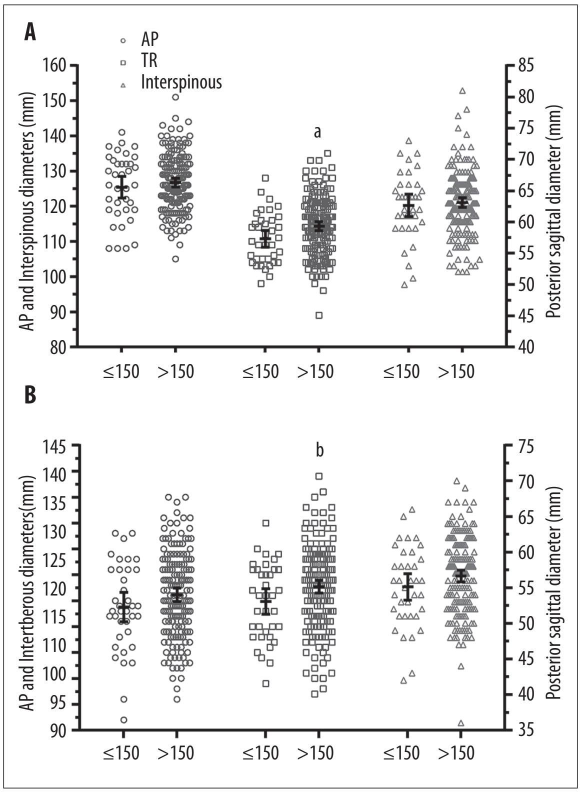

Figure 7. Anteroposterior, interspinous and intertuberous, and posterior sagittal diameters of plane of least diameter (**A**) and pelvic outlet (**B**), respectively, in patients with height of ≤150 cm and >150 cm. AP, anteroposterior and postsag, posterior sagittal. Variables were presented as mean with 95% confidence interval. ^{a} P<0.05 *vs.* ≤150 of interspinous. ^{b} P<0.05 *vs.* ≤150 of intertuberous.

higher compared to those in patients with height of ≤150 cm, those differences did not reach statistical significance (p>0.05).

Figure 7 displays the anteroposterior, interspinous and intertuberous, and posterior sagittal diameters of the plane of least diameter and pelvic outlet, respectively, in patients with height of ≤150 cm and >150 cm. The interspinous and intertuberous diameters of the plane of least diameter and pelvic outlet in patients with height of >150 cm were higher than those with height of ≤150 cm (p<0.05). Although the anteroposterior and posterior sagittal diameters of the plane of least diameter and pelvic outlet in patients with height of >150 cm were found higher compared to those in patients with height of ≤150 cm, those differences did not reach statistical significance (p>0.05).

Discussion

In the current study, 3D CT pelvimetry was performed to assess the reference values of the pelvic inlet, the planes of greatest and least diameters, and the pelvic outlet in non-pregnant multiparous women who had at least one singleton term delivery with head presentation. Women with short stature (height ≤150 cm) during the reproductive age had lower maximal birth weight. The correlation of obstetric conjugates with true and diagonal conjugates were found meaningfully high. The diagonal conjugate was found at least 15 mm longer than the obstetric conjugate. Overall, the anterior minus posterior sagittal diameters was found at least 25 mm. The anteroposterior and posterior sagittal diameters of the plane of least diameter were slightly more compared to the plane of greatest diameter; however, its transverse diameter was considerably lower compared to the plane of greatest diameter. Overall, the pelvises had transverse oval appearance in inlet and size of the female pelvis. All of the anteroposterior, transverse, and posterior sagittal diameters of the pelvic inlet, the planes of greatest and least diameters, and pelvic outlet of women with short stature were lower compared to women with normal stature. To the best of our knowledge, there was no previous imaging study investigating pelvic dimensions considering the maternal stature in the context of clinical and imaging findings together. We think that our data may contribute to the acceptance of CT or MRI imaging findings in obstetrical decision-making.

Because of the increasing trend of cesarean delivery in developed countries, without compromising safety related to childbirth, reduction of the total cesarean delivery rate is accepted as the official objective by health care authorities in many countries. Besides the total cesarean delivery rate, the primary cesarean delivery rate is the most important determinant requiring to be decreased since it has become the leading factor contributing to the total cesarean delivery rate [10]. The most common indications for primary cesarean delivery were failure to progress or cephalopelvic disproportion (CPD) (41.3% and 19.5% in primiparous and multiparous women), abnormal fetal heart rate tracing (27.3% in all women), and fetal malpresentation (18.5% in all women) [10]. In this context, there is increasing trend to guide obstetricians for excluding CPD to reduce elective cesarean rate, and predicting the labor arrest terminating eventually in cesarean section. Safe prevention of primary cesarean deliveries requires refined approaches to assess the relationship of maternal pelvis and presenting head [11].

Pelvic dimensions vary from one woman to the other according to their height, body size, and pelvic shape. During vaginal delivery, the most important factor is not the absolute pelvic size but its actual size relative to the fetal presenting part. In obstetric practice, although there are several findings described to evaluate the possibility of vaginal delivery of an average fetus presenting with head, it is not easy to predict CPD, and many obstetricians prefer a trial of labor under close observation as the best assessment of adequacy of maternal pelvis for childbirth.

Although several radiological studies contributed to the knowledge on maternal pelvis and CPD, no consensus exists on the role of pelvimetry in labor management. Conventional radiographic pelvimetry has provided the reference values of pelvic measurements available in the literature [12,13]. Nowadays, X-ray pelvimetry has a limited place in modern obstetrics after the advancement of CT and MRI.

Harper et al. [14] investigated the value of x-ray measures of the mid pelvis to predict cesarean delivery. In their study, the anteroposterior diameter of the mid pelvis was measured from S3 to the pubic symphysis in the lateral view; the transverse diameter of the mid pelvis is measured at the level of the ischial spines in the anteroposterior view; and the mean circumference of the mid pelvis was calculated from the anteroposterior diameter and transverse diameter measurements. They concluded that vaginal delivery was possible if the anteroposterior diameter of the mid pelvis was more than 9 cm. They noted that the mid pelvis mean circumference was less predictive of cesarean delivery than anteroposterior diameter, and transverse diameter was not predictive of cesarean delivery.

Zaretsky et al. [15] investigated whether MRI has the ability for prediction of dystocia with the help of measurements of the fetal head and maternal pelvic volumes. They performed MRI pelvimetry in nulliparous women scheduled for induction and measured fetal head volume and maternal pelvic volumes with the help of previously defined diameters. Keller et al. [13] assessed the value of pelvimetry including obstetric conjugate, interspinous distance, intertuberous distance, transverse diameter, and sagittal outlet by MRI in a population of spontaneous vaginal delivery and assisted or cesarean delivery; in addition, they also determined the observer or intraindividual variability of pelvic measurements. They found that in women delivered vaginally pelvic dimensions were higher compared to women subjected to assisted or cesarean delivery. They noted that variabilities were more than expected during the measurements of intertuberous distance and sagittal outlet. During the measurement of intertuberous distance, since the ischial tuberosity has a wide contour, the placement of markers by an observer may be different and change the distance measured. During the measurement of the sagittal outlet, the identification of the junction between the sacrum and coccyx on images obtained by MRI can be difficult [13]. Because of those limitations, Keller et al. [13] suggested that pelvimetry by MRI can be added to clinical procedures to determine the route of delivery; however, the intertuberous distance and sagittal outlet had not adequate power to assess the delivery type. In a recent study of pelvimetry by MRI [16], the reliability of measurements of the pelvic inlet and outlet were evaluated by the assessment of inter-observation and inter-observer variations. The authors concluded that inter-observer variations were higher than intra-observer variations. They suggested that pelvimetry by MRI needs to be performed in a centralized location to decrease observer-dependent variations and that obstetricians did not expect accuracy in millimeter range. Fakher et al. [17] conducted a study of pelvimetry with MRI in a small number of patients with a history of cesarean delivery due to CPD. They performed MRI while their patients had 37 weeks of pregnancy with an estimated fetal weight between 3.5 and 4 kg by ultrasonography. They evaluated the success of a trial of labor and found that some of the diameters of the pelvic inlet, mid pelvis, and pelvic outlet were found smaller in patients requiring cesarean delivery.

Lenhard et al. [6] performed CT pelvimetry including obstetric conjugate, transverse inlet, mid pelvis sagittal at the level of the ischial spine, sagittal outlet, interspinous, and intertuberous diameters in patients with a history of vaginal delivery and dystocia related to CPD during the postpartum period. They compared pelvic diameters of patients with or without dystocia. They stated that pelvic diameters were measured in good accordance with data of previous recent studies. In that study, the sagittal diameter of the mid pelvis revealed more clinical value to predict dystocia like the similar data of Zaretsky et al. [15] compared to other pelvic dimensions. Lenhard et al. [6] analyzed their data according to previously reported pelvimetric indices of Borell [18], Colcher [18,19], Friedman [20], Mengert [21], and fetal-pelvic index [22] They suggested that only mid pelvis sagittal diameter with a cut-off of ≤12.1 cm and the ratio of mid pelvis sagittal diameter to head circumference with a cut-off of provided clinically meaningful accuracy if midsagittal diameter was used with a cut-off of ≤0.34 although those cut-offs need further evaluation in prospective studies with 3D reformatted CT images. Lenhard et al. [6] concluded that their findings did not confirm the results of previously reported pelvimetric indices to predict CPD. Lenhard et al. [3] conducted another study using 3D CT images to assess the dimensions of the true pelvis in live subjects. They also performed the same measurements of the pelvis of a human skeleton with CT scan and later with a ruler as reference. They found considerably good interobserver agreement during measurements and that CT and ruler measurements of the skeleton provided excellent agreement. They suggested that pelvic diameters could be measured in a considerably accurate way on 3D volume-rendered CT reconstructions.

There is a rising trend in the use of CT and MRI in pregnancy although there are several misconceptions regarding pros and cons of these imaging modalities in pregnancy. Although MRI has an advantage of no radiation exposure, the fetal dose during pelvimetry by an adjusted CT scan is less than 0.1 rad. Therefore, if pelvimetry is considered clinically useful for prediction of dystocia, it is reasonable to perform pelvimetry in a short time by low-dose CT rather than by MRI providing less detail for bony structures compared to CT [23].

Maternal short stature was found as associated with an increased risk of labor complications and cesarean delivery, especially when maternal height was ≤150 cm [24–26]; however, Kara et al. [27] stated that the rates of caesarean delivery in patients who had height ≤150 cm and >150 cm were comparable. Chan and Lao [28] investigated the relationship of maternal height and risks of complicated labor. They concluded that the impact of maternal height on labor outcome could be described as a continuum. In their study, In accordance with the decrease of maternal height, the ratio of cesarean delivery increased. Toh-Adam et al. [29] evaluated the relationship between maternal height and rate of cesarean delivery due to CPD. They noted that maternal short stature increased the rate of cesarean sections with a cut-off value of maternal height ≤145 cm.

Our study has some limitations. Firstly, some of the differences between diameters and delta values were statistically significant but lower in absolute magnitude by less than 0.5 cm. Secondly, the number of patients with a height of less than 150 cm is small compared to women with normal stature. Thirdly, reliable data were not collected on whether there was abnormal progression of labor even though the delivery of baby was possible in the study population. Despite the presence of these limitations, the definition of a simple accurate way of performing measurements in non-pregnant multiparous women with successful vaginal delivery with or without short stature is the main strength of the current study.

Conclusions

Despite these limitations, the findings of the current study present the reference values for the main planes of the true pelvis in a systematic way using a standardized image acquisition method of 3D CT pelvimetry in a relatively large group of multiparous women who passed the trial of labor successfully. We think that high parity and maximum birth weight ranges of our study subjects increased the reliability of pelvimetric measurements. In women with short stature, pelvic dimensions were lower than expected, which need to be considered during obstetrical decision-making. For a sound obstetric decision on CPD that is a multifactorial condition mainly affected by maternal pelvic size with an average fetus with head presentation, development of a reliable pelvimetric test needs further studies for standardization of measurements and development of criteria useful for determination of the risk of CPD by 3D CT and MRI imaging modalities. Overall, the findings of this study contribute to the knowledge supporting the usefulness of 3D CT pelvimetry in obstetric practice in selected cases.

Conflicts of interest

The authors declare that there is no conflict of interest.

References:

1. Maharaj D: Assessing cephalopelvic disproportion: back to the basics. Obstet Gynecol Surv, 2010; 65: 387–95
2. Joyce DN, Giwa-Osagie F, Stevenson GW: Role of pelvimetry in active management of labour. Br Med J, 1975; 4: 505–7
3. Lenhard M, Johnson T, Weckbach S et al: Three-dimensional pelvimetry by computed tomography. Radiol Med, 2009; 114: 827–34
4. Morris CW, Heggie JC, Acton CM: Computed tomography pelvimetry: accuracy and radiation dose compared with conventional pelvimetry. Australas Radiol, 1993; 37: 186–91
5. Jamali AA, Deuel C, Perreira A et al: Linear and angular measurements of computer-generated models: Are they accurate, valid, and reliable? Comput Aided Surg, 2007; 12: 278–85
6. Lenhard MS, Johnson TR, Weckbach S et al: Pelvimetry revisited: analyzing cephalopelvic disproportion. Eur J Radiol, 2010; 74: e107–11
7. Huerta-Enochian GS, Katz VL, Fox LK et al: Magnetic resonance-based serial pelvimetry: do maternal pelvic dimensions change during pregnancy? Am J Obstet Gynecol, 2006; 194: 1689–94; discussion 1694–95
8. Cunningham FG, Leveno KJ, Bloom SL et al: Chapter 2. Maternal anatomy. In: Cunningham FG, Leveno KJ, Bloom SL et al. (eds.), Williams Obstetrics. 23rd Edition. New York: McGraw-Hill, 2010; 14–35
9. Varney H, Kriebs JM, Fahey JO, Gegor CL: Chapter 61. Anatomy of the Pelvis, Pelvis Types, Evaluation of the Bony Pelvis, and Clinical Pelvimetry. In: Varney H, Kriebs JM, Fahey JO, Gegor CL (eds.), Varney's Midwifery. 4th Edition. Sudbury: Jones and Bartlett Publishers, 2004; 1205
10. Boyle A, Reddy UM, Landy HJ et al: Primary cesarean delivery in the United States. Obstet Gynecol, 2013; 122: 33–40
11. American College of Obstetricians and Gynecologists; Society for Maternal-Fetal Medicine: Obstetric care consensus no. 1: Safe prevention of the primary cesarean delivery. Obstet Gynecol, 2014; 123: 693–711
12. Brown RC: A modification of the Colcher-Sussman technique of x-ray pelvimetry. Am J Roentgenol Radium Ther Nucl Med, 1972; 115: 623–29
13. Keller TM, Rake A, Michel SC et al: Obstetric MR pelvimetry: reference values and evaluation of inter- and intraobserver error and intraindividual variability. Radiology, 2003; 227: 37–43
14. Harper LM, Odibo AO, Stamilio DM, Macones GA: Radiographic measures of the mid pelvis to predict cesarean delivery. Am J Obstet Gynecol, 2013; 208: 460.e1–6
15. Zaretsky MV, Alexander JM, McIntire DD et al: Magnetic resonance imaging pelvimetry and the prediction of labor dystocia. Obstet Gynecol, 2005; 106: 919–26
16. Korhonen U, Solja R, Laitinen J et al: MR pelvimetry measurements, analysis of inter- and intra-observer variation. Eur J Radiol, 2010; 75: e56–61
17. Fakher D, Marouf T, Azab AS: Value of magnetic resonance imaging in predicting cephalopelvic disproportion in relation to obstetric outcome: A pilot study. Evid Based Health Med J, 2012; 2: 14–17
18. Borell U: Orthodiagraphic pelvimetry with special reference to capacity of distal part of pelvis and pelvic outlet. Acta Radiol Diagn, 1964; 2: 273–82
19. Freeman DW: X-ray pelvimetry by the Colcher-Sussman method; A study comparing it with stereoscopic parallax pelvimetry. Minn Med, 1956; 39: 583–85; passim

20. Friedman EA, Taylor MB: A modified nomographic aid for x-ray cephalopelvimetry. Am J Obstet Gynecol, 1969; 105: 1110–15
21. Mengert WF, Korkmas MV: 3,772 Labors following radiographic mensuration. Am J Obstet Gynecol, 1957; 74: 151–58
22. Morgan MA, Thurnau GR, Fishburne IJ Jr.: The fetal-pelvic index as an indicator of fetal-pelvic disproportion: A preliminary report. Am J Obstet Gynecol, 1986; 155(3): 608–13
23. Chen MM, Coakley FV, Kaimal A, Laros RK Jr.: Guidelines for computed tomography and magnetic resonance imaging use during pregnancy and lactation. Obstet Gynecol, 2008; 112: 333–40
24. Cnattingius R, Cnattingius S, Notzon FC: Obstacles to reducing cesarean rates in a low-cesarean setting: The effect of maternal age, height, and weight. Obstet Gynecol, 1998; 92: 501–6
25. Lowe NK: A review of factors associated with dystocia and cesarean section in nulliparous women. J Midwifery Womens Health, 2007; 52: 216–28
26. McGuinness BJ, Trivedi AN: Maternal height as a risk factor for Caesarean section due to failure to progress in labour. Aust NZJ Obstet Gynaecol, 1999; 39: 152–54
27. Kara F, Yesildaglar N, Uygur D: Maternal height as a risk factor for Caesarean section. Arch Gynecol Obstet, 2005; 271: 336–37
28. Chan BC, Lao TT: The impact of maternal height on intrapartum operative delivery: A reappraisal. J Obstet Gynaecol Res, 2009; 35: 307–14
29. Toh-Adam R, Srisupundit K, Tongsong T: Short stature as an independent risk factor for cephalopelvic disproportion in a country of relatively small-sized mothers. Arch Gynecol Obstet, 2012; 285: 1513–16