ORIGINAL ARTICLE

Three-Dimensional Magnetic Resonance Pelvimetry and Prediction of Labor Dystocia

Mohammed Abdellatif [a], Abdelsamie A. Abdelsaie [b], Ashraf Talaat [a], Maged Mahmoud [a,*]

[a] Department of Radiology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt
[b] Department of Gynecology and Obstetrics, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Introduction: ***The prevalence of unjustified caesarean section (CS) is significantly increasing in Egypt, resulting in high maternal morbidity and mortality; however, CS is indicated in a lot of cases, including dystocia. Three-dimensional (3D) magnetic resonance imaging (MRI) pelvimetry is a safe, valuable measure in the detection of dystocia and, therefore, prevention of complications to the mother or the fetus.***

Objective: ***To evaluate the validity of 3D MR pelvimetry and to predict labor dystocia.***

Patients and methods: ***In this study, fifty patients were included that are suspicious of labor dystocia. All these patients did MRI study with post imaging 3D reconstruction, and measurement of dimensions of pelvic inlet, mid pelvis and pelvic outlet dimensions, that would allow us to determinate cases susceptible of labor dystocia and prevention of foetal and maternal morbidity and mortality.***

Results: ***Our study revealed forty-two patients delivered by normal vaginal delivery, however eight patients delivered by CS. The results showed highly significant difference between pelvic dimensions in Caesarean section and normal delivery groups. Moreover, other contributing factors as foetal birth weight and maternal body mass index.***

Conclusion: Three-dimensional MRI pelvimetry is a safe and effective method for antenatal prediction of labor dystocia.

Keywords: Dystocia; MRI; Pelvimetry; Pregnancy; Term Birth

1. Introduction

Pregnant women in Egypt with middle-class and upper-class incomes are increasingly having unnecessary CS. One-third of the 18.5 million CSs performed worldwide each year are deemed unnecessary.[1] Reducing maternal and neonatal morbidity and mortality requires appropriate reasons for obstetric interventions.[2]

In addition to adding to the expenses of our healthcare system, needless CSs can have detrimental repercussions on the health of both the mother and the foetus.[3]

Among these are complications like an increased risk of preterm births and neonatal deaths [2]. Also, placental complications like placenta previa and placenta accreta, which may require a hysterectomy in subsequent pregnancies, and surgical wound complications like surgical wound infection, necrotising fasciitis, and endometritis following CS.[4]

Dystocia, a prior CS, foetal discomfort, and atypical presentations are some signs that a Caesarean is necessary.[3] With a prevalence ranging from 40% to 50%, dystocia is the most prevalent reason for CS4 and the most common maternal issue[5], linked to higher rates of maternal morbidity and mortality.[6]

A more objective and trustworthy approach is required because clinical pelvimetry has been shown to be subjective and to have poor usefulness in identifying women at risk of dystocia.[2,6] To find the tiny pelvic diameters, pelvimetry has employed a variety of imaging tests, such as computed tomography (CT)[6] magnetic resonance imaging[8] (MRI), ultrasound[7] and x-rays.[8] However, because both CT pelvimetry and X-rays include varying levels of radiation exposure and raise the possibility of foetal neoplasia, they are not regarded as trustworthy imaging techniques for expectant mothers.[9]

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* Corresponding author at: Radiology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt.
E-mail address: magedelbarawy01@gmail.com (M. Mahmoud).

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With pelvimetric errors of about 1%, magnetic resonance imaging (MRI) may be a useful imaging technique.[10]

Additionally, one of MRI's unique benefits is its capacity to generate excellent images of bone and tissue without revealing any signs of radiation exposure or foetal damage.[11] Since it can be challenging to precisely identify bone landmarks for measurements, cross-sectional MRI has been shown to measure the majority of pelvic parameters with accuracy, with the exception of the intertuberous distance and the posterior sagittal diameter of the exit.12

Ancy and better precision than two-dimensional CT[6] and its introduction based on three-dimensional (3D) models offers improvements over previous pelvimetric modalities. Better anatomical views for precisely selecting the measuring location can be obtained using 3D models as opposed to cross-sectional pelvic scans. However, pelvic modelling during pregnancy has not received much attention in research to date. Although the prediction accuracy was constrained by the measurement values, an attempt to forecast cephalopelvic disproportion utilizing a synthesized 3D pelvis based on many pregnant women's parameters produced encouraging results. Earlier feasibility study of 3D CT pelvimetry demonstrated good accuracy.[13]

Lenhard et al.,[6] presented the 1st and sole investigation of cephalo-pelvic disproportion prediction using postpartum women's 3D CT pelvimetric data. However, there was no prospective data available to confirm the technique's predictive accuracy.

The aim of this study was to evaluate the validity of 3D MR pelvimetry and to predict labor dystocia.

2. Patients and methods

Our study was conducted on fifty pregnant women between seventeen and thirty years old, all were more than 36 weeks of gestation, and all were justified by their obstetrician as at risk of dystocia and recommended for prenatal assessment by 3D MRI pelvimetry.

Exclusion criteria:

Previous CS delivery and any contraindication for MRI scanning, as well as other abnormalities that may occur during pregnancy that need immediate intervention, such as oligohydramnios, foetal distress, and premature labor.

Average age for our study group was 21.7 years. The candidate of our study were nineteen patients from Fayoum city, twenty-nine patients from rural areas related to Fayoum city, one patient from Elwahat governorate, and another patient from Cairo governorate.

All our patients did their 3D MRI between thirty- six weeks and thirty-eight weeks of gestation, they delivered either normal or CS between thirty-eight and forty-two weeks of gestation.

Magnetic resonance imaging methodology:

One fast imaging employing steady-state acquisition and one fast spin echo T2-weighted scan were used for MR imaging. We used an abdominal coil, a thoracic coil, and a 1.5 T TOSHIBA magnet. The FIESTA was a sagittal 4-mm acquisition without gap, with a field of view of 400 mm, TR4.0 ms, TE1.7 ms, matrix 192256, and NEX 1. The FSE was an axial 3-mm acquisition without a gap, with a field of view of 260 mm, TR10040 ms, TE48 ms, and a number of excitations

3. The full gravid uterus and pelvis were included in the FIESTA sequence; on average, forty to fifty pictures were obtained.

The maternal pelvis was included in the seventy-eight pictures that the FSE sequence averaged. The entire evaluation took no more than ten minutes, and the studied cases were not sedated or asked to hold their breath. MRI datasets were imported into Mimics 21.0 (Materialise's Interactive Medical Image Control System, Version 21.0, Materialise Company, Belgium) in order to generate 3D pelvic models (Figure 1).

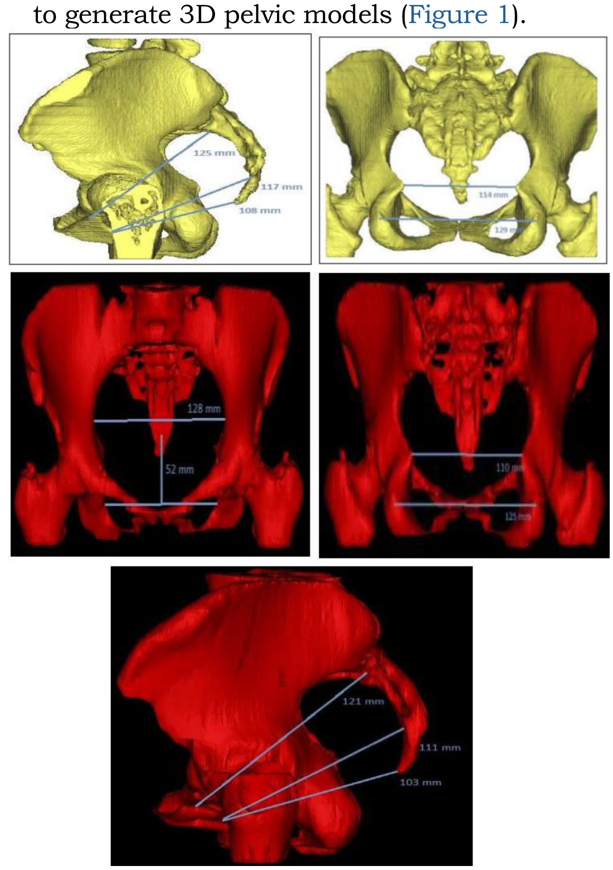

Figure 1. shows different 3D models.

The images are processed in three dimensions: the axial, coronal, and sagittal images. The bones of the pelvis were manually outlined segment by segment in the axial and sagittal images, with the coronal image as a reference for marked bones. The live wire button allows manual outlining of the bones on the respective images. The end result of manual segmentation was viewed on the coronal images. Then, the 3D model was obtained based on the images outlined on different planes. At first, the model was segmented into voxels and applied to editing tools that helped to generate our final model, ready for free navigation as a 3D model and for assessment of different measurements needed for our study.

Three-dimensional pelvimetry measurements were performed. The same observer measured the standardized pelvic dimensions on each section to avoid interobserver variability. The center of the transverse diameter to the same location on the sacrum of the corresponding planes was the posterior sagittal diameter of the pelvis. The professionals handling labor did not have access to measurement findings, and the outcomes of the birth were not communicated to the investigators. Comparing the pelvic sizes of the groups that underwent normal vaginal delivery (42 patients) and those that underwent dystocia (8 patients who underwent CS).

Ethical Approval:

This study was approved from The Ethics Committee of the Faculty of Medicine, Fayoum University, Egypt. All individuals provided written informed consents. The study was in accordance to Helsinki Declaration.

Statistical analysis:

The SPSS version 25 statistical program, developed by IBM and located in Chicago, IL, USA, was used for the study. The quantitative values were presented using the standard deviation (SD) and the mean. The enumeration data were analyzed by the x2 test, the measurement data were analyzed by the t-test, and the ranked data were analyzed by the rank-sum test. The inspection level was set at 0.05; p≤0.05 was considered statistically significant.

3. Results

Maternal and neonatal demographic features were shown in table (1). In all of our studied cases delivered either normal or CS between thirty-eight and forty-two weeks of gestation, only two patients had previous pelvic operations for pelvic fractures, however both had no obvious disability and the remaining forty-eight patients had no history of any previous pelvic operation. Twenty-one patients delivered at Fayoum University Hospital, sixteen patients delivered at Fayoum General Hospital, and the remainder thirteen patients delivered at private centers.

Two patients delivered by CS for reasons rather than 623ephalon-pelvic disproportion and were excluded. Forty-two candidates delivered by normal vaginal delivery and eight candidates delivered by CS.

Table 1. Maternal and neonatal demographic characteristics.

CHARACTERISTIC	NORMAL (N=42) MEAN ± SD	CAESARIAN SECTION (N=8) MEAN ± SD	P-VALUE
MATERNAL AGE	21.738 ± 3.0688	21.250 ± 1.9086	0.563
WEIGHT	72.786± 5.2894	78.750 ± 2.7124	0.000*
HEIGHT	159.952 ±6.1365	158.750 ±4.6214	0.536
BODY MASS INDEX	28.024 ±2.6548	31.125 ±2.2321	0.005*
GA BY LMP AT MRI	36.595 ±0.6648	37.125 ±0.8345	0.053
GA BY LMP AT DELIVERY	39.714± 0.7083	40.250 ±0.7071	0.056
FOETAL WEIGHT AT BIRTH	3438.09 ±193.7466	3600 ±169.0309	0.032*
APGAR 5 M.	9.690 ± 0.9997	9.875 ±0.3536	0.360
NEONATAL BLOOD PH	7.1767 ± 0.0496	7.2388 ± 0.0536	0.013*

SD: standard deviation; GA: gestational age; LMP: last menstrual period;
MRI: magnetic resonance imaging; *: significant.

The pelvic measures of all vaginal delivery women were displayed in table (2) along with a comparison to the dystocia group. Compared to the control group, all diameters (mm) were smaller in the dystocia group. In the dystocia group, there was a significant decrease in the transverse diameter of the intake, the anterior-posterior diameter of the mid-pelvis and the outlet, & the posterior diameter of the outlet.

Table 2. Mean values of elected pelvic measurements (mm) based on three-dimensional magnetic resonance imaging pelvimetry

	NORMAL (N=42) MEAN±SD	CAESARIAN SECTION (N=8) MEAN±SD	P VALUE
TRANSVERSE (INLET)	135.00 ±1.3066	127.750± 1.0351	0.000*
OBSTETRIC CONJUGATE (INLET)	125.429 ±1.0393	120.625± 1.0607	0.000*
INTERSPINOUS (MID-PELVIS)	113.881± 1.1306	109.500± 0.5345	0.000*
ANTERIOR-POSTERIOR DIAMETER (MID-PELVIS)	116.738± 1.5782	110.00± 0.7559	0.000*
INTERTUBEROUS (OUTLET)	128.262 ±1.0606	122.375± 1.8468	0.000*
ANTERIOR POSTERIOR DIAMETER (OUTLET)	109.667 ±1.2815	102.875 ±0.1.000	0.000*
POSTERIOR DIAMETER (OUTLET)	58.929± 1.2176	51.250 ±1.4880	0.000*

SD: standard deviation; *: significant.

4. Discussion

To prevent incidence of dystocia and decreased foetal and maternal morbidity and mortality, pelvimetry is required for pregnant women with suspicion of dystocia, x-ray and CT pelvimetry are available modalities, however radiation exposure makes there use limited to patients with history of previous dystocia to assess probable morbidities in future deliveries, therefore the role of MRI pelvimetry becomes more important as it is safe during pregnancy, however it can't measure the posterior sagittal diameter, 3D reconstructed MR pelvimetry can provide accurate idea of all pelvic diameters with accurate prediction of possible incidence of dystocia.

In our study, our results demonstrate that MR cross-sectional images of a pregnant woman's pelvis can be reconstructed in 3D with our technique. In addition to conventional pelvic diameters, other parameters, such as posterior sagittal diameter, can also be measured from the 3D models. Generally, almost all pelvic dimensions are smaller in women with dystocia than in women who deliver vaginally, consistent with the results of Liaoa et al.[14]

In contrast to published evidence from pelvimetry in several women using either 2D MRI or 3D CT[12] overall, our group's transverse and inlet sagittal dimensions were larger, but the midpelvis and outlet sagittal diameters were smaller.

Women who gave birth vaginally had bigger pelvic dimensions than those who had a Caesarean section for dystocia in this research, which is in line with published 3D MR pelvimetry data, with other important general demographic factors, particularly foetal birth weight and maternal body mass index, which are the strongest confounding factors.[14] Also, consistent with published 3D MR pelvimetry data[14], there were highly significant differences between 3D MR pelvimetry measurements of the pelvic inlet, midpelvis, and outlet between normal delivery and dystocia groups. As regards the outcome of delivery, there were significant differences in foetal blood pH between the two study groups.

The advantages of our study were the multiple factors used for differentiation between both normal delivery and dystocia groups, that helped to detect other contributing factors, as well as 3D reconstruction that allow accurate assessment of different pelvimetric values and prediction of outcome of delivery, another advantage was accurate selection of study participants to be clinically suspected for dystocia by their obstetrician.

Limitations: Our study had a small number of groups in the study that may limit the statistical results with an increasing number of pregnant women who underwent elective non-indicated Caesarian section, which may affect the number of study groups, another limitation.

was the relative high cost of MRI study and ost imaging 3D reconstruction and the high cost and unavailability of reconstruction tools as well as the relatively long time of MRI scanning and the patient's anxiety feeling during scanning that limits application on large study group.

4. Conclusion

According to the findings of our study, 3D models can provide more relevant pelvimetry, encompassing more metrics and anatomical details, and are useful when combined with MR data. Moreover, we provided more factors that are contributing to the incidence of dystocia in Egyptian pregnant women; however, further studies with larger study groups with increasing obstetrician awareness about the importance of MR pelvimetry as well as increasing the availability and reducing cost of 3D reconstruction pelvimetry would help to determine accurate cut offs for labor dystocia and need for justified Caesarian section in Egyptian population.

Disclosure

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All authors have a substantial contribution to the article

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