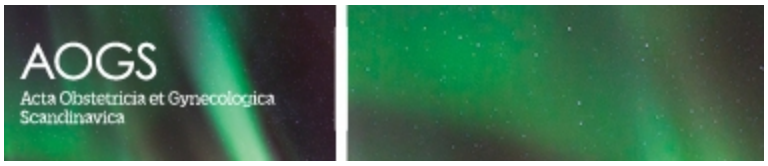
Antepartum evaluation of the obstetric conjugate at transabdominal 2D ultrasound: A feasibility study



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Keywords: pelvimetry, ultrasound, obstetric conjugate, labor dystocia

Abbreviations:

OC= Obstetric Conjugate

BMI=Body Mass Index

ICCs= intraclass correlation coefficients

CS= Cesarean Section

Key message:

The antepartum assessment of maternal pelvimetry may improve the prediction of obstructed labor. Our demonstration that an accurate measurement of the OC is achievable by standard transabdominal ultrasound may usher in a new era for the clinical use of antepartum pelvimetry in obstetrics

ABSTRACT

Objectives: The obstetric conjugate (OC) represents the shortest anteroposterior diameter of the birth canal and it reflects the capacity of the pelvic inlet to allow the passage and the engagement of the fetal head. The antepartum evaluation of this parameter may be attempted at digital examination to predict the risk of cephalopelvic disproportion but the accuracy of clinical pelvimetry is notoriously poor. The aim of our study was to describe the sonographic measurement of the OC at transabdominal 2D-ultrasound

Methods: This is a prospective cohort study conducted at a tertiary University hospital. A non-consecutive series of pregnant women with uncomplicated singleton pregnancies attending at the antenatal clinic for routine booking from 34 weeks of gestation onward were included. The ultrasound probe was longitudinally placed above the level of the symphysis and the interpubic fibrocartilaginous disk was visualized. Then the promontory was identified as the most prominent segment of the sacral vertebral column. The OC was measured as the distance between the inner edge of the interpubic disk and the promontory. The intra- and interobserver repetability of this measurement was calculated using the intraclass correlation coefficient (ICC) and the Bland-Altman method.

Results: 119 women were considered eligible for the study purpose. Overall, 111/119 (93.3%) women were included in the analysis with a median gestational age of 36.0(35.0-37.0) weeks. The mean OC measurement was 11.4±0.93 mm for the first operator and 11.4±0.91 mm for the second operator. The overall interobserver ICC was 0.95(95% CI 0.92-0.96) while the overall intraobserver ICC was 0.97(95%CI 0.96-0.98). The degree of reliability was also analyzed for women with a BMI ≥30 and for women with a gestational age ≥37 weeks. The inter and intra-observer ICCs were respectively 0.97(95% CI 0.90-0.98) and 0.98(0.95-0.99) in the former group and 0.96(95% CI 0.93-0.98) and 0.97(95%CI 0.95-0.98) in the latter one

Conclusion: Our study demonstrated that among pregnant women at term gestation the sonographic measurement of the OC is feasible and reproducible

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INTRODUCTION

Pelvimetry is the biometric evaluation of the birth canal and it has been historically used to identify those women at higher risk for labor dystocia due to cephalo-pelvic disproportion. The clinical pelvimetry is based on the measurement of the main diameters of maternal pelvis either at external or at internal digital examination. Among them the obstetric conjugate which is the linear distance between the sacral promontory and the internal edge of the pubic bone may be assessed at vaginal examination[1]. This is the shortest anteroposterior diameter of the birth canal and it is believed to reflect the capacity of the pelvic inlet to allow the passage and the engagement of the fetal head[2]. Traditionally it is reported that the digital palpation of the promontory is suspected to herald a narrower inlet of the birth canal and to anticipate the occurrence of cephalopelvic disproportion[3].

However, the digital measurement of the obstetric conjugate at vaginal examination and the clinical prediction of a narrow pelvic inlet is considered to be inaccurate and of limited reproducibility[1,4]. Also, the combination of vaginal findings with more objective maternal anthropometric parameters such as height, BMI, shoulder diameter, lower limbs length has been investigated and has shown to yield a poor sensibility and specificity in predicting the risk of obstructed labor[5-7].

The use of imaging techniques (X-ray, MRI and CT) has been claimed to provide accurate measurements of pelvic diameters with a low intra and inter-observer variability[8-10]. However, the routine use of imaging techniques in the antepartum assessment of pelvic capacity is highly controversial and not supported by rigorous randomized controlled trials. A recent Cochrane review found that women who undergo an X-ray pelvimetry may be more likely to have a CS and concluded that there is not enough evidence to support the use of X-ray pelvimetry for deciding on the mode of delivery[11]. Lastly, concerns have arisen regarding the fetal risks from radiation exposure and cost-benefit analysis especially in low-resource settings[8,12].

The assessment of the pelvic cavity size although not advisable on a routine basis might be of clinical utility especially among women who seem at higher risk of cephalopelvic disproportion such as those carrying a large for gestational fetuses or requiring a trial of labor after CS (TOLAC)[13,14].

A pioneer study had proposed to use of 2-Dimensional (2D) transabdominal ultrasound for measuring the OC and predicting of the risk of CD due to obstructed labor[15]. More recently some Authors have reported the antepartum assessment of the OC thanks to the use of the tomography[16]. However, the available data is still limited and the reliability of the sonographic assessment of the OC is still to be proven.

The aim of our study was to describe the sonographic measurement of the OC at transabdominal 2D-ultrasound and to assess its reproducibility in a group of women close to term of gestation.

METHODS

Study design and population study

This is a prospective cohort study conducted at the tertiary care Maternity Hospital of the University of Parma from December 2020 to February 2021.

A non-consecutive series of pregnant women with uncomplicated singleton pregnancies attending at the antenatal clinic for routine booking from 34 weeks of gestation onward were considered eligible for the study purposes.

Inclusion criteria were: age between 18 and 45 years, singleton gestation with fetus in cephalic presentation, absence of indications to scheduled CS delivery.

Exclusion criteria were: low lying placenta, uterine fibroids, history of pelvic bone fractures.

With the woman lying supine with a moderately repleted bladder, the ultrasound probe was longitudinally placed on maternal abdomen above the level of the symphysis. This structure was sonographically visualized as a hypoechoic oval with an internal echogenic core representing the interpubic fibrocartilaginous disk. Then the promontory was identified as the most prominent segment of the sacral vertebral column. The OC was measured as the distance between the inner edge of the interpubic disk and the promontory (fig 1).

For the study purpose two ultrasound machines equipped with a transabdominal multifrequency 2D convex transducer were employed. The standard 3rd trimester setting was used for each examination. In order to have the widest view of the maternal pelvis, the ultrasound probe sector was increased to a maximum of 120° while the probe frequency was turned down at 2.5 mHZ to increase the penetration of the ultrasound beam.

To assess the intra- and interobserver reproducibility of the sonographic measurements, all the ultrasound examinations were performed twice by the operator 1 (N.V.) and once by operator 2

(C.L.). Operator 1 had >10 years' experience in prenatal ultrasound while operator 2 was a resident with <2 years' experience.

The ultrasound measurements of the OC were not used for clinical purposes and the clinicians who were in charge of the management of the women were blinded to the values obtained by the study investigators

Clinical data regarding pregnancy, labor and neonatal outcomes were obtained in all pregnancies from medical records.

Statistical analysis

The Shapiro-Wilk test was used to assess the normality of the distribution of the data. Mean±Standard Deviation (SD) or median [IQR] were used to describe continuous data normally and non-normally distributed, respectively. The agreement between the two examiners and between the two measurements made by the first examiner, were expressed using intraclass correlation coefficients (ICCs) for single measurements and 95% confidence intervals (CI). The systematic differences were also computed by means of the paired Student t test. As far as the repeatability is concerned, in order to assess systematic bias between intra-, interobserver measurements, differences between values were plotted against means of the measurements as described by Bland and Altman and the limits of agreement were evaluated together with their 95% CI[17,18]. A p-value<0.05 was considered as statistically significant. Statistical analysis was performed by using SPSS 21.0.

Ethical approval

The study was approved by our local Ethics committee (270/2018/OSS/AOUPR, 24/04/2018).

RESULTS

During the study period, 119 women were considered eligible for the study purpose. In five cases the sacral promontory was not clearly visualized due to shadowing cast from the engaged fetal head, one case was excluded due to a previous trauma involving the sacrum, while in the remaining two cases the correct visualization of the most prominent part of the inner symphysis surface was not possible due to diastasis (figure 2). Overall, 111/119 (93.3%) women at a median gestational age of 36.0 (35.0-37.0) weeks were included in the final analysis. The main characteristics of the study population are summarized in Table 1

The median maternal age was 33.0 [29.0-36.5], the median OC measurement was 11.4±0.93 mm for the first operator and 11.4±0.91 mm for the second operator (Table 1). No significant relationship was found between the differences of the mean values of the two measurements made twice by the same operator (intraobserver) (p=0.79) and of the measurements made by the first and the second operators (interobserver) (p=0.62) (Table 2).

The overall interobserver ICC was 0.95(95% CI 0.92-0.96) while the overall intraobserver ICC was 0.97(95%CI 0.96-0.98); the Bland-Altman graphs demonstrate the degree of intra and inter-observer concordance (Figure 3 a and b). The degree of reliability was also analyzed for women with a BMI ≥30 at the enrollment and for those with a gestational age ≥37 weeks. The inter and intra-observer ICCs were, respectively, 0.97(95% CI 0.90-0.98) and 0.98(0.95-0.99) for the first group and 0.96(95% CI 0.93-0.98) and 0.97 (95%CI 0.95-0.98) for the latter group thus indicating a substantial good degree of reliability (Table 2).

DISCUSSION

Our study demonstrated that among pregnant women close to term gestation the measurement of the OC at TA 2D-ultrasound is feasible and reproducible. In particular, we found that the sonographic OC had an overall high intra-observer and interobserver agreement; and that this was not impacted by the more advanced gestational age and increased maternal BMI. We have also provided original data on the ultrasound measurement of the OC in a population of singleton pregnancies > 34 weeks and this may offer the opportunity to build specific references charts.

The development of the ultrasound technique has enormously improved our ability to recognize the bony structures of the birth canal.

Compared to X-ray and MRI pelvimetry the ultrasound evaluation of the OC has many advantages as fetal safety, low costs and the possibility to be performed at bedside evaluation also in low-resources settings[19,20].

While pubic symphysis may be easily visualized at both transperineal and transabdominal ultrasound[21-22], the sonographic demonstration of the sacrum promontory is much more challenging especially at advanced gestational ages when the interposition of the fetal head may not allow the correct visualization of this structure. In our series we found that if transabdominal ultrasound is performed between 34-36 weeks the promontory can be visualized in most cases. In addition, using

our approach the whole inner margin of the pubic symphysis is visualized leading to the correct measurement of the OC.

To our knowledge, Katanozaka et al.[15] firstly described the measurement of the OC by means of transabdominal ultrasound. More specifically, they investigated 209 women and found that the OC assessed by ultrasound normally ranged from 10.7 to 15.1 cm; those women with an OC <12 cm had a higher rate of Cesarean Section due to labor dystocia compare to those women with an OC >12 cm (50% vs 5.7% p<0.001). Interestingly, they also reported a positive correlation between ultrasonic OC and X-Ray OC ($r = 0.91$; $p < .0001$) thus concluding that ultrasonic OC measurement is a safe and useful procedure in the prediction of dystocia. The most important limit of this study was that the authors measured the antero-posterior diameter between the upper bone of the pubic symphysis and the promontory of the sacrum, and this was improperly defined OC while it corresponded to the anatomic conjugate[1]. Due to the technical limitations of the ultrasound equipment that were available at that time they were not able to visualize the most prominent part of the inner symphysis surface which is one of the reference landmarks for the correct measurement OC. Furthermore, the authors did not evaluate the inter and intraobserver agreement of their method in the sonographic assessment of the conjugate.

Beside this single report on the ultrasound evaluation of the OC, the assessment of other anatomical landmarks for the evaluation of maternal pelvimetry has been attempted with the aim to predict the risk of obstructed labor.

Some Authors have reported the sonographic measurement of the pubic arch angle (PAA) at transperineal 2D ultrasound and found that its width was inversely correlated with the risk of cesarean of delivery in a group of women with prolonged 2nd stage of labor[22]. A significant positive correlation was found by the same research group between the 2D sonographic measurement of the PAA and the OC measured on three-dimensional computed tomography[23]. In 2015, a study by Ghi et al.[24] demonstrated the reproducibility of a new 3-D transperineal ultrasound technique supported by a specific contrast-enhancing technique in the measurement of the Subpubic arch angle (SPA) among a group of women at term gestation. Subsequent studies evaluated the usefulness of the antenatal assessment of this parameter in predicting the likelihood of an obstetric intervention. Youssef et al.[25] among 145 nulliparous with uncomplicated pregnancies demonstrated that the SPA was significantly narrower in the women submitted to obstetric intervention compared with those undergoing spontaneous vaginal delivery (116.8 ± 10.3° vs. 123.7 ± 9.6°, $p < 0.01$). Another study on 368

nulliparous women at term found that a narrow SPA was associated with a higher risk of persistent Occiput Posterior position at delivery and of operative delivery also[26].

Similarly, the clinical usefulness of antepartum US pelvimetry has been assessed in particular conditions such as in women carrying a suspected LGA fetus.

In 2017 a study on 129 nulliparous at higher risk of having a LGA fetus found that the SPA was narrower among those women who underwent to unplanned obstetric intervention (vacuum delivery or cesarean section) due to prolonged or arrested labor compared with those who achieved a spontaneous vaginal delivery (107.9 13.4 vs 120.7 9.4 p<0.001); in addition, they found a smaller SPA to be independent predictor of operative delivery (OR 1.09 95%CI 1.05-1.13)[27].

The clinical usefulness of antepartum pelvimetry in anticipating the labor outcome has been suggested also by the use of non-ultrasound imaging techniques.

A randomised controlled trial of magnetic-resonance pelvimetry on 235 women with breech presentation at term showed that the emergency cesarean-section rate was significantly lower in the study group (pelvimetry results were reported to the responsible obstetricians, who used them as the basis for decisions on whether to schedule elective cesarean or trial of labor) than in the control group (pelvimetry results were not disclosed until 8 weeks post partum, and decisions about obstetric management were made on the basis of clinical factors)[28]. More recently, a large study conducted in the Frankfurt maternity on 365 women with fetuses in breech presentation has demonstrated that an increasing OC assessed by MRI pelvimetry was significantly associated with an increasing rate of successful vaginal deliveries; based on this data it is claimed by the Authors that the OC may be used to counsel the women carrying a breech fetus on the mode of delivery [29].

Clinical implication and future research

The WHO guidelines recommend against the routine use of antenatal pelvimetry [30]. On note, this recommendation is based on the Cochrane systematic review including 5 RCTs comparing X-ray pelvimetry with no pelvimetry, 2 of them including women candidate to TOLAC.

This systematic review found that women undergoing X-ray pelvimetry were more likely to have a CS (risk ratio (RR) 1.34, 95% CI1.19 to 1.52) compared to women receiving clinical pelvimetry or no pelvimetry. In addition, no significant differences were found between groups for the following clinical outcomes: perinatal mortality (RR 0.53, 95% CI 0.19 to 1.45), perinatal asphyxia (RR 0.66, 95% CI 0.39 to 1.10), and admission to special care baby unit (RR 0.20, 95% CI 0.01 to 4.13)[11].

However, as mentioned above, the growing interest towards the antepartum assessment of pelvic diameters seems justified by the reports showing that pelvimetry impacts the prediction of labor outcome[31-36]. Of course, our demonstration that an accurate measurement of the OC is achievable by standard transabdominal 2D ultrasound may usher in a new era for the clinical use of antepartum pelvimetry in obstetrics.

Following the creation of nomograms of the true OC based on 2D ultrasound, it will be necessary to assess if this measurement impacts the labor outcome and more specifically if a shorter OC is associated with an increased risk of cesarean section due to cephalo-pelvic disproportion especially. This approach may turn particularly useful among those groups who seem at higher risk of obstructed labor such as women with diabetes or those carrying a LGA fetus[27]. In addition, women who are willing to undergo a trial of labor after cesarean might also benefit from the antenatal evaluation of the OC.

Besides the assessment of the risk of obstructed labor, a correlation between the pelvic diameters assessed at postpartum MRI and the five types of Levator ani muscle (LAM) injury has been recently reported[37]. Based on these experiences, the antenatal sonographic evaluation of the OC may be finalized at the prevention and prediction of major perineal injuries.

Strengths and limitations

The prospective design and the originality in describing the transabdominal ultrasound technique to evaluate the true OC represent the main strengths of the present study. Furthermore, potential confounders as maternal BMI or advanced gestational ages have been considered in the analysis.

The small number of women and the fact that this data have not been validated in clinical practice are to be acknowledged among the main study limitations.

CONCLUSION

In conclusion, our study has provided original data on the OC values measured at transabdominal 2D ultrasound. It is still to demonstrate if the use of the antepartum evaluation of the OC alone or in combination with other fetal parameters might help the clinician in identifying women at high risk for and adverse labor outcome. Further studies on larger low-risk population or in women with

specific risk factors are required to investigate the clinical usefulness of this new ultrasound parameter.

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Author contributions statements

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References

1. Maharaj D. Assessing cephalopelvic disproportion: back to the basics. Obstet Gynecol Surv. 2010 Jun;65(6):387-95. doi: 10.1097/OGX.0b013e3181ecdf0c. PMID: 20633305
2. Baskett TF, Calder AA, Arulkumaran S. Munro Kerr's Operative Obstetrics. Twelfth Edition: Saunders Elsevier; 2014.
3. Suonio S, Saarikoski S, Räty E, Vohlonen I. Clinical assessment of the pelvic cavity and outlet. Arch Gynecol. 1986;239(1):11-6. doi: 10.1007/BF02134282. PMID: 3740960
4. Adinma JI, Agbai AO, Anolue FC. Relevance of clinical pelvimetry to obstetric practice in developing countries. West Afr J Med. 1997; 16(1):40±3. PMID: 9133823
5. Benjamin SJ, Daniel AB, Kamath A, Ramkumar V. Anthropometric measurements as predictors of cephalopelvic disproportion: Can the diagnostic accuracy be improved? Acta Obstet Gynecol Scand. 2012 Jan;91(1):122-7. doi: 10.1111/j.1600-0412.2011.01267.x. Epub 2011 Oct 13. PMID: 21895610
6. Rozenholc AT, Ako SN, Leke RJ, Boulvain M. The diagnostic accuracy of external pelvimetry and maternal height to predict dystocia in nulliparous women: a study in Cameroon. BJOG. 2007 May;114(5):630-5. doi: 10.1111/j.1471-0528.2007.01294.x. PMID: 17439570
7. Liselele HB, Tshibangu CK, Meuris S. Association between external pelvimetry and vertex delivery complications in African women. Acta Obstet Gynecol Scand. 2000 Aug;79(8):673-8. PMID: 10949233
8. Rozenberg P. Quelle place pour la radiopelvimétrie au XXI(e) siècle? [Is there a role for X-ray pelvimetry in the twenty-first century?]. Gynecol Obstet Fertil. 2007 Jan;35(1):6-12. French. doi: 10.1016/j.gyobfe.2006.09.028. Epub 2006 Dec 21. PMID: 17188014

9. Keller TM, Rake A, Michel SC, Seifert B, Efe G, Treiber K, Huch R, Marincek B, Kubik-Huch RA. Obstetric MR pelvimetry: reference values and evaluation of inter- and intraobserver error and intraindividual variability. Radiology. 2003 Apr;227(1):37-43. doi: 10.1148/radiol.2271011658. Epub 2003 Feb 11. PMID: 12601187
10. Raman S, Samuel D, Suresh K. A comparative study of X-ray pelvimetry and CT pelvimetry. Aust N Z J Obstet Gynaecol. 1991 Aug;31(3):217-20. doi: 10.1111/j.1479-828x.1991.tb02784.x. PMID: 1804081
11. Pattinson RC, Cuthbert A, Vannevel V. Pelvimetry for fetal cephalic presentations at or near term for deciding on mode of delivery. Cochrane Database Syst Rev. 2017 Mar 30;3(3):CD000161. doi: 10.1002/14651858.CD000161.pub2. PMID: 28358979; PMCID: PMC6464150
12. Badr I, Thomas SM, Cotterill AD, Pettett A, Oduko JM, Fitzgerald M, Adam EJ. X-ray pelvimetry--which is the best technique? Clin Radiol. 1997 Feb;52(2):136-41. doi: 10.1016/s0009-9260(97)80107-9. PMID: 9043048
13. Sharma V, Colleran G, Dineen B, Hession MB, Avalos G, Morrison JJ. Factors influencing delivery mode for nulliparous women with a singleton pregnancy and cephalic presentation during a 17-year period. Eur J Obstet Gynecol Reprod Biol. 2009 Dec;147(2):173-7. doi: 10.1016/j.ejogrb.2009.08.015. Epub 2009 Sep 18. PMID: 19766377
14. Sibony O, Alran S, Oury JF. Vaginal birth after cesarean section: X-ray pelvimetry at term is informative. J Perinat Med. 2006;34(3):212-5. doi: 10.1515/JPM.2006.037. PMID: 16602841
15. Katanozaka M, Yoshinaga M, Fuchiwaki K, Nagata Y. Measurement of obstetric conjugate by ultrasonic tomography and its significance. Am J Obstet Gynecol. 1999 Jan;180(1 Pt 1):159-62. doi: 10.1016/s0002-9378(99)70168-7. PMID: 9914597
16. Perlman S, Raviv-Zilka L, Levinsky D, Gidron A, Achiron R, Gilboa Y, Kivilevitch Z. The birth canal: correlation between the pubic arch angle, the interspinous diameter, and the obstetrical conjugate: a computed tomography biometric study in reproductive age women. J Matern Fetal Neonatal Med. 2019 Oct;32(19):3255-3265. doi: 10.1080/14767058.2018.1462322. Epub 2018 Apr 22. PMID: 29621904
17. Bland JM, Altman DG: Applying the right statistics: analyses of measurement studies. Ultrasound Obstet Gynecol 2003; 22: 85–93
18. Bland JM, Altman DG: Measuring agreement in method comparison studies. Stat Methods Med Res 1999; 8: 135–160.

19. Drukker L, Droste R, Chatelain P, Noble JA, Papageorghiou AT. Safety Indices of Ultrasound: Adherence to Recommendations and Awareness During Routine Obstetric Ultrasound Scanning. Ultraschall Med. 2020 Apr;41(2):138-145. English. doi: 10.1055/a-1074-0722. Epub 2020 Feb 27. PMID: 32107757

20. Ayres-de-Campos D, Stones W, Theron G; FIGO Safe Motherhood and Newborn Health Commitee. Affordable and low-maintenance obstetric devices. Int J Gynaecol Obstet. 2019 Jul;146(1):25-28. doi: 10.1002/ijgo.12838. Epub 2019 May 25. PMID: 31055829

21. Ghi T, Eggebø T, Lees C, Kalache K, Rozenberg P, Youssef A, Salomon LJ, Tutschek B. ISUOG Practice Guidelines: intrapartum ultrasound. Ultrasound Obstet Gynecol. 2018 Jul;52(1):128-139. doi: 10.1002/uog.19072. PMID: 29974596.

22. Ghi T, Youssef A, Martelli F, Montaguti E, Krsmanovic J, Pacella G, Pilu G, Rizzo N, Gabrielli S. A New Method to Measure the Subpubic Arch Angle Using 3-D Ultrasound. Fetal Diagn Ther. 2015;38(3):195-9. doi: 10.1159/000380947. Epub 2015 Apr 8. PMID: 25871360.

23. Youssef A, Salsi G, Cataneo I, Martelli F, Azzarone C, Bellussi F, Ghi T, Pilu G, Rizzo N. Agreement between two 3D ultrasound techniques for the assessment of the subpubic arch angle. J Matern Fetal Neonatal Med. 2016 Apr 28:1-5. doi: 10.1080/14767058.2016.1175000. Epub ahead of print. PMID: 27050886

24. Youssef A, Ghi T, Martelli F, Montaguti E, Salsi G, Bellussi F, Pilu G, Rizzo N. Subpubic Arch Angle and Mode of Delivery in Low-Risk Nulliparous Women. Fetal Diagn Ther. 2016;40(2):150-5. doi: 10.1159/000441517. Epub 2015 Nov 11. PMID: 26555940.

25. Gilboa Y, Kivilevitch Z, Spira M, Kedem A, Katorza E, Moran O, Achiron R: Pubic arch angle in prolonged second stage of labor: clinical significance. Ultrasound Obstet Gynecol 2013; 41: 442–446.

26. Ghi T, Youssef A, Martelli F, Bellussi F, Aiello E, Pilu G, Rizzo N, Frusca T, Arduini D, Rizzo G. Narrow subpubic arch angle is associated with higher risk of persistent occiput posterior position at delivery. Ultrasound Obstet Gynecol. 2016 Oct;48(4):511-515. doi: 10.1002/uog.15808. Epub 2016 Aug 25. PMID: 26565728

27. McMaster-Fay RA. Managing the breech presentation at term: the place of pelvimetry. Aust N Z J Obstet Gynaecol. 2015 Feb;55(1):99. doi: 10.1111/ajo.12297. PMID: 25688824.

28. Walkinshaw SA. Pelvimetry and breech delivery at term. Lancet. 1997 Dec 20-27;350(9094):1791-2. doi: 10.1016/s0140-6736(05)63631-8. PMID: 9428246.

29. Ghi T, Dall'Asta A, Suprani A, Aiello E, Musarò A, Bosi C, Pedrazzi G, Kiener A, Arduini D, Frusca T, Rizzo G. Correlation between Subpubic Arch Angle and Mode of Delivery in

Large-for-Gestational-Age Fetuses. Fetal Diagn Ther. 2018;44(3):221-227. doi: 10.1159/000481169. Epub 2017 Dec 13. PMID: 29232667

30. van Loon AJ, Mantingh A, Serlier EK, Kroon G, Mooyaart EL, Huisjes HJ. Randomised controlled trial of magnetic-resonance pelvimetry in breech presentation at term. Lancet. 1997 Dec 20-27;350(9094):1799-804. doi: 10.1016/S0140-6736(97)05431-7. PMID: 9428250.
31. Klemt AS, Schulze S, Brüggmann D, Louwen F. MRI-based pelvimetric measurements as predictors for a successful vaginal breech delivery in the Frankfurt Breech at term cohort (FRABAT). Eur J Obstet Gynecol Reprod Biol. 2019 Jan;232:10-17. doi: 10.1016/j.ejogrb.2018.09.033. Epub 2018 Oct 22. PMID: 30453166
32. WHO recommendations: intrapartum care for a positive childbirth experience ISBN 978-92-4-155021-5
33. Pavličev M, Romero R, Mitteroecker P. Evolution of the human pelvis and obstructed labor: new explanations of an old obstetrical dilemma. Am J Obstet Gynecol. 2020 Jan;222(1):3-16. doi: 10.1016/j.ajog.2019.06.043. Epub 2019 Jun 25. PMID: 3125192
34. Ferguson JE 2nd, Sistrom CL. Can fetal-pelvic disproportion be predicted. Clin Obstet Gynecol. 2000 Jun;43(2):247-64. doi: 10.1097/00003081-200006000-00004. PMID: 10863624.
35. Zaretsky MV, Alexander JM, McIntire DD, Hatab MR, Twickler DM, Leveno KJ. Magnetic resonance imaging pelvimetry and the prediction of labor dystocia. Obstet Gynecol. 2005 Nov;106(5Pt1):91926.doi:10.1097/01.AOG.0000182575.81843.e7. PMID: 16260507.
36. Floberg J, Belfrage P, Ohlsén H. Influence of pelvic outlet capacity on labor. A prospective pelvimetry study of 1,429 unselected primiparas. Acta Obstet Gynecol Scand. 1987;66(2):121-6. doi: 10.3109/00016348709083032. PMID: 3618135.
37. Harper LM, Odibo AO, Stamilio DM, Macones GA. Radiographic measures of the mid pelvis to predict cesarean delivery. Am J Obstet Gynecol. 2013 Jun;208(6):460.e1-6. doi: 10.1016/j.ajog.2013.02.050. Epub 2013 Mar 1. PMID: 23467050; PMCID: PMC3672361.
38. Macones GA, Chang JJ, Stamilio DM, Odibo AO, Wang J, Cahill AG. Prediction of cesarean delivery using the fetal-pelvic index. Am J Obstet Gynecol. 2013 Nov;209(5):431.e1-8. doi: 10.1016/j.ajog.2013.06.026. Epub 2013 Jun 19. PMID: 23791690.
39. Hampel F, Hallscheidt P, Sohn C, Schlehe B, Brocker KA. Pelvimetry in nulliparous and primiparous women using 3 Tesla magnetic resonance imaging. Neurourol Urodyn. 2018 Aug;37(6):1950-1956. doi: 10.1002/nau.23537. Epub 2018 Feb 21. PMID: 29464757.

Table 1. Maternal characteristics and Obstetric conjugate (OC) measurements obtained twice by operator 1 and once by operator 2

	N=111
Maternal age (years)	33.0 [29.0-36.5]
Caucasian	83(74.8)
Nulliparous	52(46.8)
Gestational Age (weeks)	36.0[35.0-37.0]
Gestational Age ≥37 weeks	35(31.5)
BMI at the enrollment (Kg/m2)	23.7[20.4-27.0]
BMI≥30 Kg/m^2	15(13.5)
Mean value operator 1a (mm)	11.4±0.93
Median value operator 1b (mm)	11.4±0.94
Median value operator 2 (mm)	11.4±0.91

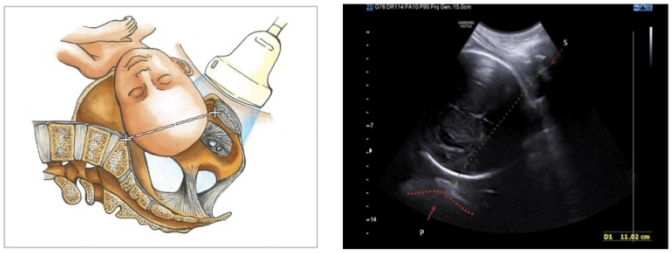
Numbers are expressed as median [IQR] or mean±SD or n(%)

Table 2. Summary of intra- and interobserver reliability measurements of the Obstetric Conjugate

	Interobserver	Intraobserver
Mean difference ±SD	-0.02±0.42	0.008±0.32
Limits of agreement	-0.80 to 0.84	-0.62 to 0.63
Systematic difference (p-value)	0.62	0.79
Overall ICC	0.95(0.92-0.96)	0.97(0.96-0.98)
ICC for BMI≥30 Kg/m^2	0.97(0.90-0.98)	0.98(0.95-0.99)
ICC for GA≥37 weeks	0.96(0.93-0.98)	0.97(0.95-0.98)

ICC=Interclass Correlation Coefficient; BMI=Body Mass Index; GA= Gestational Age

Figure 1. Ultrasound evaluation of the Obstetric Conjugate (OC). The ultrasound probe is longitudinally placed above the level of the symphysis and the **interpubic fibrocartilaginous disk (S)** is visualized. Then the **promontory (P)** was identified as the most prominent segment of the sacral vertebral column. The OC is measured as the distance between the inner edge of the interpubic disk and the promontory



419x594mm (72 x 72 DPI)

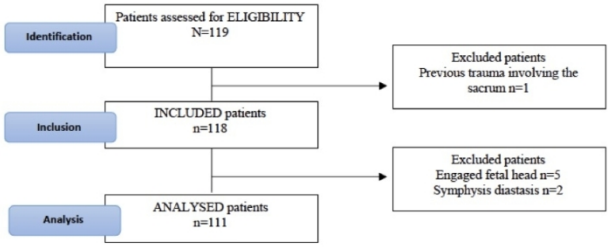


Figure. 2. Flow-chart of the included cases

419x594mm (72 x 72 DPI)

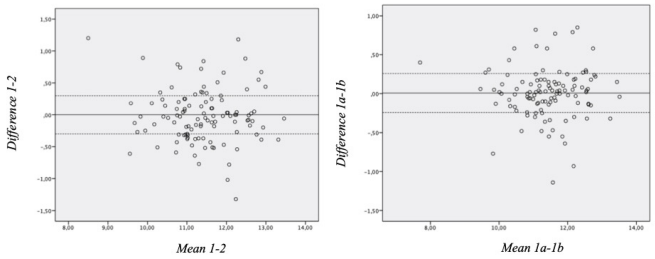


Figure 3. Bland-Altman plots of inter-(a) and intra(b)-observer variation in the measurement of the Obstetric Conjugate

419x594mm (72 x 72 DPI)