The Journal of Maternal-Fetal and Neonatal Medicine, 2012; 25(3): 253–256

ISSN 1476-7058 print/ISSN 1476-4954 online
DOI: 10.3109/14767058.2011.569616

informa
healthcare

Influence of maternal body mass index and gestational age on accuracy of first trimester gender assignment

NICHOLAS BEHRENDT[1], PAMELA FOY[2], JENNIFER CENTER[2], & CELESTE P. DURNWALD[2]

[1]*Department of Obstetrics and Gynecology, University of Colorado School of Medicine, Aurora, Colorado, USA and* [2]*Department of Obstetrics and Gynecology, The Ohio State University, Columbus 43210, USA*

Abstract

Objective. To determine the influence of maternal body mass index (BMI) and gestational age on the accuracy of image acquisition, first trimester fetal gender determination, and correct assignment.

Methods. Women presenting for first trimester aneuploidy risk assessment at 11^0 to 13^6 weeks were prospectively enrolled. A mid-sagittal view of the fetus including the genital tubercle was obtained. The angle of the genital tubercle was measured with male assigned for angle $>30^\circ$, female $<10^\circ$, and indeterminate if 10–30°. This was compared with gender at birth. The influence of maternal and pregnancy characteristics on both image acquisition and correct gender assignment were evaluated.

Results. A total of 256 women with 260 fetuses undergoing first trimester risk assessment were enrolled. The genital tubercle was identified in 247/260 (95%) of cases. Image acquisition was negatively influenced by increasing maternal BMI and early gestational age (34.8 ± 7.7 vs. 27.0 ± 6.1 kg/m^2, $p < 0.0001$ and 12.3 ± 0.5 vs. 12.6 ± 0.5 weeks, $p = 0.02$). Gender was assigned in 93.1% and correctly matched in 85.8% of fetuses. Positive predictive value (PPV) for male and female fetuses were 88.9% and 79.8%, respectively. Correct gender assignment was more likely in male compared with female fetuses (91.4 vs. 80.5%, $p = 0.02$).

Conclusion. Increasing maternal BMI negatively influences image acquisition during the first trimester for gender determination, but does not decrease the accuracy of correct gender assignment if the image is obtained.

Keywords: *Gender assignment, genital tubercle, first trimester ultrasound*

Introduction

In utero assessment of fetal gender is important to many expectant parents, with social as well as genetic implications. Accurate determination of fetal gender in the first trimester may offer the opportunity for early intervention in fetuses affected by sex-linked disorders such as fragile-X, hemophilia, Duchene's muscular dystrophy in addition to other diseases such as congenital adrenal hyperplasia. Diagnostic procedures such as amniocentesis and chorionic villus sampling are offered to women with at-risk pregnancies, but they are invasive and associated with some, albeit small, risk of pregnancy loss of 1 in 300–500 [1]. Traditional gender assignment is performed during the anatomic survey between the 17th and 22nd week of gestation when differentiation of the fetal sex organs is more readily established with greater than 97% accuracy [2]. However, as maternal body mass index (BMI) increases, visualization of fetal anatomy decreases and the rate of completion of the anatomic survey can be as low as 50% [3,4].

With the advent of more sophisticated ultrasound technology, attempting earlier gender assignment has been proposed especially in light of the growing popularity of first trimester risk assessment for the most common chromosomal abnormalities, Trisomy 21, 13, and 18 [5]. Since fetal gender differentiation does not begin until at least the 9th week in utero [6], this test is timed very close to the cusp of external genitalia development. Previous studies have shown that first and early second trimester ultrasound can be used to determine fetal gender with accuracy greater than 90% [7–10]. To date, factors that may affect image acquisition and accuracy of gender assignment during first trimester ultrasound have not been completely explored. The objective of our study was to assess the accuracy of fetal gender determination in the first trimester, and assess whether increasing maternal BMI and an earlier gestational age at examination may influence the ability to both obtain an adequate image and correctly assign gender.

Methods

With Institutional Review Board Approval, we performed a prospective, observational study of pregnant women undergoing first trimester risk assessment for aneuploidy at The Ohio State University. All pregnant women presenting between 11^0 to 13^6 weeks for first trimester screen with a planned delivery at our academic medical center were offered participation. Informed consent was obtained.

All examinations were performed transabdominally on Medison Accuvix machines with a 4–6 MHz curvilinear transducer using the harmonics setting. After crown rump

(Received 21 December 2010; revised 1 February 2011; accepted 23 February 2011)

Correspondence: Dr Celeste P. Durnwald, Department of Obstetrics and Gynecology, The Ohio State University, 395 West 12th Avenue, Room 544, Columbus 43210, USA. E-mail: celeste.durnwald@osumc.edu

length and nuchal translucency were measured, an additional sagittal image of the fetus identifying the fetal genital tubercle was obtained. Images in which the fetus was either hyper-extended or hyperflexed were excluded. The angle of the tubercle was then measured in the mid-sagittal plane in relation to a horizontal line drawn through the lumbosacral skin surface using a protractor, as previously described by Efrat et al. [8]. An angle of $>30^\circ$ was assigned male gender (Figure 1) and an angle $<10^\circ$ from the lumbosacral skin surface was assigned female (Figure 2) [8]. An angle between 10° and $\leq 30^\circ$ was categorized as indeterminate [8]. Images in which the genital tubercle could not be identified were considered unobtainable. The genital tubercle angle was drawn and measured independently by two examiners blinded to the other's result. A third examiner reviewed the measurements of both examiners for agreement. Cases in which a discrepancy existed between the two initial examiners ($n=8$) were reviewed jointly and subsequently assigned to the appropriate category.

Infant gender at the time of birth was then compared with gender determination at the time of the first trimester ultrasound. Maternal clinical characteristics such as age, race, parity, and BMI at the time of first trimester ultrasound were collected. BMI was categorized according to WHO guidelines: underweight <18.5 kg/m^2, normal 18.5–24.9 kg/m^2, overweight 25–29.9 kg/m^2, and obese $\geq$ 30 kg/m^2. Pregnancy characteristics such as fetal crown rump length, placental location, and gestational age at the time of ultrasound were recorded.

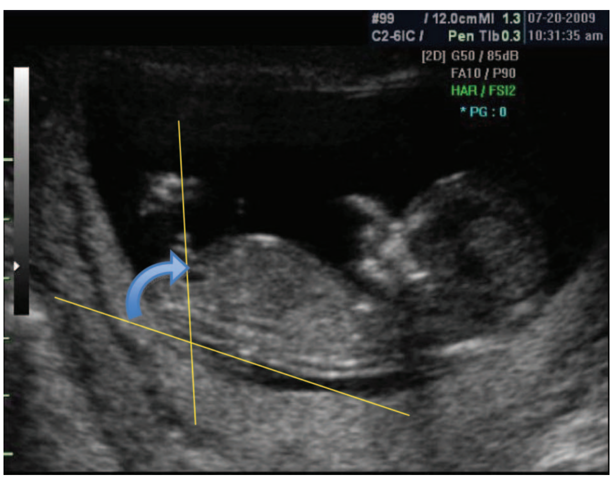

Figure 1. Genital tubercle measurement indicating male assignment.

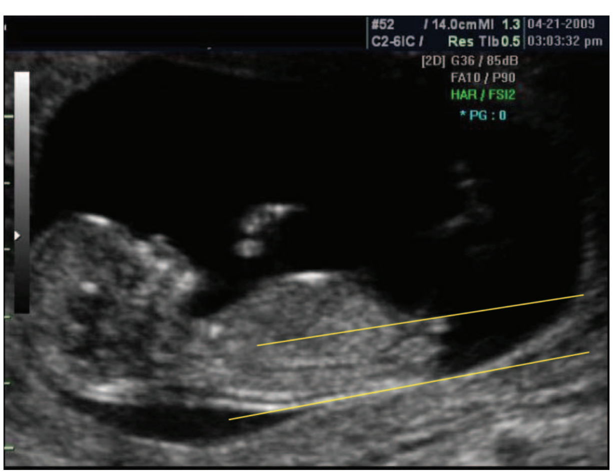

Figure 2. Genital tubercle measurement indicating female assignment.

Statistical analysis was conducted with Statview 4.0 (SAS Institute Inc, Cary, NC). Positive predictive value of first trimester gender assignment was calculated. Chi square test and *t*-test were used for nominal and continuous variables, where appropriate. Regression analysis was used to influence maternal parity, BMI, placental location, gestational age at examination, and fetal gender on the accurate identification of first trimester gender assignment. A two-tailed p value of <0.05 was considered significant.

Results

During the study period, 256 women with 260 fetuses undergoing first trimester aneuploidy risk assessment were prospectively studied. Of those studied, 81.6% were Caucasian and 57.6% were multiparous. Mean maternal age and BMI were 32.9 ± 5.0 years and 27.4 ± 6.5 kg/m^2, respectively. A total of 28% of women studied had a BMI $\geq$30 kg/m^2. Four women had twin gestations. Mean gestational age at first trimester ultrasound was 12.3 ± 0.5 weeks.

Adequate image acquisition was obtained in 247/260 (95%) of fetuses. In 13 fetuses, the genital tubercle could not be visualized. Seven of these infants were female and six were male. First trimester gender was assigned in 242/260 (93.1%) of fetuses. Five fetuses had indeterminate measurements. Three of these infants were male and two were females. Three women had non-continuing pregnancies by the second trimester. Clinical characteristics influencing correct image acquisition for first trimester gender assignment are listed in Table I. Women for whom images could not be obtained had a significantly higher BMI and were at an earlier gestational age compared to those with adequate image acquisition. When analyzed according to BMI category, there was a progressive decrease in the ability to obtain the genital tubercle measurement with advancing BMI category as follows: underweight (100%), normal (99.1%), overweight (96%), and obese (87.7%), $p=0.006$.

Gender was correctly matched in 205/239 (85.8%) of fetuses. Positive predictive value for male fetuses was 88.9%. Positive predictive value for female fetuses was 79.8%. Correct gender assignment was more likely in male compared with female fetuses (91.4% vs. 80.5%, $p=0.02$). Clinical characteristics influencing the accuracy of first trimester gender determination compared with fetal gender assignment at the anatomic survey are shown in Table II. Gender assignment was more accurate when ultrasound was performed at a later gestational age. Maternal age, BMI, and

Table I. Clinical characteristics influencing correct image acquisition for first trimester fetal gender assignment.

	Image obtained, ($n=247$)	No image obtained, ($n=13$)	p
Maternal age (years)*	32.9 ± 5.0	33.5 ± 5.4	0.69
BMI (kg/m^2)*	27.0 ± 6.1	34.8 ± 7.7	<0.0001
Gestational age (weeks)*	12.6 ± 0.5	12.3 ± 0.5	0.02
Anterior placentation (%)	38.9	46.2	0.28
Multiparous (%)	58.3	53.8	0.75

*Mean $\pm$ SD.

Table II. Clinical characteristics influencing accuracy of first trimester fetal gender assignment compared with infant sex determination at birth.

	Correct identification of gender, (n = 205)	Incorrect identification of gender (n=34)	p
Maternal age (years)*	33.2 ± 4.8	31.5 ± 5.6	0.08
BMI (kg/m^2)*	27.1 ± 6.2	26.2 ± 6.4	0.44
Multiparous (%)	58.5	58.8	0.97
Gestational age (weeks)*	12.3 ± 0.5	12.1 ± 0.5	0.03
Anterior placentation (%)	34.9	26.5	0.94

*Mean ± SD.

multiparity did not influence the ability to correctly identify fetal gender in the first trimester.

Rates of adequate image acquisition and correct first trimester gender assignment were similar between the first and the second half of the study period (97.5% vs. 92.9%, p=0.09 and 85.0% vs. 86.5%, p=0.73, respectively).

Discussion

In our study, we were able to accurately determine fetal gender in 85.8% of pregnancies studied. Our results closely reproduce the findings of previous studies, the majority by Efrat et al. that reported 85–97% accuracy in 656 pregnancies [8]. In contrast to prior studies [7–14], we did not identify a trend for improved accuracy with advancing gestation. Although Mazza et al. has shown 99–100% accuracy in those fetuses with a biparietal diameter greater than 22 mm (corresponding to 12 weeks 2 days' gestation), they reported on pregnancies through the 14th completed week of pregnancy, a time in which overall accuracy is likely to improve [14].

Our study is the first to report on the influence of maternal BMI on first trimester gender assignment. We found that women with a higher BMI had a lower rate of adequate image acquisition for genital tubercle measurement. This is similar to a recent study evaluating the effect of increasing maternal BMI on the ability to adequately visualize fetal anatomy during standard ultrasound examination between 18 and 24 weeks' gestation [4]. Dashe et al. reports that only 50% of fetal anatomic surveys could be completed during initial evaluation in an obese population [4]. In our study, we were able to identify the genital tubercle in 87.8% of the women classified as obese. Interestingly, a higher maternal BMI did not affect the ability to correctly identify gender if the appropriate image was obtained. This is in contrast to the effect seen with increasing maternal BMI and decreased detection of fetal anomalies during targeted ultrasound [15,16].

In our study, there was not a required time allowance in attempts for image capture before a case was classified as unobtainable. We must consider that sonographers were more likely to classify images as unobtainable in heavier women without giving adequate time for image capture. Also, we did not include any fetal images that were obtained using transvaginal ultrasound. In obese women, transvaginal sonography may aid in obtaining the appropriate images for genital tubercle assessment even if it may be more undesirable than the transabdominal technique. Further investigation is warranted to determine if transvaginal ultrasound improves the rate of adequate image capture. Based on our findings, women should be counseled that their weight may reduce the ability to capture the necessary image, but it is unlikely to influence the accuracy of gender assignment compared with normal weight women. However, women must also understand the limitations of gender assessment in the first trimester and that accuracy rates are not comparable to those of the anatomic survey. The gold standard for noninvasive means of fetal gender determination in utero should remain the second trimester anatomic survey.

We found a higher accuracy in the identification of male compared with female fetuses. It is plausible that examiners are able to identify the genital tubercle with greater ease when the angle of inclination is over 30°. Also, the genital tubercle may be less likely to be mistaken for other fetal structures such as the umbilical cord at such an angle. In further analysis, we were unable to attribute the difference in accuracy to determination of maternal BMI, gestational age at tubercle measurement, or any other pregnancy characteristic recorded.

To explore if accuracy of gender assignment improved with time and experience, we evaluated our results in the first and second half of the study period. We did not find a difference in either adequate image acquisition or accurate gender assignment between time periods. All sonographers were previously certified in first trimester nuchal translucency assessment and subsequently underwent training in the technique to obtain the necessary image for genital tubercle prior to implementation of the research protocol. There were periodic assessments of images, and sonographers were reeducated as necessary in technique. The skill of the sonographers, image quality review, and ongoing education may be contributing factors to the consistency of our results throughout the study period. Our results, at a large referral center, may not be generalizable to all obstetrical populations. However, the use of a standardized protocol may improve this generalizability as opposed to other studies that have not used a strict protocol [11].

Although we were able to accurately predict fetal gender during the first trimester in the majority of cases, this technique should not replace invasive testing such as chorionic villus sampling or amniocentesis which yield more reliable and accurate results or the second trimester anatomic survey. Gender determination may be appealing to women undergoing first trimester ultrasound; however, women must be counseled regarding the limitations of this technology including the negative influence increasing maternal BMI and early gestational age place on adequate image acquisition and overall accuracy of correct gender assignment.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

1. ACOG Committee on Practice Bulletins. Invasive prenatal testing for aneuploidy. ACOG Practice Bulletin No. 88. Obstetrics & Gynecology 2007;110:1179–1198.
2. Harrington K, Armstrong V, Freeman J, Aquilina J, Campbell S. Fetal sexing by ultrasound in the second trimester: maternal preference and professional ability. Ultrasound in Obstetrics and Gynecology 1996;8:318–321.
3. Thornburg LL, Miles K, Ho M, Pressman EK. Fetal anatomic evaluation in the overweight and obese gravida. Ultrasound Obstetrics and Gynecology 2009;33:670–675.
4. Dashe JS, McIntire DD, Twickler DM. Maternal obesity limits the ultrasound evaluation of fetal anatomy. Journal of Ultrasound in Medicine 2009;28:1025–1030.

5. Malone FM, Canick JA, Ball RH, Nyberg DA, Comstock CH, Bukowski R, Berkowitz RL, Gross SJ, Dugoff L, Craigo SD, Timor-Tritsch IE, Carr SR, Wolfe HM, Dukes K, Bianchi DW, Rudnicka AR, Hackshaw AK, Lambert-Messerlian G, Wald NJ, D'Alton ME For the First- and Second-Trimester Evaluation of Risk (FASTER) Research Consortium. First-trimester or second-trimester screening, or both, for Down's syndrome. New England Journal of Medicine 2005; 353: 2001–2011.
6. Migeon C, Wisniewski A. Sexual differentiation: From genes to gender. Hormone Research 1998;50:245–251.
7. Mileke G, Kiesel L, Baecksch C, Erz W, Gonser M. Fetal sex determination by high resolution ultrasound in early pregnancy. European Journal of Ultrasound 1998;7:109–114.
8. Efrat Z, Perri T, Ramati E, Tugendereich D, Meizner I. Fetal gender assignment by first-trimester ultrasound. Ultrasound in Obstetrics & Gynecology 2006;27:619–621.
9. Efrat Z, Akinfenwa O, Nicolaides K. First-trimester determination of fetal gender by ultrasound. Ultrasound in Obstetrics & Gynecology 1999;13:305–307.
10. Whitlow B, Lazanakis, M, Economides D. The sonographic identification of fetal gender from 11 to 14 weeks gestation. Ultrasound in Obstetrics & Gynecology 2002;12:301–304.
11. Hsiao C, Wang H, Hsieh C, Hsu J. Fetal gender screening by ultrasound at 11 to 13 + 6 weeks. Acta Obstetricia et Gynecologica 2008;87:8–13.
12. Chelli D, Methni A, Dimassi K, Boudaya F, Sfar E, Zouaoui B, Chelli H, Chennoufi M. Fetal sex assignment by first trimester ultrasound: a Tunisian experience. Prenatal Diagnosis 2009; 29:1145–1148.
13. Mazza V, Falcinelli C, Paganelli S, Contu G, Mantuano S, Battafarano S, Forabosco A, Volpe A. Sonographic early fetal gender assignment: a longitudinal study in pregnancies after in vitro fertilization. Ultrasound in Obstetrics & Gynecology 2001;17:513–516.
14. Mazza V, Di Monte I, Pati M, Contu G, Ottolenghi C, Forabosco A, Volpe A. Sonographic biometrical range of external genitalia differentiation in the first trimester of pregnancy: analysis of 2593 cases. Prenatal Diagnosis 2004;24:677–684.
15. Dashe JS, McIntire DD, Twickler DM. Effect of maternal obesity on the ultrasound detection of anomalous fetuses. Obstetrics & Gynecology 2009;113:1001–1007.
16. Aagaard-Tillery KM, Flint PT, Malone FD, Nyberg DA, Collins J, Comstock CH, et al. Influence of maternal BMI on genetic sonography in the FaSTER trial. Prenatal Diagnosis 2010;30:14–22.