Ultrasound in Med. & Biol., Vol. 39, No. 9, pp. 1552–1559, 2013

0301-5629/$ - see front matter

http://dx.doi.org/10.1016/j.ultrasmedbio.2013.02.003

● *Original Contribution*

MEASURING FETAL VOLUME DURING LATE FIRST TRIMESTER BY THREE-DIMENSIONAL ULTRASONOGRAPHY USING VIRTUAL ORGAN COMPUTER-AIDED ANALYSIS

Daniela A. Barra,*† Jailson C. Lima,*† Francisco Mauad Filho,*† Edward Araujo Júnior,‡ and Wellington P. Martins*†

*Department of Obstetrics and Gynecology, Medical School of Ribeirao Preto, University of Sao Paulo (DGO-FMRP-USP), Ribeirao Preto, Brazil; †Ultrasonography and Retraining Medical School of Ribeirao Preto (EURP), Ribeirao Preto, Brazil; and ‡Department of Obstetrics, Sao Paulo Federal University (UNIFESP), Sao Paulo, Brazil

(*Received 27 August* 2012; *revised* 2 *February* 2013; *in final form* 7 *February* 2013)

Abstract—Our aim was to determine whether rotating the fetus over its largest axis and reducing the rotational step angle can improve reliability/agreement of fetal volume measurements obtained with three-dimensional ultrasonography (3-DUS). Two observers acquired three 3-DUS data sets for a fetus with a crown–rump length between 45 and 84 mm. These observers determined the fetal volume using virtual organ computer-aided analysis (VOCAL), by three different methods, with a rotational step angle of 30°: (1) minimal manipulation of the 3-DUS data set, fetus rotated over any axis; (2) manipulation of the 3-DUS data set until the fetus could be seen in a standardized manner, fetus rotated over its anteroposterior axis; (3) same 3-DUS data set manipulation, fetus rotated over its longitudinal axis. Intra- and inter-observer reliability/agreement was determined with intra-class correlation coefficients and limits of agreement. In addition, we tested the method that provided the best reliability/agreement results using 15° and 9° of rotational step angles. The time taken to manipulate 3-DUS and determine fetal volume was recorded. The best intra- and inter-observer reliability/agreement results were observed when the fetus was rotated over its longitudinal axis. Reducing rotational step angle to 15° or 9° did not further improve reliability/agreement. The observer took approximately 1 min to determine fetal volume using this method. Our findings indicate that fetal volume should be determined by rotating the fetus over its longitudinal axis, at a rotational step angle of 30°, which is relatively fast and allows analysis of fetal volume with good reliability and agreement. (E-mail: wpmartins@gmail.com) © 2013 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Ultrasonography, Gestational age, Three-dimensional imaging, Reproducibility of results.**

INTRODUCTION

Accurate pregnancy dating is essential for the correct diagnosis of either prolonged pregnancy or pre-mature labor (American College of Gynecologists [ACOG] 2004; Thorsell et al. 2008). Crown–rump length (CRL) during the first trimester of pregnancy is currently considered the best determinant of gestational age (Chalouhi et al. 2011), with relatively good precision: ±7 d (Grange et al. 2003; Schmidt et al. 1981).

Fetal volume (FV), obtained using three-dimensional ultrasonography (3-DUS), is another biometric measurement that can be used to date pregnancy (Blaas et al. 1998, 2006; Falcon et al. 2005b; Martins et al. 2008). It is postulated that FV improves precision in predicting gestational age for two reasons: (1) the weekly relative increase in FV is higher than that in CRL (Falcon et al. 2005b); (2) FV is likely to be less dependent on fetal attitude/movements than CRL, particularly after 10 wk of gestation (Martins et al. 2008, 2009). Probably because of these differences, FV has been shown to be better than CRL in evaluating early growth impairment in chromosomally abnormal fetuses (Falcon et al. 2005a). Despite these possible advantages, FV is not routinely assessed during the first trimester of pregnancy, probably because FV measurement requires more expensive ultrasound machines, specific training, additional scan time to acquire data sets and the additional time needed to analyze these data sets using specific software (Martins 2012).

Address correspondence to: Wellington P. Martins, Department of Obstetrics and Gynecology, Medical School of Ribeirao Preto, University of Sao Paulo (DGO-FMRP-USP), Av. Bandeirantes 3900, Hospital das Clinicas FMRP-USP, 8 Andar, Ribeirao Preto, Sao Paulo CEP 14048–900, Brazil. E-mail: wpmartins@gmail.com

The authors declare no conflicts of interest.

One of the most frequently used methods of assessing fetal volume is a rotational method called virtual organ computer-aided analysis (VOCAL) (Cheong et al. 2009, 2010; Falcon et al. 2005a, 2005b, Martins et al. 2008, 2009; Smeets et al. 2011). This method has proven validity in the measurement of small organic tissues (Martins et al. 2007) and small *in vitro* structures (Raine-Fenning et al. 2003). Additionally, the FV results obtained using VOCAL are comparable to those obtained using other methods, such as multiplanar and extended imaging VOCAL (Cheong et al. 2009).

When using VOCAL to estimate FV, the observer is required to make several choices. One important choice is rotational step angle. The number of planes needed to delineate fetal contour until FV measurement is dependent on rotational step angle: 30° = 6 planes, 15° = 12 planes, 9° = 20 planes. Therefore, it is faster to determine a volume using larger rotational step angles (Martins et al. 2006). However, there is some concern over possible increases in random error when using larger rotational step angles, particularly when measuring irregular objects; the reliability of endometrial volume assessment was better when rotational step angles ≤15° were used rather than a 30° angle or the multiplanar method (Martins et al. 2006, Raine-Fenning et al. 2002). These findings might not be applicable to FV, as there are large differences between the fetus and the endometrium, in both shape and surrounding echogenicity. Currently, there is a great heterogeneity among studies with respect to rotational step angle: angles of 30° (Falcon et al. 2005a, 2005b), 18° (Cheong et al. 2009), 15° (Martins et al. 2008, 2009) and even 9° (Smeets et al. 2011) have been used. It is possible that using a larger rotational step angle will not jeopardize the reproducibility of FV, particularly if the fetus is rotated through its largest axis, because the changes in fetal contour between planes will be small.

In this study our aim was to evaluate whether rotating the fetus over its largest axis and reducing the rotational step angle improve the reliability/agreement of FV measurements. We also sought to compare the times taken to measure FV using the different methods.

METHODS

Study design and settings

We designed an observational study to compare the reliability/agreement of different methods of measuring FV. All exams were performed at the Maternidade do Complexo Aeroporto (Ribeirao Preto, Sao Paulo, Brazil) during 2008 and 2009. The research protocol was approved by the local institutional review board, and all participants were asked to sign an informed consent before being included in this study.

Participants

To be eligible, pregnant womean had to be literate, between 18 and 40 y and undergoing their first-trimester ultrasonography, and the fetus had to have a CRL between 45 and 84 mm and have no identified fetal malformation or nuchal translucency (NT) ≤ 2.5 mm. After completion of the routine first-trimester ultrasonography, pregnant women who met the eligibility criteria were invited to participate.

Observers and ultrasound scans

Two physicians were included as observers: Daniela A. Barra (Ob1), specialist in obstetrics and gynecology, with 8 y experience in ultrasonography and 4 y of experience in 3-DUS; Jailson C. Lima (Ob2), specialist in obstetrics and gynecology, with 6 y of experience in ultrasonography and 2 y experience in 3-DUS. All exams were performed using a Voluson 730 Expert (GE Healthcare, Zipf, Austria) equipped with a 4- to 7-MHz transabdominal probe (3-D4–7 EK). Ob1 acquired a 3-DUS data set on the whole fetus, in the absence of Ob2, and then left the exam room; Ob2 entered the room, acquired a 3-DUS data set and left the exam room; finally Ob1 entered the room and acquired another 3-DUS data set. These 3-DUS data sets were acquired using a sweep angle of 60° and highest quality. All 3-DUS data sets were stored for later analysis. All operators followed the ALARA (as low as reasonably achievable) principle in conducting ultrasound scans, maintaining the thermal index (TI) and mechanical index (MI) at or below 0.5; the maximum observed TI was 0.1 and the maximum observed MI was 0.5.

Fetal volume measurement

Fetal volumes were measured using 4-D View software (GE Healthcare) in personal computers. Ob1 performed two sets of FV measurements for each fetus: one for each of the two 3-DUS data sets previously acquired by this observer. Ob2 performed one set of FV measurements for each fetus using the only 3-DUS data set acquired. During the first analysis by Ob1, the time from opening of the 3-DUS data set to completion of FV measurement was recorded.

Fetal volume measurements were performed using three methods:

1. **Unmodified multiplanar view.** The 3-DUS was minimally manipulated before measuring FV, with the reference (central) point placed in the center of the fetal chest (Fig. 1). Fetal contour was delineated using any plane, randomly chosen by the observer. After FV was measured using the unmodified multiplanar view (UMV), the 3-DUS data set was set to the original by clicking “Init.”
2. **Standardized multiplanar view-A.** The initial data set was again manipulated until a standardized