International Journal of Gynecology and Obstetrics 133 (2016) 98–102

Contents lists available at ScienceDirect

International Journal of Gynecology and Obstetrics

journal homepage: www.elsevier.com/locate/ijgo

www.figo.org

CLINICAL ARTICLE

Ductus venosus blood flow velocity waveforms during the early second trimester of pregnancy in a Thai population

Manaphat Suksai [a,*], Chitkasaem Suwanrath [a], Ounjai Kor-anantakul [a], Thitima Suntharasaj [a], Ninlapa Pruksanusak [a], Alan Geater [b]

[a] Department of Obstetrics and Gynecology, Faculty of Medicine, Prince of Songkla University, Songkhla, Thailand
[b] Epidemiology Unit, Faculty of Medicine, Prince of Songkla University, Songkhla, Thailand

ARTICLE INFO

Article history:
Received 29 March 2015
Received in revised form 7 September 2015
Accepted 11 January 2016

Keywords:
Doppler ultrasonography
Ductus venosus
Pregnancy
Reference range
Second trimester

ABSTRACT

Objective: To establish reference ranges for ductus venosus (DV) blood flow velocities and indices during the early second trimester. *Methods:* A cross-sectional DV Doppler study of fetuses at 15–22 weeks of gestation was conducted at Songklanagarind Hospital, Songkhla, Thailand, during 2013–2014. The peak forward velocities were recorded and the DV indices were calculated. Predicted reference ranges based on the 5th and 95th percentiles according to the week of gestation were constructed. *Results:* Among 371 fetuses, measurement of DV Doppler waveforms in the sagittal plane was achieved in 97.5% of cases. With advancing pregnancy (weeks 15 to 22), the DV velocities during ventricular systole, early diastole, and atrial contraction increased from 47.48 cm/s to 68.22 cm/s, 42.23 cm/s to 60.52 cm/s, and 15.94 cm/s to 34.84 cm/s, respectively. The time-averaged maximum value increased from 37.61 cm/s to 55.42 cm/s. The DV indices—pulsatility index for the vein, peak velocity index for the vein, preload index, and systolic/a-wave ratio—decreased from 0.79 to 0.59, 0.71 to 0.53, 0.63 to 0.47, and 2.72 to 1.90, respectively. The systolic/diastolic ratio remained relatively constant at 1.12. *Conclusions:* Normal reference ranges for DV flow velocities and indices during the early second trimester were established.

1. Introduction

The ductus venosus (DV) is a major branch of the umbilical vein that traverses the liver to enter the inferior vena cava directly. It carries well-oxygenated blood directly to the heart. DV Doppler velocity and waveform are useful for the evaluation of the fetus throughout pregnancy. Doppler sonographic findings for the DV consist of a maximum forward flow during ventricular contraction (S-wave), a maximum forward flow during early ventricular filling (D-wave), and the lowest flow during atrial contraction (a-wave). Previous studies in the first and early second trimesters have reported the detection of chromosomal abnormalities on the basis of these variables, with sensitivities of 65%–90% [1–4]. Abnormal DV waveforms could be a consequence of delayed maturation of the cardiovascular system, fetal chromosomal abnormalities without cardiac malformations [1,5], cardiac dysfunction from congenital cardiac anomalies [6], or fetal growth restriction.

Normal reference ranges of DV velocity have been studied. Most studies have focused on the second half of pregnancy to detect fetal compromise from placental insufficiency [7–9]. Only three studies [10–12] have been published on the early second-trimester period and these have yielded conflicting results in terms of the systolic/diastolic (S/D) ratio. Therefore, the present study was conducted to establish normal ranges for Thai fetuses. These ranges could, in the future, be used as an adjunct to identify fetuses with chromosomal abnormalities.

2. Materials and methods

A prospective, cross-sectional study was conducted between November 1, 2013, and March 31, 2014, after approval by the Ethics Committee, Faculty of Medicine, Prince of Songkla University, Songkhla, Thailand. Women with singleton pregnancies who attended the Maternal-Fetal Medicine Unit of the Department of Obstetrics and Gynecology at Songklanagarind Hospital, Songkhla, Thailand, for an amniocentesis indicated by advanced maternal age and for second-trimester screening were recruited. The perinatal outcomes were documented. Pregnancies in which the fetus had a structural or chromosomal abnormality, and those resulting in fetal growth restriction, fetal death, pregnancy loss, or preterm birth were excluded from the study. All women provided informed consent to undergo Doppler flow examination of the DV and to participate in the present study.

The gestational age was calculated from reliable menstrual histories and confirmed by first-trimester crown–rump length measurement [13] or assessment of fetal biometry measures in the early second trimester, including biparietal diameter, head circumference, abdominal circumference, and femur length [14]. The gestational age was

* Corresponding author at: Department of Obstetrics and Gynecology, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla, 90110, Thailand. Tel.: +66 74451201; fax: +66 74429671.
E-mail addresses: s.manaphat@gmail.com, smanapha@medicine.psu.ac.th (M. Suksai).

http://dx.doi.org/10.1016/j.ijgo.2015.09.021
0020-7292/

recalculated on the basis of ultrasonography when there was a discrepancy of more than 7 days between the menstrual age and the predicted age determined by crown–rump length measurement, and when there was a discrepancy of more than 10 days between the menstrual age and the predicted age determined by the biometry variables.

Targeted ultrasonography with DV Doppler flow measurement between weeks 15 and 22 of gestation was performed by an appropriately trained and experienced specialist using the Voluson E8 (GE Healthcare, Milwaukee, WI, USA) or the Xario 200 TUS-X200 (Toshiba Medical Systems, Otawara-shi, Japan) ultrasonography system after adjustment of the Doppler velocity scale, gain, and wall filter while fetal breathing and body movements were absent. The Doppler measurements of the DV were obtained from the anterior lower fetal abdomen in the sagittal plane to achieve the best alignment with the isthmus. The DV was first identified by color flow mapping and the pulsed Doppler gate was then adjusted to the vessel diameter. The following waveforms were recorded using a maximum insonation angle of 30°: peak forward velocity during ventricular systole (S-wave), peak forward velocity during early diastole (D-wave), and lowest forward velocity during atrial contraction in late diastole (a-wave) (Fig. 1). For each waveform, the mean value of three consecutive high-quality measurements was used for analysis. In addition, the time-averaged maximum velocity (Tamx) was calculated and the following DV indices were determined: pulsatility index for the vein (PIV), calculated as (S–a)/Tamx; peak velocity index for the vein (PVIV), calculated as (S–a)/D; preload index (PLI), calculated as (S–a)/S; S/a ratio [5]; and S/D ratio.

For the statistical analysis, the distribution of each blood flow velocity and DV index was examined using scatter plots against the gestational age. Median regression of each index on centralized values of gestational age (actual gestational age minus mean gestational age) was then performed, and transformations were made to achieve approximate symmetry around the median regression line (square transformation for the PVIV and PLI, inverse square root transformation for the S/a ratio, and inverse square transformation for the S/D ratio). The 5th and 95th regression lines were then constructed, constrained to have the same slope as the median line on the basis of the following calculation: median regression line plus/minus 1.64 times the SD of the residuals from the median regression. The distributions were displayed graphically showing the raw or back-transformed data and the raw or back-transformed median, 5th, and 95th percentile regression lines plotted against the gestational age. Because of the descriptive nature of the study, no tests of statistical significance were performed. All analyses were performed using Stata version 10.0 (StataCorp, College Station, TX, USA).

3. Results

A total of 408 pregnant women were enrolled in the present study. Measurement of the DV Doppler waveforms in the sagittal plane during the second trimester was successful in 398 (97.5%) women. Thirty-seven women were excluded from the analysis owing to inability to obtain good-quality waveforms (n = 10), chromosomal abnormalities (n = 5), pregnancy loss (n = 2), preterm birth (n = 15), and fetal growth restriction (n = 5). The data from the remaining 371 women with normal second-trimester ultrasonography and a normal fetal karyotype in the setting of advanced maternal age with subsequent uneventful obstetric outcome were used to establish the reference ranges.

Table 1
Demographic data and pregnancy outcomes (n = 371).[a]

Variable	Value
Age, y	31.99 ± 5.86
Ethnic origin	
Thai	371 (100.0)
Other	0
Parity	
Primigravida	161 (43.4)
Multigravida	210 (56.6)
Body mass index [b]	23.40 ± 4.06
Gestational age at delivery, wk	38.87 ± 1.05
Birth weight, g	3164.40 ± 351.10

[a] Values are given as mean ± SD or number (percentage).
[b] Calculated as weight in kilograms divided by the square of height in meters.

The mean maternal age of the participants was 32 years. All women were Thai nationals without medical complications and nonsmokers. The average number of participants for each week of gestation was 46, ranging from 41 to 53. The mean gestational age at the time of Doppler measurement was 18.89 ± 2.25 weeks. The mean gestational age at delivery was 38.87 ± 1.05 weeks, and the mean birth weight was 3164.4 ± 351.1 g (Table 1).

The best-fitting regression equations for the different DV velocities and indices, if necessary after transformation and back-transformation, are presented in Table 2. The DV velocities increased with advancing pregnancy. The predicted reference ranges of the DV blood flow velocities in relation to the gestational age are shown in Fig. 2 and Table 3. With regard to the DV indices, the PIV, PVIV, PLI, and S/a ratio decreased, whereas the S/D ratio remained constant. The predicted reference ranges are presented in Fig. 3 and Table 4.

4. Discussion

During the early second trimester of pregnancy, the maximum DV flow velocity during ventricular systole, early diastole, and atrial contraction, as well as the Tamx increased considerably with advancing pregnancy. By contrast with the flow velocity, the calculated DV Doppler indices (PIV, PVIV, PLI, and S/a) decreased remarkably. The S/D ratio remained relatively constant.

The reference values and patterns identified in the present study are in accordance with data from previous reports [10,11], although they differ in some details such as that the present ranges are narrower than those previously published (except for the a-wave), possibly because of differences in the measurement technique, the ultrasonography equipment, the ethnic origin of the population, or because of limited sample sizes in previous studies. Previous studies [10,11] have yielded conflicting results with regard to the relationship between ventricular systole and diastole. In the present study, the S/D ratio was stable throughout the early second trimester, similar to the results

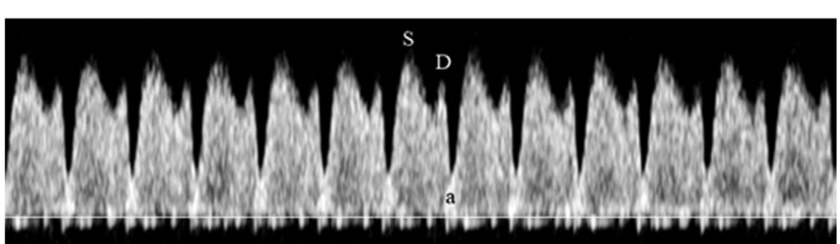

Fig. 1. The ductus venous waveforms. The S-wave and D-wave represent the peak forward velocity during ventricular systole and diastole, respectively. The a-wave depicts the lowest forward velocity during atrial contraction.