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Learning curve for Doppler assessment of ductus venosus flow at 11 + 0 to 13 + 6 weeks' gestation

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KEYWORDS: Doppler ultrasound; ductus venosus; first-trimester screening; trisomy 21

ABSTRACT

Objective *To determine the number of scans necessary for training sonographers to examine accurately the ductus venosus at 11 + 0 to 13 + 6 weeks' gestation.*

Methods *Ten sonographers with prior extensive experience in the measurement of nuchal translucency thickness were given practical training in the accurate assessment of the ductus venosus. They were then asked to examine the ductus venosus during the routine 11 + 0 to 13 + 6 weeks' scan. Each scan was assessed by an experienced sonographer and classified as being successful or unsuccessful (failure to obtain a waveform, poor quality image with contamination or wrong classification of the A-wave). Each sonographer performed a total of 300 examinations, the data were analyzed in 15 groups of 20 examinations and in each group the percentage of unsuccessful examinations was calculated.*

Results *In the total 3000 cases examined by the 10 sonographers there were 2849 (95.0%) successful examinations and 151 unsuccessful, including 104 failures to obtain a waveform, 30 cases where the quality of the image was considered to be inadequate and 17 cases in which the classification of the A-wave was wrong. The overall frequency of unsuccessful examinations decreased significantly with the number of scans carried out* ($r = 0.982$, $P < 0.0001$). *The sonographers required an average of 80 examinations before they could successfully examine the ductus in at least 19 of a group of 20 scans. Although one of the 10 trainees achieved this standard within the first block of 20 scans some of the sonographers required training in 100 cases.*

Conclusion *Competence in Doppler assessment of the ductus venosus is achieved only after extensive supervised training. Copyright © 2008 ISUOG. Published by John Wiley & Sons, Ltd.*

INTRODUCTION

The ductus venosus is a unique shunt directing well-oxygenated blood from the umbilical vein to the coronary and cerebral circulation by preferential streaming through the foramen ovale into the left atrium. Blood flow in the ductus has a characteristic waveform, with high velocity during ventricular systole (S-wave) and diastole (D-wave), and forward flow during atrial contraction (A-wave). A high proportion of fetuses with trisomy 21 have increased impedance to flow in the ductus venosus at 11 + 0 to 13 + 6 weeks of gestation, manifested as absent or reversed A-wave (Table 1)[1–8].

However, assessment of the A-wave can be technically difficult because of the small size of the ductus venosus and contamination of the flow pattern from this vessel by signals from the adjacent umbilical vein, hepatic vein or inferior vena cava.

The aim of this study was to determine the number of scans necessary for training sonographers to examine accurately the ductus venosus at 11 + 0 to 13 + 6 weeks' gestation.

METHODS

This was a prospective study involving 10 sonographers who had received The Fetal Medicine Foundation Certificates of Competence in the 11 + 0 to 13 + 6 weeks' scan and in uterine and umbilical artery Doppler. The sonographers were given practical training in the accurate assessment of the ductus venosus by fulfilling the following criteria (Figures 1 and 2):

(a) the examination should be undertaken during fetal quiescence;
(b) the magnification of the image should be such that the fetal thorax and abdomen occupy the whole screen;

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Table 1 Studies reporting on the incidence of abnormal flow in the ductus venosus (DV) in first-trimester trisomy 21 and non-trisomy 21 fetuses

Reference	GA (weeks)	No. of fetuses (% with abnormal DV)	
		Trisomy 21	Non-trisomy 21
Matias *et al.*[1] (1998)	10 to 13 + 6	38 (92.1)	448 (3.1)
Antolin *et al.*[2] (2001)	10 to 13 + 6	7 (71.4)	917 (4.3)
Murta *et al.*[3] (2002)	10 to 13 + 6	18 (100)	354 (1.7)
Zoppi *et al.*[4] (2002)	10 to 13 + 6	20 (70.0)	305 (13.0)
Borrell *et al.*[5] (2003)	10 to 13 + 6	48 (75.0)	3334 (5.0)
Toyama *et al.*[6] (2004)	11 to 13 + 6	7 (71.4)	1090 (3.1)
Prefumo *et al.*[7] (2005)	11 to 14 + 1	47 (38.3)	581 (5.2)
Borrell *et al.*[8] (2005)	10 to 13 + 6	25 (76.0)	3706 (5.0)
Total		210 (71.4)	10 735 (5.0)

Abnormal flow was defined as absent or reversed A-wave or pulsatility index for veins above the 95th centile. GA, gestational age.

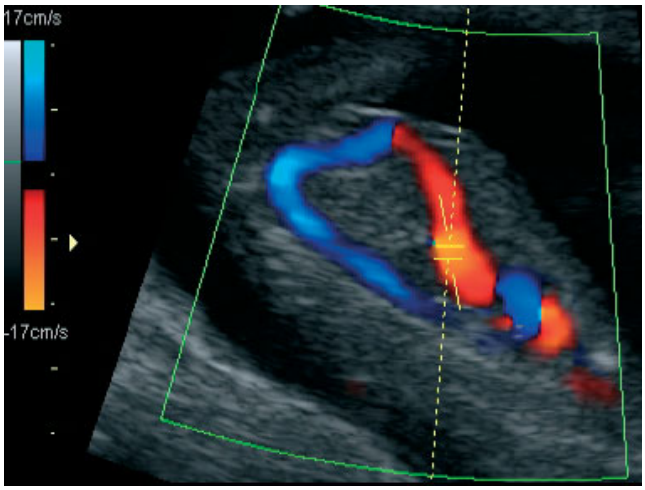

Figure 1 Right ventral mid-sagittal ultrasound image of the fetal trunk demonstrating the position of the pulsed Doppler gate for the study of ductus venosus blood flow.

(c) a right ventral mid-sagittal view of the fetal trunk should be obtained and color flow mapping should be undertaken to demonstrate the umbilical vein, ductus venosus and fetal heart;
(d) the pulsed Doppler sample should be small (0.5–1 mm) to avoid contamination from the adjacent veins, and it should be placed in the yellowish aliasing area, which is the portion immediately above the umbilical sinus;
(e) the insonation angle should be less than 30°;
(f) the filter should be set at a low frequency (50–70 Hz) so that the A-wave is not obscured; and
(g) the sweep speed should be high (2–3 cm/s) so that the waveforms are spread allowing better assessment of the A-wave.

When these criteria are satisfied, it is possible to assess the A-wave and determine qualitatively whether the flow is positive, absent or reversed.

The sonographers were asked to examine the ductus venosus during the routine 11 + 0 to 13 + 6-week scan, which is carried out transabdominally, and either to record that they were unable to do so or, if they were successful, to obtain a hard record of the waveform and to classify this according to the A-wave into normal (positive) or abnormal (absent or reversed). On a daily basis one of two highly trained sonographers examined all the images and determined whether the quality was adequate and whether the original diagnosis of normal or abnormal A-wave was correct. Consequently, each scan was assessed by the experienced sonographers as being successful or unsuccessful (failure to obtain a waveform, poor quality image with contamination or wrong classification of the A-wave).

Each sonographer performed a total of 300 examinations, the data were analyzed in 15 groups of 20 examinations and in each group the percentage of unsuccessful examinations was calculated. Regression analysis was used to examine whether successful examination of the ductus was significantly related to fetal crown–rump length (CRL) in mm, maternal ethnic origin (Caucasian, Afro-Caribbean, Asian, Oriental or mixed), body mass index (BMI) in kg/m^2 and number of scans (in chronological order from 1 to 300 for each sonographer).

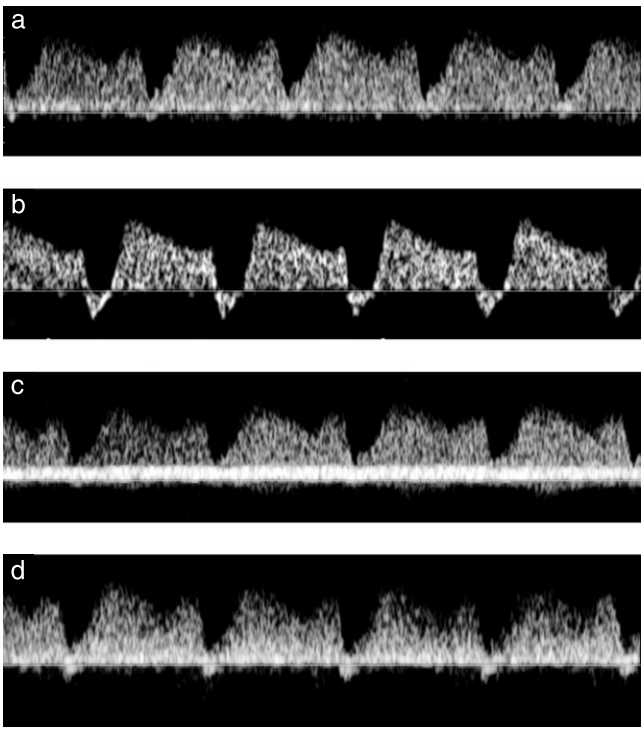

Figure 2 Flow velocity waveforms from the ductus venosus in 12-week fetuses: (a) normal waveform with positive A-wave; (b) reversed A-wave; (c) contamination from the umbilical vein, which could lead to the erroneous diagnosis of positive A-wave; and (d) contamination from the hepatic vein, which could lead to the erroneous diagnosis of reversed A-wave.

RESULTS

The 10 sonographers carried out a combined total of 3000 scans at a mean gestational age of 12 (range, 11 + 0 to 13 + 6) weeks; the median fetal CRL was 63.4 (range,

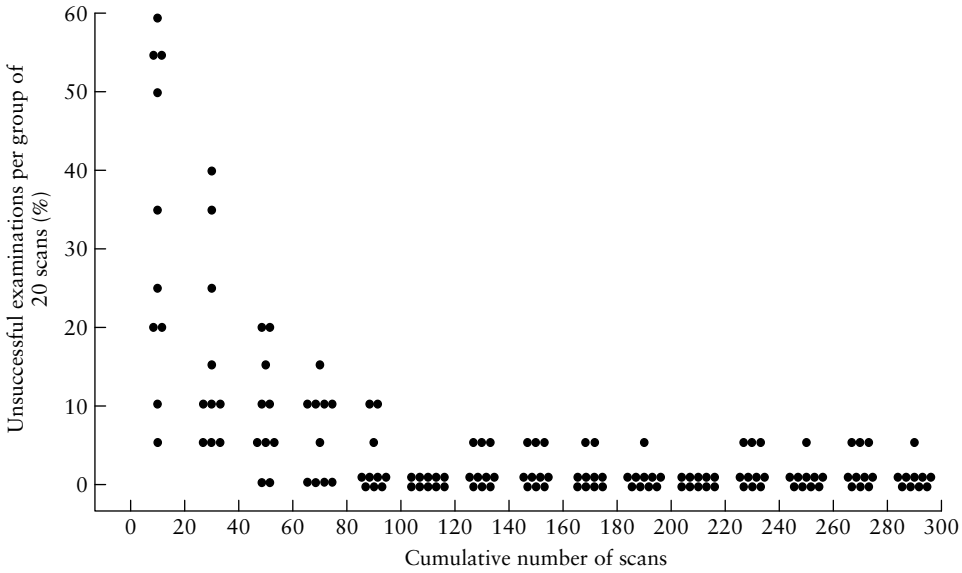

Figure 3 Frequency of unsuccessful examinations in the Doppler assessment of the ductus venosus by 10 sonographers in consecutive groups of 20 scans.

Table 2 Regression analysis in the prediction of adequate assessment of the ductus venosus

	Univariate analysis		*Multivariate analysis*	
Prediction	*Odds ratio (95% CI)*	P	*Odds ratio (95% CI)*	P
Crown–rump length (mm)	1.03 (1.006–1.052)	0.014	1.02 (0.996–1.045)	0.106
Body mass index (kg/cm^2)	0.98 (0.950–1.016)	0.302	—	—
Cumulative number of scans	1.02 (1.019–1.027)	< 0.0001	1.02 (1.019–1.027)	< 0.0001
Ethnic origin				
Caucasian	1			
Afro-Caribbean	1.09 (0.714–1.656)	0.697	—	—
Asian	1.43 (0.577–3.547)	0.440	—	—
Oriental	2.52 (0.345–18.367)	0.363	—	—
Mixed	0.66 (0.302–1.458)	0.307	—	—

45–84) mm and the median nuchal translucency (NT) thickness was 1.8 (range, 0.9–9.3) mm. The ethnic origin of the women was Caucasian in 2124 (70.8%) cases, Afro-Caribbean in 594 (19.8%), Asian in 138 (4.6%), Oriental in 48 (1.6%) and mixed in 96 (3.2%). The median maternal BMI was 24.5 (range, 15.4–53.5) kg/m^2.

In the total 3000 cases examined by the 10 trainee sonographers there were 2849 (95.0%) successful examinations (A-wave positive, $n = 2681$, absent, $n = 57$, reversed, n = 111) and 151 unsuccessful, including 104 failures to obtain a waveform, 30 cases where the quality of the image was considered to be inadequate and 17 cases in which the classification of the A-wave was wrong.

The overall frequency of unsuccessful examinations decreased significantly with the number of scans carried out ($r = 0.982$, $P < 0.0001$; Figure 3). Regression analysis demonstrated that successful examination of the ductus depended on the experience of the sonographer (defined by the cumulative number of scans) but not fetal CRL, maternal ethnic origin or BMI (Table 2).

Successful examination of at least 19 of the 20 cases was first achieved (and remained so in all subsequent groups) within the first group of 20 scans by one sonographer, after the first 40 scans by a further two, after 60 scans by a total of five and after 100 scans by all.

DISCUSSION

The findings of this study demonstrate that competence in Doppler assessment of the ductus venosus is achieved only after extensive supervised training. Sonographers with prior extensive experience in the 11 + 0 to 13 + 6 weeks' scan required an average of 80 examinations before they could successfully examine the ductus in at least 19 of a group of 20 scans. Although one of the 10 trainees achieved this standard within the first block of 20 scans, some of the sonographers required training in 100 cases. This finding is compatible with the results of two previous studies reporting that competence in the measurement of NT thickness and assessment of the nasal bone in the first-trimester scan is also achieved after a minimum of 80 scans[9,10].

The study has also shown that the impact of factors which could pose technical difficulties in achieving a

successful examination of the ductus venosus, such as high maternal BMI or low fetal CRL is insignificant compared to the level of training of the sonographers.

The high association between abnormal flow waveforms in the ductus venosus with chromosomal abnormalities makes it likely that this sonographic marker will be incorporated in first-trimester screening for trisomy 21[1–8]. Abnormal flow waveforms are found in about 70% of trisomy 21 fetuses and in 5% of chromosomally normal fetuses (Table 1). Consequently, in screening for trisomy 21 the patient-specific risk is increased by a factor of about 14-fold (70% ÷ 5%) if the A-wave is abnormal and it is reduced by a factor of 3-fold (95% ÷ 30%) if it is normal. Such a major effect on the estimated risk for trisomy 21, and inevitably on the decision for or against invasive testing, necessitates accurate assessment of the A-wave and avoidance of contamination from adjacent vessels. An absent or reversed A-wave can be wrongly classified as positive if there is contamination from the umbilical vein, and a positive A-wave can be erroneously considered to be reversed if there is contamination from the hepatic vein or inferior vena cava.

Sonographers undertaking risk assessment by Doppler examination of the ductus venosus should receive appropriate training and certification of their competence in performing such a scan. As shown in this study a good sonographer experienced in NT scanning needs to perform on average 80 scans in order to achieve this level of competence.

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