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Color Doppler twinkling artifact in fetuses with echogenic intracardiac foci: echocardiographic observation and clinical significance

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KEYWORDS: echogenic intracardiac focus/foci; fetal echocardiography; fetus; prenatal diagnosis

ABSTRACT

Objective *To evaluate echocardiographic characteristics and clinical relevance of color Doppler twinkling artifacts in fetuses with isolated echogenic intracardiac foci (EIF).*

Methods *This study included 50 fetuses with EIF, at 18–38 weeks of gestation. Echocardiographic examination, which was performed using a 1.0–5.0-MHz phased array probe, included gray-scale, color and spectral Doppler imaging. Twinkling artifacts were assessed using fetal color Doppler echocardiography on isolated EIF situated in the left and/or right ventricles. The prevalence, appearance and clinical relevance of the color Doppler twinkling artifacts were analyzed.*

Results *Eight of 50 fetuses with EIF (16%) showed color Doppler twinkling artifacts, which appeared as a rapidly changing color complex seen persistently behind the EIF. The spectra obtained in all eight with color Doppler artifacts were composed of straight vertical bands occurring in mid to late systole and early diastole. After birth, none of 50 fetuses with EIF had structural heart diseases or showed clinical signs of cardiac failure.*

Conclusions *Color Doppler twinkling artifacts from isolated EIF occur in some fetuses and may be considered as an additional echocardiographic feature of EIF. Attention should be paid to the identification and interpretation of these artifacts so that they may be accurately distinguished from true color flow generated by atrioventricular valvular regurgitation jets. Copyright © 2010 ISUOG. Published by John Wiley & Sons, Ltd.*

INTRODUCTION

Color Doppler ultrasound artifacts are frequently encountered in clinical practice. One such artifact is the color Doppler twinkling artifact, which is generated by a strong reflecting medium and was first described by Rahmouni *et al.*[1]. Since then, color Doppler twinkling artifacts have been reported to occur behind highly reflective objects, such as tissue calcifications, stones in the urinary tract and gallbladder[1–4], encrusted indwelling ureteral stents[5], strongly reflecting orbital structures[6], intracranial microcoil[7], parenchymal calcification associated with chronic pancreatitis[8] and gas accumulation on the intestinal wall in intestinal pneumatosis[9]. These artifacts appear as a rapidly changing mixture of red and blue signals and may mimic flow. Fetal echogenic intracardiac foci (EIF) are defined as small discrete structures found within the fetal heart with an echogenicity similar to that of bone, moving in synchrony with the atrioventricular valves during the cardiac cycle. Histological studies have suggested that EIF probably represent microcalcifications of the papillary muscles[10–14].

The new ISUOG consensus statement emphasizes that one of the main goals for a fetal echocardiogram is to confirm the presence or absence of cardiac disease[15]. Because color Doppler examination is considered as a mandatory component of fetal echocardiography, caution must be exercised to differentiate artifacts from true signals. This study was conducted to evaluate the echocardiographic characteristics and clinical relevance of color Doppler twinkling artifacts in fetuses with EIF.

PATIENTS AND METHODS

This prospective study consisted of 50 fetuses with isolated EIF in the left ventricles (Figure 1) and/or right ventricles

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at 18–38 weeks (28.6 ± 4.6 weeks) of gestation. Among these fetuses, 44 had single left ventricular EIF (LV-EIF), three had multiple LV-EIF and three had multiple LV-EIF with right ventricular EIF (RV-EIF). Serum screening results showed that all 50 fetuses had a low risk of chromosomal abnormality (because of technical limitations in our hospital, we could not perform fetal nuchal translucency examinations). The foci were detected via routine obstetric examination or fetal echocardiographic evaluation. Fetuses with abnormal prenatal ultrasound findings or structural cardiac diseases were excluded from the study.

All echocardiographic studies, including two-dimensional (2D) gray-scale, M-mode and color and pulsed spectral Doppler imaging, were performed using a Philips IE33 scanner (Philips Medical System, Bothell, WA, USA) equipped with a 1–5-MHz phased array probe. A relatively low frequency phased array probe was chosen because we and others[16,17] have found that this probe, which has a smaller footprint than conventionally-used curvilinear probes, allows greater accessibility to different planes thereby acquiring a broader range of diagnostic views[1,2].

Gestational age was calculated by measuring the fetal biparietal diameter and femur length. The fetal cardiac/thoracic area ratio was recorded. 2D fetal echocardiography was used to exclude a structural cardiac anomaly. M-mode directed fetal echocardiography was performed to measure the left and right ventricular free walls, interventricular septal thickness, and systolic and diastolic ventricular dimensions.

For visualization of EIF, focal zones were placed at the depth of, or slightly deeper than, the EIF, with careful control of the B-mode gain setting. For color Doppler flow imaging, a red-and-blue color map was used, and the size of the color window was adjusted to cover the EIF and adjacent ventricular cavities of concern. The color Doppler gain was set to the point just below the threshold for color noise; the color signal was used as a guide to obtain the pulsed Doppler spectrum. On color Doppler images, the presence and appearance of the artifacts were assessed using spectral Doppler echocardiography and the pattern of the spectrum was analyzed.

RESULTS

Successful measurements and Doppler recordings were obtained in all 50 fetuses. Resolution of the echogenic foci occurred by 28–32 weeks of gestation in six of 50 (12%) fetuses. Postnatal follow-up showed that none of the infants had cardiac structural malformations, clinical signs of aneuploidy or cardiac failure. Neonatal echocardiography was performed on 47 infants in the study group, 41 of whom exhibited persistent LV-EIF at the level of the chordae or the papillary muscle.

Details of fetuses with EIF and color Doppler twinkle artifacts are summarized in Table 1. On color Doppler echocardiography, the twinkle artifacts were observed in eight of 50 (16%) fetuses (Figure 2), generated from 57 observed EIF (14%). Seven fetuses with LV-EIF presented color twinkle artifacts, and one fetus with both LV-EIF and RV-EIF showed the artifact in the LV-EIF. Among the seven fetuses with color twinkle artifacts from LV-EIF, six had isolated LV-EIF, and the one fetus with multiple LV-EIF showed a color twinkle artifact from one of the LV-EIF. These artifacts appeared as rapidly changing or persistent color Doppler signals behind the EIF (Figure 2). On spectral Doppler echocardiography, spectra with noise and saturated amplitude were obtained from all eight fetuses with color Doppler twinkling artifacts. The spectra from the artifacts were composed of straight vertical bands with a clear beginning-and-end outer profile, and occurred in mid to late systole and in early diastole (Figure 3).

DISCUSSION

Color Doppler twinkling artifacts have been investigated in previous studies with respect to their formation and underlying causes[1–5]. Several causes have been proposed[1–3,18]. One possible leading cause, speculated by Ramouni *et al.*, was that rough surfaces with multiple

Table 1 Details of fetuses with echogenic intracardiac foci (EIF) and color Doppler twinkling artifacts

Characteristic	n
Fetuses with EIF	50
With color Doppler twinkling artifacts	8
Without color Doppler twinkling artifacts	42
EIF	57
Isolated LV-EIF	44
Multiple LV-EIF	6
LV- and RV-EIF	7

LV-EIF, left ventricular echogenic intracardiac focus; RV-EIF, right ventricular echogenic intracardiac focus.

Figure 1 Fetal echocardiogram in the four-chamber view in a 26-week fetus demonstrating a left ventricular echogenic intracardiac focus (arrow). LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle.

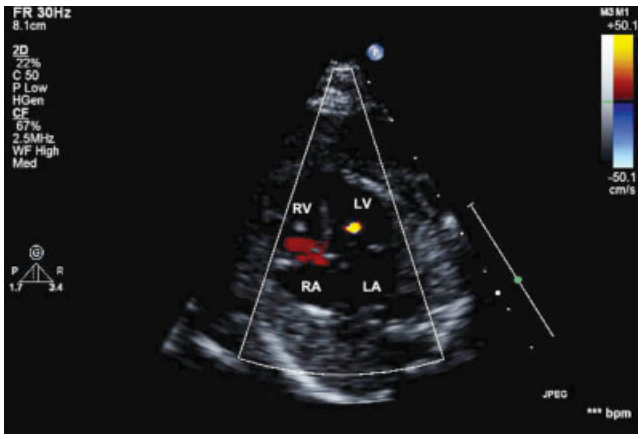

Figure 2 In the same fetus as that in Figure 1, color Doppler echocardiography shows a twinkling artifact behind the left ventricular echogenic intracardiac focus. LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle.

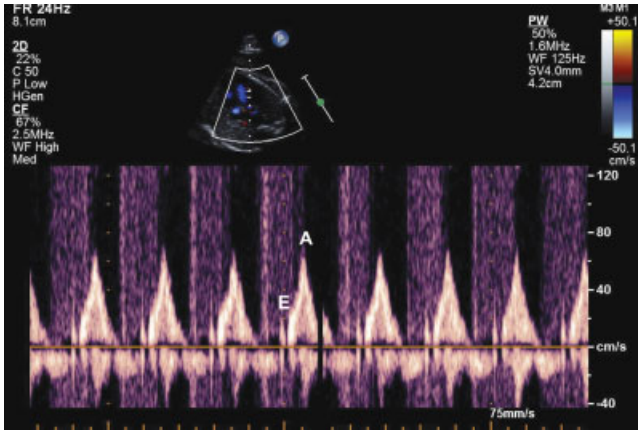

Figure 3 Pulsed Doppler echocardiogram with sample volume located on the color signal behind the left ventricular echogenic intracardiac focus revealing an artifactual spectrum composed of straight vertical bands with a clear outer profile, occurring in middle to late systole and in early diastole. The mitral valve signal shows fusion of early diastolic filling (E) and active atrial contraction (A).

reflectors split the incident ultrasound beam, creating an increased pulse duration of received radiofrequency signal that is interpreted as movement[1]. The experimental investigation carried out by Kamaya *et al.* further demonstrated that a combination of broadbanded noise introduced by phase jitter and surface roughness of the reflector can lead to the generation of color Doppler twinkling artifacts[18].

EIF have been sonographically detected in 0.46–22% of fetuses[19,20], with an overall frequency of 3.9–5.6% in the general population[21]. These structures typically measure 1–6 mm in diameter and have bone-like echogenicity. Previous studies have demonstrated that most EIF cause no hemodynamic disturbance, and when observed in a normal four-chamber view they do not seem to be associated with structural cardiac abnormalities. Histopathological findings indicate that this sonographic sign is caused by microcalcifications or mineralizations of the papillary muscle. To the best of our knowledge this is the first report of echocardiographic observations and investigation of color Doppler twinkling artifacts in fetuses with EIF. The occurrence of color Doppler twinkling artifacts in fetuses with EIF is not well documented in the literature. The likely explanation for our novel finding is that even very small calcification spots in the fetal heart (EIF) could also generate rough surfaces, which reflected the echocardiographic incidental beam and then produced color Doppler and pulsed spectral Doppler artifacts. Our findings are consistent with the results previously described in the literature[1–8].

Some limitations of the study should be considered when interpreting the data. It has been reported that the appearance of color Doppler twinkling artifacts is highly dependent on the machine setting[2–4,18]. Our investigation is limited because we could not pre-set and optimize our system for more sensitive and specific detection of the artifact. The nature of fetal echocardiography precluded testing multiple variables of machine settings; however, we attempted to maintain the same settings, including pulse repetition frequency, color-write priority and gray-scale gain, throughout this study. Recently Shabana *et al.*[22] showed that ultrasound field fluctuations occur largely independently of beam focusing. Thus, we believe that other issues, including fetal position, maternal habitus, or the phased array probe used in this study may have less impact on the occurrence of the artifact.

In contrast to the spectrum obtained in previous studies from stable or unmoving objects with an irregular surface, we obtained a spectrum composed of straight vertical bands with a clear beginning-and-end outer profile, which occurred in mid-to-late systole and in early diastole. This may be related to the fact that the EIF was moving with the motion of the atrioventricular valves during the cardiac cycle, when pulsed Doppler was used to obtain a spectrum; given the tiny EIF and small twinkle artifacts, the small sample volume (in this investigation, we used 4.0 mm) probably intermittently targeted the artifactual signal and thus an incomplete spectrum of noise was produced and recorded. Another limitation of our observation is that we did not vary the pulsed Doppler sample volume or use continuous-wave Doppler to assess, in more detail, the subsequent change of Doppler spectral characterization. This issue will require further investigation.

These results raise concern that when color Doppler flow imaging and pulsed Doppler are used prenatally to evaluate intracardiac blood flow dynamics of fetuses with EIF, the presence of color Doppler artifacts could lead to the false diagnosis of true intracardiac flow. In particular, when EIF appears within the right ventricular cavity, color Doppler twinkling artifacts may be confused with the tricuspid regurgitation jet from Ebstein's anomaly. However, fetal 2D echocardiography can reliably identify abnormal attachments of septal and posterior tricuspid valves. In addition, hyperechogenicity is not a feature of a displaced tricuspid valve, and color Doppler signal and pulsed Doppler spectrum occur in different patterns[23–25].

In conclusion, color Doppler twinkling artifacts from isolated EIF occur in some fetuses and may be considered as an additional echocardiographic feature of EIF. The observation and interpretation of these artifacts should be performed with caution, taking care to differentiate them from the true color flow of atrioventricular valvular regurgitation jets.

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