Fetal Echocardiography: A 9-Year Experience in Rajavithi Hospital (1999-2007 AD)

Ekachai Kovavisarach MD*,
Chanin Mitinunwong MD*

** Department of Obstetrics and Gynecology, Rajavithi Hospital, College of Medicine, Rangsit University, Bangkok, Thailand*

Objective: *To determine obstetric characteristics of pregnant women underwent fetal echocardiography (FE), details of FE and postnatal echocardiographic abnormality.*

Material and Method: *Between January 1, 1999 and December 31, 2007, pregnant women who had the indication for FE were examined at the Department of Obstetrics and Gynecology, Rajavithi Hospital. Standard obstetric ultrasonographic examinations such as fetal biometry, placental localization, and congenital anomaly were initially performed. Then, extensive fetal echocardiographic examination including conventional real time B-mode and Doppler color flow mapping were performed in the following views: four chamber, five chamber, right long axis, left ventricular long axis, aortic arch, ductal arch, and short axis view of great vessels and ventricles.*

Results: *Eight hundreds fifteen pregnant women were examined for FE (37 pairs of twin pregnancies but one pairs of them were single fetal demise and one triplet with a single fetal demise, so 852 fetuses were examined). The mean maternal and gestational ages at examination were 28.8 years and 27.3 weeks, respectively. The most common indication for FE was diabetes mellitus (25.6%). Percentages of abnormal and unsatisfied FE were 7.7% and 7.9%, respectively. The most common abnormal FE was generalized cardiomegaly (34.8%). Hypoplastic left heart syndrome (HLHS) was the most common cardiac abnormalities diagnosed by postnatal examination (16.6%).*

Conclusion: *Percentage of abnormal FE were 7.7%, most of them were generalized cardiomegaly. The most common indication for FE was diabetes mellitus (25.6%). The most common abnormal postnatal echocardiography was HLHS (16.6%).*

Keywords: *Fetal echocardiography, Rajavithi Hospital*

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After Winsberg firstly introduced fetal echocardiography (FE) for prenatal diagnosis of congenital heart disease (CHD) in 1972 [1], the ultrasound machine and technology as well as advance in operation process have improved the detection rate of prenatal CHD[2]. FE was introduced to Rajavithi Hospital (RH) in 1999 by the obstetric staff, EK, after his graduation in FE study from National Cardiovascular Center, Osaka, Japan. Nowadays, only a few studies about FE in Thailand were reported[3-6].

FE results of 196 pregnant women were reported in 2001 after the first two years' experience in RH[6]. In the present retrospective study, the FE data will be analyzed again, after nine years' experience, to determine the obstetric characteristics of the pregnant women underwent FE, the indications for FE, details of FE abnormality and postnatal echocardiographic abnormality.

Correspondence to:
Kovavisarach E, Department of Obstetrics and Gynecology, Rajavithi Hospital, College of Medicine, Rangsit University, Bangkok 10400, Thailand.
Phone & Fax: 0-2354-8084
E-mail: ekachai959@yahoo.com

Material and Method

In Rajavithi Hospital, the first author (EK) was the only obstetrician who solely performed the fetal echocardiography from January 1, 1999 to December 31, 2007 using three ultrasonographic machines at different time:

1. ALOKA SSD 680 with 2.5-5.0 MHz transducer (January 1, 1999-March 31, 2000)
2. ALOKA SSD 5500 with 3.5 MHz transducer (April 1, 2000-December 28, 2006)
3. VOLUSON 730 Expert with 2.0-7.0 MHz transducer (December 29, 2006-December 31, 2007)

Standard obstetric ultrasonographic examinations such as fetal biometry, placental localization and congenital anomaly, were initially performed. Then extensive fetal echocardiographic examinations including conventional real time B-mode, M-mode, and Doppler color flow mapping were examined in the following views: four-chamber, five-chamber, right long axis, left ventricular long axis, aortic arch, ductal arch and short axis view of great vessels and ventricles.

The indications for fetal echocardiography were as followings:

1. Fetal factors: chromosomal anomaly, fetal anomaly, hydrops fetalis, fetal arrhythmia, intrauterine growth restriction (IUGR), oligohydramnios, polyhydramnios multifetal pregnancy and suspected of cardiac anomaly from first level ultrasonographic screening.

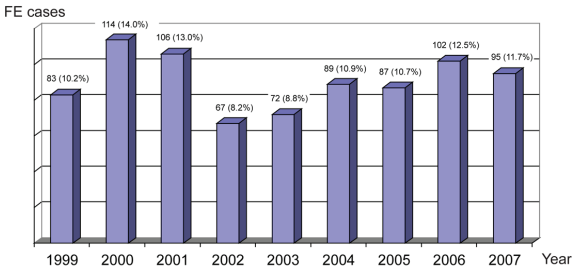
2. Maternal factors: congenital heart disease, collagen vascular diseases such as systemic lupus erythematosus (SLE), diabetes mellitus (DM), drug exposure such as alcohol and warfarin, infectious diseases such as rubella, and patient's need.

3. Familial factors: congenital heart disease, previous perinatal death.

All the neonates delivered in RH were taken into care by pediatric residents under supervision of the neonatologist from Queen Sirikit National Institute of Child Health (QSNICH) located nearby RH. Routine neonatal echocardiography was not performed to every neonate except for abnormal physical examination with or without prenatal abnormal fetal echocardiography. Obstetric characteristics, indications for fetal echocardiography and fetal and neonatal echocardiography findings were collected and analyzed retrospectively using arithmetic mean, range, percentage and standard deviation. The hospital's ethics committee approved the study.

Results

During the study period, 815 pregnant women with indications for FE were examined. There were 37 twin pregnancies but one pairs of them was a single fetal demise. One triplet with a single fetal demise was also enrolled. Therefore, fetal echocardiography was performed in 852 fetuses. The obstetric characteristics are shown in Table 1. The annual number of pregnant women underwent fetal echocardiography are demonstrated in Fig. 1. Most of the cases were examined in 2000 AD. Table 2 shows the indications



FE = fetal echocardiography

Fig. 1 Number of pregnant women underwent fetal echocardiography between 1999-2007 AD (n = 815 cases)

Table 1. Obstetric characteristics (n = 815)

Characteristics	Number (%)
Age of patients (mean ± SD) (years)	28.86 ± 6.7
GA at FE examination (mean ± SD) (weeks)	27.3 ± 4.7
GA at delivery (mean ± SD) (weeks)	37.3 ± 3.1
Birth weight (mean ± SD) (grams)	2,831.71 ± 717.88
Pregnancy termination (n = 549)	
Normal delivery	195 (35.5)
Forceps extraction	67 (12.2)
Vacuum extraction	15 (2.7)
Breech assisting	4 (0.7)
Cesarean delivery	256 (46.6)
Induced abortion	9 (1.6)
Spontaneous abortion	3 (0.5)

GA= gestational age; FE = fetal echocardiography

Table 2. Indications for fetal echocardiography

Characteristics	Number (n = 771) (%)
Maternal factors	
Diabetes mellitus	209 (27.11)
Congenital heart disease	113 (14.66)
Collagen vascular disease	47 (6.09)
Drug exposure	11 (1.43)
Patient's need	2 (0.26)
Other	30 (3.89)
Fetal factors	
Other fetal anomalies (except heart disease)	82 (10.64)
Suspected of cardiac anomaly from first level ultrasonographic screening	49 (6.35)
Fetal arrhythmia	40 (5.19)
Multifetal pregnancy	37 (4.80)
Polyhydramnios	21 (2.72)
Hydrops fetalis	11 (1.43)
Oligohydramnios	8 (1.04)
Chromosomal anomaly	5 (0.65)
Intrauterine growth restriction	4 (0.52)
Other	39 (5.06)
Familial factors	
Congenital heart disease in family (except maternal)	58 (7.52)
Previous stillbirth	3 (0.38)
Other	2 (0.26)

for fetal echocardiography. The most common indication was diabetes mellitus (27.11%). The numbers of normal FE, abnormal FE and unsatisfied FE were 719 (84.4%), 66 (7.7%) and 67 (7.9%), respectively. Comparison of cardiac abnormalities diagnosed by antenatal FE and postnatal examined by neonatologist are shown in Table 3. General cardiomegaly was the most common abnormal FE finding (Table 3). Table 4 shows the comparison of cardiac abnormalities diagnosed by postnatal examination and their antenatal FE. There was no false positive in hypoplastic left heart syndrome (HLHS) case (Table 4).

Discussion

In the present study, the mean gestational age (GA) at the time of FE examination was 28.8 weeks, similar to those of the studies reported in Thailand and other countries, varying from 27.6 to 29 weeks[3,4,6,7]. In their systematic review in 2003, Rasiah et al reported a high sensitivity (85%) and specificity (99%) for first-trimester FE in detecting major CHD[8]. They recommended performing a first-trimester FE to the women with high risk of having children with CHD. However, in RH, FE was usually performed during 18-32 weeks of gestation. This was because it was started at 1999 before an establishment of first-trimester FE and most of cases came to the antenatal clinic in a second trimester. Diabetes mellitus was the most common indication for FE (25.6%), similar to those reported in previous study in the same hospital in 2001 (28.1%)[6]. Odibo et al[9] evaluated the cost effectiveness of universal FE for all pregnant diabetic mothers as a screening tool for CHD using a decision-analysis model. They suggested selective FE if abnormal (or suspected) cardiac views were observed during a detailed anatomic examination.

Soongswang et al[3,4] in Thailand, Hsiao et al[7] in Taiwan and Allan et al[2] in UK reported that cardiac anomaly from obstetrician's ultrasound was the most common indication for FE (36.6-72%). The percentages of this indication in these studies were much higher than those found in the present study (6.35%), Bakiler et al study[10] in Turkey (8.6%) and Li et al[11] study in China (14.8%). Routine FE screening was recommended for detection of CHD among unselected and low-risk mothers because the majority of babies with CHD are born from mothers without high-risk factors[12]. Nevertheless, Randall et al[13] concluded from their systematic review that FE should not be used to detect CHD among unselected

Table 3. Comparison of cardiac abnormalities diagnosed by antenatal FE and their postnatal examinations

Type of cardiac abnormalities (FE)	Number	Undelivered in RH	Delivered in RH	True positive	False positive	Unknown
Structural cardiac abnormalities						
General cardiomegaly	23	14	9	0	9	14
Hypoplastic left heart syndrome	12	7	5	3	2	7
Situs inversus	2	1	1	0	1	1
Hypoplastic right heart syndrome	1	1	0	-	-	1
Cardiac tumor	1	0	1	1	0	0
Ebstein anomaly	1	0	1	0	1	0
Complex heart disease	1	1	0	-	-	1
Other	2	2	0	-	-	2
Rhythmic abnormalities						
Sinus arrhythmia	7	4	3	-	3	4
Transient bradycardia	7	3	4	1	3	3
Congenital heart block	5	3	2	1	1	3
Premature ventricular contraction	1	0	1	0	1	0
Sinus tachycardia	1	0	1	0	1	0
Sinus bradycardia	1	1	0	-	-	1
Supraventricular tachycardia	1	0	1	1	0	0
Total	66	37	29	7	22	37

FE = fetal echocardiography; RH = Rajavithi Hospital

Table 4. Comparison of cardiac abnormalities diagnosed by postnatal FE and their antenatal FE

Type of Cardiac abnormalities	Number	Type of cardiac anomalies (FE)		Diagnosis (if false positive)
		True positive	False positive	
Structural cardiac abnormalities (postnatal FE)				
Ventricular septal defect (VSD)	1	0	1	Normal
Hypoplastic left heart syndrome (HLHS)	3	3	0	
Complex heart disease	1	0	1	Ebstein anomaly
Ebstein anomaly	1	0	1	Complex heart disease
PDA	1	0	1	Normal
VSD + PDA	2	0	2	Congenital heart block Normal
Cardiac tumor	1	1	0	
ASD + PDA	1	0	1	Normal
Pulmonary atresia + TR	1	0	1	HLHS
PDA+TR+MR	1	0	1	Situs inversus
Pulmonary atresia (PA) + PDA + ASD	1	0	1	Generalised cardiomegaly
PA	1	0	1	Normal
Rhythm abnormalities				
Congenital heart block	1	0	1	Normal
Congenital heart block + PDA	1	1	0	Congenital heart block
Transient bradycardia	1	1	0	Transient bradycardia

PDA = patent ductus arteriosus, TR = tricuspid regurgitation, ASD = atrial septum defect, MR = mitral regurgitation

and low-risk mothers during second trimester because of insufficient evidence. The most common abnormal FE finding in the present study was generalized cardiomegaly (34.8%), while those found in Soongswang et al study[4], Barkiler et al study[10] and Jamiureeruk study[5] were frequent premature

atrial contraction (18.4%), atrioventricular septal defect (AVSD, 30%) and ventricular septal defect (33.3%), respectively. Acherman et al[14] reported that univentricular heart (UVH), hypoplastic left heart syndrome (HLHS) and isolated AVSD were the most common abnormalities found by FE (8%, each).

One of the problems in the present study was that pediatric cardiologist did not examine neonatal echocardiography in every normal FE case. Others are that several important statistical parameters, such as sensitivity, specificity and accuracy, could not be determined. In addition, a large number of abnormal FE was not delivered in RH (54.5%, Table 3) because some mothers decided to give birth in their hometowns. It is interesting that generalized cardiomegaly (GC), the most common abnormal FE, was all false positive in postnatal diagnosis (9/9 cases). One of these cases was PA + PDA + ASD while the other eight cases were normal. GC was diagnosed when only generalized cardiac enlargement was identified in FE without other visible anatomic pathology. The criteria for diagnosis of GC was C/T area ratio (cardiac area/chest area) > 0.35 or C/T circumference ratio (cardiac circumference/ chest circumference) > 0.5[15]. True positive anomalies were identified in HLHS, cardiac tumor, congenital heart block and transient bradycardia (Table 4) because of the clear anatomical and rhythmic abnormality in the 4-chamber view and M-mode, respectively. Some abnormal neonatal echocardiography such as PDA and ASD were normal physiologic FE findings in fetal life. Similar percentage of unsatisfied FE and abnormal FE were demonstrated (7.9% and 7.7%, respectively). These unsatisfied FE could be explained by improper fetal position, bony calcification, older GA, and maternal obesity. However, there was no cardiac abnormality diagnosed by postnatal FE in these groups. Abnormal FE found in the present study (7.7%) were remarkably lower than those of Soongswang's studies[3,4] (35.9% and 41.8%) but higher than those of Jamjureeruk's study (1.2%)[5].

Meyer-Wittkopf et al[16] analyzed the accuracy of FE diagnosed by obstetricians and pediatric cardiologists using level of agreement between their diagnosis of fetuses with suspected CHD and comparing this with final postnatal diagnosis. They discovered that complete agreement between prenatal and postnatal diagnosis in fetuses with complex congenital heart disease was better achieved by pediatric cardiologists than by obstetricians, (95%:59% of cases, 2%: 17% false positive and 5%: 41% false negative)[16]. During the study period in RH, only one obstetrician (EK) performed FE while the other studies in Siriraj Hospital, only pediatric cardiologists did it[3,4].

In those studies the authors reported very good statistical values, for example: sensitivity = 96.9-100%, specificity = 90.6-96.3%, positive predictive value = 84.2-94.7%, negative predictive value = 98.3-100% and accuracy = 92.8-97.8%. Unfortunately, in the present study, the data could not be statistically analyzed because of the loss of follow-up cases and all normal FE diagnosed were not postnatally confirmed. One of the limitations in the present study is that it is a retrospective type, so some data were lost especially in cases delivered in the other hospitals. Three different ultrasonic machines used during the 9-year period was another limitation. Therefore, setting the data collection system especially cases delivered in other hospitals and confirmation of postnatal echocardiographic diagnosis in all FE are suggested for future study.

In conclusion, abnormal FE were found to be 7.7%, most of them were generalized cardiomegaly. The most common indication for FE was diabetes mellitus (25.6%). The most common abnormal postnatal echocardiography was HLHS (3/18, 16.6%).

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Potential conflicts of interest

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การตรวจหัวใจทารกในครรภ์ด้วยคลื่นเสียงสะท้อนความถี่สูง: ประสบการณ์ 9 ปี ในโรงพยาบาลราชวิถี (พ.ศ. 2542-2550)

เอกชัย โควาวิสารัช, ชนินทร์ มิตินันท์วงศ์

วัตถุประสงค์: *เพื่อตรวจสอบลักษณะทางสูติศาสตร์ของหญิงตั้งครรภ์ที่ได้รับการตรวจหัวใจทารกในครรภ์ด้วยคลื่นเสียงสะท้อนความถี่สูงในรายละเอียดต่าง ๆ และความผิดปกติในการตรวจหัวใจทารกในครรภ์ และทารกหลังคลอดด้วยคลื่นเสียงสะท้อนความถี่สูง*

วัสดุและวิธีการ: *หญิงตั้งครรภ์ที่มีข้อบ่งชี้ในการตรวจคลื่นเสียงสะท้อนความถี่สูงหัวใจทารกในครรภ์ ตั้งแต่วันที่ 1 มกราคม พ.ศ. 2542 ถึง 31 ธันวาคม พ.ศ. 2550 ณ กลุ่มงานสูตินรีเวชศาสตร์ โรงพยาบาลราชวิถี การตรวจคลื่นเสียงความถี่สูงทางสูติศาสตร์ได้แก่ การวัดทารกเพื่อหาอายุครรภ์ การเกาะของรก และความพิการแต่กำเนิด ได้รับตรวจเบื้องต้น และได้รับการตรวจคลื่นเสียงสะท้อนความถี่สูงของหัวใจทารกในครรภ์อย่างละเอียด*

ผลการศึกษา: *หญิงตั้งครรภ์ 815 คน ได้รับการตรวจคลื่นเสียงสะท้อนความถี่สูงหัวใจทารกในครรภ์ (มีครรภ์แฝดสอง 37 คู่ แต่มี 1 คู่ ที่มีทารกในครรภ์เสียชีวิต 1 คน รวมทารกในครรภ์ที่ได้รับการตรวจทั้งหมด 852 คน) อายุมารดาและอายุครรภ์ขณะตรวจคลื่นเสียงสะท้อนหัวใจความถี่สูงเท่ากับ 28.8 ปี และ 27.3 สัปดาห์, ตามลำดับข้อบ่งชี้สำหรับการตรวจที่พบมากที่สุดคือ โรคเบาหวาน (25.6%) ผลการตรวจคลื่นเสียงสะท้อนความถี่สูง หัวใจทารกในครรภ์ที่ผิดปกติ และที่ไม่น่าพอใจเท่ากับร้อยละ 7.7 และ 7.9 ตามลำดับ ผลการตรวจ ฯ ที่ผิดปกติที่พบบ่อยที่สุดคือ generalized cardiomegaly (34.8%) hypoplastic left heart syndrome เป็นความผิดปกติของหัวใจทารกหลังคลอดที่พบบ่อยที่สุด (16.6%)*

สรุป: *ผลของการตรวจคลื่นเสียงสะท้อนความถี่สูงหัวใจทารกในครรภ์ที่ผิดปกติ เท่ากับร้อยละ 7.7 โดยความผิดปกติที่พบบ่อยที่สุดคือ generalized cardiomegaly ข้อบ่งชี้ในการตรวจคลื่นเสียงสะท้อนความถี่สูงหัวใจทารกในครรภ์ที่พบบ่อยที่สุดคือ โรคเบาหวาน (25.6%) ความผิดปกติของหัวใจทารกหลังคลอดที่พบบ่อยที่สุดคือ hypoplastic left heart syndrome (16.6%)*