Efficacy of Fetal Echocardiography and an Evaluation of Indications

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Fetal echocardiography has been accepted as a prenatal noninvasive diagnostic tool of cardiovascular diseases in fetuses for more than three decades. There are limited data in Thailand. A retrospective study of prenatal, natal and postnatal data of pregnant women who had fetal echocardiography at Siriraj Hospital, Bangkok, Thailand, from January 1999 to July 2005 was conducted. In total, there were 117 pregnant women who had fetal echocardiography under standard indications. Median age of pregnant women was 30.2 (17.3-44.2) years old. Median gestational age at the first fetal echocardiography was 29 (17-40) weeks. Median number of time the women had fetal echocardiography was 1 (1-10). Indications for fetal echocardiography were; obstetricians suspected of fetal cardiovascular diseases, multiple anomalies, family history of congenital heart diseases, chromosome anomalies, hydrops fetalis, and other indications (53.8%, 12%, 11.1%, 8.5%, 8.5% and 6.0% respectively). There were 49 (41.8%) cases who had abnormal cardiovascular problems, i.e., structural heart diseases 26 cases, rhythm disturbance 15 cases, and cardiac masses 8 cases. Upon comparison with postnatal echocardiography and/or autopsy findings, fetal echocardiography had a sensitivity of 96.9%, specificity of 90.6%, and accuracy of 92.8%. There was various degrees of risk to have cardiovascular problems for each of the indication taking fetal echocardiography and postnatal data into consideration. Fetal echocardiography had an impact on the management in 57.3% of cases.

Conclusion: *Fetal echocardiography is a reliable prenatal diagnostic tool for cardiovascular problems with high accuracy and has an impact on the management at prenatal, natal and postnatal period. Different indications for fetal echocardiography have an effect on the relative risk of fetal cardiovascular diseases.*

Keywords: *Prenatal diagnosis, Fetal echocardiography*

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The effect of prenatal diagnosis of cardiovascular diseases by fetal echocardiography on the management and outcome of pregnancy can be substantial[1,2]. Various studies have demonstrated the impact of fetal echocardiography in reducing prevalence of severe congenital heart diseases (CHD) together with reducing morbidity and mortality in peri-natal and post-natal periods[3,4]. Prenatal diagnosis has been recommended in pregnant women with maternal, genetic, and familial risk factors together with fetal abnormalities detected by obstetricians, i.e., multiple anomalies, fetal arrhythmia. This study intended to find the distribution of indications, cardiovascular problems, outcomes, accuracy of fetal echocardiography and relative risk associated with each indication.

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Material and Method

A retrospective review of the medical records of pregnant women and their offspring who had fetal echocardiography done at Siriraj Hospital, Bangkok, Thailand, from January 1999 to July 2005 was performed. Fetal echocardiography was done by pediatric cardiologists using echocardiographic machine Hewlett Packard Sonos 5500 (Hewlett Packard, Andover, MA, USA) with 2.25 transducer. The indications for fetal echocardiography were as standard recommendations. The echocardiography was done as previously described[5].

Indications, obstetric data, maternal problems, gestational age at the first fetal echocardiography and fetal echocardiographic results were collected. The parents and obstetricians were informed regarding the results, severity, options of management and possible outcomes of cardiovascular problems. Then, appropriate management plan i.e., mode, time and place of delivery were thoroughly discussed and chosen. The abortion committee was consulted to assist in making the decision for cases of severe form of cardiovascular diseases especially those associated with multiple anomalies. Outcomes of pregnancy and autopsy results were also collected.

Statistical analysis

Categorical data was presented as percentage and count. Measured data was described as median (range) because of data skewness. Accuracy was evaluated by using two by two analysis. Relative risk of having cardiovascular problem for each indication was calculated by conventional method as well as 95% confident interval (CI). P value < 0.05 was considered as statistically significant.

Results:

Prenatal data

There were 117 pregnant women who underwent fetal echocardiography from January 1999 to July 2005. Median age of these women was 30.2 (17.3-44.2) years old. Median gestational age at the first fetal echocardiography was 29 (17-40) weeks. Indications for fetal echocardiography were depicted in Figure 1. Median number of time the women underwent fetal echocardiogram was 1 (1-10). Thirty percent of pregnant women had fetal echocardiogram more than once. Forty nine cases (41.8%) had cardiovascular problems as demonstrated in Table 1. Examples of abnormal fetal echocardiogram were shown in Figure 2. Fetal echocardiography had an impact on the management of 67 fetuses (57.3%), e.g., provision of maternal oral medications, effect on the decision of therapeutic abortion in multiple anomalies and lastly, effect on mode, time and place of delivery.

Natal and postnatal data

Mode of delivery was normal labor in 63

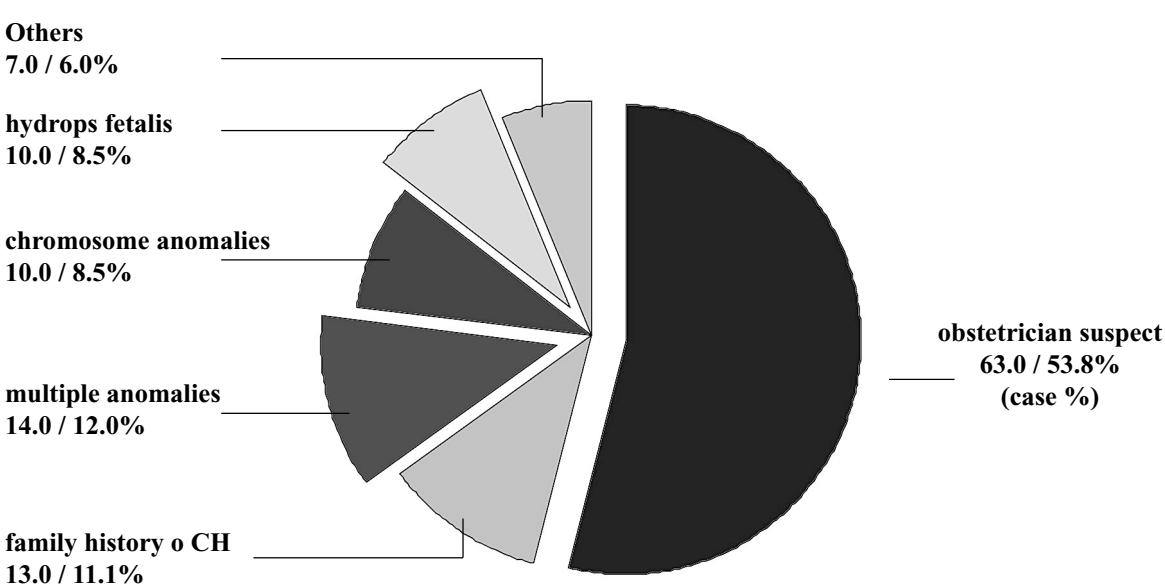

Fig. 1 Indications of fetal echocardiography

Table 1. Cardiovascular abnormalities found in fetal echocardiography

	cases
Rhythm disturbance	**15**
Frequent PAC	9
Atrioventricular block, Mobitz 1	1
Complete atrioventricular block	1
Atrial tachycardia	3
Atrioventricular reentry tachycardia	1
Structural heart defects	**26**
Common ventricle, common AVV	5
DORV	4
HLHS	3
Ebstein s anomaly	2
Myocardial diseases (HCM 1, DCM 3)	4
Cardiomegaly with moderate TR	3
Hypoplastic arch	2
Partial atrioventricular septal defect	1
Multiple ventricular septal defect	1
Ectopia cordis	1
Cardiac mass	**8**
Single mass (RV 3, RA 2)	5
Multiple masses (LV &RV)	3

AVV = atrioventricular valve, DCM = dilated cardiomyopathy, DORV = double outlet right ventricle, HCM = hypertrophic cardiomyopathy, HLHS = hypoplastic left heart syndrome, LV = left ventricle, PAC = premature atrial contraction, RA = right atrium, RV = right ventricle, TR = tricuspid regurgitation

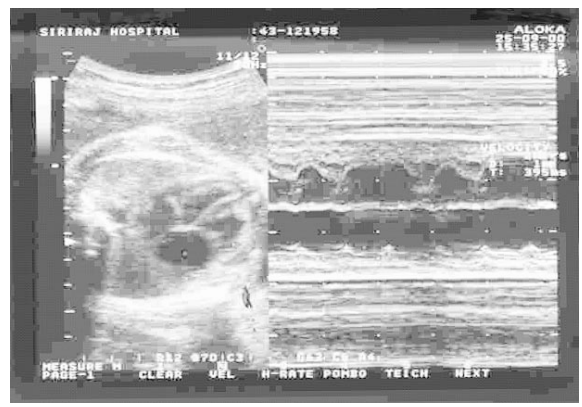

Fig. 2a Two dimensional echocardiogram and M-mode imaging of a fetus with second degree atrioventricular block, Mobitz I

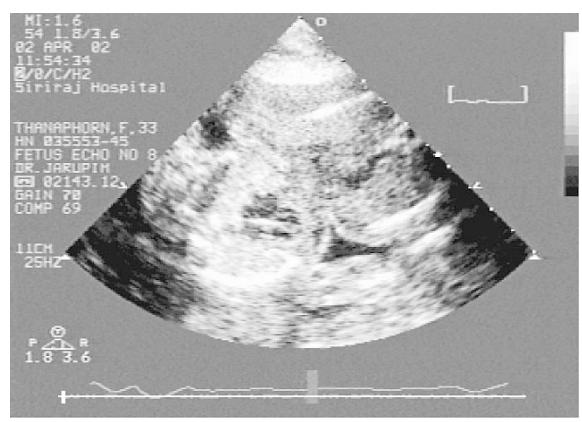

Fig. 2b Fetal echocardiogram of conjoin twin with normal cardiovascular systems

(53.8%) cases, Caesarian section in 24 (20.5%) cases, therapeutic abortion in 20 (17.1%) cases, and death fetus in utero in 8 (6.8%) cases. There were 2 pregnant women who had no delivery at the time of the study. Ninety-seven neonates or bodies had cardiovascular system examined either by echocardiogram or autopsy. Pre and postnatal comparison of cardiovascular problems were shown in Table 2. There were 20 cases that had no postnatal cardiovascular data. The misdiagnosis encountered was in a trisomy 21 fetus. The prenatal echocardiogram reported a suspicion of partial atrioventricular septal defect whereas postnatal echocardiogram showed no cardiac lesion. There was a slight discrepancy in the diagnoses of 5 cases with prenatal diagnosis of atrial arrhythmia (PAC, 4 cases and atrial tachycardia, 1 case). These fetuses had normal post natal ECG. The woman with fetal atrial tachycardia was put on oral digitalis for 6 weeks and discontinued after the arrhythmia resolved. One woman with normal fetal echocardiogram delivered a newborn with mild pulmonary valve stenosis (PS) in postnatal imaging. Considering each indication of fetal echocardiography in terms of relative risk to have cardiovascular disease in postnatal outcome was shown in Table 3. Accuracy of fetal echocardiography was shown in Table 4. Outcomes of the 117 fetuses were 8 cases of death fetus in utero, 20 cases of therapeutic abortion, and 3 cases of postnatal death (one with diaphragmatic hernia, one from acute post Norwood operation and the other died in other hospital with unidentified cause). The outcome of forty-nine fetuses with prenatal diagnoses of cardiovascular problems were alive and well in 21 cases, alive but sick in 10 cases, therapeutic abortion in 13 cases, and death in 5 cases (death fetus in utero 4 cases and post Norwood operation 1 case).

Discussion

Prenatal period

Median gestational age of the first fetal echocardiography done was at 29 weeks. The optimum time for transabdominal fetal echocardiogram has been described at 18-28 weeks gestation[6]. This might be too late for the decision of simpler and safer therapeutic abortion for poor prognosis fetus with multiple anomalies. The introduction of high resolution transvaginal probe allows assessment of the fetal heart at 10-16 weeks gestation[7]. If a suspicion of CHD is raised early enough, it is possible to perform chorionic villus sampling to exclude aneuploidy. This method is considered to be more expeditious than amniocentesis[8]. Forty-nine cases had cardiovascular problems detected by fetal echocardiography. This accounted for 7.7% of the expected number of cases at Siriraj Hospital when calculated by the incidence of CHD at 8:1000 life-births. The other study was able to detect prenatal CHD in approximately 15%[9]. There were 23.4% of major forms of CHD detected in the UK prenatally[10]. Multi-factorial etiology in the majority of CHD resulted in underdetection especially when using conventional indications for fetal echocardiography and with no routine obstetric abdominal ultrasound of every fetus at second trimester. There is substantial effect on the detection of CHD especially when routine ultrasound showed abnormal 4-chamber view of the fetal heart or certain extra cardiac abnormalities[11]. Increased nuchal translucency thickness to 3.1 (2.2-8.0) mm was found to associate with increased incidence of major CHD by 49.4:1000[12]. The main indication of fetal echocardiography was obstetrician suspected of fetal cardiovascular problems which had high relative risk (detection rate 52.4%) of having fetal cardiovascular

Table 2. Comparison of cardiovascular problems pre and postnatal data

Cardiovascular data	frequency	%
Same	90	92.8
Slightly different	6	6.2
Different	1	1.0

Table 4. Accuracy of fetal echocardiography compared to postnatal data

Fetal echocardiography	Postnatal echocardiography or autopsy	
	CVS diseases	No CVS diseases
CVS diseases	32	6
No CVS diseases	1	58

CVS = cardiovascular system
Sensitivity = 96.9%, Specificity = 90.6%, Positive predictive value = 84.2 %, Negative predictive value = 98.3%, Accuracy = 92.8%

Table 3. Indications and relative risk of having cardiovascular problems detected by fetal echocardiography together with postnatal outcome

Indications	CHD or arrhythmia detected			
	Fetal echocardiogram		Postnatal	
	Cases	**Crude Relative Risk**(95% CI)**	**Cases**	**Crude Relative Risk**(95%CI)**
Obstetrician suspected	32 (63)	23.5 (5.8-94.1)*	24 (59)	40.0 (5.6-285.4)*
Multiple anomalies	5 (14)	18.0 (4.4-72.8)*	2 (9)	22.0 (3.0-160.1)*
Family history of CHD	1 (13)	4.0 (0.9-18.3)	0 (11)	0
Chromosome abnormality	3 (10)	15.0 (3.7-61.1)*	3 (5)	60.0 (8.4-424.8)*
Hydrops fetalis	5 (10)	25.0 (6.2-99.9)*	3 (7)	43.0 (6.0-306.3)*
Maternal diseases	1 (5)	10.0 (2.4-41.6)*	1 (5)	20.0 (2.7-146.2)*
Previous fetal death	1 (2)	25.0 (6.2-99.9)*	0 (1)	0
Total	49.0 (117)		33.0 (97)	

* Significant at p value < 0.05

** Relative risk defines as the likelihood of the fetuses with one condition (indication) to have cardiovascular diseases compared to the fetuses in general population.

problems. This indication had been reported with the detection rate of 68% and yielded most cases of severe CHD by Cooper MJ[9]. Patients with atrial tachycardia and cardiomegaly with moderate tricuspid regurgitation has been treated with digitalis. Verganip reported fetal arrhythmia with 100% conversion rate using medical treatment of tachyarrhythmia with digitalis and propafenone[2]. Excellent outcome of in utero supraventricular tachycardia has also been reported by Naheed ZJ[13]. Only 50% of atrioventricular block survived[2]. Hydrops fetalis and CHD were risk factors for prenatal and postnatal death in atrioventricular block[14]. Cardiac tumor accounted for 16.3% of cardiovascular problems detected in utero. This was a rare condition. The majority were rhabdomyomas and were often benign[15,16].

Natal and postnatal data

Seventeen percent of cases in this study had termination of pregnancy especially in severe multiple anomalies and/or severe CHD fetuses that was incompatible with life. There was a report of close to 50% of termination of pregnancy in fetus with cardiac malformation[10]. This affects the incidence and distribution of CHD. Sensitivity, specificity, and accuracy rate of fetal echocardiography in this study were comparable to the others[17,18]. Premature atrial contraction was not uncommon in prenatal period with benign course and likely to spontaneously resolve. Family history of CHD and previous fetal death were not significant risks for cardiovascular problems in this study. Buskens reported that mother and sibling with CHD were not considered a significant risk for having fetal cardiovascular diseases[18]. Whereas obstetrician suspected of fetal cardiovascular disease, multiple congenital anomalies, chromosome anomalies, hydrops fetalis and maternal diseases were found to be significant risks for cardiovascular problems detected pre and postnatally. The outcome of prenatal diagnosis of CHD is influenced by several factors, i.e., progressive nature of obstructive lesions, different spectrums of diseases in prenatal life. There were reports of no difference in the outcome of serious cardiovascular diseases diagnosed prenatally except for therapeutic abortion[19,20].

Conclusion

Fetal echocardiography is a highly accurate essential tool for diagnosing, management and for follow-up of cardiovascular problems in prenatal lives. Indications for fetal echocardiography had an effect on relative risk to have fetal and neonatal cardiovascular problems.

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ประสิทธิผลของการตรวจหัวใจทารกในครรภ์ด้วยคลื่นเสียงสะท้อนความถี่สูง และการประเมินข้อบ่งชี้

จารุพิมพ์ สูงสว่าง, วิบูลพรรณ ฐิตะดิลก, ประเสริฐ ศันสนีย์วิทยกุล, อนุวัฒน์ สุตัณฑวิบูล, พรพิมล เรืองวุฒิเลิศ, กาญจนา หวานสนิท, เกษรี ปั้นลี้, สุธีรา ภู่ไพศาล, จารุวรรณ คังคะเกตุ

การตรวจหัวใจทารกในครรภ์ด้วยคลื่นเสียงสะท้อนความถี่สูงเป็นที่ยอมรับว่าเป็นการตรวจที่น่าเชื่อถือและไม่มีผลกระทบต่อผู้ถูกตรวจมานานมากกว่า 3 ทศวรรษ ข้อมูลทางด้านนี้ในประเทศไทยยังมีจำกัด การศึกษานี้เป็นการศึกษาย้อนหลังในสตรีตั้งครรภ์ทุกรายที่ได้รับการตรวจหัวใจทารกด้วยคลื่นเสียงสะท้อนความถี่สูงที่โรงพยาบาลศิริราช ตั้งแต่เดือนมกราคม พ.ศ. 2542 ถึงกรกฎาคม พ.ศ. 2548 มีสตรีตั้งครรภ์ที่ได้รับการตรวจตามข้อบ่งชี้มาตรฐานทั้งหมด 117 ราย อายุของสตรีตั้งครรภ์ อายุครรภ์ที่ได้รับการตรวจหัวใจทารกด้วยคลื่นเสียงสะท้อนความถี่สูงครั้งแรกและจำนวนครั้งของการตรวจเฉลี่ย 30.2 (17.3-44.2) ปี, 29 (17-40) สัปดาห์ และ 1 (1-10) ครั้งตามลำดับ ข้อบ่งชี้ของการตรวจหัวใจทารกในครรภ์ด้วยคลื่นเสียงสะท้อนความถี่สูงมีดังนี้: สูติแพทย์สงสัยโรคหัวใจ 53.8%, มีความผิดปกติของทารกในหลายระบบ 12%, มีประวัติครอบครัวเป็นโรคหัวใจพิการแต่กำเนิด 11.1%, ผลการตรวจโครโมโซมผิดปกติ 8.5% ทารกมีบวมน้ำ 8.5%, และอื่นๆ อีก 6% ตรวจพบมีความผิดปกติของหัวใจและหลอดเลือดตั้งแต่ในครรภ์ 49 ราย (41.8%) เป็นโครงสร้างหัวใจผิดปกติ 26 ราย จังหวะการเต้นหัวใจผิดปกติ 15 ราย และก้อนในหัวใจ 8 ราย เมื่อเปรียบเทียบผลการตรวจหลังคลอดด้วยคลื่นเสียงสะท้อนความถี่สูงและ/หรือการตรวจศพ พบว่าการตรวจหัวใจทารกในครรภ์ ด้วยคลื่นเสียงสะท้อนความถี่สูงมีความไว 96.9% ความจำเพาะ 90.6% และความแม่นยำ 92.8% พบว่ามีโอกาส พบความผิดปกติของหัวใจทั้งที่ตรวจพบก่อนคลอดและหลังคลอด แตกต่างกันในข้อบ่งชี้ที่ต่างกัน การตรวจหัวใจทารกในครรภ์ ด้วยคลื่นเสียงสะท้อนความถี่สูงมีผลต่อการติดตามดูแลรักษาทารกในครรภ์ถึง 57.3%

สรุป: *การตรวจหัวใจทารกด้วยคลื่นเสียงสะท้อนความถี่สูงให้ผลที่แม่นยำและมีผลต่อการดูแลทารกตั้งแต่ในครรภ์ระหว่างคลอดและหลังคลอด ข้อบ่งชี้ที่ต่างกันมีโอกาสพบความผิดปกติของระบบหัวใจ และหลอดเลือดทั้งในครรภ์และหลังคลอดแตกต่างกัน*