三维超声时间空间联合成像技术对早孕期胎儿心脏畸形的筛查价值

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摘 要：【目的】三维超声时间空间联合成像技术对早孕期胎儿心脏畸形筛查的临床应用价值。【方法】回顾性分析2013年1月4日至2016年6月30日在我院行早孕期心脏筛查且产前可疑心脏畸形共87例，与追踪结果比较，分析三维超声时间空间联合成像技术对心脏畸形诊断的价值，同时分析不同切面包括四腔心切面、左心室流出道切面、右心室流出道切面及三血管-气管切面的诊断价值。【结果】纳入本研究的87例病例中，包括严重心脏畸形62例(71.3%，62/87)和非严重心脏异常25例(28.7%，25/87)。与出生后超声心动图或引产后尸检结果比较，应用三维超声STIC技术共分析诊断正确心脏畸形78例(89.7%)。单纯四腔心切面对心脏畸形的检出率为48.3%(42/87)，四腔心切面联合左心室流出道切面的检出率为64.4%(56/87)，四腔心切面联合右心室流出道切面的检出率为66.7%(58/87)，四腔心切面联合三血管气管切面的检出率为79.3%(69/87)，四腔心切面联合左心室、右心室流出道切面及三血管气管切面的检出率为89.7%(78/87)。【结论】三维超声时间空间联合成像技术可在早孕期进行胎儿心脏筛查，联合四腔心切面、左右心室流出道及三血管气管切面筛查可提高心脏畸形的检出率。

关键词：三维超声；时间空间复合成像技术；心脏畸形；早孕期
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Cardiac Screening in the First Trimester Using Three-dimensional Ultrasound with Spatiotemporal Image Correlation

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Abstract: 【Objective】To evaluate the value of cardiac screening in the first trimester by using three-dimensional ultrasound with spatiotemporal image correlation (STIC) and to analyze the value of different views for cardiac assessment. 【Methods】This study retrospectively reviewed the eighty-seven fetuses with congenital heart diseases which were diagnosed in our institution between January 4th 2013 and June 30th 2016. We compared the detection rate of prenatal ultrasound screening with STIC in the first trimester and the results of postnatal echocardiography or autopsy. In addition, the detection rates of the different planes, including four-chamber view (4CV), outlet of the left ventricle (OLV), outlet of the right ventricle (ORV) and three vessels-trachea view (3VT) were analyzed. 【Results】Severe cardiac anomalies were identified in 62 fetuses (71.3%) and non-severe cardiac anomalies were identified in 25 fetuses (28.7%). Seventy-eight cases (89.7%, 78/87) with congenital heart diseases could be detected by using three-dimensional ultrasound with STIC.The detection ratesfor 4CV, 4CV+OLV, 4CV+ORV, 4CV+3VT, 4CV+OLV+ORV and 4CV+OLV+ORV+3VT were 48.3%, 64.4%, 66.7%, 79.3%, 69.0% and 89.7% respectively. 【Conclusions】Three-dimensional ultrasound with STIC could detect congenital heart disease in the first trimester. The four-chamber view plus outlet of the left ventricle, outlet of the right ventricle and three vessels-trachea view could increase the detection rates of congenital heart diseases.

Key words: three-dimensional ultrasound; spatiotemporal image correlation; cardiac defects; first trimester
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Congenital heart disease is one of the most common malformations that could be detected prenatally and also was the main reason for neonatal death. If the cardiac anomalies could be identified as early as possible, anxiety of the parents may be decreased. Spatiotemporal image correlation (STIC) has been demonstrated that could add more information for cardiac defects[1-3]. In this study, we aimed to evaluate the value of cardiac screening in the first trimester by using STIC and to analyze the value of different views for cardiac assessment.

1 Material and Methods

1.1 Objectives

Fetuses that were performed cardiac screening and were suspected with cardiac defects in the first trimester in our institution between January 4th 2013 and June 30th 2016 was enrolled. The gestational age was between 11 weeks and 1^{3+6} weeks. Postnatal echocardiography and autopsy was collected in all fetuses. Written informed consent was obtained in all patients. This experiment was proved by the medical Ethics Committe.

1.2 Methods

The first trimester ultrasound screening was performed following the guidelines. Nuchal translucency (NT), nasal bone, Doppler wave of ductus venous and tricuspid valve was evaluated. After two dimensional ultrasound examinations, fetal cardiac volume data were acquired by using STIC through the fetal thorax. The four-chamber view was used as the initial plane.Acquisition time was set as 10 s and volume angle was set as 20°. Two or three volume datasets were acquired for each fetus. The volumes were analyzed off-line in the personal computer by using 4D View software. The four-chamber view (4CV), outlet of the left ventricle (OLV), outlet of the right ventricle (ORV) and three vessels-trachea view (3VT) were evaluated.

1.3 Statistical Analysis

SPSS 17.0 was used for statistical analysisin this study. Categorical variables was compared by using χ^2 test. P value less than 0.05 was considered as significant.

2 Results

2.1 Clinical features

A total of 110 fetuses were suspected with cardiac anomalies in the first trimester. Eight fetuses were lost to follow up. Volume quality was inadequate in fifteen fetuses.At last, 87 fetuses were included into this study, with a median gestational age of 13^{+1} weeks at the diagnosis. The median maternal age was 31 (range from 22 to 42) years old. A total of 172 volumes were obtained and analyzed.

2.2 Cardiac defects

Severe cardiac anomalies were identified in 62 fetuses (71.3%) and non-severe cardiac anomalies were identified in 25 fetuses (28.7%). The severe cardiac malformations that were diagnosed by postnatal echocardiography or autopsy were as follows: three cases with cardiac extroversion, thirteen cases with endocardial cushion defect, eight cases with single ventricle, eleven cases with hypoplastic left heart syndrome, four cases with tetralogy of Fallot, two cases with transposition of great arteries, eight cases with double outlet of right ventricle, nine cases with pulmonary atresia, four cases with truncus arteriosus. Non-severe cardiac anomalies included 18 cases with ventricular septal defect and seven cases with aberrant right subclavian artery. Totally, seventy-eight cases (89.7%, 78/87) with congenital heart diseases could be detected by using three-dimensional ultrasound with STIC. Severe cardiac anomalies could be successfully detected by STIC in 91.9% (57/62) and non-severe cardiac anomalies could be successfully detected by STIC in 84.0% (21/25)(P = 0.271). Comparisons between the results of three-dimensional ultrasound with STIC and the results of postnatal echocardiography or autopsy are shown in Table 1.

2.3 Different views for screening cardiac anomalies

If only the four chamber view was visualized, the detection rate was 48.3% (42/87). The detection

Table 1 Comparisons between the results of three-dimensional ultrasound with STIC and the results of postnatal echocardiography or autopsy

Cardiac anomalies	STIC	Postnatal echocardio-graphy or autopsy	Detection rate
Cardiac extroversion	3	3	100.0%
Endocardial cushion defect	13	13	100.0%
Single ventricle	8	8	100.0%
Hypoplastic left heart syndrome	11	11	100.0%
Tetralogy of Fallot	4	2	50.0%
Transposition of great arteries	2	2	100.0%
Double outlet of right ventricle	8	6	75.0%
Pulmonary atresia	9	8	88.9%
Truncus arteriosus	4	4	100.0%
Ventricular septal defect	18	14	77.8%
Aberrant right subclavian artery	7	7	100.0%
Total	87	78	89.7%

rate of the four chamber view plus three vessels-trachea view was 79.3% (69/87). If all the 4CV, OLV, ORV and 3VT views were visualized, the detection rate was 89.7% (78/87). The $P < 0.001$ value was compared with the detection rate of 4CV. The different detection rates of cardiac anomalies with different views are listed in Table 2.

Table 2 The detection rates of cardiac anomalies with different views

Views	Fetuses that could be detected	Detection rates	*P* value
4CV	42	48.3%	-
4CV+OLV	56	64.4%	0.032[1)]
4CV+ORV	58	66.7%	0.014[1)]
4CV+3VT	69	79.3%	< 0.001[1)]
4CV+OLV+ORV	60	69.0%	0.006[1)]
4CV+OLV+ORV+3VT	78	89.7%	< 0.001[1)]

4CV, four chamber view; OLV, outlet of the left ventricle; ORV, outlet of the right ventricle; 3VT, three vessels-trachea view. 1)Compared with the detection rate of 4CV.

3 Discussions

Prenatal ultrasound screening was the main approach for detecting congenital heart diseases. The detection rate of congenital heart disease has been increased by using color Doppler and three-dimensional ultrasound in recent years. Different modes, including inversion mode, glass body, tomography ultrasound image, surface mode and so on, has been used for detecting cardiac defects and those modes could provide additional information and different perspectives for cardiac malformations. Three- dimensional ultrasound with STIC could show the relationship between atriums, ventricles and great arteries clearly. Three-dimensional ultrasound with STIC has played an important role in clinical medicine.

In this study, 89.7% fetuses with congenital heart diseases could be detected by using three- dimensional ultrasound with STIC in the first trimester, which is relative high.Three vessels and trachea view (3VT) was firstly proposed by Yagel in 2002 and they confirmed that this view is superior to the classical views for assessment the great arteries, trachea and superior vena cava[4]. According to our data, the detection rate of the four- chamber view plus 3VT view was significantly higher than the four chamber view. In addition, the detection rate of the four-chamber view plus 3VT view was higher than the four-chamber view plus outlet of the left ventricle or outlet of the right ventricle view. Although the four chamber view was the most important view for ultrasound screening in the fetus, conotruncalanomalies[5], aortic arch anomalies[6], and even ventricular septal defect may be missed in this section. We recommended that the four chamber view, outletof the left ventricle, outlet of the right ventricle view and three vessels and trachea view should be visualized for standard screening. Cardiac anomalies were detected in the first trimester and the parents could choose to perform other tests for identifying the reasons that may cause the defects[7-9].

It is different from the ultrasound screening in

the second trimester that cardiac screening in the first trimester could be performed by using transabdominal or transvaginal screening[10-11]. If the patients were too fat and the shadow was very obviously. We can choose transvaginal ultrasound screening, however, the angle of the probe is relative limited. The quality of the images obtained from transvaginal is clearer than from transabdominal[12]. So we can change to perform transvaginal cardiac screening if we suspect that there may be cardiac defects for accuracy of the diagnosis[13].

We have to acknowledge that there are some limitations of three-dimensional ultrasound with STIC technology. For example, fetal breathe, maternal breathe and fetal movement would cause artifact for the cardiac volume datasets. If we obtain the volumes during the fetal resting, we may avoid these artifacts[14]. In addition, irregular fetal heart rhythm may also cause inadequate quality, so when we obtain the cardiac volumes, we should pay attention to the fetal heart rhythm. Furthermore, the scanning time may also influence the quality of the cardiac volumes.

In conclusion, three-dimensional ultrasound with STIC could detect congenital heart disease in the first trimester. The four-chamber view plus outlet of the left ventricle, outlet of the right ventricle and three vessels-trachea view could increase the detection rates of congenital heart diseases.

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