

Fetal cardiac evaluation by 3D/4D ultrasonography (STIC): what is its real applicability in the diagnosis of congenital heart disease?

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The congenital heart diseases (CHD) are the most common major malformations at birth [1], with prevalence ranging from 0.6% to 5% of live births [2]. Despite great efforts and technological advancement of two-dimensional echocardiography (2D) in the past two decades, the accuracy in the detection of CHD at prenatal is between 31% and 96% [3].

In 2003, with the development of Spatio-Temporal Image Correlation (STIC), scientists started the use of third and fourth dimension ultrasonography (3D/4D) in fetal cardiac evaluation [4]. The STIC is a software that enables acquiring volumetric fetal heart with its vascular connections, whose images can be evaluated in either multiplanar or rendering modes, or even surface mode, in a static or moving ways (4D) by means of a sequence of cineloop, which simulates a complete cardiac cycle [4]. This software provides an innovation absent in 2D ultrasound, which is the storage volume of the heart for an offline analysis, in other words, in the absence of the patient. Thus, a detailed assessment of the anatomy and the functioning fetal heart is possible without the need to

cause major discomfort to pregnant women, a relatively frequent situation when more prolonged ultrasound studies are used. Moreover, the storage allows the sending of volumes to specialized centers through an internet link, strengthening the telemedicine and improving the prenatal period tracking [5].

Standardization of volume storage is already a reality, so the investigator responsible for offline analysis has knowledge of the actual position of the heart chambers with respect to the right and left fetal axis to evaluate the presence of possible cardiac isomerisms. Therefore, when the fetus is in cephalic presentation, it should be considered that the heart side corresponds to the fetal side, unlike the pelvic fetuses which stay in opposite sides [6].

The gray scale and color Doppler applications are also present in the STIC, used to improve the evaluation of the ventricular outflow tracts, aortic and ductal arches, besides assisting in the location of septal defects [7]. The 3D technology has allowed the development of new techniques known as inversion mode (analysis technique of liquid structures which reverses voxels of gray scale,

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Abbreviations, acronyms and symbols	
2D	Second Dimension
3D	Third Dimension
4D	Fourth Dimension
CHD	Congenital Heart Diseases
STIC	Spatio-Temporal Image Correlation
TUI	Tomographic Ultrasound Imaging

so anechoic structures such as the heart chambers, lumen vessels, stomach, bladder and renal pelvis, with inversion mode they become echogenic, whereas normally echogenic structures, such as bone, become anechoic) [8] (Figure 1) and B-flow imaging (technique that improves the weak signal reflected from the blood, and suppresses the strong signals of the surrounding structures) [9]. The inversion mode allows the reconstruction of the cardiac chambers, aortic and ductal arches, and abnormalities of venous connections [8]. The B-flow imaging shows high sensitivity and angle independence, then it is potentially advantageous over color Doppler for the visualization of large vessels and venous return, allowing the identification of small vessel with low-velocity flows, such as pulmonary veins, enhancing the detection of anomalies in pulmonary venous return [9].

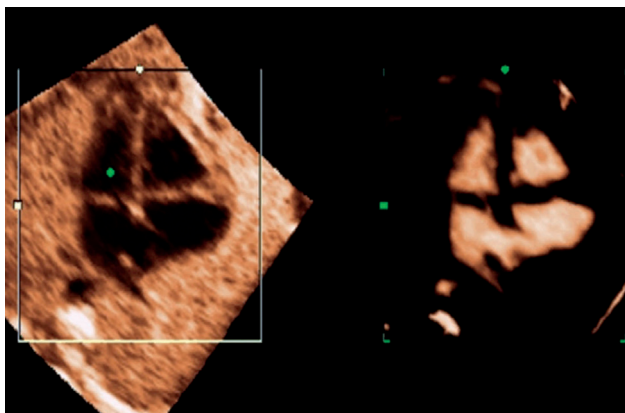


Fig. 1 – Visualization of four heart chambers plane using the inversion mode

Another technique also addressed by STIC Tomographic Ultrasound Imaging's (TUI), which enables the achievement of all the axial planes of the heart from the abdomen to the apex of the chest, increasing the fetal heart tracking and analysis [10] (Figure 2) . STIC also allows the measurement of volumes of cardiac chambers, as well as the calculation of systolic volume, ejection fraction and cardiac output. Thus, to obtain relevant information about

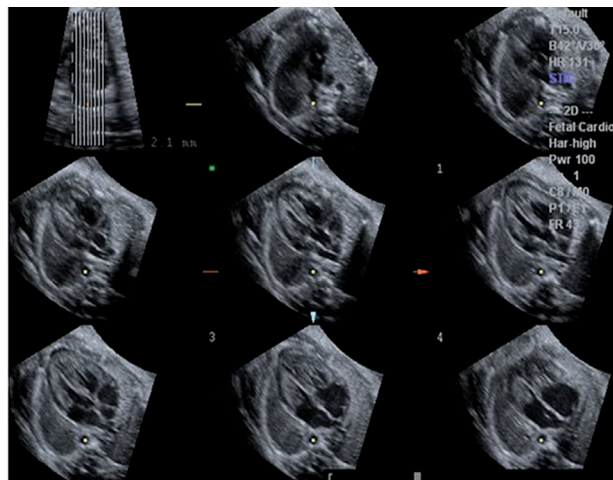


Fig. 2 - Use of TUI with simultaneous visualization of sequential axial planes of the fetal chest at heart level (3VT, 5C, 4C). TUI: tomographic ultrasound imaging. 3VT: three vessels and trachea; 5C: five chambers; 4C: four chambers

cardiac function is possible due to the CHD [11]. More recently, a new approach to STIC rendering mode analysis obtained measurements of mitral and tricuspid valves areas, and also and the interventricular septum, determining reference values for these parameters, making it feasible to apply in suspected or pathological cases[12,13].

Recently, some studies have attempted to correlate the technical 3D/4D (STIC) and 2D (echocardiography) with the diagnosis of CHD, however, these studies have shown conflicting results [14,15]. In one of these studies, with the STIC being conducted by the general obstetricians, without specific knowledge of the methodology, the STIC proved itself to be inferior to 2D echocardiography, performed by a specialist in the diagnosis of CHD [14]. In another study, where the STIC was performed by experienced examiners in this methodology, the accuracy in the diagnosis of CHD was similar to that obtained by echocardiography 2D [15].

Based on recent studies, it is still early to say whether the 3D/4D ultrasound (STIC) will surpass 2D echocardiography as a gold standard in prenatal diagnosis of CHD. In our reality, the biggest obstacles are the need for sophisticated and expensive equipment and people with specific training in 3D/4D ultrasound. However, some benefits are already envisioned, as less operator dependence and the possibility of sending volumes to reference centers for fetal and pediatric cardiology, which is of fundamental importance in a country like ours, where these centers are located in major cities.

In summary, only in multicenter studies, with examiners experienced in 3D/4D technology, can confirm the real benefits of STIC in prenatal diagnosis of CHD.

REFERENCES

1. Hoffmann JI. Incidence of congenital heart disease: I. Postnatal incidence. *Pediatr Cardiol.* 1995;16(3):103-13.
2. Grandjean H, Larroque D, Levi S. The performance of routine ultrasonographic screening of pregnancies in the Eurofetus Study. *Am J Obstet Gynecol.* 1999;181(2):446-54.
3. Stümpflen I, Stümpflen A, Wimmer M, Bernaschek G. Effect of detailed fetal echocardiography as part of routine prenatal ultrasonographic screening on detection of congenital heart disease. *Lancet.* 1996;348(9031):854-7.
4. DeVore GR, Falkensammer P, Sklansky MS, Platt LD. Spatio-temporal image correlation (STIC): new technology for evaluation of the fetal heart. *Ultrasound Obstet Gynecol.* 2003;22(4):380-7.
5. Gonçalves LF, Nien JK, Espinoza J, Kusanovic JP, Lee W, Swope B, et al. What does 2-dimensional imaging add to 3- and 4-dimensional obstetrics ultrasonography? *J Ultrasound Med.* 2006;25(6):691-9.
6. Paladini D. Standardization of on-screen fetal heart orientation prior to storage of spatio-temporal image correlation (STIC) volume datasets. *Ultrasound Obstet Gynecol.* 2007;29(6):605-11.
7. Gonçalves LF, Lee W, Chaiworapongsa T, Espinoza J, Schoen ML, Falkensammer P. Four-dimensional ultrasonography of the fetal heart with spatiotemporal image correlation. *Am J Obstet Gynecol.* 2003;189:1792-802.
8. Lee W, Gonçalves LF, Espinoza J, Romero R. Inversion mode: a new volume analysis tool for 3-dimensional ultrasonography. *J Ultrasound Med.* 2005;24(2):201-7.
9. Pooh PK, Korai A. B-flow and B-flow spatio-temporal image correlation in visualizing fetal cardiac blood flow. *Croat Med J.* 2005;46(5):808-11.
10. Yagel S, Cohen SM, Rosenak D, Messing B, Lipschuetz M, Shen O, et al. Added value of three-/four-dimensional ultrasound in offline analysis and diagnosis of congenital heart disease. *Ultrasound Obstet Gynecol.* 2011;37(4):432-7.
11. Simioni C, Nardoza LM, Araujo Júnior E, Rolo LC, Zamith M, Caetano AC, et al. Heart stroke volume, cardiac output, and ejection fraction in 265 normal fetus in the second half of gestation assessed by 4D ultrasound using spatio-temporal image correlation. *J Matern Fetal Neonatal Med.* 2011;24(9):1159-67.
12. Rolo LC, Nardoza LM, Araujo Júnior E, Hatanaka AR, Rocha LA, Simioni C, et al. Reference ranges of atrioventricular valve areas by means of four-dimensional ultrasonography using spatiotemporal image correlation in the rendering mode. *Prenat Diagn.* 2013;33(1):50-5.
13. Nardoza LM, Rolo LC, Araujo Júnior E, Hatanaka AR, Rocha LA, Simioni C, et al. Reference range for fetal interventricular septum area by means of four-dimensional ultrasonography using spatiotemporal image correlation. *Fetal Diagn Ther.* 2013 [ahead of print].
14. Wanitpongpan P, Kanagawa T, Kinugasa Y, Kimura T. Spatio-temporal image correlation (STIC) used by general obstetricians is marginally clinically effective compared to 2D fetal echocardiography scanning by experts. *Prenat Diagn.* 2008;28(10):923-8.
15. Bennasar M, Martínez JM, Gómez O, Bartrons J, Olivella A, Puerto B, et al. Accuracy of four-dimensional spatiotemporal image correlation echocardiography in the prenatal diagnosis of congenital heart defects. *Ultrasound Obstet Gynecol.* 2010;36(4):458-64.