Ultrasound / White paper

Fetal cardiac examinations in the first trimester: The diagnostic role of Superb Micro-vascular Imaging (SMI)

A. Sciarrone, S. Bastonero, A. Pertusio, I. Dusini, E. Fornaciari
Obstetric and Gynecological Ultrasound and Prenatal Diagnosis Center,
Città della Salute e della Scienza,
Turin, Italy

Introduction

Diagnostic ultrasound is a common method for evaluating fetal cardiac structures in the second trimester of pregnancy – either as a screening tool or as a diagnostic method. Recently, modern ultrasound technologies have opened up the possibility for studying fetal anatomy, including the fetal heart, at an earlier gestational age (GA). In general, the study of fetal anatomy in the first trimester benefits from the use of a transvaginal probe.

A number of relevant studies have recently investigated the possibility of examining the fetal heart during the first trimester ultrasound examination, which is mainly performed to measure fetal nuchal translucency (NT). However, NT evaluation is typically performed using a transabdominal approach.

A recent meta-analysis on the benefits of a transvaginal versus a transabdominal approach (Yu et al, J Ultrasound Med, 39: 471, 2020) highlighted sensitivity and specificity values of 75% and 99% respectively; positive and negative likelihood ratios as well as area under the curve (AUC) values of 392, 277 and 0 respectively. In addition, the meta-analysis demonstrated better performance in cases where the examination was performed transabdominally. This result can be explained by the fact that, despite the high resolution of the transvaginal probe, this method has significant limitations in terms of proper orientation of the probe compared to the transabdominal approach. In this regard, it is likely that the two methods can be complementary.

Technically, the location and anatomical relationships of the individual components of fetal cardiovascular anatomy are similar in both the first and second trimesters of pregnancy. Studies have shown that early confirmation of normal heart anatomy can reduce anxiety for the expecting mother and her family. When an abnormal feature is suspected, early information allows for immediate clinical management and better decision-making regarding the continuation of the pregnancy.

First trimester echocardiography: our experience

At our facility, we performed fetal cardiac examinations in 25 cases during the first trimester of pregnancy (GA of 11wk - 13wk + 6d). NT measurements were found normal in 24 cases. In one case, it was higher than the 99th percentile (5.4 mm). Obese women (BMI > 35) were excluded from the study. The Crown-Rump Length (CRL) measurement ranged from 50 to 83 mm. The investigations were conducted with a micro-convex probe (1-10 MHz) available on the Aplio platform.

In the initial phase of the study, an attempt was made to obtain the two-dimensional images necessary for a complete assessment of the cardiac anatomy. SMI was then used in both the mono- and bi-directional versions, while increasing the frame rate to the maximum and using the signal suppression function of the anatomical structures. The fetal anatomy was then re-examined at 20 weeks and found to be normal in all cases.

Cardiac structure analysis: grey scale ultrasound

A complete cardiac analysis was possible and sufficiently informative in all cases analyzed by two-dimensional ultrasound (Fig. 1), even if the performance of this early approach was lower than that obtained at 20 weeks GA with the same equipment, which is in accordance with the specialist literature.

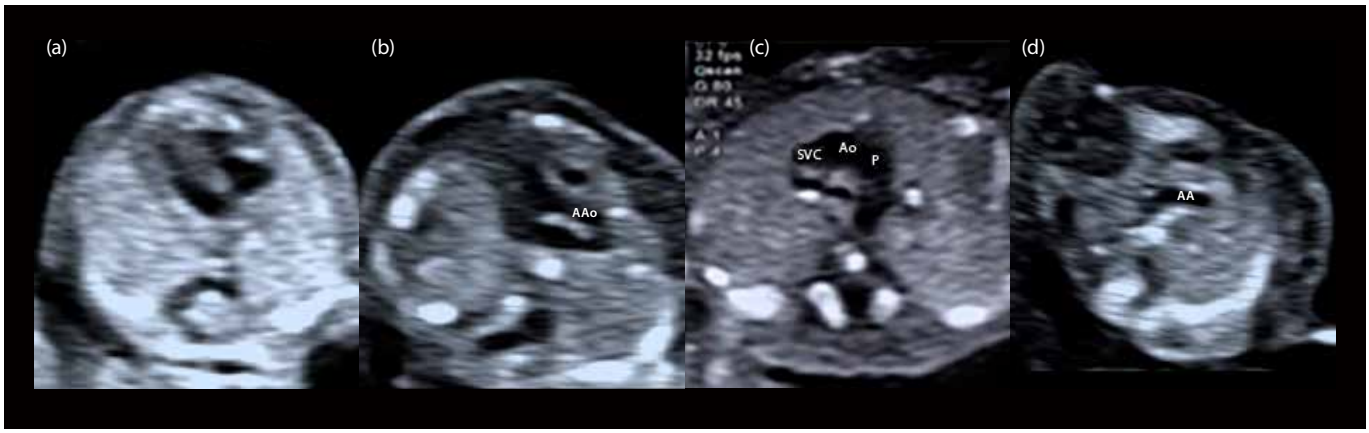

Figure 1: Useful scan planes in the study of the fetal heart in B-mode examinations.
a) Four-chamber view b) Left heart long axis view c) Three-vessel view d) Transverse aortic arch

Cardiac structures analysis: SMI technology

The use of SMI was qualitatively relevant in that it provided an "imprint" of the cardiovascular structures. The visualization of the four heart chambers was particularly useful, as it allowed us to assess the patency of the atrioventricular valve openings and the symmetry of the right and left fetal heart. The depiction of the left and right cardiac outflow tracts, as well as the three-vessel and trachea view enabled us to verify the respective positions and relationship of the great arteries, the aortic and ductal arch, while also providing a subjective estimation of their dimensions (Figs. 2 and 3).

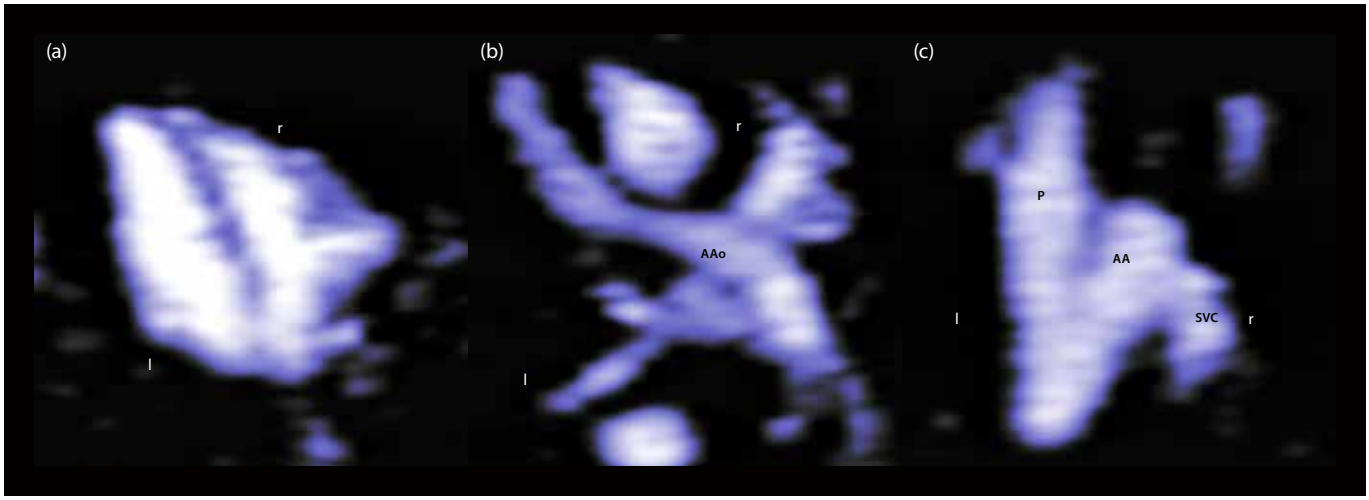

Figure 2: Monochromatic SMI used for the study of some scans of the fetal heart.
a) Four-chamber view b) Left heart long axis view c) Three-vessel view with trachea

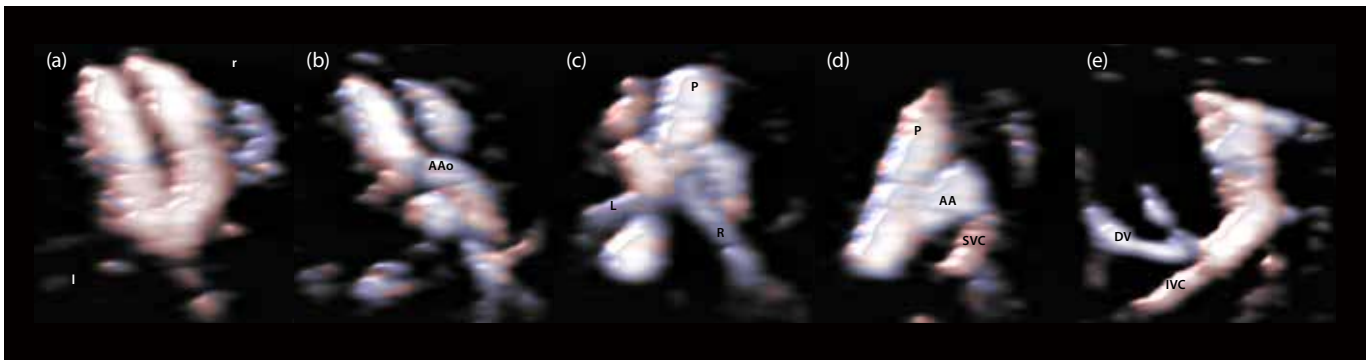

Figure 3: Bi-directional monochromatic SMI used for the study of some scans of the fetal heart.
a) Four-chamber view b) Left heart long axis view c) Bifurcation of the pulmonary artery d) Three-vessel view with trachea
e) Longitudinal scan showing ductus venous and inferior vena cava

Using monochromatic SMI, it was possible to distinguish the pulmonary artery branches from the venous branches by means of the exhibited Doppler pattern (more pulsatile for arteries and more continuous and sustained for veins throughout the cardiac cycle). The bifurcation of the main pulmonary artery trunk was clearly visible in all cases (Fig. 3c).

SMI always showed the pulmonary veins and it was possible to visualize the shape of at least two pulmonary veins on the left atrium. Other additional views used in fetal echocardiography (longitudinal scan of the ductal arch and the aortic arch) have also been imaged successfully (Fig. 4). Despite the early GA, SMI was able to highlight the signal of some supra-aortic branches and the internal mammary arteries anteriorly to the left brachiocephalic vein.

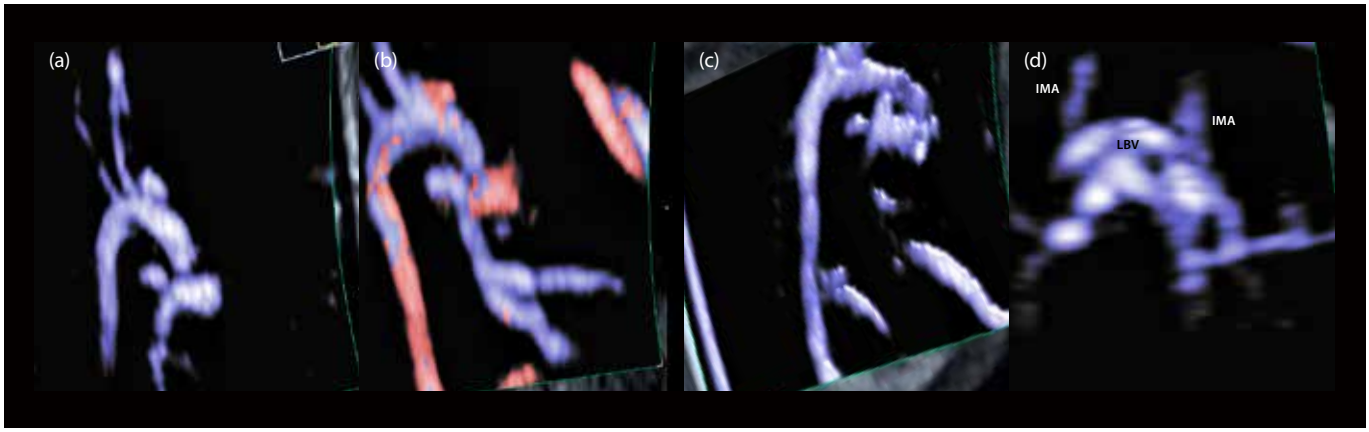

Figure 4: Longitudinal scan of pulmonary structures with SMI.
a,b) Aortic arch c) Ductal arch d) Cross-section of the fetal trunk (LBV: left brachiocephalic vein; IMA: internal mammary arteries)

Conclusion

In our initial experience, the examination protocol normally followed during second trimester fetal echocardiography can be successfully applied transabdominal during first trimester scans. The images obtained with SMI were very informative in terms of size, morphological features, and reciprocal relationships of the various cardiovascular structures of the fetus. Further studies with this method are required for cardiac malformations and obese pregnant women.

In any case, Canon's micro-convex probe technology, in particular on the Aplio platform, has proven to be extremely versatile in performing screening and diagnostic testing in the first trimester of pregnancy. In our experience, the transvaginal approach has never been necessary for the evaluation of cardiac structures.

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MWPUS0015EA 2022-09 CMSC/Produced in Japan

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