



# SlowflowHD for the examination of the fetal heart in the first trimester

A novel ultrasound capability enables more complete early-pregnancy screening. Timely detection of cardiac and other fetal anomalies gives parents and doctors valuable information on which to base appropriate decisions relatively early in gestation.

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## Introduction

In recent years there has been a shift in the role of the first-trimester ultrasound examination. Initially it was used mainly to ensure viability, to enable accurate dating and to provide an estimation of the risk of trisomies. With advances in ultrasound imaging, the approach has shifted toward a detailed evaluation of fetal anatomy in order to improve detection rates of severe fetal malformations in the first trimester. Diagnosis of fetal anomalies at the earliest gestation possible is the cornerstone of prenatal diagnosis and provides valuable time to provide appropriate counseling to the expecting parents. Moreover, detection of a fetal anomaly in the first trimester may contribute to a better understanding of the underlying mechanisms involved in its progression throughout pregnancy.

Screening studies demonstrate first trimester detection rates of fetal anomalies in low-risk populations of 32% (95% CI, 22.5-43.1%), whereas in high-risk populations the rate is 62% (95% CI, 37.7-82.2%)<sup>[1]</sup>. In addition, even higher detection rates have been reported using high-resolution ultrasound equipment<sup>[2]</sup>.

Congenital structural heart abnormalities are among the most common severe fetal malformations and represent a leading cause of infant mortality. Cardiac abnormalities are usually and classically diagnosed in the second trimester during the routine anomaly scan. Fetal echocardiography, performed between 18 and 24 weeks, is reserved for cases with either increased background risk (family history, previous pregnancies, teratogen

exposure), or presence of “markers” in the first trimester scan (increased nuchal translucency, presence of tricuspid regurgitation). However, the detection rate of these structural heart abnormalities in the first trimester is generally low and varies depending on the severity of the malformation, ultrasound equipment resolution and limitations, maternal body habitus, and sonographer skill. For early detection, it is increasingly essential for sonographers to have expertise in fetal echocardiography and to be fully competent in the detailed first-trimester assessment.

The approach to the fetal heart examination in the first trimester is very similar to the systematic approach that is essential for second- and third-trimester echocardiography. However, selection of the correct ultrasound equipment, including the use of transabdominal and transvaginal transducers, as well as the appropriate use of presets and adjustment of acoustic output, imaging depth and zoom, are essential in obtaining good image quality<sup>[3]</sup>. The most important step in first-trimester examination of the fetal heart is the confirmation of normal situs and the acquisition of the apical and transverse four-chamber views. The next steps include examination of the great arteries, as many common cardiac defects, such as tetralogy of fallot (TOF) and transposition of the great arteries (TGA), are associated with a normal four-chamber view. Due to the small size of the heart in the first trimester, most of the cardiac views cannot be adequately visualized using B-Mode imaging. Colour Doppler

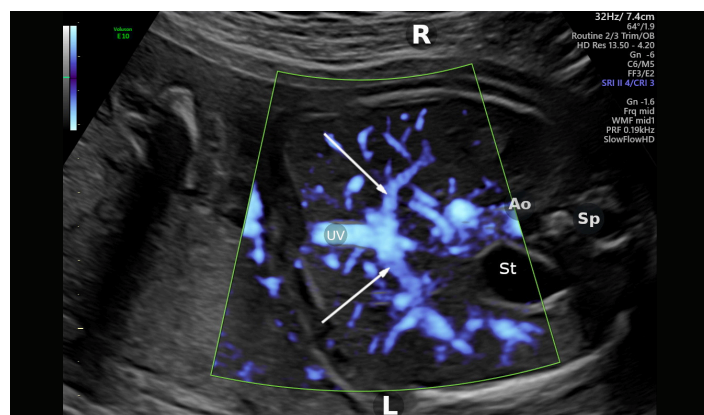
has been used as an adjunct method to evaluate the size, shape and direction of flow within the great vessels. This method, though, cannot precisely delineate the structure of fine vessels, especially in suboptimal insonating angles. Transvaginal examination has been proposed to enhance image quality, and may indeed do so in selected patients, but it is often inconvenient and time-consuming, and it requires additional operator skills.

A novel ultrasound imaging application can provide clear visualization of blood flow in extremely small vessels, facilitating the examination of the fetal heart in the first trimester. The application *SlowflowHD* is available on Voluson™ Expert Series BT18+ ultrasound systems from GE Healthcare.

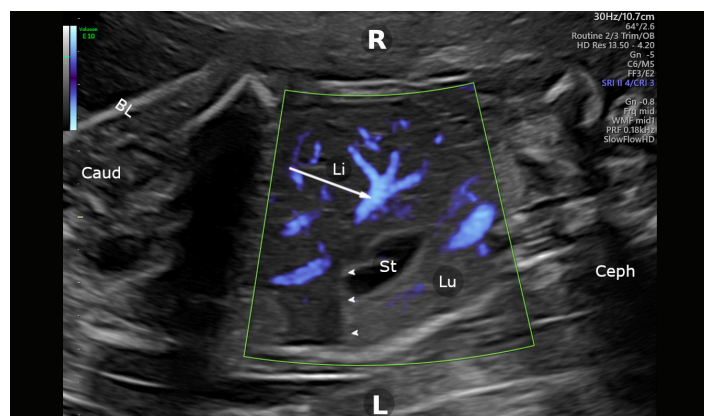
## A new acquisition technique

*SlowflowHD* is an especially sensitive form of power Doppler, designed specifically to detect the low flow velocities found in fine blood vessels. Low-velocity sensitivity can be increased by reducing the pulse repetition frequency in traditional Doppler methods, but this results in unacceptable levels of artifact in the ultrasound images. Instead, *SlowflowHD* uses a completely new acquisition architecture that automatically calculates the optimal pulse repetition frequency. This, combined with highly sophisticated wall filters, increases sensitivity to fine vessels while producing little or no motion artifact. This mode has the significant benefit of detecting flow even when the insonation angle is suboptimal. Similarly to conventional Doppler imaging modalities, *SlowflowHD* has different colour maps that allow the examiner to select directional (dual colour) or non-directional flow imaging (single colour). Vessel appearance can be further enhanced with the additional activation of *Radiantflow*, which provides a three-dimensional appearance to the vessels.

As it can be seen in the following images, this technology makes the imaging of small vessels technically easier in day-to-day practice, allowing more detailed visualization of solid organ vasculature.



*Image 1.* Transverse section of the upper abdomen at 20 weeks in a fetus with right atrial isomerism. The branching of the umbilical vein (UV) to the portal veins (white arrows) in the fetal liver follows a symmetrical pattern across both sides, a finding consistent with midline liver. (St: Stomach, Ao: Aorta, Sp: Spine).



*Image 2.* Coronal plane of the chest and abdomen in a fetus at 31 weeks of gestation with right-sided congenital diaphragmatic hernia. *SlowflowHD* reveals the vasculature of the liver (Li – white arrow), which is herniated in the thorax. The stomach (St) is also in the thorax, and the white arrowheads indicate the intact part of the diaphragm. (Lu: Lung).

## SlowflowHD in the first trimester fetal heart examination

SlowflowHD can become an important tool in the first trimester echocardiogram. By detecting and imaging blood flow, it enhances the resolution of the B-Mode image, so that the shape of the cardiac atrial and ventricular chambers, as well as the great arteries, can be accurately delineated. The following cases are examples of detailed transabdominal echocardiograms performed in early gestation using SlowflowHD as an adjunct imaging modality.

**Case 1: 13+3 weeks, normal fetal heart** – This echocardiogram was performed in a normal fetus during the first-trimester scan.

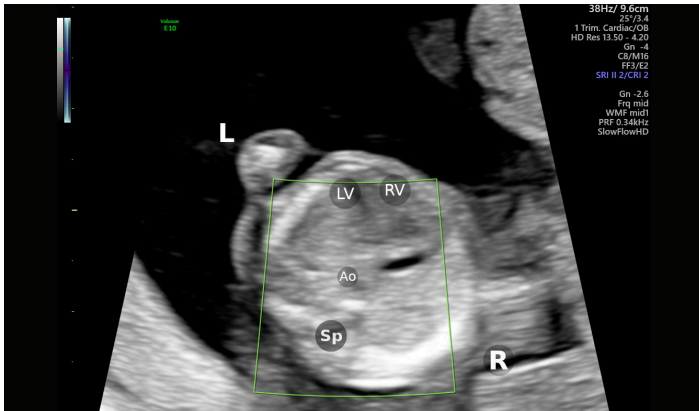


Image 3a. Four-chamber view using B-Mode imaging. (LV, RV: Left and Right Ventricle, Ao: Aorta, Sp: Spine).

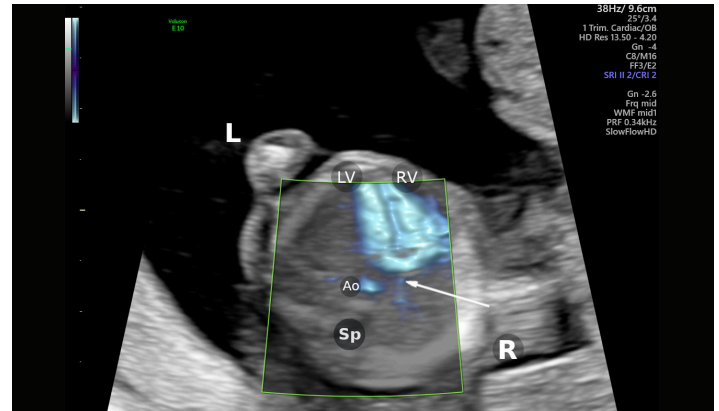


Image 3b. Same view with the addition of SlowFlowHD as an adjunct modality. Symmetrical filling of colour can be seen in both sides of the heart, separated by the interventricular septum. Normal right pulmonary venous return is also demonstrated (white arrow). The aorta (Ao) can be seen anteriorly to the spine (Sp), toward the left side.

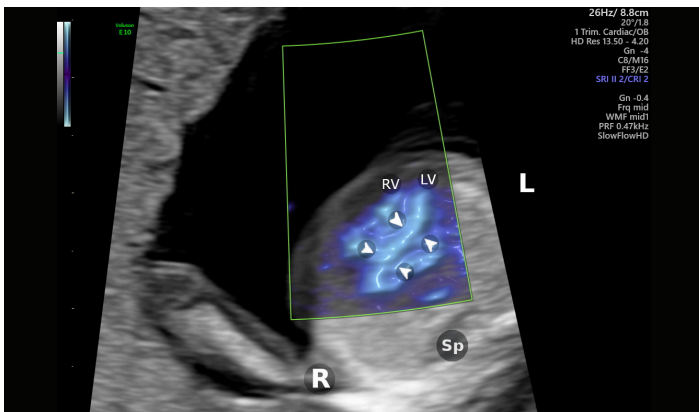


Image 4. Demonstration of the left ventricle outflow tract (LVOT) using SlowFlowHD, showing the aorta arising from and being “committed” to the left ventricle (between arrowheads). Radiantflow mode also enhances the tubular appearance of the vessel.

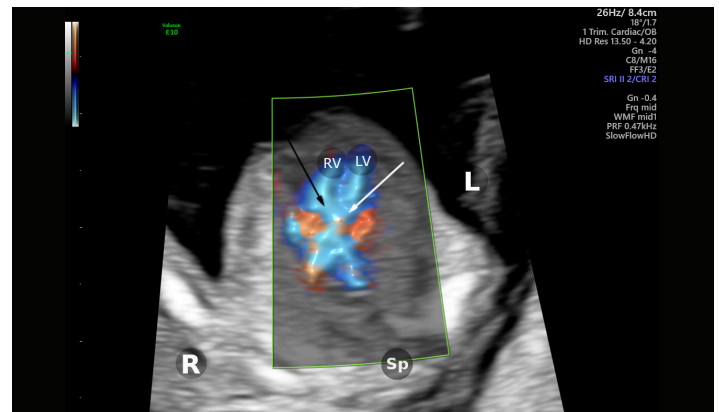


Image 5. Crossover of the great arteries. This is a plane between the left ventricle outflow tract (LVOT) and right ventricle outflow tract (RVOT) planes. In early pregnancy, both outflows can be demonstrated on the same plane due to the small size of the heart. (LVOT – white arrow, RVOT – black arrow).

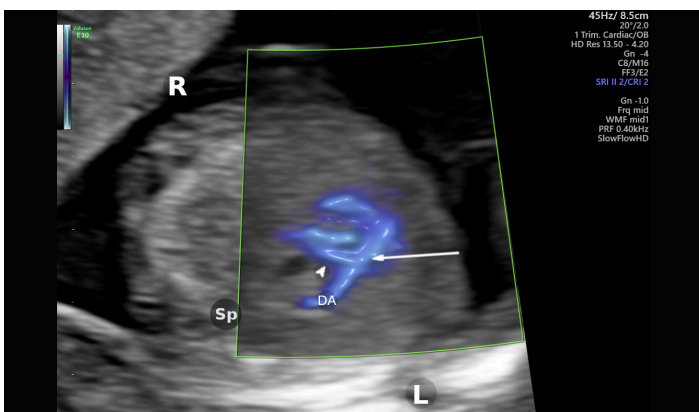


Image 6. Demonstration of the RVOT, showing the pulmonary trunk arising from the right ventricle (white arrow). The right pulmonary artery can be seen arising from the pulmonary trunk (white arrowhead). (DA: ductus arteriosus).

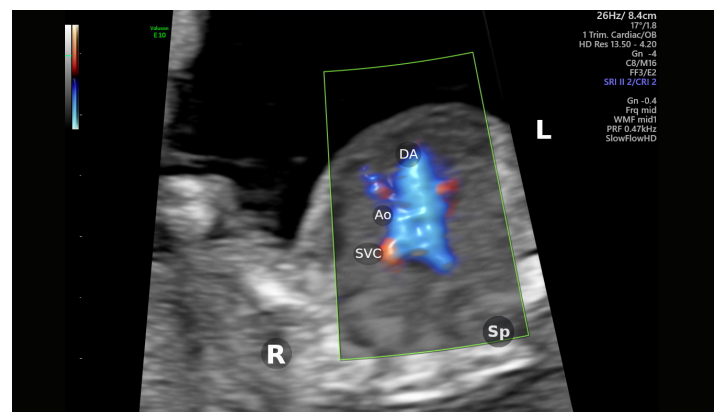


Image 7. 3VT view with SlowflowHD, demonstrating the left aortic arch (Ao) of equal size to the arterial duct (DA) with antegrade flow in both vessels, as well as the superior vena cava (SVC).

## Case 2: 13+6 and 16+2 weeks, Left SVC, pericardial effusion

This case was referred to the Fetal Medicine Centre at 13+6 weeks with pericardial effusion. Early echocardiography revealed the presence of a persistent left superior vena cava, while the rest of the cardiac anatomy appeared normal. Subsequent scans (including postnatal scans) confirmed the presence of LSVC draining to a dilated coronary sinus as an isolated finding.

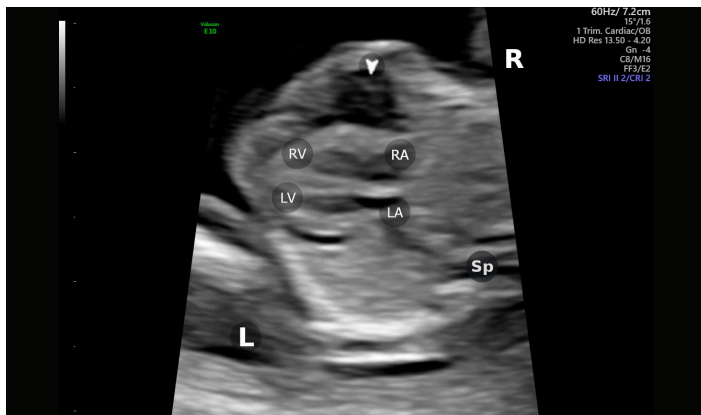


Image 8. Four-chamber view at 13+6 weeks using B-Mode imaging. There is pericardial effusion (white arrowhead). (LA-RA: Left and Right Atrium, LV-RV: Left and Right Ventricle).

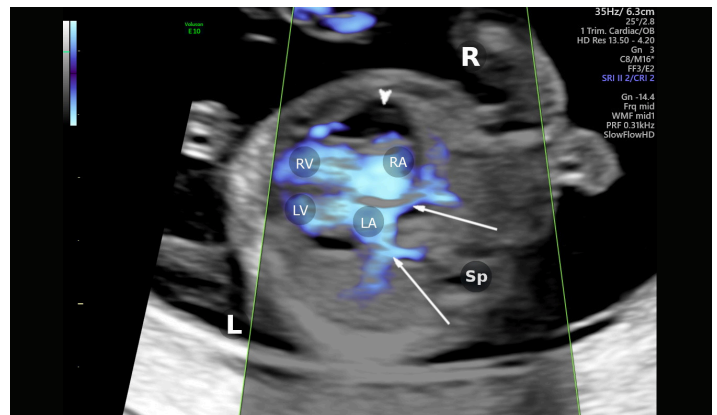


Image 9. Four-chamber view at 13+6 weeks with SlowflowHD, demonstrating normal pulmonary venous return (white arrows). Pericardial effusion also visible (white arrowhead).



Image 10. 3VT view at 13+6 weeks demonstrating the presence of a fourth vessel. This represents a persistent left superior vena cava (LSVC). There is a normal left-sided aortic arch.

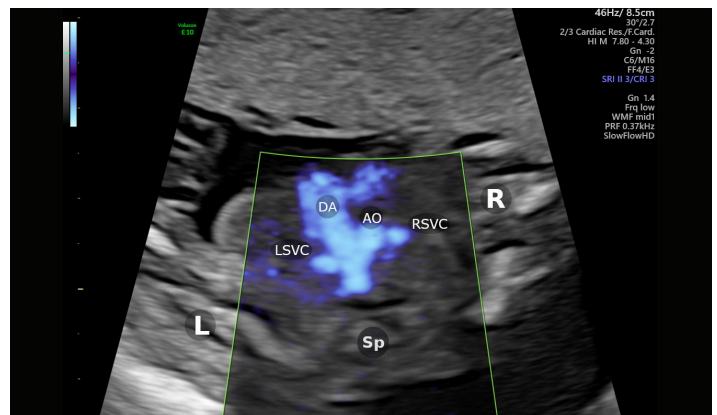


Image 11. 3VT view of the same patient at 16+2 weeks.

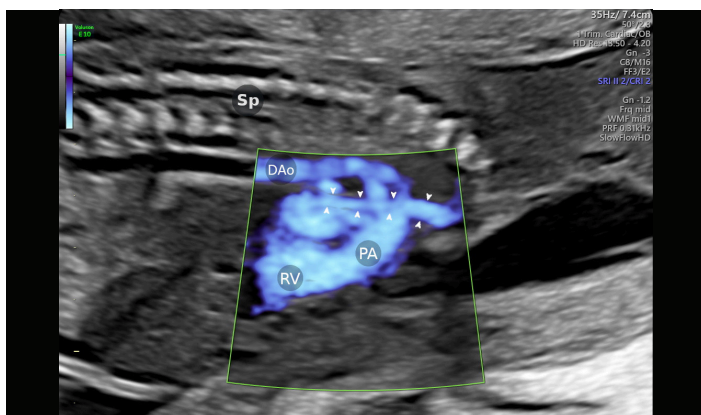


Image 12. Sagittal view of the left SVC draining to the coronary sinus at 16+2 weeks (LSVC visible between white arrowheads). The pulmonary artery (PA) is seen emerging from the right ventricle.



### Case 3: 12+2 weeks. Fetus with Pulmonary Atresia/Ventricular Septal Defect (VSD)/Major Aortopulmonary Collateral Arteries (MAPCAs)

This case was referred to the Fetal Medicine Centre with an increased nuchal translucency measurement (4.3 mm). The initial scan revealed the presence of fetal hydrops (pleural effusion and skin oedema) and an abnormal cardiac axis. Detailed echocardiograms performed at 12+2 and 15 weeks raised the suspicion of pulmonary atresia with a VSD and MAPCAs. This diagnosis was confirmed with further scans later in pregnancy, as well as with postnatal scans.



Image 13. Four-chamber view with two ventricles of equal size. There is deviation of the cardiac axis to the left, as well as marked skin oedema (white arrowheads).

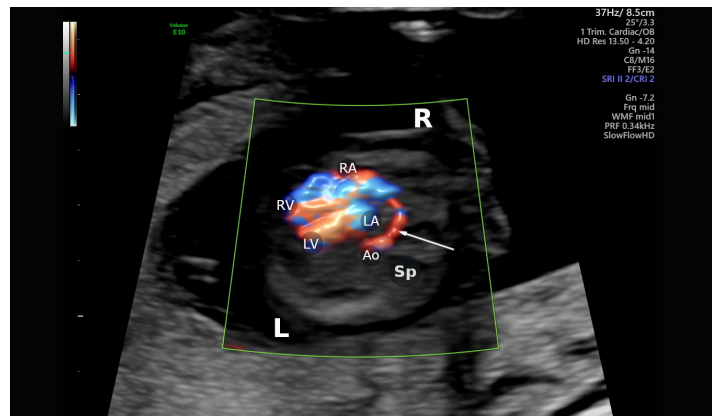


Image 14. Adding SlowflowHD to B-Mode imaging in the same four-chamber view reveals a vessel arising from the right side of the aorta (white arrow). This raises the suspicion of a major MAPCA.

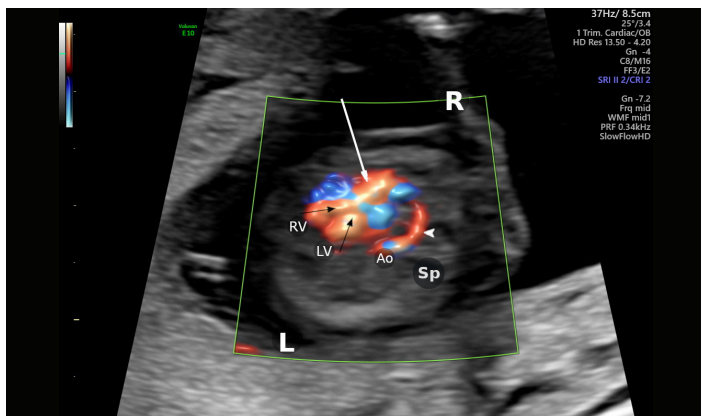


Image 15. LVOT view using SlowflowHD mode raises the suspicion of an overriding great vessel (white arrow), receiving flow from both ventricles (black arrows), raising the suspicion for an outlet VSD. The white arrowhead marks the vessel, which is arising from the right side of the aorta and can also be seen in image 14.

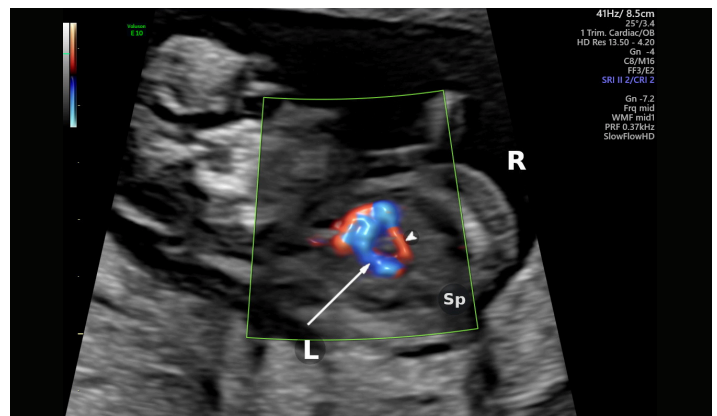


Image 16. On the 3VT view the ductus arteriosus cannot be demonstrated to the left of the aorta. The aorta is seen to the left of the trachea (white arrow). There is another vessel arising from the right side of the aorta, which might also represent a MAPCA.

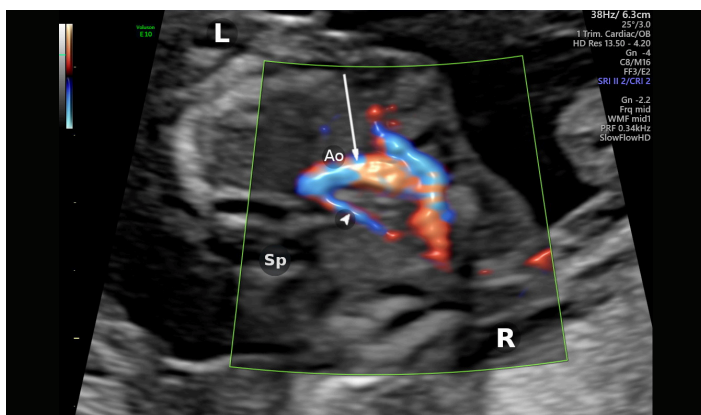


Image 17. At 15 weeks on the 3VT view using SlowflowHD, the aorta (white arrow) can be seen on the left of the trachea. There is no visible arterial duct. A small vessel can be seen arising from the right side of the aorta (white arrowhead), which most likely represents the same collateral vessel seen in image 16 (MAPCA).

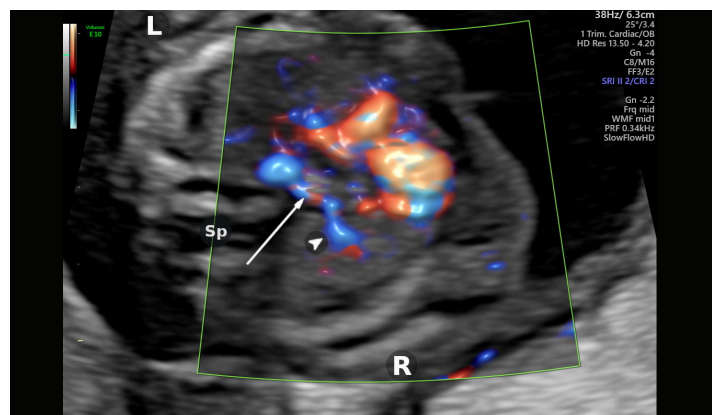


Image 18. Using SlowflowHD and moving the transducer caudally, a second vessel can be seen arising from the right side of the descending aorta (white arrow) which is in communication with a small right pulmonary artery (white arrowhead).

#### Case 4: 16+4 weeks. Fetus with double-outlet right ventricle with transposed great vessels

This fetus was referred to the Fetal Medicine Centre for an early echocardiographic examination. There was increased nuchal translucency in the first trimester, with a normal scan at 13 weeks and normal karyotype from invasive testing. During examination with colour Doppler, a suspicion was raised for the existence of a double-outlet right ventricle with transposed great vessels. Switching to SlowflowHD provided more accurate images that facilitated diagnosis. Further examinations later in gestation, as well as postnatally, confirmed this diagnosis.

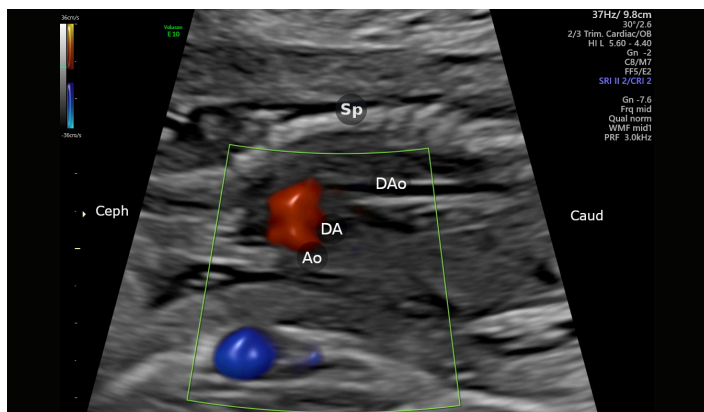


Image 19. Sagittal view of the aortic and ductal arches using traditional colour Doppler.

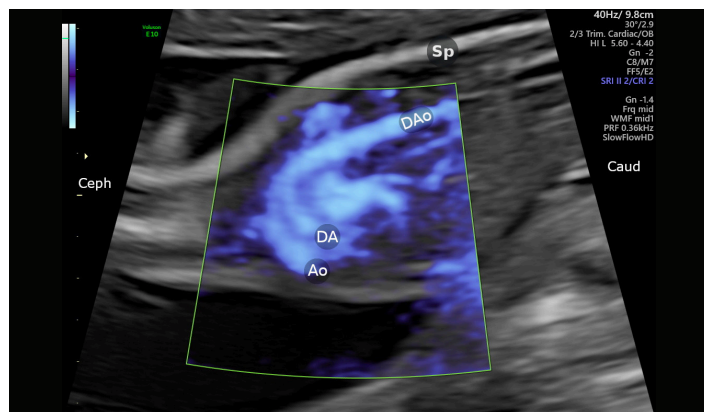


Image 20. The same sagittal view with SlowflowHD, clearly demonstrating the characteristic parallel course of the transposed great vessels.

#### Case 5: 20 weeks. Right Atrial Isomerism with Total Abnormal Pulmonary Vein Drainage (TAPVD)

This case was referred to the Fetal Medicine Centre at 20 weeks of gestation with suspicion of hypoplastic left heart syndrome. A detailed scan and echocardiogram revealed the presence of abnormal abdominal situs and cardiac axis. Use of the SlowflowHD mode on the transabdominal plane (see image 1) revealed the presence of abnormal portal vein branching in the fetal liver that followed a symmetrical pattern across both sides, a finding consistent with midline liver. The same imaging modality was used to facilitate examination of the pulmonary venous return. In this case, there was total anomalous pulmonary venous return to a confluence behind the atria, draining in the innominate vein.

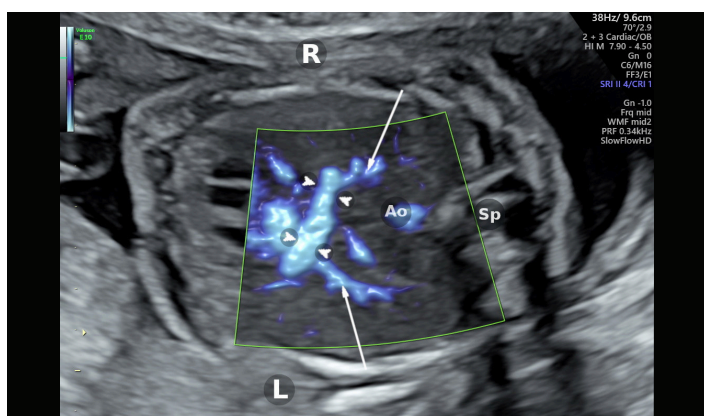


Image 21. Total anomalous pulmonary venous return (white arrows) draining in a confluence situated behind the atria (white arrowheads), as demonstrated with SlowflowHD. Please note that the region of interest (ROI – "green Doppler box") does not include the ventricular walls, in order to reduce artifacts.

## Case 6: Fetus with Trisomy 21 at 13+6 and 21 weeks. Severe tricuspid regurgitation, absence of flow through the pulmonary valve

This case was referred to the Fetal Medicine Centre in the first trimester following a high-risk combined screening test for trisomies. A detailed scan and an invasive test were performed. Fetal heart examination at this point showed a structurally normal fetal heart with tricuspid regurgitation. The result of invasive testing was consistent with Trisomy 21. An additional fetal echocardiogram performed at 21 weeks showed severe tricuspid regurgitation, right atrial dilatation and absence of flow through the pulmonary valve. The parents opted not to continue with the pregnancy.

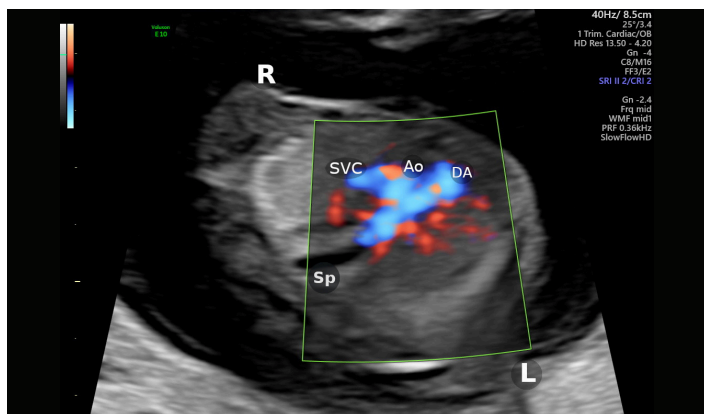


Image 22. 3VT view at 13+6 weeks demonstrating normal forward flow in the arterial duct using directional SlowflowHD imaging.

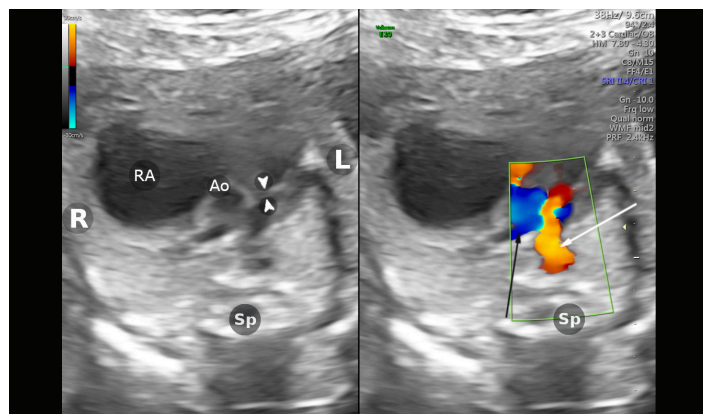


Image 23. RVOT view using normal colour Doppler at 21 weeks, showing a severely dilated right atrium (RA). The pulmonary valve is shown between the white arrowheads. There is reversal of flow in the arterial duct (white arrow). The right pulmonary artery also demonstrated (black arrow).

## Tips, tricks and pitfalls

Use of SlowflowHD does not differ from the use of normal colour/power Doppler, and its use does not require any additional specialized training. There are, though, some important aspects that examiners must keep in mind:

- During the examination of the fetal heart in the first trimester, it is essential to reduce the Acoustic Output (AO) to about 75% in order to reduce artifacts produced by the movement of the ventricular wall. Moreover, examiners should reduce the SlowflowHD gain to a level so that no colour bleed is visualized. Further optimization can be achieved by reducing the Balance setting.
- Sometimes, especially when examining the four-chamber view, Radiantflow™ might introduce artifacts and reduce the diagnostic accuracy of the image. On the other hand, during the examination of the outflows, it can facilitate imaging by enhancing the borders of the arteries. The amount of Radiantflow effect can either be adjusted or completely deactivated, according to examiner's preferences, in order to optimise the image.
- SlowflowHD also enables examiners to reduce the level of B-Mode gain, or even completely switch it off within the region of interest, with the rest of the field of view remaining unaltered. As a result, the flow of the vessels appears enhanced and well defined, while the low-gain B-Mode in the background within the region of interest facilitates orientation of the examiner.
- SlowflowHD is very sensitive to motion. As pregnancy advances beyond 16 weeks, the movement of the ventricular walls might create significant artifacts in the image. The Acoustic Output, Gain and Balance should be set to lower levels (e.g. AO to 50%) in order to reduce the artifacts. The region of interest (ROI) should be kept as small as possible. During the assessment of pulmonary venous return, the examiner must ensure that the ROI does not include the ventricular or atrial walls.
- Fetal movements can also create significant artifacts. This is very important especially when using bidirectional colour maps. The examiner must keep in mind that movements of the fetus toward or away from the probe can produce false flow signals. It is advisable to examine the heart and obtain images only during periods of fetal quiescence.
- SlowflowHD use should be limited to the shortest duration possible in order to obtain adequate clinical information, in concordance with the ALARA principle (As Low As Reasonably Achievable). Clips using SlowflowHD can be acquired while performing a slow sweep from the transabdominal plane to the 3VT plane. Appropriate diagnostic images can then be stored through frame-by-frame review of the acquired clip.
- It is also very important to note that some cardiac abnormalities, such as cardiac tumors and cardiomyopathies, are not evident until later in pregnancy. Some forms of congenital heart disease, including aortic and pulmonary stenosis, might be associated with a normal appearance in the first trimester and progress into significant malformations with advancing gestation. A repeat examination in the second trimester is necessary in all cases with a normal first trimester examination to further assess cardiac anatomy.

## Conclusion

Following the trend for earlier prenatal diagnosis, there is growing interest in earlier diagnosis of congenital heart disease. Traditional imaging modalities such as B-Mode greyscale imaging and colour Doppler are not sufficient in the acquisition of the necessary planes that constitute a complete fetal heart examination. *Slowflow*HD can be incorporated into first-trimester ultrasound examinations of the fetal heart to improve the imaging of cardiac anatomy, and especially the outflow tracts, which may lead to an improvement in early detection of fetal structural heart malformations.

### References

- [1] JN Karim et al. Systematic Review of First-Trimester Ultrasound Screening for Detection of Fetal Structural Anomalies and Factors That Affect Screening Performance. *Ultrasound Obstet Gynecol.* 2017 Oct;50(4):429-441.
- [2] EA Springhall et al. How to perform a sonographic morphological assessment of the fetus at 11–14 weeks of gestation. *AJUM* 2018 Aug; 21(3):125-137.
- [3] LJ Salomon et al. ISUOG Practice Guidelines: Performance of First-Trimester Fetal Ultrasound Scan. *Ultrasound Obstet Gynecol.* 2013 Jan;41(1):102-13.

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