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Visualization of Pericallosal Artery (PCA) by MV-Flow™ and LumiFlow™ at 12 weeks scan

Anticipating integrity of Corpus Callosum

Gerard Albaigés, M.D.
Laura Perdomo, M.D.
Alberto Rodriguez Melcon, M.D.

Fetal Medicine Unit, Department of Obstetrics, Gynecology, and Reproductive Medicine, Hospital Universitari Dexeus, Barcelona, Spain

Introduction

The corpus callosum is the primary brain commissure. The complete and natural development of the corpus callosum is a late event in the ontogenesis of the fetal nervous system that cannot be entirely assessed until late in pregnancy. There are several primary sonographic findings in cases of corpus callosum agenesis. Direct non-visualization of the corpus callosum is observed during the late second trimester, along with colpocephaly that presents a tear-drop shape of the lateral ventricle of the brain. Furthermore, there is an absence of the cavum septum pellucidum and an abnormal vascular map of the pericallosal artery (PCA), which usually runs sagittally over the corpus callosum and is responsible for the blood flow to the corpus callosum and internal wall of the brain hemispheres. PAs, which are branches of the anterior cerebral arteries that originate from the arterial circle of Willis, develop a vascular pattern during embryonic development. However, this pattern has been identified as abnormal only through the use of colour Doppler ultrasonography during the second and third trimesters of pregnancy[1, 2].

Antenatal imaging of the pericallosal artery (PCA) using conventional Doppler imaging during midtrimester is difficult and requires early testing in pregnancy[3]. Power Doppler imaging also presents challenges in establishing the normal course of the PCA and its branches.

Visualising the PCA, as an indirect sign of corpus callosum agenesis, was explored by Pati et al. (2012)[4] (Figure 1).

Additionally, research has demonstrated that the anterior portion of the PCA may remain intact in the presence of an abnormal corpus callosum. It is therefore crucial to examine the entire PCA, rather than solely its origin. This is particularly important given that prenatal evaluation of intracerebral vascular anatomy is usually restricted by the available ultrasound technology, necessitating the use of delicate colour Doppler ultrasound[1].

Within this context, MV-Flow™ and LumiFlow™ are recently introduced Doppler technologies able to present a detailed vision of the blood flow concerning surrounding tissue and offer a substitute for Power Doppler for visualizing slow flow microvascularized structures and vascular connections. MV-Flow™ technology features high tissue suppression, minimizing tissue noise signals and effectively suppressing flash artefacts and compound images due to its high sensitivity. Consequently, it enhances the imaging of low velocity flow structures, including the cerebral dural sinuses and the medullary veins that have been associated with fetal brain developmental irregularities[5].

LumiFlow™ facilitates an intuitive display of blood flow and small vessel structure, providing a 3-dimensional visualisation of blood flow in a 2-dimensional image. This high-resolution trait is inclusive of all Doppler technologies allowing for a more accurate assessment of the vascular flow.

Materials and Methods

We assessed the effectiveness of MV-Flow™ technology in conjunction with the LumiFlow™ algorithm to produce images of the pericallosal artery in a group of non-consecutive pregnant women at gestational age between 11 and 13+6 weeks. MV-Flow™ and LumiFlow™ are pre-installed, commercially available software on the high-resolution ultrasound system HERA W10, manufactured by SAMSUNG MEDISON, CO. LTD., in Korea.

Prospective recruitment of consecutive pregnancies undergoing the 11 to 13+6 weeks scan for screening will be conducted after verifying the normality of Nuchal Translucency(NT) and anatomy. Novel tools, highly sensitive to detect microvascular flow (MV-Flow™, Samsung HERA W10), will be used to examine the presence of the Pericallosal artery. All examinations will be performed using transabdominal convex probes with high frequency CA of 3-10 Hz. The pericallosal artery was traced from the cerebral anterior artery along a curved path. The entire artery was measured from its beginning to its end. All scans adhered to the ALARA principles.

Results

When scanning the fetal brain along the midsagittal plane via the anterior fontanelle, we utilised both MV-Flow™ and LumiFlow™ imaging. This aided us in accessing the vascular structures of the midline, including the pericallosal artery (PCA) with its uniquely curvilinear course and form. Additionally, we were able to discern the venous structures of the tentorium and sagittal sinuses.

The highly sensitive MV-Flow™ and the post-processing of LumiFlow™ enabled the display of precise and sharp images of vascular structures (Figure 1-3).

The study incorporated 70 female participants, and PCA was identified in all cases. Furthermore, the use of MV-Flow™ allowed a detailed anatomical evaluation of the artery and its branching. However, in a single instance, identifying the terminal point of the artery prevented measuring the PCA's length. The PCA length exhibited a linear increase with gestation age, starting at 5.47 mm (sd 1.3 mm) at 12 weeks and reaching 6.4 mm at 13 weeks (Figure 2-4).

The study aimed to assess the feasibility of capturing the pericallosal artery image during the early screening scan at 12 weeks. It was possible to obtain imaging of the PCA in all cases but one, proving that it's now a reality to examine the pericallosal artery by using the combination of MV-Flow™/ LumiFlow™ and high-frequency transabdominal probes.

This allows us to screen for the integrity of the vascular surrogates of corpus callosum before its development.

Conclusion

The MV-Flow™, combined with high frequency abdominal probes, enables a thorough examination of the midline. In most cases, the pericallosal artery can be identified in its entirety, providing an indirect sign of corpus callosum integrity, which can be depicted early in pregnancy[6].

Although the corpus callosum cannot be observed using ultrasonography during the early stages of pregnancy because of its relatively late development, the presence of the early normal cerebral vascular net could suggest the possibility that the initial corpus callosum morphogenesis is taking place, meaning its presence but whose normality has to be addressed[4,7].

In conclusion, the development of MV-Flow™ and LumiFlow™ may represent an important tool in the advancement of current ultrasound equipment, especially when the technology is applied to obstetric practice.

This pilot study has shown the feasibility of the combined use of MV-Flow™ and LumiFlow™, which is an easy-to-use tool with the potential to enable a comprehensive assessment of the pericallosal artery in the fetus and to add substantial information over conventional Doppler imaging, thus improving our capability to assess normal anatomy and fetal malformations.

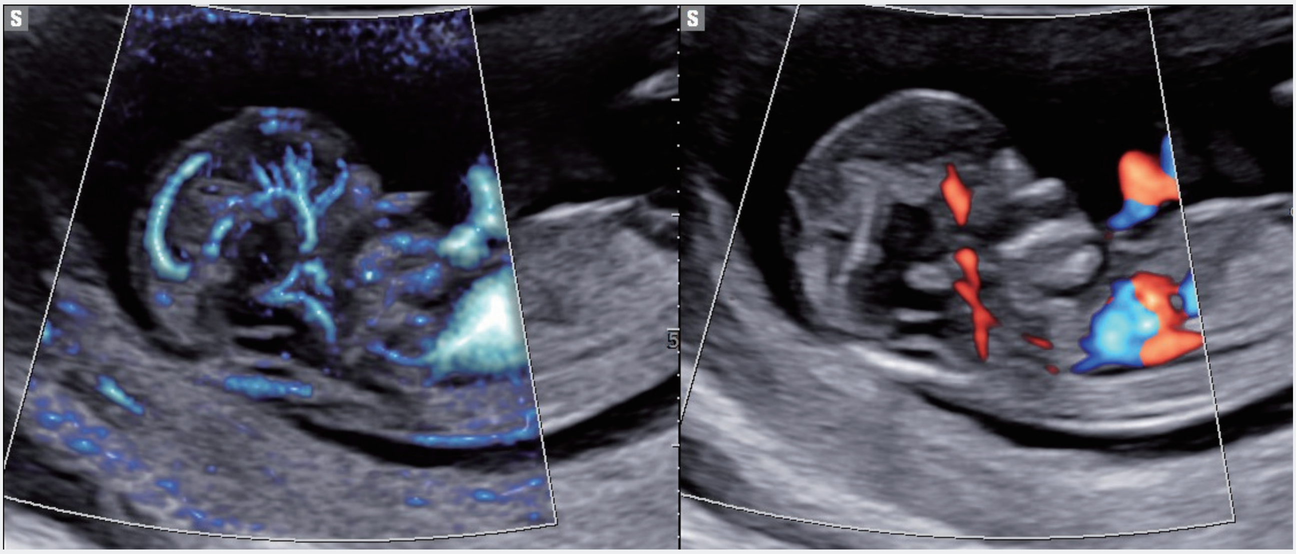

Figure 1. Comparison between MV-Flow™ and Power Doppler in the same fetus at 12 weeks. MV-Flow™ provides a much more detailed vascular branching whereas the conventional power Doppler only depicts the anterior part of Pericallosal artery. (MV-Flow™ blue, Power Doppler orange.)

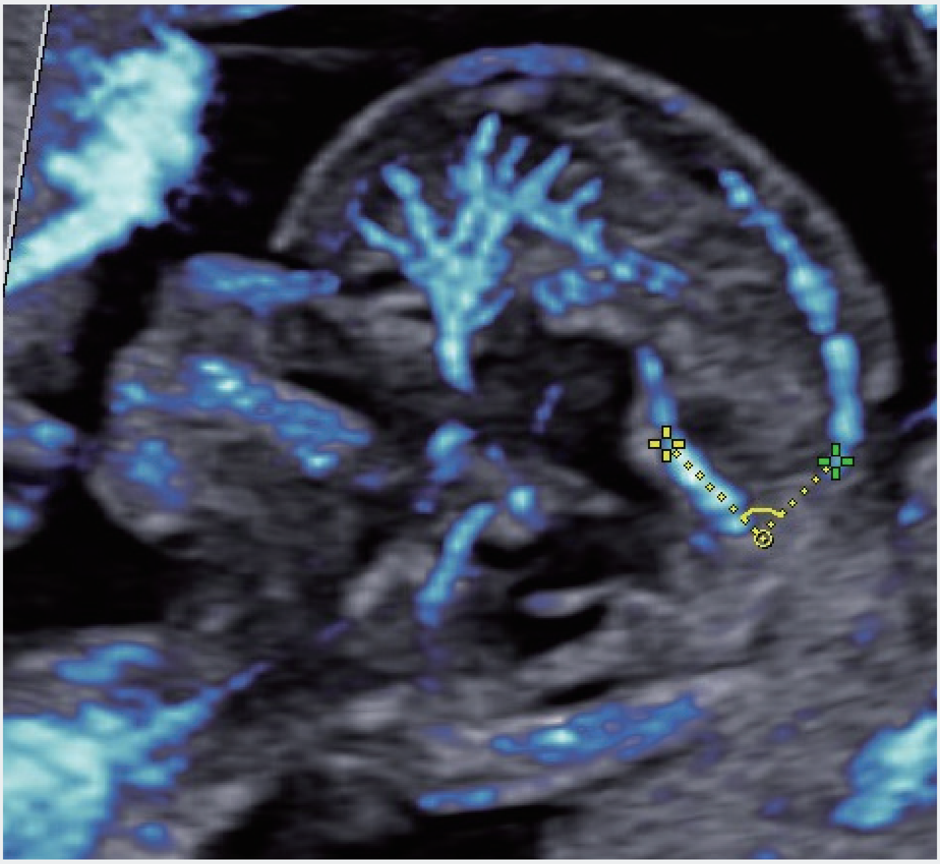

Figure 2. Midsagittal view with MV-Flow™ and LumiFlow™ at 12 weeks of Pericallosal Artery (PCA). It can visualize the full trajectory and curvature of the future corpus callosum area, as well as present the tentorioum angle.

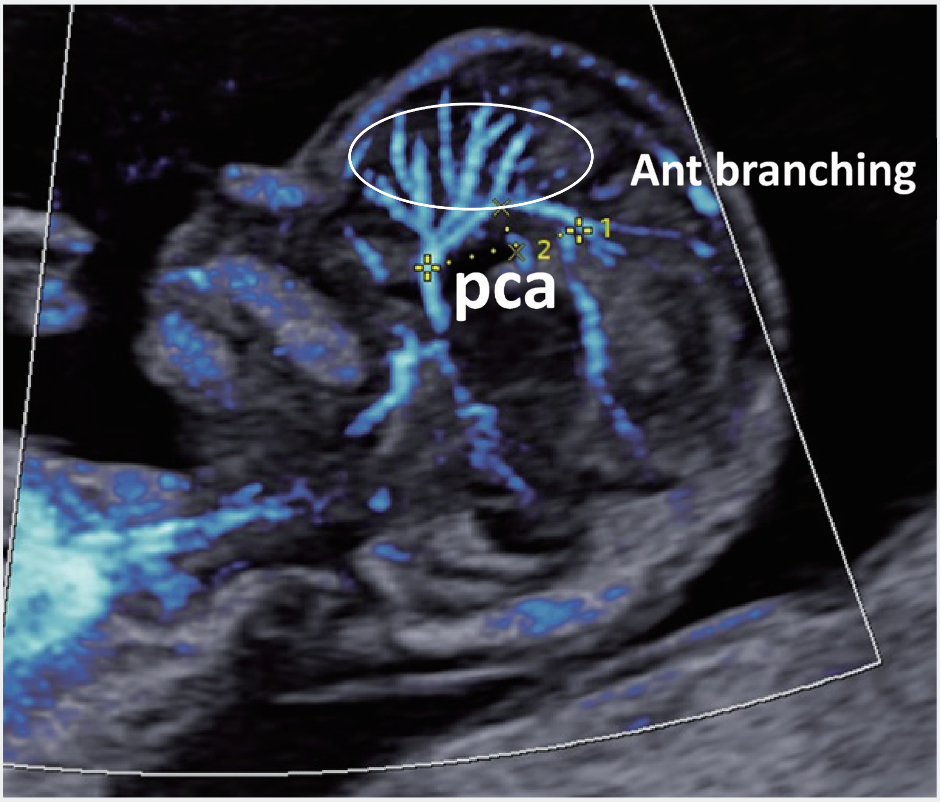

Figure 3. Midsagittal. Detailed branching of the anterior components of PCA at 13 weeks.

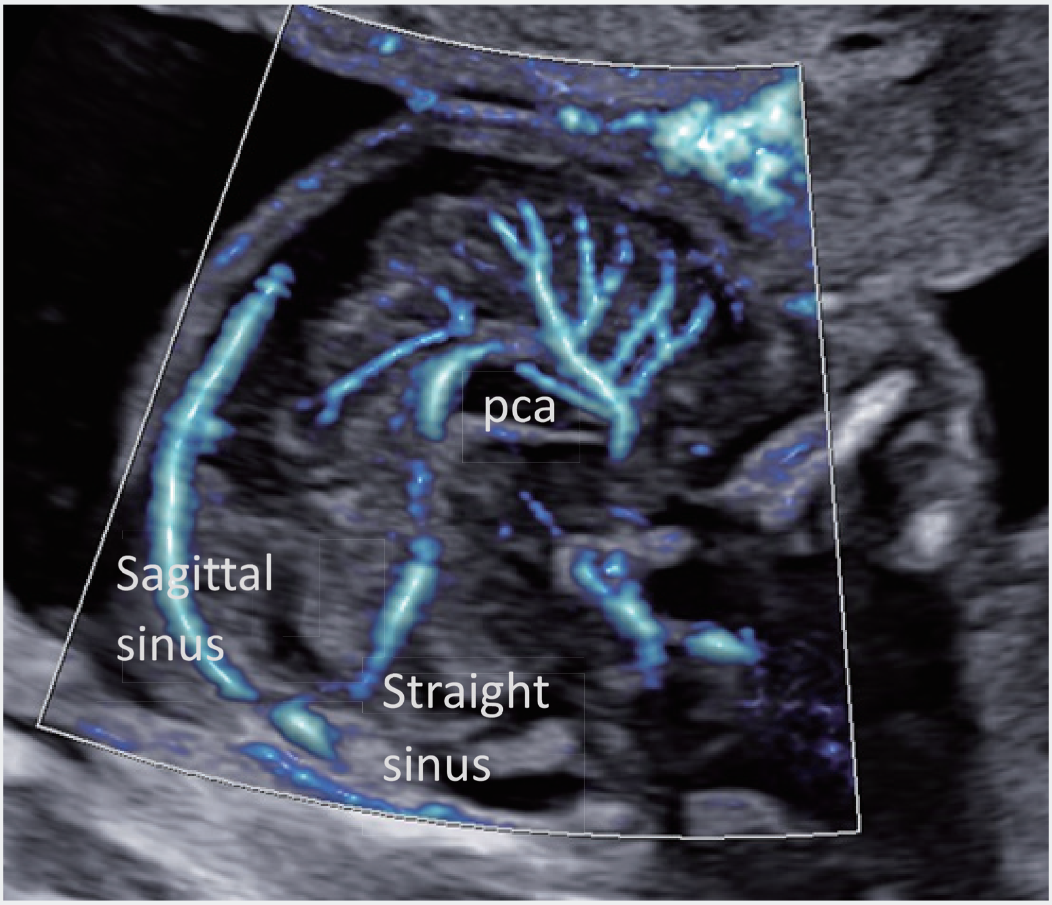

Figure 4. Midsagittal view including the venous system to check integrity of tentorium angle and pericallosal artery with branching. It also highlighted the length of PCA from anterior to posterior.

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