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White paper

Visualization of the Torcular Herophili by MV-Flow™ and LumiFlow™ Doppler Technology: A Step Forward in the Prenatal Assessment of the Cerebral Tentorium.

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Introduction

The torcularherophili (TH), also known as “confluence of sinuses”, is a venous structure draining the major vessels of the intracerebral venous system, which includes the superior sagittal sinus and the straight, transverse, sigmoid, cavernous and occipital sinuses (1). Under normal circumstances the TH is located inferior to the occipital bones and posterior to the cerebellum, just inside the cranial vault (2), at the junction of the falxcerebri with the tentorium cerebelli.This latter anatomic structure has been acknowledged by radiologists and fetal medicine specialists among those involved in the differential diagnosis of posterior fossa abnormalities. Inparticular,the upwards displacement of the tentorium cerebelli in respect to its normal insertion on the occipital clivus(defined as the part of the skull base, which forms a gradual sloping process at the most anterior portion of the basilar occipital bone, where the neck muscles are inserted) is among the diagnostic criteria of classic Dandy-Walker Malformation (DWM)in fetuses with or without hypoplastic and supraelevated cerebellar vermis, and abnormal communication between the fourth ventricle and the cisterna magna(1,3,4).

The posterior insertion of the tentorium on the skull has been recently described in 2D and 3D ultrasound imaging either in structurally normal fetusesor in those with posterior fossa anomaly (5). However, the antenatal visualization of the position of the tentorium cerebelli in grey-scale ultrasound is technically challenging also on the midsagittal plane and this may lead to a limited agreement in the diagnosis of DWM in fetuses with abnormal findings of the posterior fossa. On the other hand, due to the relevant prognostic implications of DWM, the correct diagnosis of such condition is expected to be achieved antenatally in order to optimize of counselling of prospective parents. The antenatal demonstration of the TH using Doppler imaging has been proposed as a more feasible alternative to the sonographic visualization of the tentorium (1). On the midsagittal view of the fetal brain the position of the TH may be assumed as an indirect clue of the level of the tentorium insertion on the fetal skull. Using this latter approach, some authors have accurately determined the insertion of the tentorium in fetuses with normal or abnormal posterior fossa in the 1st trimester, by measuringthe brainstem-tentorium angle (6). However, the measurement of the brain-stem-tentorium angle has yet to be widely implemented on a clinical basis.

Furthermore, the antenatal imaging of the TH in conventional Doppler imaging at midtrimesteris also technically challenging. This is mainly because prenatal assessment of the intracerebral vascular anatomy is mostly limited by the paucity of ultrasound techniques in the imaging of the intracerebral

veins, which are characterized by low blood flow velocities and therefore require sensitive color Doppler ultrasound to be reliably visualized (1).Within this context, MV-Flow™ and LumiFlow™ are newly launched Doppler technologies capable of providing a detailed view of the blood flow in relation to surrounding tissue and represents an alternative to Power Doppler for the visualization of slow flow microvascularized structures and vascular connections. MV-Flow™ technology is characterized by high tissue suppression in order to abolish tissue noise signal and is also capable of suppressing flash artifacts – thanks to its high filter – and to compound images thanks to its high sensitivity, all of which contribute to optimizing the imaging of low velocity flow structures such as the cerebral dural sinuses and the medullary veins, which have also been linked to developmental abnormalities of the fetal brain (7,8).

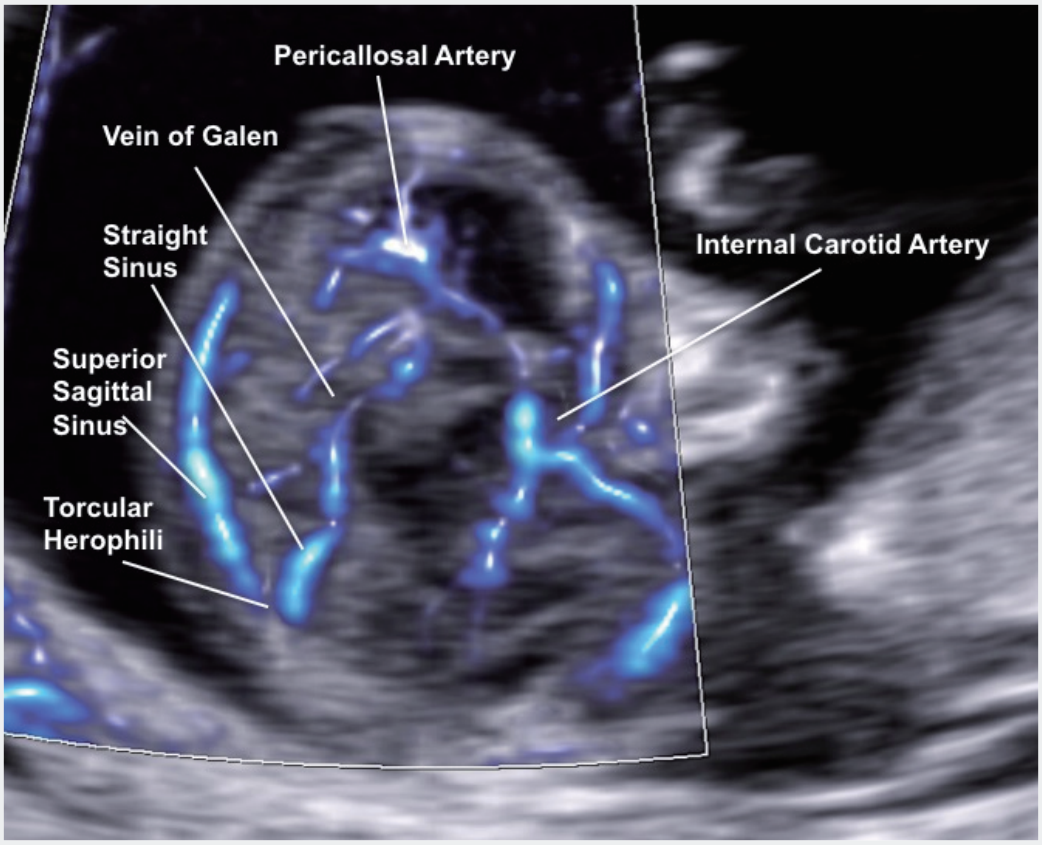
LumiFlow™ helps to display the structure of blood flow and small vessels intuitively, providing a three-dimensional visualization of blood flow in a two-dimensional image. This high resolution feature is available in combination with all Doppler technologies allowing a more realistic assessment of the vascular flow.

Material and Methods

In this work, we evaluated the performance of MV-Flow™ technology combined with LumiFlow™ algorithm for the imaging of the TH in a non-consecutive series of pregnant women at gestational age between 12 and 32 weeks. MV-Flow™ and LumiFlow™ are built-in, commercially available software installed on the high-resolution ultrasound system HERA W10 (SAMSUNG MEDISON, CO. LTD., Korea).

Results and Discussion

By insonating the fetal brain on the midsagittal plane through the anterior fontanelle, MV-Flow™ and LumiFlow™ imaging were selected from the control touch screen and allowed to easily access the TH together with the other main vessels and structures seen in the midline of the fetal head such as the superior sagittal and the straight sinuses, the corpus callosum, the cerebellar vermis and the pericallosal artery with its branches (Figures 1-3)



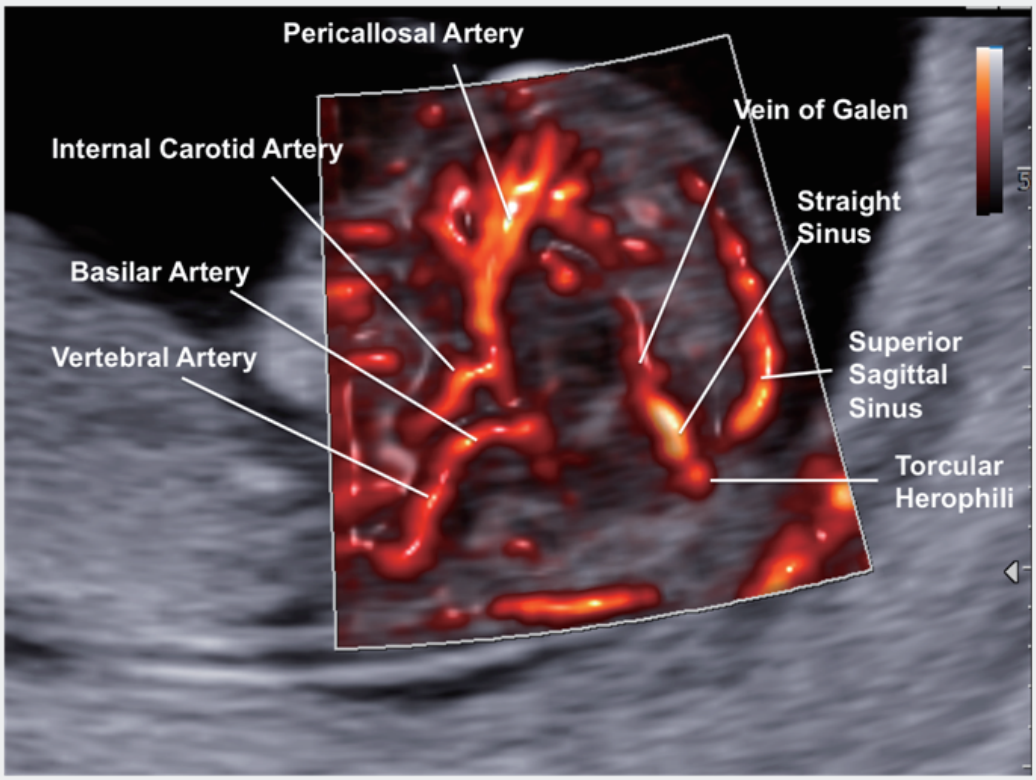


Figure 1 A and B. Midsagittal view of the normal fetal brain through the anterior fontanelle in a 12 weeks' fetususing MV-Flow™ and LumiFlow™ technology

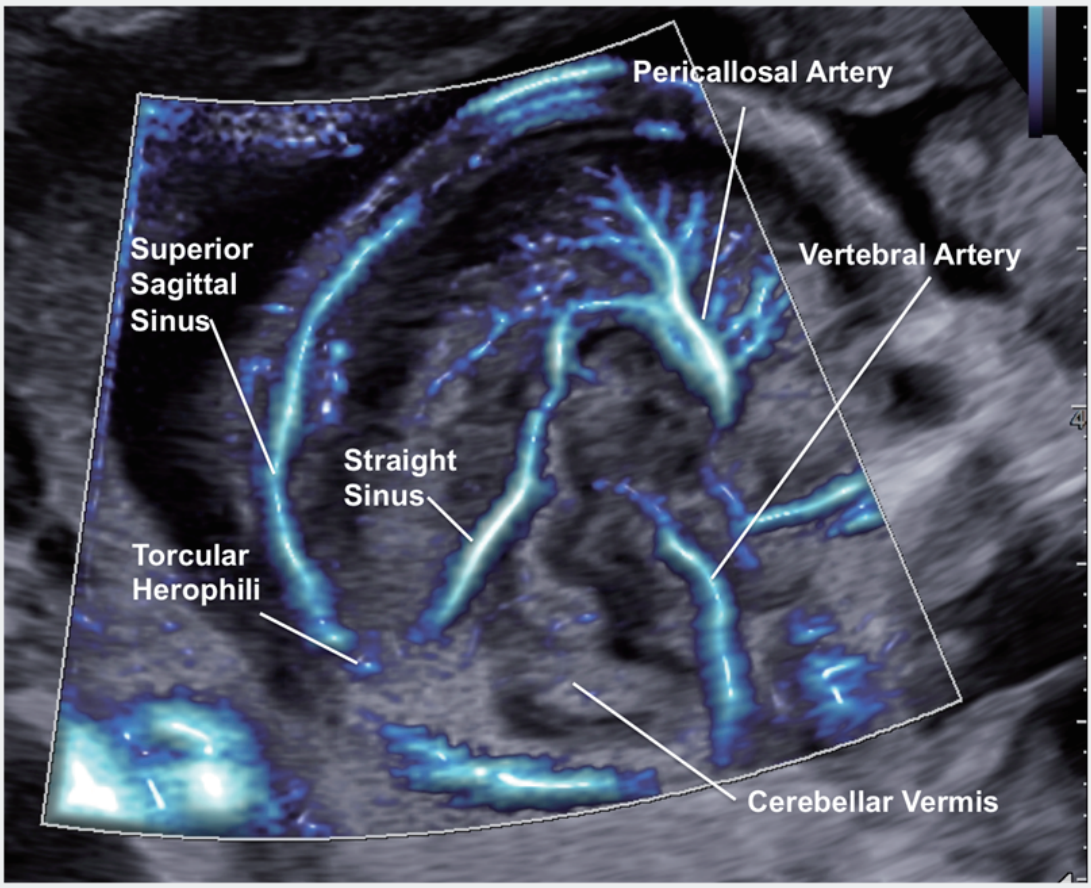
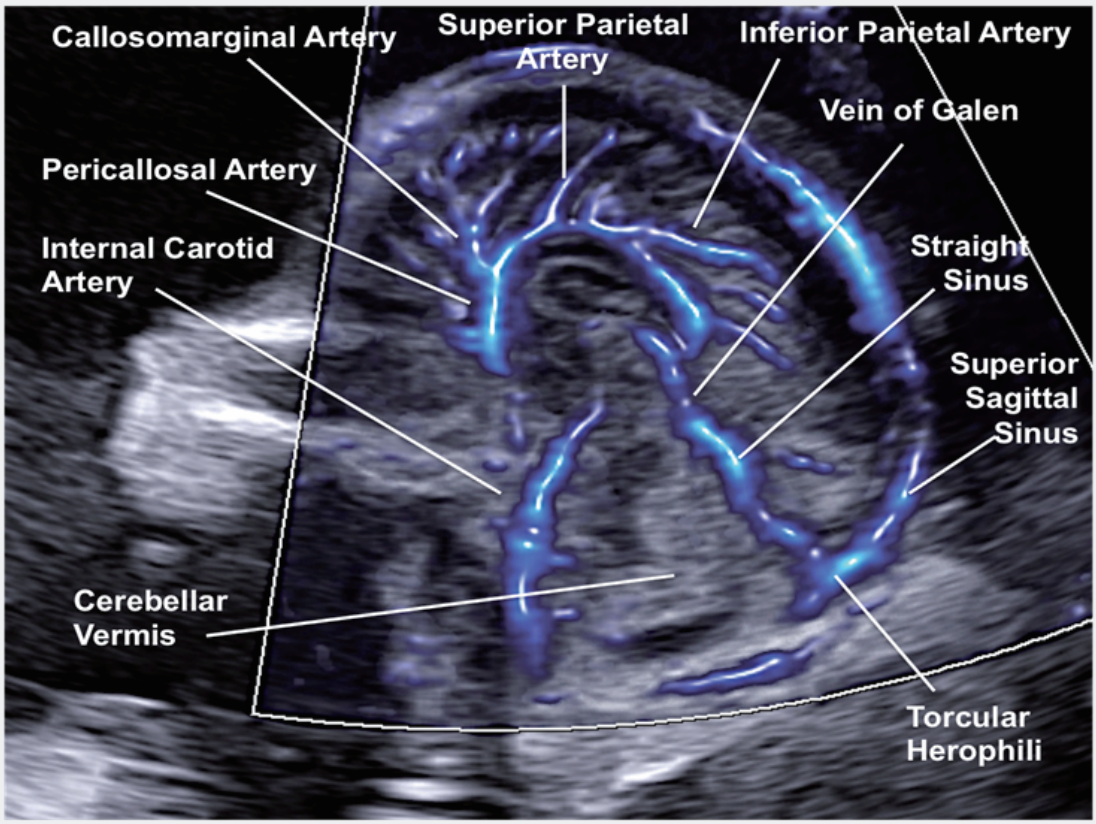


Figure 2. Midsagittal view of the normal fetal brain through the anterior fontanelle in a 17 weeks' fetususing MV-Flow™ and LumiFlow™ technology.



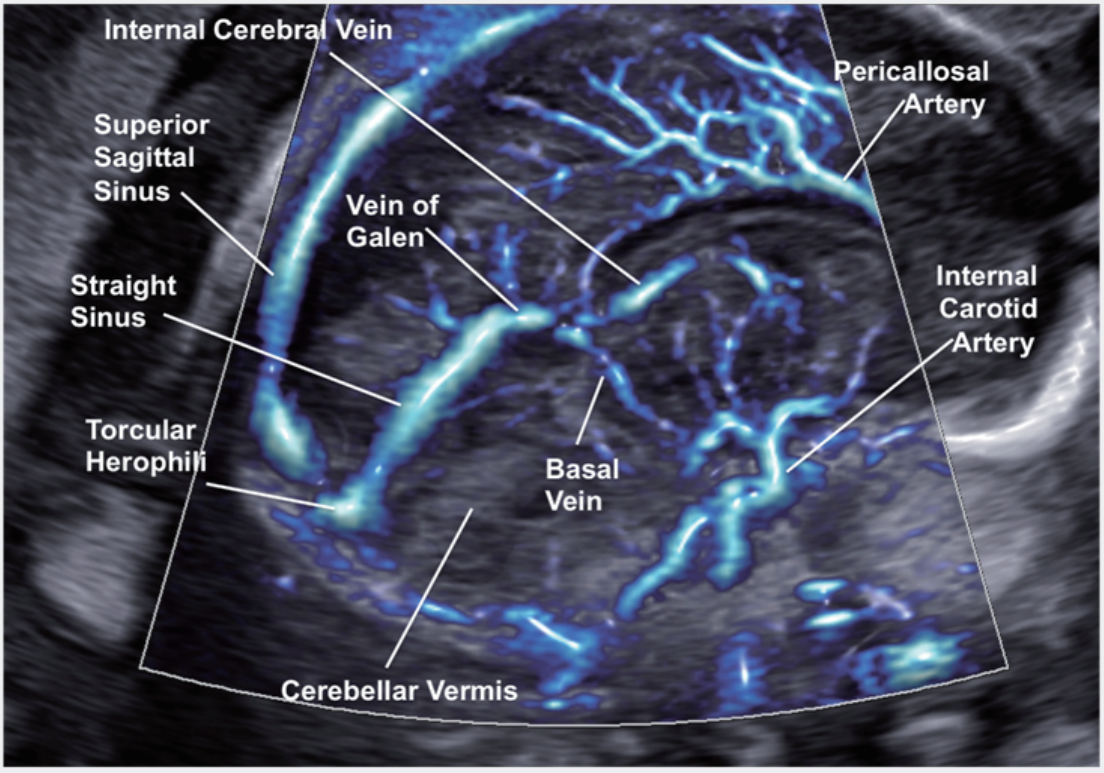


Figure 3 A and B. Midsagittal view of the normal fetal brain through the anterior fontanelle in a 20 weeks' fetus using MV-Flow™ and LumiFlow™ technology.

In all cases the appearance of the posterior fossa was normal for the gestational age. When insonating the internal cranial base by an axial orientation it was also possible to visualize the vessels forming the circle of Willis, anteriorly, and the transverse sinuses lying within the lateral insertions of the tentorium and joining posteriorly in their confluence, the TH (Figure 4).

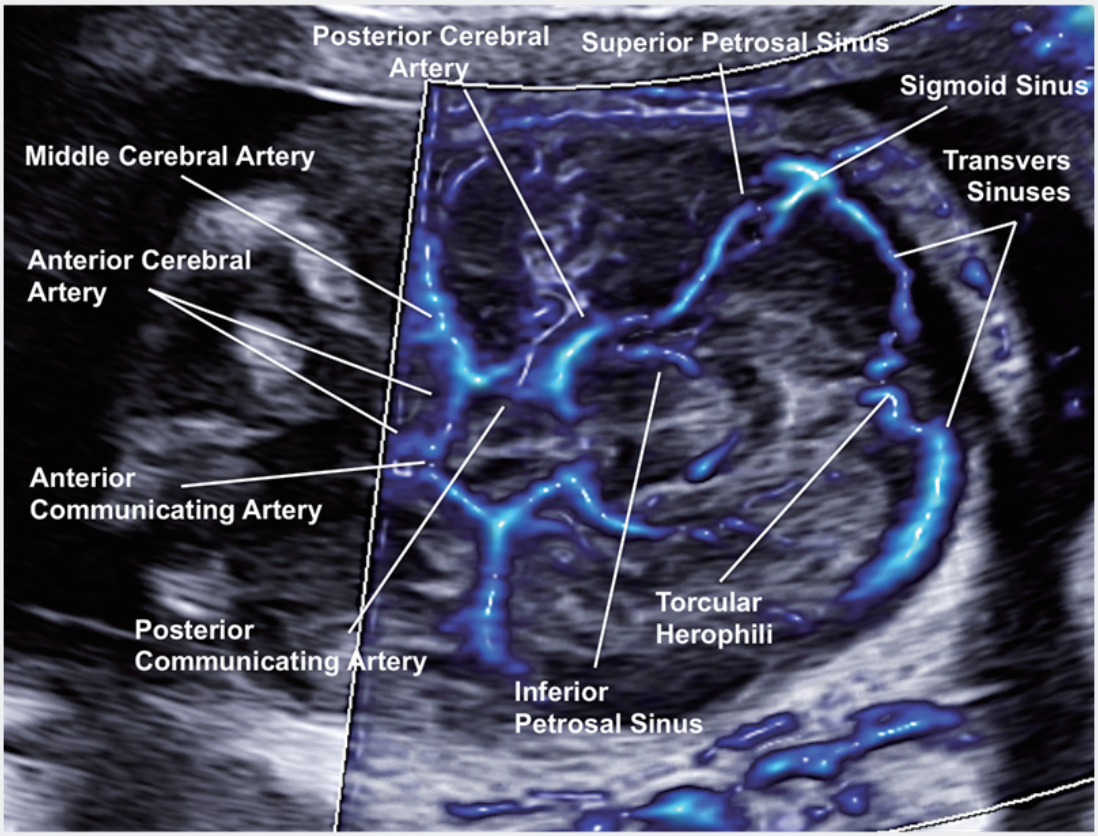


Figure 4. Axial view of the normal fetal brain in a 20 weeks' fetus using MV-Flow™ and LumiFlow™ technology.

In the only case in which the appearance of the posterior fossa was abnormal and consistent with a diagnosis of DWM, the insonation of the midsagittal view of the fetal brain plane through the anterior fontanelle with MV-Flow™ and LumiFlow™ allowed the confirmation of the upward displacement of the TH (Figure 5).

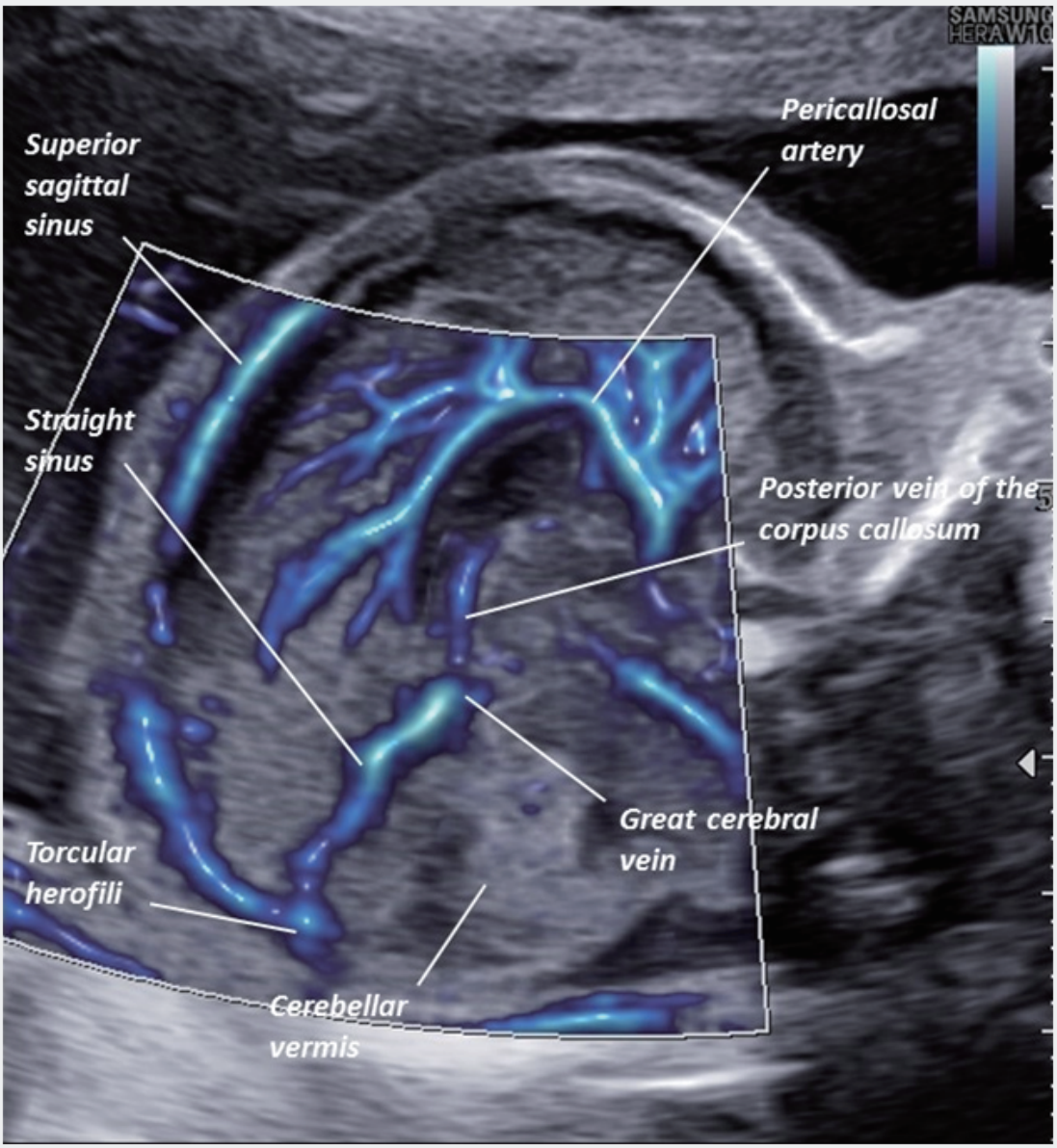


Figure 5. Midsagittal view of the fetal brain through the anterior fontanelle in a 21 weeks' abnormal fetus with a final diagnosis of Dandy-Walfer malformation. In this case the theinsonation of the midsagittal view of the fetal brain plane through the anterior fontanelle with MV-Flow™ and Lumi-Flow™ allowed the confirmation of the upward displacement of the torcularherofili.

The quality of the imaging was optimal in all cases with clear definition of the vascular contour of the imaged venous and arterial structures. In all cases the appearance of the posterior fossa was normal. The mean time required to image the TH was less than 1 minute in all cases.
Using this sonographic approach in a cohort of structurally normal fetusesit seems possible to define objectively the position of the TH and on this basis that of the tentorium insertion on the fetal skull.

Conclusion

In conclusion, the development of MV-Flow™ and LumiFlow™ may represent a milestone in the technological advancement of modern ultrasound equipment, especially when the technology is applied to obstetric practice. Our work has shown that the combined use of MV-Flow™ and LumiFlow™ is an easy-to-use tool which has the potential to enable a comprehensive assessment of the intracranial venous system of the fetus and to add substantial information over conventional Doppler imaging, thus improving our capability to assess normal anatomy and fetal malformations. Further prospective studies are ongoing in order to demonstrate the usefulness of MV-Flow™ technology for the visualization of the TH as an indirect evaluation of the tentorium cerebelli in a clinical setting.

MV-Flow™ and LumiFlow™ are available in the following systems;

- HERA W10

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