Fetal Intracranial Hemorrhage: From Ventriculomegaly to Prenatal Diagnosis. A Pictorial Review

Poster No.: C-0839
Congress: ECR 2018
Type: Educational Exhibit
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Keywords: Foetal imaging, CNS, Obstetrics (Pregnancy / birth / postnatal period), Ultrasound, MR, Intrauterine diagnosis, Hemorrhage, Obstetrics, Foetus
DOI: 10.1594/ecr2018/C-0839

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Learning objectives

1. Concisely describe the radiological approach to ventriculomegaly in fetuses and pearls to diagnosis of fetal intracranial hemorrhage.
2. Present a pictorial review of fetal intracranial hemorrhage depicted on obstetric ultrasound (US) and magnetic resonance imaging (MRI) that were referred for ventriculomegaly to our department.
Background

Fetal intracranial hemorrhage (ICH) is a rare condition, with an incidence unclear, estimated around 1 in 10000. The diagnosis is usually difficult but can be done in utero by ultrasound with integration of magnetic resonance imaging in the diagnostic work-up. Prenatally diagnosed ICH have a poor outcome: fetal death or neonatal death occurring in about 40 % and abnormal neurodevelopment seen at short term follow-up among more than half of the survivors.

Sonographic findings of fetal ICH are variable and sometimes subtle. Putting it together with its low prevalence, the diagnosis of ICH is most of the time challenging for obstetricians and radiologists involved in prenatal ultrasound. A higher detection rate and a better approach to this condition can be achieved by screening the fetal brain in a systematic approach and knowledge of the subtle sonographic findings.
Findings and procedure details

WHEN TO SUSPECT ICH IF VENTRICULOMEGALY IS DIAGNOSED AND WHAT TO LOOK FOR ON ULTRASOUND SCAN?

Evaluation of the fetal brain must be realized during the routine mid-trimester fetal ultrasound scan. It consists of acquiring two axial planes of the fetal brain, the transventricular and transthalamic planes (Fig. 1 on page 15). These planes allow visualization of the cerebral structures relevant to assess the anatomical integrity of the brain. Evaluation of the posterior fossa is done on a third axial plane, the transcerebellar plane (Fig. 2 on page 15). ³,⁴

DEFINING VENTRICULOMEGALY (VM) … A SINGLE MEASUREMENT

• THE "DANGLING CHOROID"

The normal choroid plexus normally fills the ventricular atrium. When a ventricle enlarges, its choroid plexus hangs in a dependent location and thus separates from the non-dependent wall of the ventricle. (Fig. 5 on page 17)

This appearance of a 'dangling choroid' is an indication that attention should be paid to the lateral ventricles. ⁵

• THE MEASUREMENT

Assessment of the width of the atrium of the lateral cerebral ventricles is recommended as part of the routine anomaly scan ⁶⁻⁸ as it is the most effective approach for assessing the integrity of the ventricular system.

For reproducibility, measurement should be obtained at the level of the glomus of the choroid plexus, perpendicular to the ventricular cavity, positioning the calipers inside the echoes generated by the lateral walls (Fig. 3 on page 16). ⁴,⁶,⁹ Acquiring the ventricular measurement on oblique views can falsely increase its size.

Atrium size is almost constant in the second and early third trimesters, with a mean diameter of 6-8 mm and is considered normal when less than 10 mm. ⁴,⁶ Atrium measurement between 10.0 and 15.0 mm constitutes mild VM, and a measurement in excess of 15.0 mm constitutes severe VM. ¹⁰

ISOLATED MILD VENTRICULOMEGALY, THE "TIP OF THE ICEBERG"
VM is defined as isolated if there is no sonographic evidence of associated malformations or markers of aneuploidy at the time of the initial presentation. Thought, when VM is detected on routine scan, a detailed fetal survey should be performed for both Central Nervous System (CNS) and non-CNS associated pathologies. Assessment of the CNS should include cerebellar measurements and views of the corpus callosum.

Isolated mild VM represents a considerable diagnostic dilemma as it can be an apparently benign finding with good overall outcome, but can also be associated with chromosomal abnormalities, congenital infection, cerebral vascular accidents or hemorrhage, and other fetal cerebral and extracerebral abnormalities; it may also have implications regarding long-term neurodevelopmental outcome and behavioral outcome is disturbed in about 15% or more of cases.

Follow-up scans are needed to assess VM evolution and to re-evaluate for associated anomalies, as some anomalies may become apparent only in the third trimester.

VENTRICULOMEGALY IN THE SETTING OF FETAL ICH

VM detected in association with

- hyperechogenic and sometimes indented ventricular walls (Fig. 5 on page 17, Fig. 8 on page 19, Fig. 9 on page 20),
- irregular bulky choroid plexus (Fig. 5 on page 17),
- and intraventricular hyperechogenic debris suggestive of clots (Fig. 5 on page 17, Fig. 8 on page 19, Fig. 9 on page 20, Fig. 11 on page 22)

is diagnostic of fetal ICH.

This aspect of echogenic irregular lining of the lateral ventricle - Ventriculitis - along with VM may persist long after the bleeding. It reflects the involvement of the choroid plexus and spread of the hemorrhage to the ventricular system and can sometimes be the only indicative of ICH.

Note that intraventricular hyperechogenic debris are sometimes very subtle, detected only after fetal motion or patient repositioning. (Fig. 4 on page 23)
Fig. 4: Sonography Examination of Fetal Brain: Showing ventriculomegaly associated with thick hyperechoic ventricular walls. Hemorrhagic debris are very subtle, located in the dependent part of the ventricle, clearly identifiable after patient repositioning.

References: Department of Radiology, Abou Jaoude Hospital, Jal El Dib, Lebanon

FETAL INTRACRANIAL HEMORRHAGE

WHAT TO LOOK FOR ON SONOGRAPHY SCAN?

Fetal ICH ultrasonography manifestations are variable and subtle, depending on the location and extent of the hemorrhage and on the volume of bleeding, but its appearance mostly depends on the timing of the sonographic scan, making the prenatal diagnose challenging.

• THE TIME CHALLENGE...NATURAL HISTORY OF ICH

The variability of ultrasonography features of fetal ICH over time is due to the natural evolution of hemorrhage to coagulated blood products.
It has been divided into four phases:

1. **in the acute stage, fresh hemorrhage appears as hyperechoic homogeneous lesion (Fig. 5 on page 17),**
2. **in the subacute phase, the center of the hemorrhage is hypoechoic surrounded by thin, echogenic rim (representing intact red blood cells at the periphery of hemorrhage, and lysed centrally) (Fig. 8 on page 19, Fig. 9 on page 20).**
3. **As hemorrhage is over, the clot will liquefy, demonstrating a hypoechoic cystic aspect (Fig. 11 on page 22).**
4. **When complete resolution occurs, the brain structure regain their normal appearance.**

**• SPOT THE HEMORRHAGE, NAME IT, GRADE IT:**

Fetal ICH have been described in the literature as occurring in the ventricles, in the subdural space, in the cerebellum, in the subarachnoid space and in the brain parenchyma. Intraventricular hemorrhage (IVH) is the most common subtype, characteristic of the immature brain, as seen in neonates.\(^{1,16}\)

Grading prenatal intracerebral hemorrhage is comparable to that in newborns, the first three grade describing hemorrhage limited to the ventricles, the grade four involving the parenchyma.\(^{2,16-18}\)

**Papile Classification of Intraventricular Hemorrhage\(^{18}\)**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>limited to subependymal matrix</td>
</tr>
<tr>
<td>II</td>
<td>&lt;50% of the lateral ventricle and without ventriculomegaly;</td>
</tr>
<tr>
<td>III</td>
<td>&gt;50% of one or both lateral ventricles and ventriculomegaly;</td>
</tr>
<tr>
<td>IV</td>
<td>Any grade with involvement of periventricular parenchyma.</td>
</tr>
</tbody>
</table>

**FETAL MRI FOR ACCURACY OF DIAGNOSIS**

The ultrasound scanning has multiple technical limitations:

The reverberation artifact limits the visualization of the proximal side of the brain or the posterior fossa, particularly in late gestation due to cranial ossification. Limitations can also be inherent to the maternal body habitus or an oligoamnios. Aside to these limitations, some anomalies are nonspecific or too subtle to be detected on ultrasound.
Adjunction of fetal brain MRI will provide additional information to evaluate cases where the ultrasound diagnosis is unclear or when there is an anomaly that cannot be adequately assessed with ultrasound. 19-21

FETAL INTRACRANIAL HEMORRHAGE ON MRI

MRI studies of the fetal brain have greater sensitivity for detection of CNS lesion compared to US5,21-23.

Sanapo et Al. classified the imaging age pattern of fetal intracranial hemorrhage on MRI according to postnatal hemorrhagic evolution as described in the previous literature, which correlates to the blood product signal21:

- **Acute** isointense signal on T1-weighted images and hypointense signal on T2-weighted images
- **Early subacute** hyperintense signal on T1-weighted images and hypointense in T2-weighted images;
- **Late subacute** hyperintense signal on both T1-weighted and T2-weighted images
- **Chronic** hypointense signal on T1-weighted images and hypointense signal on T2-weighted images.


Although MRI has been shown to have a greater sensitivity5,21-23, more incidental findings will be encountered, as well as difficulties to overcome a moving subject, the size of the structure to be imaged as well as by safety concerns.

A CASE BASED REVIEW WITH MAGNETIC RESONANCE IMAGING

In this section, we will illustrate ICH findings on ultrasound and MRI with examples referred to our institution for further evaluation of ventriculomegaly, hydrocephalus.

**Case no.1:** 31-year-old female with singleton pregnancy at 29 weeks of gestation.
Fig. 5: Axial Ultrasound Planes of Fetal Brain: Showing ventriculomegaly of the left ventricle (18mm) with hyperechoic ventricular wall (short white arrows), bulky and dangling aspect of the choroid plexus (\(*\)), hyperechoic fluid level in the ventricle (short red arrows) and increased echogenicity of the periventricular white matter (long white arrow).

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Fig. 6: Brain MRI of the Same Fetus: Axial T1-Weighted image (Left Image), and Axial T2-Weighted image (Right Image) at 0.35 T: Showing ventriculomegaly with fluid-fluid levels (short red arrows), demonstrating hyperintense signal on T1W and hypointense signal on T2W in their dependent aspect (*) compatible with intraventricular blood.

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Fig. 7: Imaging of the Posterior Fossa of Same Fetus: Axial ultrasound plane on the level of the Posterior Fossa (Left Image) showing hyperechoic cerebellum (white arrow) and hyperechoic occipital periventricular white matter (*). Axial T1-Weighted image (Right Image) showing hyperintense signal in the subarachnoid space in the posterior fossa (black arrow) compatible with subarachnoid associated hemorrhage.

References: Department of Radiology, Abou Jaoude Hospital, Jal El Dib, Lebanon

Case n.2: 25-year-old female with singleton pregnancy at 31 weeks of gestation
Fig. 8: Ultrasound Planes of Fetal Brain: Showing ventriculomegaly (31mm), thick echogenic ventricular walls (red arrows), dilated frontal horns (white arrow heads), dilated 3rd ventricle (*), with posterior horn containing echogenic debris (long white arrows). Note the heterogeneous aspect of the intraventricular lesion (short white arrows) having a hyperechoic lining and hypoechoic center compatible with an intraventricular clot.

References: Department of Radiology, Abou Jaoude Hospital, Jal El Dib, Lebanon
Fig. 9: Axial Ultrasound Planes of Same Fetus Brain with magnification views on frontal horn showing hyperechoic ventricular walls (white arrow heads), heterogeneous echoic periventricular white matter (short white arrows), avascular mixed echogenicity mass with hyperechoic lining and hypoechoic center(*), and ventricular debris (long white arrow) compatible with parenchymal involvement of ICH.

References: Department of Radiology, Abou Jaoude Hospital, Jal El Dib, Lebanon
Fig. 10: Brain MRI of the Same Fetus: Axial T1-Weighted image (Left Upper Image), and Axial T2-Weighted image (Right Upper Image), Sagittal T1-Weighted image (Left Lower Image) and Sagittal T2-Weighted image (Right Lower Image) showing a coronal view of the fetal brain - at 0.35 T; Showing Ventriculomegaly (*); a heterogeneous image of the lateral ventricle (short white arrows) showing mainly hyperintense signal on T1W and hypointense signal on T2W, compatible with an intraventricular blood clot; High-signal intensity on T1W, hypointense signal on T2W in the periventricular area of the anterior horn of the left lateral ventricle (short red arrows) associated with an area (long white arrows) of hypointensity on T1W and hyperintensity on T2W, denoting the presence of an intraparenchymal bleed with surrounding vasogenic edema.

References: Department of Radiology, Abou Jaoude Hospital, Jal El Dib, Lebanon

Case no.3: 27-year-old female with singleton pregnancy at 30 weeks of gestation

Fig. 11: Axial Ultrasound Plane of Fetal Brain: Showing ventriculomegaly, with echoic thick indented ventricular walls (short white arrows), dilated frontal horns, and dilated 3rd ventricle (long white arrows); a cystic aspect of the choroid plexus (*) demonstrating a hyperchoic lining surrounding an hypoechoic center compatible with a liquefaction of
the clot; a heterogeneous aspect of the white matter in the periventricular area (short red arrows) showing similar sonographic findings, hyperechoic lining an hypoechoic content compatible with a parenchymal hematoma. Note on the Right Upper Ultrasound Plane of the Posterior Fossa the absence of vermis of the cerebellum (white arrow head)

References: Department of Radiology, Abou Jaoude Hospital, Jal El Dib, Lebanon
Fig. 1: Axial Plane of Fetal Brain based on ISUOG Image Criteria

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Fig. 2: Posterior Fossa Plane of Fetal Brain based on ISUOG Image Criteria

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Fig. 3: Magnified Lateral Ventricle Ultrasound Plane: Caliper positioning for measurement of Atrium of Lateral Ventricle. Normal when < 10mm

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Conclusion

Ventriculomegaly is a non-specific finding on fetal imaging which can result from various processes. These may not be immediately apparent on ultrasound. It is of a major importance to determine the specific etiology, as the prognosis can be altered depending on concomitant anomalies and may change the course of the pregnancy.

Although fetal ICH is a rare condition, the diagnose must be done *in-utero*.

Thus, familiar to radiologists who interpret neonatal brains imaging in their daily practice, fetal ICH findings on ultrasound may not be as easily recognized for others with less exposure and limited experience.

Knowledge of the ventriculitis aspect, recognizing sonographic subtle signs of ICH on prenatal ultrasound scan (Fig. 12 on page 26) will permit to identify cases for referral to tertiary centers and in adjunct to MRI, give more accurate diagnosis for better management.
Fig. 12: Pearls Sonographic Signs to Diagnose Fetal ICH

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