Basic Fetal Brain:
What is normal and what is not. When do I call for help?

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What is unique about fetal neuroscan?
• The brain is the only fetal organ that constantly develops & changes during fetal life
• The largest changes occur within the 1st 20 wks, when most scans are done
• Scanning the fetal brain without knowledge of its developmental milestones is like going to the battlefield without a gun

Facts
• CNS anomalies are among the most common fetal anomalies (2nd or 3rd after cardiac anomalies)
• The fetal CNS develops slowly & continuously
• To do fetal neuroscan one has to:
  - know some basic embryology
  - Know the developmental milestones
  - have a high frequency transducer
  - understand the most frequent CNS anomalies
• Lately: do understand how 3D works

Therefore....
If you want to properly scan the fetal brain, know developmental state of the CNS at the gestational age at which you scan

My simple plan:
• The 1st ∆ fetal brain
• Minimum requirements of evaluating the 2nd ∆ fetal brain (AIUM, ISUOG guidelines)
• Basic fetal neuroscan
  - What is NORMAL and what is NOT
• Extended, targetted fetal neuroscan
  - What is NORMAL and what is NOT
• If we have time: Abbreviated TVS & 3D

The 1st ∆ fetal brain
• No AIUM, ACR, SRU guidelines!
• There are ISUOG guidelines (11-14w)
• New AIUM guidelines on the way!!
• Many structures can be evaluated at the time of the 1st ∆ screening (i.e at 12-14 weeks).
This is a “sneak preview” of the future implementation of the First Trimester Anatomy Scan. At the present it is in the “pipeline” and awaits FINAL approval of the involved societies.
Minimum requirements of evaluating the 2nd Δ fetal brain
(AIUM, ISUOG guidelines)

American Institute of Ultrasound in Medicine
AIUM
Anatomic Survey must include:
- Biometry: BPD & HC
- Head & neck
- Cerebellum (measure)
- Choroid plexus
- Cisterna magna (measure)
- Lateral ventricles (measure)
- Midline Falx
- Cavum septi pellucidi

International Society of Ultrasound in Obstetrics and Gynecology
2007 (updated on the way!)

Sonographic examination of the fetal central nervous system: guidelines for performing the ‘basic examination’ and the ‘fetal neurosonogram’
These guidelines were developed under the auspices of the ISUOG Education Committee. Chair, Dario Paladini, University of Naples, Italy

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Ultrasound Obstet Gynecol 2007;29:109-16

The Basic Brain Scan

What is NORMAL and what is NOT

Basic Brain Scan
Transabdominal sonography: Axial

Biometry:
- Biparietal diameter
- Head circumference
- Occipitofrontal diameter
- Atrium of the lateral ventricle at the level of the choroid plexus
- Transcerebellar diameter
- Depth of cisterna magna

The brain structures:
- Head shape
- Lateral ventricles
- Cavum septi pellucidi
- Thalami
- Cerebellum
- Cisterna magna
- Spine

You can generate MANY axial sections using the transabdominal US probe,.....

Slide showing the consecutive section from top to bottom of the fetal brain in the axial planes

.....but out of the MANY axial sections the Basic Fetal Brain Scan uses only THREE.
Basic Brain Scan:

The 3 compulsory Axial Planes:

Plane 1°: Transventricular plane

1. Cavum septi pellucidi
2- Lateral ventricles
3- Frontal horns
4- Posterior horns
5- Choroid plexuses of lateral ventricles
6- Frontal lobes
7- Cavum septi pellucidi

If you see the midline and the brain is symmetric, you are done! Next!

If you don't see it, or there is asymmetry:

Think of: space occupying lesion, unilateral V-megaly, etc..

Head shape

This is normal: You are done!

These are not! Get help!

Think of: Genetic diseases, trisomies, spina bifida, cephaloceles, hygromas, OI

Correct measurement of the ventricles opposite the parieto-occipital fissure

One more thing.....

The choroid plexus should fill the atrium of the lateral ventricles

This is normal!

This is not!

Dangling choroid plexus

Think of: V-megaly = look for reasons

Get help!
Shape of lateral ventricles on the axial planes

Back-to-back letters 'C'

This is normal: you are done! Next!

This is normal!

This is not!

Think of: colpocephaly, AGCC.....

Shape of the anterior horns of the lateral ventricles on the axial planes

This is NL: you’re done!

This is not! Get help

Upward & laterally diverging anterior horns

Think of: AGCC.....

Are the anterior horns of the lateral ventricles separated by septae of the cavum pellucidi on the axial planes?

Yes: You are done!

These are not! Get help

You MUST get coronal & sagittal planes!!

Think of: lobar HPE, SOD, AGS

Plane 2º: Transthalamic plane

Imaging the cava

The CSP should be routinely imaged on the 3 obligatory views of the fetal head obtained during obstetric sonography.
Imaging the cava
WE can see it reliably both by US as well as MRI.

Warning!!!
Do not confuse the CSP with the fornices!!
They are seen several mm below the plane of the CSP.

Recap: Make sure you have the right plane.
The mistake often made is that the small rectangle at the level of the fornices is mistaken as the CSP.
Most of these cases occur when someone is desperate to display the CSP however the underlying diagnosis most of these cases is AGENESIS OF THE CORPUS CALLOSUM.

Plane 3º: Transcerebellar plane
First: how do you get the transcerebellar plane or "tilted axial plane"??

Imaging the posterior fossa using the axial view approach.
Demo on bone obliterating the view

...and getting around the problem

A “secret” window to the posterior fossa

Blake’s Pouch a.k.a. Cisterna Magna Septa

Quick Facts

• The cisterna magna septa are the walls of Blake’s pouch
• Blake’s pouch is a normal fingerlike appendage of the 4th ventricle.
• ‘Potential marker’ for normal development

References:
- Pretorius DH et al, JUM 1992;11:125
- Knutzon RK et al, Radiology 1991;190:70
- Robinson AJ & Goldstein R, JUM 2007;26:83
Blake's Pouch a.k.a. Cisterna Magna Septa Normal Anatomy

The cisterna magna (cerebello-peduncular cistern)

If all the above were seen, documented and measured as NL: THE BASIC SCAN IS COMPLETED AND YOU ARE DONE!

If an abnormality is detected during the Basic Scan, a detailed, targetted fetal neurosonogram is recommended, or GET HELP.
The Fetal Neuroscan (Targetted Brain Scan)

What is NORMAL and what is NOT

Fetal neurosonogram = detailed 2D scan or 3D multiplanar imaging
- This scan looks at the brain in greater detail
- Coronal and sagittal planes are included
- Can be performed
  - transabdominally, and/or
  - transvaginally.....using
  - 2D and/or 3D sonography

The ventricular system
- Lateral ventricles
  - Anterior (frontal) horn
  - Posterior (occipital) horn
  - Inferior (temporal) horn
- Third ventricle
- Fourth ventricle
- Interventricular foramina (Monro)
- Median aperture (Magendie)
- Lateral apertures (Luschka)

Targetted Fetal Neuroscan
Transvaginal/transabdominal sonography:
Coronal & Sagittal
The brain structures
- Anterior horns
- Posterior horns
- 3rd and 4th ventricle
- Interventricular foramina
- Cavum septi pellucidi
- Corpus callosum
- Pericallosal artery
- Caudate nuclei
- Thalami
- Cerebellum & vermis
- Cisterna magna
- Interhemispheric fissure
- Fissures
- Sphenoidal bone
- Ocular orbits

Multiplanar scanning: 2DTVS
- Transfontanelle scan
- Coronal, & sagittal planes
- All brain sections “radiate” from one point

Coronal planes
You can generate MANY coronal sections using the transabdominal US probe,.....

.....but out of the MANY axial sections the Basic Fetal Brain Scan uses only about FOUR.

The Most Useful 2D Coronal Sections

The Frontal group
Anterior frontal (2) or transfrontal plane
- Interhemispheric fissure
- Orbits

The Midcoronal group
Mid-coronal-1 or transcaudate plane
- Interhemispheric fissure
- Caudate nuclei
- Genu corpus callosum
- Cavum septi pellucidi
- Frontal horns
The Midcoronal group

**Mid-coronal-2 or transthalamic plane**
- Interhemispheric fissure
- Thalami
- Interventricular foramina
- Atrium Lat Ventr
- 3rd Ventricle
- Body of C C

The Occipital group

**Occipital-1& 2 or transcerebellar plane**
- Interhemispheric fissure
- Occipital horns
- Tentorium
- Cerebellar hemispheres
- Vermis
- Cisterna Magna

Are the anterior horns of the lateral ventricles visible on this anterior coronal section (steer's head configuration)?

**Not seen!** This is normal: You are done!
**Seen!** This is abnormal! Get help

Think of: Unilateral v-megaly; look for a reason

Are the anterior horns of the lateral ventricles separated by septae on this coronal planes boxing-in the CSP?

**Yes!** This is normal: You are done!
**No septae! Get help**

Think of diff dx: HPE, SOD, ASP

Are the anterior horns of the lateral ventricles separated by septae on this coronal planes flanking the CSP?

**Yes!** This is normal: You are done!
**No! Get help**

Think of: lobar HPE, SOD, AGS
Are the anterior horns of the lateral ventricles diverging up and laterally on this coronal plane?
Yes! This is normal: You are done!
Not diverging?! Get help

Upward & laterally diverging anterior horns
Straight upward pointing anterior horns
Think of: AGCC

Does the falx “stop” at the corpus callosum?
Yes! This is normal: You are done!
No! Get help

Think of: AGCC

Are the lateral ventricles of normal size?
Yes! This is NL! You are done!
No! They are not! Get help

This is V-megaly, determine the cause
V-megaly is NOT a diagnosis, it is a sign!

Are the lateral ventricles of the same size? Are they separated?
Yes! This is normal: You are done!
No! They are not! Get help

Think of: asymmetric v-megaly, HPE, bleed

Are the posterior horns of the lateral ventricles of the same size?
Yes! (almost) This is normal: You are done!

Remember, the occipital horns are most of the time slightly asymmetrical.
This is quite normal
Is the cerebellum symmetrical & of normal size on the posterior coronal plane?

Yes! You are done!! No! They are small! Get help!

Think of: hypoplasia, rhombencephalosynapsis

Overview of structures on the three orthogonal planes at 22 weeks

MANY consecutive sections can be generated in the sagittal plane.

The most important one is the MEDIAN plane (mid-sagittal)
Regional anatomy of the 3rd ventricle at 31 weeks 6 days imaged in the median plane

- CSP: Cavum septi pellucidi
- CV: Cavum Vergae
- CP: Choroid plexus of 3rd ventricle
- MI: Mass intermedia of the thalamus
- 3rd V: 3rd Ventricle

Parts of the corpus callosum:
- B: Beak (rostrum)
- K: Knee (genu)
- C: Body (corpus)
- T: Tail (splenium)

Anatomy of the corpus callosum

- Genu
- Corpus
- Splenium
- Rostrum
- CSP
- CV

Do you see the entire corpus callosum or only part of it?

Entire CC?, Yes! This is normal: You are done!

Only part or none! Get help

Think: partial/total agenesis or hypogenesis of CC

Do you see a nice figure of 3 outlining the thalamus and the quadrigeminal plate?

Yes! This is normal: You are done!

No! Get help

Think: 1st or 2nd grade IVH, quadrigeminal cistern cyst

How to determine if the corpus callosum is normal: Look at the FIGURE OF 3!!

Imaging of the corpus callosum from 14 to 26 weeks
Pericallosal arteries

- Paired vessels
- Their presence predicts a normal corpus callosum

Do you see the entire pericallosal artery above the CC on the median plane?

Yes? You are done!
No? Get help!

Think of: partial or total AGCC

Do you see the normal position, size of the vermis and the tentorium?

Yes! This is normal: You are done!
No! Get help

Think of: DWM

The Rt & Lt Oblique

- Entire lateral ventricle
  - Anterior horn
  - Posterior horn
  - Inferior horn
- Choroid plexus
- Periventricular tissue
- Thalamus
Additional structures to scan

**Gyri, sulci and fissures**
- Not mandatory by any existing guideline
- There are several clear and easy ones, that you may want to remember

Median surface: Cortical surface: Gyri & Sulci
Corpus callosum & cingulate gyrus: 34 weeks

Coronal section: Gyri & Sulci
Corpus callosum & cingulate gyrus: 34 weeks

Axial section: Sylvian fissure
(Insula) 22-23 wks

Imaging the spine
Coronal planes
Sagittal plane
The sagittal plane of the spine

Normal? : You are done.

No? Get help

The most common pathology on the sagittal plane: Spina bifida

Don’t Forget to Look at

The Face

A fetal neuroscan is NOT complete unless the fetal face is thoroughly examined.

End

Extra slides if needed

Transvaginal Sonography

Only if there is time. If not skip to Conclusions

• Imaging intracranial anatomy with 2D Transvaginal Sonography was described a decade ago*
• Although this technique has gained some popularity, it is still not as widely used as it should or could be.
• It is perceived as a cumbersome and time-consuming process.
• HOWEVER: scanning the fetal brain by 2D TVS is relatively easy & fast

*Timor-Tritsch & Monteagudo 1996
Multiplanar scanning by 2D TVS

- Coronal, & sagittal planes
- Sections "radiate" from one point

Transvaginal Acquisition

- Our preferred mode: Excellent resolution (high frequency probe through the fontanelle / sutures
- Fetal position: Gentle manipulation of the fetus by the examiners’ free hand to perfectly align the footprint of the probe with a fontanelle / suture
- Version in selected cases

Coronal Planes

- The Frontal group
- The Midcoronal group
- The Occipital group

Ant coronals

1. Orbits
2. The falx
3. Anterior horn of lateral ventricles
4. Cerebella peduncles between the two walls of the cingulum
5. Subarachnoid space
6. Caudate nucleus

Anterior coronals
Mid-c coronals

1. Orbit
2. The falx
3. Anterior horn of lateral ventricles
4. Caudate nucleus
5. Subarachnoid space
6. Thalamus
7. Fissure of Sylvian fissure

Middle group of coronal sections of a 22 week fetal brain, B Slice spacing 4.5mm

Post coronals

1. Cerebellar hemisphere
2. Occipital horns of lateral ventricles
3. Choroid plexus in the posterior horn
4. Corpus callosum
5. Quadrigeminal plate of the caudate nucleus
6. Thalamus
7. Fissure of Sylvian fissure

Posterior coronal sections of a 22 week fetal brain, S Slice spacing 1.7mm

Sagittal Planes

• The Median
• The Rt & Lt Oblique-1
• The Rt & Lt Oblique-2

Can you do more?

• Yes you can!
  - If you have a 3D machine
  - If you are interested in advanced fetal brain scan
  - If you invest the use of volume scanning
• Then you move up one step to 3D
The many ways to display structures

- Calculate volume
- Orthogonal planes
- Localize structures
- Tomography
- Angiography
- Inversion
- Thick slice/volume contrast imaging

3D Fetal Neuroscan

- The most useful features of 3D scanning the fetal CNS:
  - Orthogonal planes
  - Tomographic imaging
  - Angiography
  - Inversion
  - Thick slice/volume contrast imaging

3D Angiography

- Power/Color Doppler (brain vasculature)
- Pericallosal branch of the anterior cerebral artery

A systematic technique using 3-dimensional ultrasound provides a simple and reproducible mode to evaluate the corpus callosum

OBJECTIVE: The aims of the study were to evaluate a rapid 3-dimensional ultrasound-assisted technique for evaluation of the corpus callosum as an integral part of the anatomic survey.

STUDY DESIGN: Transcranial 3-dimensional gray-scale and power Doppler volumes of the fetal brain were acquired in 102 consecutive healthy fetuses of 20-32 completed gestational weeks. Offline analysis was performed by 2 of the authors using a systematic approach of "volume manipulation." Diagnostic-quality visualization of the corpus callosum and the pericallosal arteries or the median plane was recorded by the 2 examiners independently.

RESULTS: The median plane was evaluated in all cases. Diagnostic-quality images of the corpus callosum, pericallosal arteries, and the median plane were recorded by the 2 examiners independently.

CONCLUSION: Three-dimensional ultrasound provides a simple and easy evaluation of the corpus callosum and the pericallosal arteries as an integral part of the routine obstetric examination. Key predictive signs of corpus callosum atrophy, fetal macrosomia, pericallosal arteries, and 3D ultrasound.
Inversion Rendering

Concluding suggestions

Summary & conclusions

- The basic normal and abnormal fetal brain scan was presented having in mind its daily use
- My suggestion: basic brain scan for all fetuses regardless of risk!!
- Targetted scan for suspicious brain findings & for fetuses with any anomaly
- The median (mid-sagittal plane is essential for a complete fetal brain scan

Summary & conclusions

- If the fetus is in vertex presentation, use transvaginal neuroscan (if breech and TAS not clear, consider version)
- In tertiary centers or for an in-depth scan: 3D fetal neuroscan (if vertex: transvaginal)