Introduction

• Many, find the brain anatomy challenging.
• It is true, that in order to understand what is seen in the ultrasound screen a basic understanding of the developmental embryology of the brain is necessary.
• In this lecture, will review the pertinent ‘highlights’ of the brain anatomy in the first trimester, but the main focus is the anatomy during the second trimester and beyond.

Fetal Brain Scan

• The ‘basic’ or ‘every day’ brain scan is performed by TAS using 3 axial planes: the transventricular, transthalamic and transcerebellar planes.
• The ‘expert’ or targeted fetal brain scan or neurosonography is performed by 2D and 3D TAS and TVS adding the coronal and sagittal planes to the axial planes of the ‘basic scan’.

The First Trimester

• The first brain structure that is easy to evaluate sonographically is the Rhombencephalon.
  • It represents the hindbrain: medulla, pons and cerebellum
• Appears as an anechoic structure, in the posterior region of the head/brain, measuring approximately 3-4 mm.
• Marker of the ~8 weeks US brain scan

The Rhombencephalon: 8+ weeks

• Anechoic structure posterior embryonic brain
The First Trimester

- The next brain structure that is easy to evaluate sonographically is the midline falx; seen at 9+ weeks.
- It divides the brain into the right and left hemispheres with the choroid plexus seen to each side of the falx.
- The CP is brightly echogenic, symmetric and fills 2/3 the cavity of the lateral ventricle.

Fetal Brain Scan 11 to 13 6/7 weeks

- The correct plane to adequately measure the NT is the median plane of the fetus.
- This plane, provides more than just an opportunity to measure the NT thickness and assess for the presence of the nasal bone.
- It allows evaluation of the developing fetal head and brain.

Fetal Brain Scan 11 to 13 6/7 weeks

- Structures seen using the median plane are the:
  - Cranium
  - Frontal horn
  - Choroid plexus
  - Thalamus
  - Posterior fossa
  - Occipital bone

Fetal Brain Scan 11 to 13 6/7 weeks

- Posterior fossa in the median plane during the 1st trimester
- ‘3 sonolucent spaces’
- Brainstem is the widest and the cisterna magna is the thinnest
- Non-visualization of these 3 spaces may be a clue to the presence of ONTD- spina bifida.

Fetal Brain Scan Second Trimester and Beyond

- The ‘basic’ or ‘every day’ brain scan is performed by TAS using 3 axial planes: the transventricular, transthalamic and transcerebellar planes.

Transventricular plane

- Landmarks
  - Cavum septi pellucidi (1)
  - Frontal horns (2)
  - Choroid plexus (3)
  - Posterior horn (4)
  - Parieto-occipital fissure (POF)
  - Sylvian Fissure (SF)
- Measure LV
**Criteria for appropriate measurement of Lateral Ventricle**
- Measuring of the LV is part of the 2nd trimester.

**Where to Measure the Lateral Ventricle**
- Normal < 10mm - accepted post 20 wks.

**Asses for the Normal Shape of Lateral Ventricles**
- Falx (4)
- Frontal horns (1)
- Choroid plexus (6)

**Anterior & Posterior Brain Complexes**
- Recently, in an effort to standardize and subsequently improve diagnosis of fetal midline brain anomalies the terms anterior and posterior brain complexes has been introduced.
- Normal appearance of the complexes is reassuring while abnormal appearance can aid in the detection of midline brain anomalies such as: HPE and AGCC.

**Anterior (AC) & Posterior (PC) Complexes of the Brain**
- Best plane for the AC is the transventricular
- Best for the PC is 2-3 mm above the transventricular plane

**Anterior Complex**
- Interhemispheric fissure (1)
- Callosal sulcus (2)
- Genu of the corpus callosum (3)
- Cavum septi pellucidi (4)
- Anterior horns (AH)

**Normal CSP ‘shape’ variations**

Graphs from: Hormazabadi et at. Prenat Diagn 2015; 35: 151-154
**Posterior Complex**

- Choroid plexus (CP)
- Parieto-occipital fissure (POF)
- Splenium corpus callosum (S)
- Callosal sulcus (CS)
- Interhemispheric fissure (IHF)

Oblique to midline disposition of the LV

From Viñales et al. UOG 2015; 46: 585-594

**Transventricular plane**

Asses for the Normal Sylvian Fissure aka Lateral Sulcus

- With increasing GA; the fissure becomes more angular and deeper
- Abnormal S. fissure may be a marker of an underlying CNS anomaly

Diagram from Ultrasound Obstet Gynecol 2008; 32: 50-60

**Transthalamic plane**

- **Landmarks**
  - Cavum septi pellucidi (1)
  - Frontal horns (2)
  - Thalami (3)
  - Choroid plexus (6)
  - Posterior horn (7)
  - Sylvian Fissure (SF)
  - Measure BPD and HC

**Transthalamic plane**

- **Landmarks**
  - Cranium
  - Falx
  - Frontal horns
  - Cavum septi pellucidi
  - Thalami
  - Cerebellar pedunculi
  - Hippocampal gyrus
  - Sylvian fissure
  - Measure BPD, HC, OFD

**Transthalamic plane**

Where to measure the **BPD**

- Transducer must be perpendicular & hemispheres and head should be symmetric.
- Calipers should be placed at: the outer edge of the near calvarial wall inner edge of the far calvarial wall
- Orbits, ears or cerebellar hemispheres should not be in the plane

**Transthalamic plane**

Where to measure the **HC**

- Transducer must be perpendicular & hemispheres and head should be symmetric.
- Ellipse should be placed around the outer table of the calvarium
- Orbits, ears or cerebellar hemispheres should not be in the plane

Around the outside of the skull bones
**Transthalamic plane**
Asses for the Normal Shape of Anterior Horns

- Shaped like a “V”
- Upward & laterally diverging anterior horns

**Transthalamic plane**
Asses for the Normal CSP

- A fluid filled structure between the leaves of the septum pellucidum
- If a central ‘third-line’ is seen this is NOT the cavum, but the fornix

**Transthalamic plane**
Echogenic Central Line

- If a central ‘third-line’ is seen this is NOT the cavum, but the fornix

**Transthalamic plane**
What is the Fornix?

- Located inferiorly to the CSP
- By US can be recognized as the central ‘third’ line*

**Transthalamic plane**
Normal CSP and Fornix

- A fluid filled structure between the leaves of the septum pellucidum
- Fornix Central ‘third-line’
- Non-visualization of the fluid filled FH

**Transcerebellar plane**

- Landmarks
  - Frontal horns (1)
  - Frontal lobes (4)
  - Cavum septi pellucidi (6)
  - Cerebellum (7)
  - Vermis (V)
  - Cisterna magna (8)
  - Cerebellar pedunculi (9)
  - Parietal lobes (10)
  - Sylvian fissure (SF)

- Measure the transcerebellar diameter and cisterna magna
The TCD is measured at the widest part of the cerebellum, perpendicular to the falx.

- TCD in mm correlates with GA up to 20 weeks. After 20 weeks is larger than GA.
- A TCD ≤ 2mm than the estimated GA or < 5% is a concerning finding.

Where to measure the transcebrellar diameter (TCD)

- The CM is measured from the posterior margin of the vermis to the inside of the occipital bone in the midline.
- Measurement of 2-10 mm is normal during 2nd to the 3rd trimesters.

Where to measure the Cisterna Magna (CM)

- The CM is measured from the posterior margin of the vermis to the inside of the occipital bone in the midline.
- Measurement of 2-10 mm is normal during 2nd to the 3rd trimesters.

Transverse plane

- Are NL anatomic structures; seen during the NL embryologic development of the posterior fossa.
- Usually, 2 septae are imaged inferior and posterior from the vermis forming a cyst-like structure.
- Present in most fetuses (84-92%)
- In actuality, they represent the walls of Blake’s pouch.

Blake’s Pouch

- 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.

The Vermis < 20 weeks

- Absent-vermis
If your scanning plane is too low... it can be confused with posterior fossa abnormality (abnormal vermis)

The Vermis < 20 weeks
The “Absent-Vermis”

15 1/2 weeks
Normal

Fetal Brain Scan Second Trimester and Beyond
• Up to this point we have concentrated in the normal anatomy using the 3 classic transabdominal (TAS) axial views.
• Let’s go beyond and look at the anatomy in coronal and median (sagittal) planes.

The Normal Fetal Brain- Beyond the Basics
• The ‘expert’ or targeted fetal brain scan or neurosonography is performed by adding the coronal and sagittal planes, typically by TVS, to the axial planes of the ‘basic scan’.

Coronal Plane
• Numerous tomographic coronal sections of the fetal brain is possible.
• However, will concentrate on the mid-cortical plane

Mid-Coronal (or Transthalamic plane)
• Cavum septi pellucidi (1)
• Anterior horns (2)
• Thalami (3)
• Falx (4)
• Choroid plexus (5)
• Body of corpus callosum (6)
• Interventricular foramina (*)
• Sylvian fissure (SF)

Mid-Coronal Plane
Falx Cerebri
• Midline
• Superior sagittal sinus
• Subarachnoid space
• Falx
• Interhemispheric fissure
• Body of the corpus callosum
• Cavum septi pellucidi
### Mid-Coronal Plane

**Interhemispheric Fissure**
- Smooth
- "Squiggly"

**EGA 34 weeks**
- Cingulate sulcus and gyrus
- Midcoronal Plane
- Corpus callosum

**EGA 20 weeks**
- Interhemispheric fissure
- Cingulate sulcus and gyrus

**EGA 28 weeks**
- Midcoronal Plane
- Corpus callosum

### Mid-Coronal Plane

**Cavum Septi Pellucidi**
- A fluid filled structure between the sidewalls of the septum pellucidum

### Mid-Coronal Plane

**Anterior Horns**
- Anterior horns diverge up and laterally on this coronal plane

### Mid-Coronal Plane

**Third Ventricle**
- Slit-like structure seen between the thalami
- Typical width is about 1 mm up to 28 weeks; afterwards may enlarged to reach a width of 1.9 mm
- If the width measures greater than 3.5 mm anytime during the pregnancy, it should be considered abnormal

### Sagittal Plane
- Numerous tomographic sagittal sections of the fetal brain is possible.
- However, will concentrate on the median plane

### Sagittal Median Plane
- Corpus Callosum
- CSP (& Vergae)
- Thalamus (3rd ventricle)
- Tela choroidea
- Tectum (corpora quadrigemina)
- Posterior fossa
- Cerebellar vermis
- Cisterna magna
- 4th ventricle
- Fastigium
**Corpus callosum & Cavum Septi Pellucidi**
- The rostrum (beak), genu (knee), corpus (body) and the splenium (tail)
- Cavum septi pellucidi & vergae
- CC develops in an anterior to posterior fashion
- Exception: Rostrum & anterior genu which develop last

**Median Plane**
Corpus Callosum & Cavum Septi Pellucidi
- Splenium (tail) extends to quadrigeminal cistern (tectal plate)
- If it doesn’t this is suspicious for partial AGCC

**Median Plane**
The tectal plate (Quadrigeminal Plate)
- It is the portion of the midbrain (tectum) upon which the superior and inferior colliculi sit.
- When fully formed, the tail of the corpus callosum reaches it
- Site for pathologies such as: Cysts, Lipomas

**Median Plane**
Nomograms Corpus Callosum
- Connects the 3rd ventricle with the 4th ventricle
- It appears as two parallel echoic lines

**Median Plane**
The Cavum Vergae
- Develops together with the CC
- Continues posteriorly as the cavum vergae

**Median Plane**
The rostrum (beak), genu (knee), corpus (body) and the splenium (tail)
**Median Plane**

The tectal plate (Quadrigeminal Plate)

- The choroid plexus of the 3rd ventricle covering the thalamus and the choroid plexus of the quadrigeminal plate generates a figure of 3 appearance. Tail of CC reaches the middle of the 3.

**Median Plane**

Gyri & Sulci

- Brain changes from smooth; to having multiple hyperechoic sulci
- Cingulate gyrus from about 24 weeks

**Median Plane**

Gyri & Sulci - Adult-like appearance

- Cingulate gyrus (hyperechoic stripe)
- Sulcus of the corpus callosum (hyperechoic line)
- Fissura calcarina or parieto-occipital fissure (calcar avis

**Median Plane**

Corpus Callosum & Cavum Septi Pellucidi

- The development of corpus callosum is closely associated with that of the CSP
- There cannot be a CSP without a covering corpus callosum
- However, a corpus callosum can be present in the absence of the CSP such as in septal agenesis as the result of SOD

**Median Plane**

Corpus Callosum & Cavum Septi Pellucidi

Best time to image is after 20 weeks
**Median Plane**

**Corpus Callosum & Cavum Septi Pellucidi**
- The CC reaches its final adult-like appearance at around the 28 wks.
- By the 3rd trimester the CSP begins to narrow in an occipital-to-rostral fashion; closure of the posterior part will occur in most fetuses by term.
- The cingulate sulcus is seen from 24-26 wks on.

**Median Plane**

**Arteries, Veins & Sinuses**
- Best plane to image vessels that are in the midline.
- Color/power Doppler reveals both the arterial and the venous system.

**Median Plane**

**Corpus Callosum & Pericallosal Arteries**
- The presence of normal pericallosal arteries predicts normal development of the corpus callosum.

**Median Plane**

**Corpus Callosum & Pericallosal Arteries**
- Before 18 weeks, using only gray scale, the corpus callosum may not be evident.
- However, when using color Doppler if the pericallosal artery is present it is proof that the CC is developing.

**Median Plane**

**Pericallosal arteries at 11-13 weeks**
- Several authors have demonstrated the presence of the pericallosal arteries in the 1st trimester using 2D and 3D Power Doppler.
- It may be used to screen pregnancies at increased risk of AGCC.
In Summary……
• Becoming comfortable with the normal anatomy of the brain is the key to diagnose complex brain malformations.
• Always start with the axial planes using TAS.

In Summary……
• If an anomaly is suspected the next step is adding the coronal and sagittal planes; ideally obtained by TVS.
• The mid-coronal and the median plane are the most valuable.
• Don’t hesitate to add color Doppler.