Measurements of the Posterior Fossa in Normal Fetus MRI

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Outline

- Overview of the development and malformations of the posterior fossa (PF)
- Diagnosis of posterior fossa malformations
- Measuring new reference data – methods and initial results
- Possible Clinical Applications
Anatomy of the PF

Midsagittal plane
Anatomy of the PF

Midsagittal plane

Brain stem

- Midbrain
- Pons
- Medulla oblongata

Tentorium Cerebelli

4th Ventricle

Torcular

Vermis

Cisterna Magna (CM)
Anatomy of the PF

Axial plane

- Pons
- Cerebellum
- Vermis
- 4th Ventricle
- Cisterna Magna
Development of the PF
Development of the Vermis

- Cephal to caudal development of the vermis
- 16\textsuperscript{th} week – full vermis and cerebellum (3 lobes)
- 18\textsuperscript{th} week – 4\textsuperscript{th} ventricle fully covered
- The formation of fissures and lobules continue

![Development of the Vermis](image)

<table>
<thead>
<tr>
<th>22GW</th>
<th>28GW</th>
<th>32GW</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Image" /></td>
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PF malformations

- Abnormal PF takes a major part in fetal brain abnormalities

- No universally acceptable classification:
  - Patel and Barkovich (2002): Hypoplasias and displasias
  - Tortori-Donati (2005): Cystic and non-cystic
  - Guibaud (2006): Agenesis: Complete or partial absence of a structure Hypoplasia: Small but complete structure Atrophy: Secondary volume diminution
Diagnosis of PF malformations

Plea for an anatomical approach to abnormalities of the posterior fossa in prenatal diagnosis

L. Guibaud and V. des Portes

*Ultrasound Obstet Gynecol* 2006; 27: 477–481
Dandy-Walker malformations

- Recognized by Dandy 1914 (described by Virchow 1863)
- **The classic triad:**

  - Complete/partial vermian agenesis
  - Enlarged PF with upward displacement of the tentorium and the torcular
  - Cystic dilation of the 4th ventricle
Dandy-Walker malformations

Axial

Coronal
Dandy-Walker malformations

- Well defined anatomical entity
- Isolated or as a part of a syndrome (Joubert, Walker-Warburg and more)
- Prognosis varies
- Other PF malformations:
  - With enlargement of the CM: Blake pouch, Arachnoid cyst, Mega CM
  - Without enlargement of the CM: Dysplasia, infections, ischemia…
  - Prognosis vary even more
Diagnosis of PF malformations

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Existing biometric data

Comprehensive study by Garel et al.:
- Cohort of 589 fetuses
- 5 measurements of structures in the PF:
  - Vermis: A-P, S-I, cross sectional area (CSA)
  - Pons: A-P
  - Cerebellum TCD
New reference data

Objectives:

- Re-evaluation of normal MRI existing reference data of fetal posterior fossa, and evaluation of new reference data of normal MRI of fetal posterior fossa
Cohort:
- Fetuses with no pathological finding in the posterior fossa, and mild to none pathological finding in the brain
- 200 fetuses
- GA 27-39 wks

Indication stats:
- CMV infection 25%
- Ventricular asymmetry 25%
- Disorders in the family/previous pregnancies 8%
- Extra-cranial anomalies 8%
- Others

Finding stats (MRI):
- No finding 80%
- Mild Vent. asymmetry 20%
Methods

**Measurements:**

- Brainstem, Cerebellum, Vermis, CM
- Sagittal and axial planes
- 5 of existing data
- 12 of new reference data
- Relations between structures’ biometry:
  - Ant/Post vermian lobes
  - Cerebellar hemispheres
  - CM CSA – Vermian CSA = fluid filled space
- Inter-observer deviation will be calculated
Measurements of the Posterior Fossa

Measurements of existing reference data

Vermis A-P, S-I
Measurements of the Posterior Fossa

Measurements of existing reference data

Vermian Perimeter and CSA, Pons A-P
Measurements of the Posterior Fossa

Measurements of existing reference data

TCD
Measurements of the Posterior Fossa

Measurements of new reference data

<table>
<thead>
<tr>
<th>Ant./post. Lobe CSA</th>
<th>0.03th</th>
<th>0.15th</th>
<th>0.5th</th>
<th>0.85th</th>
<th>0.97th</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.48</td>
<td>0.55</td>
<td>0.64</td>
<td>0.73</td>
<td>0.80</td>
<td></td>
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</table>

Brainstem and vermis lobes perimeter and CSA + relation
Measurements of the Posterior Fossa

Measurements of new reference data

Pons S-I and CSA, CM CSA
Measurements of the Posterior Fossa

Measurements of new reference data

<table>
<thead>
<tr>
<th>Cerebellar hemispheres relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.03th</td>
</tr>
<tr>
<td>0.88</td>
</tr>
</tbody>
</table>

Cerebellum with/without pons perimeter and CSA + relation
**Initial Results**

For practical use:

<table>
<thead>
<tr>
<th>Brainstem Biometry GW 28</th>
<th>0.03th</th>
<th>0.15th</th>
<th>0.5th</th>
<th>0.85th</th>
<th>0.97th</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM CSA</td>
<td>340.24</td>
<td>370.50</td>
<td>407.66</td>
<td>444.81</td>
<td>475.07</td>
</tr>
<tr>
<td>BS CSA</td>
<td>258.35</td>
<td>277.36</td>
<td>300.71</td>
<td>324.05</td>
<td>343.06</td>
</tr>
<tr>
<td>BS Per</td>
<td>85.34</td>
<td>90.44</td>
<td>96.69</td>
<td>102.95</td>
<td>108.05</td>
</tr>
<tr>
<td>Pons A-P</td>
<td>9.22</td>
<td>9.69</td>
<td>10.27</td>
<td>10.85</td>
<td>11.32</td>
</tr>
<tr>
<td>Pons S-I</td>
<td>10.29</td>
<td>10.93</td>
<td>11.70</td>
<td>12.47</td>
<td>13.11</td>
</tr>
<tr>
<td>Pons CSA</td>
<td>90.78</td>
<td>99.29</td>
<td>109.73</td>
<td>120.18</td>
<td>128.69</td>
</tr>
</tbody>
</table>
A possible case study

Pathologic

Normal
A possible case study

Pathologic

Normal
A possible case study

- Measurements (based on 32nd GW biometry):
  - Vermis – all measures above 10th percentile
  - Ant/post lobes – normal
  - Brain stem – all measures around 50th percentile
  - CM CSA – above 97th percentile

- Normal/ Pathological?
- What is the pathology?
- Prognosis?
Possible clinical applications

Routine ultrasound examination

(1) Increased ‘fluid-filled’ space of the posterior fossa
  - Elevated torcular
    - Dandy-Walker malformation
  - Torcular in place

(2) Decreased biometry (decreased TCD for GA)
  - Normal cerebellar anatomy
    - Focal reduction
    - Global reduction

(3) Abnormal cerebellar anatomy
  - Chiari II
    - Neural tube defect?
      - "banana sign"
      - Decreased TCD
      - Cisterna magna = 0
  - Rhombencephalosynapsis
    - Decreased TCD

Cerebellar anatomy / biometry

- Decreased biometry
  - See section (2)
- Abnormal anatomy
  - See section (3)

Normal rotated vermis?

- Hydrocephalus?
  - Megacisterna magna
  - Arachnoid cyst
  - Blake pouch cyst

- Dysplasia
- Ischemia
- Hemorrhage

- Barth
- OPHN-1
- Reelin

- Aneuploidy
- CMV infection
- CDG syndrome

Partial

Complete

Brain stem

- Pontocerebellar hypoplasia
- Cerebellar hypoplasia

Vermian agenesis

TCD: decreased / usually normal / increased
- Increased / normal
  - ‘fluid-filled’ space of the PF
Bottom line

We will have another objective tool to make the correct diagnosis
Questions?

Coronal

Sagittal

Thank you