Ultrasound Scanning of Neonatal Hips
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Outline
• Why?
• Why performing hip ultrasound (USG)?
• Why USG?
• How?
• What?

• Why?
• How?
• How to perform?
• How to interpret?
• How to perform better?
• What?

• Why?
• How?
• What does it look like?
• What is your question (Q & A session)?

The Paediatric Hip
• Femoral head - non-ossified at birth
• Ossification takes place 2 - 8 months
• Ossific nucleus is not anatomically the centre of the femoral head
• USG becomes increasingly difficult with age
• Practical up to 6 months of age
Paediatric Hip USG

- Aim = to diagnose DDH < 3 months
- >3 months = late diagnosis: potential risk of irreversible hip dysplasia / early OA
- Sensitivity & specificity near 100%
- False +ve and –ve: ~1% and 2%
- <30 d/o: physiological laxity of hip
- 1st scan at 4-6 weeks of age

Paediatric Hip USG

- Developmental Dysplasia of Hip (DDH)
  - A spectrum of abnormalities
  - Commonest MSK disorder in children (Incidence 1.5 - 3 : 1000 births)
  - 9-10% of all hip replacements
  - Female >> Male (4-8 : 1)
  - Left > Right (3 : 1)
  - Can be asymptomatic in the early phase
  - Hip development, maturation, stability & degeneration

Why performing hip USG?

- Early detection (age related)
  - Growth potential
  - Ossification potential
  - The later the diagnosis is made, the harder the treatment will be, leading to greater risk of complications and a higher chance of failure
- Avoid damage
  - No treatment (deformity)
  - Over treatment (Avascular necrosis)

Why using USG?

- USG vs Clinical exam
- USG
  - Diagnosis of DDH
  - Monitor treatment

Why using USG?

- Not need to sedate the patient
- High resolution
- Multiplanar
- Dynamic
- Radiation-free
- Objective & Subjective

Why using USG?

- USG vs Clinical exam
- USG vs XR vs CT vs MRI
**Clinical Exam**

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<th>USG</th>
<th>XR</th>
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**Objective/Subjective**

- Objective
- Subjective

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**How to perform & interpret?**

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**Anatomy**

- **Y cartilage**
  - The Y-shaped connecting cartilage in the acetabulum that joins the ilium, ischium, and pubis

- **Lower limb of os ilium → centre of the acetabulum in USG**

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**Anatomy**

- **Acetabulum**
  - *Bony portion*
  - Cartilaginous portion
    - Hyaline cartilage of the acetabular roof
      - A few echoes only and looks like an "echo gap"
    - Fibrocartilaginous acetabular labrum
      - Triangular in cross-section
      - Highly echogenic

- **Perichondrium**

- **Acetabular labrum**

- **Osseous rim**
Anatomy

1. Labrum
2. Lower limb of os ilium
3. Cartilaginous part of acetabular roof

Perichondrium
- Lateral boundary of the cartilaginous acetabular roof
- Distally continuous with joint capsule (less/no echo) [perichondrial gap]
- Proximally merges in to the periosseum of the iliac bone (thick) [proximal perichondrium]
- May mistaken as the acetabular labrum

Acetabular labrum
- Triangular in cross-section
- On inner side of the joint capsule, but not connected with it
- Fixed to the hyaline cartilage acetabular roof
- Tips for identifying the labrum (4 guides)

Acetabular labrum
- Tips for identifying the labrum (4 guides)
  1. The labrum echo is always lateral and distal to the "echo gap" of the hyaline cartilage acetabular roof on the inner side of the joint capsule
  2. The labrum is always in contact with the femoral head
  3. The labrum is always caudal to the perichondrial gap
  4. The labrum is where the contour of the joint capsule diverges from the surface of the femoral head

Labrum definitions
- Lateral and distal to the "echo gap" of the hyaline cartilage
- In contact with femoral head
- Caudal to the perichondrial gap
- Joint capsule diverges from the surface femoral head
Anatomy

Labrum definitions
- Lateral and distal to the “echo gap” of the hyaline cartilage
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Osseous rim
- Most lateral point of the concavity of the bony socket
- The point where the concavity of the bony acetabular roof changes to the convexity of the ilium (where the concavity becomes the convexity)

Anatomy

Bony rim definition
1. Concavity (bony acetabular roof)
2. Turning point (measurement point)
3. Convexity (of ilium)

What to look for?

3 major components of DDH:
1. Morphology
2. Position
3. Stability

How to look for?
- 5-7 MHz, linear probe
- Three distinct methods:
  1) Static method by Graf (morphology/position)
  2) Femoral head coverage by Morin (Terjesen) method (morphology/position)
  3) Dynamic method by Harcke (stability)

The 3 views
1) Coronal view in Graf format
2) Transverse view with hip flexion
3) #2 with Barlow’s stress manoeuvre
Coronal view
- Angle adjusted → max. depth of acetabulum
- Hip either in neutral / flexed position
  - Neutral position → usu. 15-20° of hip flexion
  - Flexed position → 90° of hip flexion
  - Independent of hip / leg position
- Femoral head coverage
- Acetabular maturity

Problem(s)
- Oblique angle → made to look erroneously deep or shallow
- Precise plane of imaging is a critical issue → demands training and audit of the technique

What to look for?
3 major components of DDH:
1) Morphology
   - Morin (Terjesen) method
   - Graf technique
2) Position
   - Morin (Terjesen) method
   - Graf technique
3) Stability

Morin (Terjesen) method

Femoral head coverage
- Coverage of the femoral head by the bony acetabulum in the standard coronal plane

Acetabular development
- Distance between medial aspect of femoral head and the baseline (d)
- Maximum diameter of the femoral head (D)
- d/D x 100%

Graf’s Technique
**Graf’s Technique**

- Popular in central Europe
- A single coronal image of the hip irrespective of position of femur
- Lateral position
- Hip flexed to 90 degrees

**Measurement Technique (Graf)**

- Baseline
- Roof line (bony roof line)
- Inclination line (cartilage roof line)
- $\alpha$ angle (bony part)
- $\beta$ angle (cartilaginous part)

**Acetabular maturity**

- 3 lines
  - Baseline
  - Roofline
  - Inclination line

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**Graf’s Technique**

- Must have presence of 3 structures on the same plane:
  1. Lower limb of bony ilium (must be parallel to the probe)
  2. Middle of bony acetabular roof
  3. Cartilaginous acetabular labrum

**Measurement Technique (Graf)**

- $\alpha$ angle & $\beta$ angle
- Independent of the
  - position of the baby
  - position of the femoral head
  - position of the leg
  - femoral head ossification

**Acetabular maturity**

- 3 lines
  - Baseline
  - Roofline
  - Inclination line
### Baseline
- A line drawn through the plane of the ilium, where it connects to the osseous acetabular convexity.

### Acetabular maturity
- **3 lines**
  - Baseline
  - Roofline
    - A line drawn through the plane of the bony acetabular convexity
  - Inclination line

### Roof line (bony roof line)
- A line drawn through the plane of the bony acetabular convexity.

### Acetabular maturity
- **3 lines**
  - Baseline
  - Roofline
    - Inclination line
      - A line drawn from the osseous rim to the middle of the labrum
      - Parallel to the cartilaginous roof

### Inclination line (cartilage roof line)
- A line drawn from the osseous rim to the middle of the labrum.

### Acetabular maturity
- **Alpha angle (α angle)**
  - A measurement of acetabular concavity
  - The angle between baseline and roofline
Acetabular maturity

- Alpha angle (α angle)
  - A measurement of acetabular concavity
  - The angle between baseline and roofline
  - Normal > 60°
  - 50-60° may be physiologically typical in neonate (<2-week old)
  - < 50° considered abnormal

- Beta angle (β angle)
  - A measurement of the acetabular cartilaginous roof coverage
  - The angle between baseline and inclination line
  - Normal < 55°
  - The smaller the angle, the less the cartilaginous coverage and the better the bony acetabular coverage of the femoral head

Graf’s Sonographic hip type

- Correlates with the pathological changes in the hip joint (cartilage & bony socket) rather than with the height of the dislocated femoral head
- The more accurate and precise the typing, the more appropriate and precise the treatment can be
Graf’s Sonographic hip type

- 4 main sonographic types
  - **Bony roof** (α angle)
  - **Superior bony rim**
  - **Cartilaginous roof** (β angle)
  - **Age** (subtypes)

- Type III and IV are both decentered hips with different deformations of the hyaline cartilage roof

**Myths**
- The 3 lines should intersect at 1 point!!

**Truth**
- The 3 lines seldom intersect at 1 point
- Only type 1 joint with sharp bony rim has 3 lines intersect at 1 point (~20% of all type 1 joint)
3 Landmarks

1. Osseous rim
2. Ilium
3. Acetabular labrum

A hip USG can only be evaluated if all 3 landmarks are shown

Effect of tilting

- Only *mid (standard) sectional plane* should be used for measurement
- The tilting can be distinguished from the shape of iliac bone proximal to the bony acetabular rim

Problems

- Graf’s technique requires supervised training with considerable learning curve
- Studies have shown poor reproducibility for placement of lines
- Interobserver & Intraobserver error

Latest literature cast doubt on diagnostic validity and reliability of USG hip in infants

- Great uncertainty in the group with alpha angle <60 and >43 (Graf’s II)
  - Significance of Graf’s II unknown
  - No true information on prognosis
- No universal agreement on management decision (US vs clinical)

What to look for?

3 major components of DDH:

1) Morphology
2) Position
3) Stability
  - Harcke dynamic method
**Harcke dynamic method**

**Dynamic Technique**
- Relaxed hips x for instability
- Supine or lateral decubitus position
- Transverse images of hip (posterolaterally)
- Stress image in transverse plane
  - Hip flexion, adduction with gentle posterior push
  - >= 2mm displacement

**Dynamic Hip Assessment**
- Objective
  - Position of the femoral head
    - Normal
    - Subluxated
    - Dislocated
  - Stability of the hip (motion & stress)
    - Normal
    - Lax
    - Dislocatable (Reducible / Not reducible)

- Transverse flexion view (Harcke)
  - Flexing the femur 90°
  - Transducer maintained at posterolateral position over the hip joint
    - Metaphysis
    - Femoral head
    - Bony acetabulum
  - Sonogram changes its appearance in abduction and adduction (U → V)
**Dynamic Hip Assessment**

- Stress (gentle posterior push + adduction)
  - Barlow test
- Dislocation
  - Posterior + Lateral displacement
  - +/- Superiorly displaced
  - Disruption of normal U pattern
- Reduction
  - Abduction
  - Ortolani maneuver

**US Report**

1) Appearance of bony and cartilaginous acetabulum, alpha + beta angle
2) Appearance of femoral head
3) Position of femoral head in relation to acetabulum at rest
4) Dynamic stress view findings

**How to perform better?**

- Clear instructions to mother / accompanying person
- Mother / accompanying person at opposite side of the table / bed
- Calm and stabilize the baby by putting her / his hand on the baby’s shoulder
- Screen the L hip first

**Points for sharing**

- Legs need not be straight during coronal view
- Do not flex your fingers
  - Fingernails could scratch the baby and cause struggling
- Avoid tilting the transducer
  - May cause error in measurement

**Points for sharing**

- The plate of iliac bone (NOT spine) must be parallel to the surface of probe
- Gentle force for stress image
- Use pedal to help
- Messy!
- Practise more!!
Who to screen?

- Evidence is lacking either for or against a generalized screening of all child for DDH
- Conclusion: routine use of USG hip in all neonates cannot be recommended
- Screening for those with risk factors:
  1. Breech presentation
  2. Family history
  3. Club foot / torticollis
  4. Positive physical examination

Summary

- Hip USG enables accurate analysis of the patho-anatomical situation in the hip joint
- Early detection becomes possible, so that the hip joint has lots of time available when there is good potential for maturation

Summary

- Coronal + Transverse scans
  - Redundant
  - To confirms findings
  - ↑ the level of confidence
- Widespread availability of USG
  - A/v in many areas

Summary

- USG hip
  - Diagnosis
  - Monitor treatment
- Over-aggressive treatment
  - Damage the growing epiphysis \( \rightarrow \) deformity & delay in ossification
  - Avascular necrosis of femoral head
- Cost impact on health care system
  - Cost of screening VS treatment

Problems

- ? How and when to treat
- ? Universal screening
- ? Splint treatment in all abnormal cases

Better ultrasound today than a limp tomorrow!
Reference

- Developmental dysplasia of the hip -- Child; ACR Appropriateness Criteria; 2010.
- Paediatric Musculoskeletal Disease with an emphasis on ultrasound; A.L. Baert, K. Sartor, Springer.
- Hip Sonography, Diagnosis and management of infant hip dysplasia; 2nd edition; R Graf, Springer.

Thank you!!