Say Cheese!
Imaging in the Newborn
Mary E. Flynn, DNP, CPNP-AC, PPCNP-BC
Pediatric Hospitalist: Children's National Health Systems
Assistant Clinical Professor: The Catholic University of America
Washington DC

Speaker Introduction

• Dr. Mary Flynn serves as an assistant clinical professor at The Catholic University of America Conway School of Nursing in Washington, D.C., and is director of the acute care pediatric nurse practitioner program. She has 19 years of experience as a pediatric nurse practitioner and the last 10 years as a pediatric hospitalist in a newborn nursery implementing evidence based protocols to improve newborn care.

Disclosures

I have no relevant financial relationships to disclose.

Learning Objectives

• Identify if there are any indications for testicular ultrasound in the newborn.
• Identify appropriate timing for renal imaging when indicated in the newborn.
• Recognize sacral dimple and associated findings that may require imaging.
• Recognize which infants or murmurs require echocardiography.
• Identify the next imaging steps in the newborn with an abnormal hip exam.
• Identify when an x-ray is needed for musculoskeletal findings in newborns.

Imaging

• Can be very costly
  • US (sacral, renal, testicular)
  • ECHO
  • X-rays
  • MRI
• May be anxiety-provoking for the parents
• Determine the appropriate time and understand the supportive evidence that leads to appropriate imaging
  • Eliminate unnecessary parental anxiety
  • And.....decreases healthcare costs.

Identify if there are any indications for testicular ultrasound in the newborn.
Cryptorchidism (Undescended Testis)

• One of the most common genital disorder identified at birth.
• Delay in referral and treatment lead to a Potential Risk for:
  • impairment of fertility
  • testicular malignancy

Initial Evaluation

Note the Gestational Age in males with suspected cryptorchidism.

• prevalence of cryptorchidism is > in preterm males
  • 1-3% in full-term
  • 15-30% in preterm male infants
• Descent of the testes into the scrotum is unlikely after 6 months of corrected age

Testicular Exams

• Testes must be palpated for quality and position at each well-child visit.
  • In most cases, spontaneous descent occurs in the first six months of life
  • Testes may also “ascend” out of the scrotum → acquired cryptorchidism
  • The AAP recommends careful evaluation of the scrotum at every scheduled well-child check.

How to properly diagnose UDT

• Can the testes be palpated and manually manipulated into the scrotum?
  • If so, manipulate and position the testis in the scrotum and hold it in place for ~ 30 seconds to relax the cremaster muscle.
  • After 30 seconds, release the testis
    • Does it remain in place → retractile testis.
    • Does it immediately retract to a pre-scrotal position → undescended testis.

When to Ultrasound → Never

• Ultrasound of the testes for presence or location rarely assists in the decision-making process.
  • > 70% of cryptorchid testes are palpable by physical examination and need no imaging.
  • “30% of the remaining cases of nonpalpable testis: NO radiological test exists that can conclude with 100% accuracy the location of the testis or if it is absent.
Referral to Surgical Specialist

- At six months (corrected for gestational age):
  - Unlikely to descend spontaneously after 6 months of age.
  - Will receive a timely orchidopexy if necessary
  - Delayed referral may lead to the probable continued damage to testes that remain in a non-scrotal location.

Education on Long Term Risks

- Provide education on cancer and infertility risk
  - an increased incidence of developing testicular cancer
    - Warrants close follow-up, especially after puberty.
    - Every previously cryptorchid boy should be taught how to perform a monthly testicular self-examination after puberty to potentially facilitate early cancer detection.
  - heightened risk of subfertility.
    - Formerly bilateral cryptorchid men have greatly reduced fertility compared with men with a history of unilateral cryptorchidism and the general male population

Bilateral Nonpalpable Testes

- For all phenotypic male newborns with bilateral, nonpalpable testes
  - Immediately consult an appropriate specialist to evaluate for a possible disorder of sex development.
  - This newborn is potentially a genetic female (46 XX) with congenital adrenal hyperplasia until proven otherwise.
- Failure to diagnose congenital adrenal hyperplasia can result in serious harm
  - Many are unable to regulate their electrolyte levels and may present with shock, hyponatremia and hyperkalemia.

Identify appropriate timing for renal imaging when indicated in the newborn.

Single Umbilical Artery (SUA)

- A SUA is present in 0.2 - 0.6% of live births.
- More commonly found in SGA, preterm, and twin births
- Increased risk for chromosomal and other congenital anomalies
  - Some studies show up to 20-30% have major structural anomalies
  - Heart, GI tract and CNS are the most affected organs.
- Isolated finding in 70-80% infants.
  - There is an increased risk of occult renal anomalies
  - With current technology, most significant renal anomalies are picked up prenatally.

Recommendations:

- If SUA is identified,
  - Review prenatal ultrasound, pay close attention to kidneys, were they visualized and reported as normal.
  - Perform a thorough PE
    - Focus closely on CVS, GI tract, and CNS.
    - Consider renal ultrasound (RUS) if clinical findings are concerning
    - Additional imaging (other than RUS) may be indicated based on PE findings
  - If prenatal u/s and PE are normal, imaging is not indicated with an isolated SUA, but a RUS may be obtained at the provider’s discretion.
Fetal Hydronephrosis

• Frequent antenatal ultrasound finding
  • Often a transient physiologic condition
  • May be associated with significant congenital anomalies of the kidney and urinary tract (CAKUT).
• GOAL
  • Identify those with clinically significant CAKUT
  • Avoid unnecessary testing of the newborn
  • Avoid unnecessary anxiety for parents
  • Identify infants early with significant disease to minimize adverse effects of CAKUT.
• No single test can accurately differentiate infants with significant disease from those with insignificant findings.

Renal pelvic diameter (RPD)

• Most accepted measurement used to define fetal hydronephrosis
  • Size determined by maximum AP diameter of renal pelvis in a transverse plane, obtained in 2nd and/or 3rd trimester of pregnancy.
• Lack of consensus exists on the threshold RPD to define clinically significant fetal hydronephrosis. In general:
  • 2nd Trimester:
    • > 4 to 5 mm is considered the lowest cutoff for fetal hydronephrosis
    • Pyelectasia (mild RPD) is defined as an RPD ≥4 to 10 mm in the second trimester
    • RPD >10 mm is associated with an increased risk of significant CAKUT
  • Fetuses with RPD >15 mm during the third trimester are at the greatest risk for CAKUT

Renal Ultrasound within 24-48 hours of life.

• Bilateral involvement
  • Suggestive of an obstructive process at the level of or distal to the bladder
    • Ureterocolic
    • Posterior urethral valves (PUV) in a male infant
    • Increased likelihood to have significant disease requiring immediate intervention
• Severe hydronephrosis
  • RPD >15 mm
• Severe oligohydramnios
  • Consistent feature of severe renal disease, affecting either both kidneys or a solitary kidney.
• Will require prophylactic amoxicillin until results of renal u/s and a referral to pediatric urology or nephrology.

Unilateral Fetal Hydronephrosis (Normal Contralateral Kidney)

• In 2nd trimester:
  • RPD between 4 mm - 7 mm, without a repeat antenatal u/s in the 3rd trimester - obtain a postnatal ultrasound at 3-4 weeks of life.
• In 3rd trimester:
  • If there is resolution and/or unilateral RPD <10 mm, there is a low risk of significant renal pathology – no postnatal u/s is indicated
  • RPD >10 mm – obtain a postnatal u/s within 1-2 weeks of life.
  • RPD > 15 mm correlates with the greatest risk of CAKUT → u/s within 24-48 hours of life.

But which newborns or infants will need imaging?

• Bilateral involvement
• Severe hydronephrosis
• Severe oligohydramnios
• Increase in RPD in the 3rd trimester
• Severe congenital anomalies
• Significant decrease in amniotic fluid volume
• Need for postnatal imaging

Renal Ultrasound

• Preferred initial postnatal imaging study for fetal hydronephrosis
• Able to detect most CAKUT
• Should be avoided in the first 1-3 days after birth
  • Extracellular fluid shifts may underestimate the degree of hydronephrosis.
• For mild unilateral hydronephrosis should be performed after the infant returns to birth weight (1-2 weeks of life)
• If there is concern for significant renal disease – do not delay ultrasound.
Dx of Prenatal Hydronephrosis

Most studies indicate that mild pelviectasis with an RPD < 10 mm will self resolve and considered to no cause any significant uropathy.

But...

All infants with an antenatal diagnosis of hydronephrosis require close clinical follow up.

• Should monitor for UTI and progression of mild hydronephrosis.
• In the first year of life, a few studies show an increased risk pyelonephritis, especially in females and at-risk males.

Recognize sacral dimple and associated findings that may require imaging.

Occult Spinal Dysraphism (OSD)

• Range of congenital anomalies
  • Caused by defects in neural tube formation
• Tethered cord syndrome
  • Ischemia from traction of the spinal cord occurring with growth and flexion
• Frequently asymptomatic
• May present at any age

Associated Symptoms

• Monitor for other associated symptoms:
  • Orthopedic
    • Clubfoot, scoliosis, gait changes, leg/foot asymmetry, deviated gluteal cleft
  • Neurologic
    • Sensory changes, delayed walking, back/leg pain, decreased reflexes
  • Urologic
    • Unable to toilet train, frequent UTIs, New incontinence after toilet training

Cutaneous Stigmata

• 2.2–7.2% of all newborns
  • 0.5% of them require surgical intervention
• 2 or more cutaneous stigmata has a high predictive value for OSD

Occult Spinal Dysraphism

• Frequently associated with various cutaneous markers
  • Dermal sinus
  • Hypertrichosis
  • Hemangioma
  • Cutis aplasia
Tips to Consider

- Simple low-lying dimples, found within the gluteal fold → imaging will almost always show normal spinal contents.
- Atypical dimples should consider imaging:
  - > 5mm
  - > 2.5 mm above the anus
  - Or seen with other lesions

Ultrasound

- Noninvasive
- Can easily be performed on infants younger than 4 months of age
  - Before ossification of vertebrae
- Limitation
  - Operator dependent
  - High false-positive rates
- Abnormal findings include:
  - Low conus medullaris
  - A blunt conus medullaris
  - A thickened or fatty filum terminale
  - Lipoma
  - Fixed dorsal position of the cord in the thecal sac
  - Lack of pulsatile movement of the cord
  - Will need to perform an MRI on all inconclusive and/or abnormal ultrasound findings
  - Refer abnormal findings to Neurosurgery for evaluation

MRI

- Gold standard for the diagnosis of OSD
- Has limitations:
  - Availability of the test
  - Cost of the test
  - Need for sedation to perform the test
- Unless there is an emergent need, refer to neurosurgery prior to ordering an MRI

OSD

- Associated with a combination of 2 or more congenital lumbar sacral lesions
  - Lipoma
  - Dermal sinuses
  - Tails
  - These all have a high correlation of OSD
  - Ultrasound has a poor sensibility and high risk of false negative results
  - With these clinical findings, an MRI is indicated
Sacral Ultrasound: Recommended with these Findings

- Patients with <2 cutaneous stigmata's
  - Atypical dimple
    - Sacral dimple >0.5 cm.
  - Sacral dimple >2.5 cm from the anus.
  - Deviation of gluteal cleft
    - Bifurcation (fork) or asymmetry of the superior gluteal crease
  - Dimples associated with cutaneous markers:
    - True hypertrichosis, or hairs within the dimple
    - Skin tags
    - Apparent aplasia cutis

- Ultrasound is recommended as initial screening.

Simple sacral dimples

- Found alone with any of the following cutaneous findings
  - Pigmented nevi
  - Little hemangioma

- Monitor these patients closely, perform an MRI with the presentation of any neuro or ortho findings.

Simple Sacral Dimple

- The most common single finding.
- Low lying dimple, found midline within the gluteal fold
- <2.5 cm from the anus
- A visible base
- Not associated with any other anomalies on exam
- No imaging required.

Deep Simple Dimple

- This same dimple with the skin stretched lateral to the dimple to visualize the base
- Found within the gluteal cleft
- Coccygeal pits with visualized bases are benign
- Requires NO further imaging.

Skin Tags

- Indicator of a potential spinal dysraphism
- Small skin tags can be a residual tail
- It appears small and superficial
- Spinal ultrasound SHOULD be ordered.
- If the ultrasound is normal - no further testing is warranted.

Midline Vascular Lesions

- Evaluation of an isolated lower vascular lesion
- A small hemangioma or nevus simplex
- As a solitary finding this does not require further imaging.
- Monitor closely for any associated changes:
  - Orthopedic
  - Neurologic
  - Urologic
- In the presence of other clinical findings imaging would be indicated.
**Increased “Hairiness” over Sacrum**

- Newborns with increased amounts of hair over the lower back and sacrum
  - This “hairiness” is within normal limits, this is not considered hypertrichosis
  - This is not an indicator of an underlying spinal dysraphism
  - NO further imaging is required

**Congenital Heart Disease (CHD)**

- Prevalence of CHD ~0.6 - 1.3 % of live births
  - Critical CHD accounts for ~ 25% of all CHD
- Most common CHD bicuspid aortic valve
  - as an isolated lesion it is rarely diagnosed in infancy
- In infancy, most common defects seen are ventricular septal defects (VSDs) and secundum atrial septal defects (ASD)
- Tetralogy of Fallot (TOF) is the most common cyanotic lesion

**Risk Factors associated with CHD**

- Prematurity
  - Gestational age < 37 wks (2-3 times > risk)
- Family history
  - 1st degree relative (3 times > risk)
- Genetic syndromes
  - chromosomal defects were detected in 7 % of patients with CHD
- Maternal factors
  - Diabetes, Obesity, HTN, thyroid disease, lupus, epilepsy
  - Medications/substances use (phenytoin, retinoic acid, smoking, ETOH, Zoloft)
- In utero infection
  - Congenital TORCH infections, influenza or flu-like illnesses
  - Congenital cardiomyopathy may result from infection with CMV, coxsackie, herpes virus 6, parvovirus B19, HIV, toxoplasmosis, and possibly HIV

**Physical Exam Findings suggestive of CHD**

- abnormal precordial activity
  - thrill, radiation of murmur, displaced PMI
- abnormal heart sounds
  - third heart sound (S3) gallop, click, or single second heart sound (S2)
  - pathologic murmurs
  - loud, harsh, pansystolic, diastolic, or loudest at upper left or right sternal border or apex
  - hepatomegaly
  - diminished or absent lower extremity pulses
- abnormal four extremity blood pressure
  - blood pressure ≥ 10 mmHg higher in the arms than legs
- respiratory difficulties, cyanosis, poor growth, poor feeding (infants), diaphoresis, chest pain, syncopal episodes
- Age < 1 year of age

**Features associated innocent murmurs**

- Negative family history
- Normal prenatal ultrasound
- Non-syndromic
- Age > 2 years
- Asymptomatic
- Murmur:
  - Grade ≤ 2 intensity
  - Softer intensity when the patient is sitting compared with when the patient is supine.
  - Short systolic duration (not holosystolic, not diastolic).
  - Minimal radiation – located in a limited region of the precordium.
  - Musical or vibratory quality.
Screen and Testing:

**Pulse oximetry: Routine or Symptomatic Infant**
- Pre- and post-ductal pulse oximetry to assess for cyanosis and differential cyanosis.
- May be helpful in differentiating between cardiac and pulmonary disorders
  - cyanosis and/or symptoms
  - noncardiac causes of cyanosis, including pneumothorax, pulmonary hypoplasia, diaphragmatic hernia, pleural effusion, or airway disease.

**Electrocardiogram (ECG)**
- May be normal in many cyanotic heart lesions

**Chest XR**
- May be helpful in differentiating between cardiac and pulmonary disorders
- cyanosis and/or symptoms
- noncardiac causes of cyanosis, including pneumothorax, pulmonary hypoplasia, diaphragmatic hernia, pleural effusion, or airway disease.
- Cardiomegaly, dextrocardia, or an abnormal cardiac silhouette

**Echocardiography (ECHO)**
- Used for definitive diagnosis of CHD
  - Obtain for any of the following clinical findings:
    - Signs or symptoms concerning for critical CHD (shock unresponsive to volume resuscitation, cyanosis or differential cyanosis, unexplained respiratory symptoms, or pulmonary edema)
    - If CXR and/or EKG is obtained and suggestive of CHD
    - PE: abnormal heart sounds (e.g., S3 gallop, single S2, click), pathologic murmur, diminished or absent lower extremity pulses, abnormal four extremity blood pressures
    - Positive pulse oximetry screening
    - Genetic disorder or extracardiac malformation associated with cardiovascular malformations
    - ECHO can also be valuable in the diagnosis of some noncardiac causes of cyanosis (e.g., persistent pulmonary hypertension of the newborn)

Postnatal Presentation

- Infants with CHD may appear normal on routine examination and signs of critical CHD may not be apparent until after discharge.
- The timing of presentation varies with the underlying lesion and its dependence upon a patent ductus arteriosus (PDA).
- Prior to the routine use of pulse oximetry screening, ~30 percent of patients were discharged home undiagnosed.
- Pulse oximetry screening now will identify infants with some of these critical CHD lesions, but not all.
- Closure of the PDA in ductal dependent lesions within the first few days of life can lead to rapid clinical deterioration with potentially life-threatening consequences.
- When critical CHD is not diagnosed during the birth hospitalization, the risk of mortality is as high as 30 percent.

Undiagnosed CHD

- Critical CHD may be missed during the birth hospitalization
  - Critical CHD manifestations of CHD during the first discharge visit at three to five days of age.
  - Symptoms are nonspecific and include difficulty in feeding, poor weight gain, cyanosis, respiratory findings, decreased activity, irritability, and excessive sweating.
  - Complete physical exam should include:
    - Measurements (including weight), HR, upper and lower extremity blood pressure; a detailed cardiac examination (including auscultation for murmurs and/or abnormal heart sounds); palpation of the liver; and assessment of peripheral pulses.

Normal Hip Development

The femoral head must be stable in the hip socket for both to form spherically and concentrically.

If the head is loose in the acetabulum, or if either component is deficient, the entire hip joint is at risk for developing incongruence and lack of sphericity.
Developmental Dysplasia of the Hip (DDH)

- Abnormal development of the hip
  - Dysplasia
    - shallow or underdeveloped acetabulum
  - Subluxation
    - displacement of the joint with some contact remaining between the articular surfaces
  - Dislocation
    - complete displacement of the joint with no contact between the original articular surfaces

Spectrum of DDH

- Normal
- Dysplastic
- Subluxated
- Dislocated


Developmental Dysplasia of the Hip (DDH)

- Incidence
  - most common orthopedic disorder in newborns
  - dysplasia is 1:100
  - dislocation is 1:1000
- Location
  - most common in left hip (60%)
    - due to the most common intrauterine position being left occiput anterior (left hip is adducted against the mother's lumbosacral spine)
  - bilateral in 20%

Risk Factors

- Firstborn
  - due to unstretched uterus and tight abdominal structures compressing the uterus
- Female
  - due to increased ligamentous laxity that transiently exists as the result of circulating maternal hormones and the estrogens produced by the fetal uterus
- Breech
  - more commonly seen in female children, firstborn children, and pregnancies complicated by oligohydramnios
  - higher risk of DDH with frank/single breech position compared to footling breech position
- Family history
- Oligohydramnios
- Native Americans and Laplanders
  - due to cultural traditions such as swaddling with hips together in extension

Physical Exam (Under 3 months)

- Barlow
  - abduction and depression of the flexed femur will dislocate a dislocatable hip.
  - "click of exit"
- Ortolani
  - reduces a dislocated hip by elevation and abduction of the flexed femur
  - "click of entry"
- Galeazzi (Allis) Sign
  - hip flexed at 90 degrees and feet flat on the table
  - + sign when discrepancy seen in knee height
  - In a unilateral dislocated hip, appearance of limb length discrepancy femur appears shortened on dislocated side
  - hip clicks are nonspecific findings
  - https://www.youtube.com/watch?v=Qy3uSkDhMZs

Diagnosis by Exam

Barlow and Ortolani

Allis/Galeazzi
Ortolani maneuver
• is the most important clinical test for detecting newborn dysplasia

Barlow maneuver
• is a test of laxity or instability and has less clinical significance than the Ortolani maneuver

Barlow and Ortolani are rarely positive after 3 months of age
• soft-tissue contractures form around the hip
• Limitations in hip abduction
  • most sensitive test once contractures have begun to occur
  • occurs as laxity resolves and stiffness begins to occur
  • decreased symmetrically in bilateral dislocations

Leg length discrepancy predominates
• Klisic test
  • used to detect bilateral dislocations

Physical exam (3 months to 1 year)

• pelvic obliquity
• lumbar lordosis
  • response to hip contractures resulting from bilateral dislocations in a child of walking age
• Trendelenburg gait
  • results from abductor insufficiency
• toe-walking
  • attempt to compensate for the relative shortening of the affected side

Physical exam (1 year - walking child)

• pelvic obliquity
• lumbar lordosis
  • response to hip contractures resulting from bilateral dislocations in a child of walking age
• Trendelenburg gait
  • results from abductor insufficiency
• toe-walking
  • attempt to compensate for the relative shortening of the affected side

Indications for Ultrasound Imaging
• Two of the strongest risk factors for DDH
  • Female neonate in a frank breech presentation at birth
  • Family history of parent and/or a sibling with DDH
• Accepted indications for ultrasound of the infant hip include:
  • Abnormal or equivocal findings of hip instability on physical examination of the hip
  • Any family history of DDH
  • Breech presentation at birth
  • Neuromuscular conditions
• Other indications for ultrasound of the infant hip may include:
  • Oligohydramnios
  • Other intrauterine causes of postural molding.
• Ultrasound is imaging of choice before 4 months of age

Indications for Radiograph Imaging
• Xray may be useful in the evaluation of DDH after 4-6 months of age
• Limited value <4 months due to the femoral head and acetabulum being cartilaginous and unossified.
• If Xray indicated in newborn, a single anterior-posterior (AP) view with the hips held in 20 to 30° flexion
  • A frog lateral view is unnecessary and increases radiation exposure
  • The flexion is necessary to accommodate the physiologic flexion contracture of the newborn hip.
Use of Alternative Imaging

No indication for use in the diagnosis of DDH

- Arthrography
- Computed tomography (CT)
- Magnetic resonance imaging (MRI)

Safe Swaddling

- Traditional swaddling
  - In the womb the baby's legs are in a fetal position with the legs bent up and across each other. Sudden straightening of the legs to a standing position can loosen the joints and damage the soft cartilage of the socket.
  - Hips in an extended and adducted position, are at increases the risk of DDH.
  - Improper swaddling may lead to DDH.

- The concept of "safe swaddling," which allows for hip flexion and abduction and knee flexion, has been shown to lessen the risk of DDH

Safe Swaddling

- Traditional swaddling
  - In the womb the baby's legs are in a fetal position with the legs bent up and across each other. Sudden straightening of the legs to a standing position can loosen the joints and damage the soft cartilage of the socket.
  - Hips in an extended and adducted position, are at increases the risk of DDH.
  - Improper swaddling may lead to DDH.

- The concept of "safe swaddling," which allows for hip flexion and abduction and knee flexion, has been shown to lessen the risk of DDH

Clavicle Fracture

- Most reported fracture in neonates
- Incidence during birth is 0.5 to 1.6 percent
- Often associated with difficult vaginal delivery
- Can also occur in infants who are products of a normal spontaneous vaginal or cesarean delivery:
  - shoulder dystocia
  - increased maternal age
  - increased birth weight (particularly if >4 kg)
  - lower mean head-to-abdominal circumference ratio
- Displaced (complete) fractured clavicles are more likely to be accompanied by physical findings in the immediate post-delivery time period
  - crepitus, edema, lack of movement of the affected extremity, asymmetrical bone contour, and crying with passive motion.
- Nondisplaced clavicular fracture diagnosis often delayed by days or weeks until discovery of a visible or palpable callous over the clavicle.

Diagnosis:

Made through X-ray

- The condition should be differentiated from a humerus fracture or brachial plexus injury.
- Obtain a full radiograph of the chest and upper extremities because other diagnoses, which present with similar findings, may be detected with a fuller view
- The presence of a clavicle fracture warrants further investigation for accompanying brachial plexus injury.

Treatment

- Treatment (conservative)
  - Most non-displaced fractures heal spontaneously within 2–3 weeks without sequelae
  - Provide parental reassurance.
  - Careful handling to decrease pain
  - Pinning sleeve at 90-degree angle may help with comfort but is not necessary for healing.
  - Callus formation and resolution of tenderness are usually predictive of appropriate healing.
Humer Fracture

• Less common than clavicles.
• Associated with prolong labor, extension of extremity with breech presentation, rapid extraction and forceps delivery.
• In these cases, dx is made by Xray

Treatment

• Ortho referral
• Immobilization of the limb for 3 weeks
• Reassure that prognosis is excellent
• Reassure parents there usually is no residual shortening or angulation

References