

## Pediatric Radiology

The Pediatric Radiology Elective is offered to pediatric residents as an elective in their 2<sup>nd</sup> or 3<sup>rd</sup> year of residency (or 4<sup>th</sup> year for Medicine-Pediatrics Residents). The rotation is meant to be an introduction to pediatric radiology and the imaging exams and disease processes unique to the pediatric population, including neonates, infants, children and adolescents. Residents are expected to work with the pediatric radiologist when he/she is doing procedures or reading films on infants, children and adolescents. In addition, they must go through the teaching files in the pediatric radiology section and attend afternoon didactic sessions with the pediatric radiologists.

The goals of the elective include:

### **I Patient Care:**

GOAL: Residents should be able to become proficient at reading the most common radiographs done on infants, children and adolescents. They should also be able to decide what radiographs are needed in emergency situations, as well as be able to read those studies, when necessary.

- 1) Participate in interpretation of plain films, ultrasound, CT and MRI of the pediatric patients including the neonatal intensive care unit, pediatric inpatient, and outpatient exams.
- 2) Participate in daily viewbox teaching
- 3) Participate in the performance of fluoroscopic and ultrasound examinations

### **II Medical Knowledge:**

GOAL: Residents will improve their knowledge of pediatric radiology by being involved in didactic teaching sessions and by going through the teaching files in the Pediatric Radiology section.

- 1) Demonstrate basic comprehension of pediatric plain films including chest, abdomen, and bone radiographs
- 2) Attend all pediatric radiology conferences and (when available) multidisciplinary conferences including pediatric urology, genetics, inpatient rounds, pediatric problem conference, and NICU rounds
- 3) Demonstrate the ability to read radiographic evaluations of child abuse.
- 4) Be able to order the best radiologic procedures for various symptoms and signs in pediatric patients.
- 5) Demonstrate the ability to interpret full spine xrays for scoliosis.
- 6) Demonstrate the ability to read hip films for congenital hip dislocation.
- 7) Demonstrate the ability to order and interpret radiologic examinations for the top 25 emergencies in pediatrics, including intussusceptions, torsion testis, retropharyngeal abscess, small bowel obstruction, and appendicitis.
- 8) Demonstrate comprehension of basic pediatric ultrasound including cranial ultrasound, abdominal ultrasound, and basic musculoskeletal ultrasound

- 9) Demonstrate basic comprehension of pediatric CT and MRI exams to include neuro and body imaging
- 10) Understand common congenital abnormalities
- 11) Read the textbook: The Fundamentals of Pediatric Radiology by Donnelly.
- 12) Complete the “pediatric resident” modules from the Cleveland Clinic Pediatric Radiology website
- 13) Complete the “Top 20 ER cases”
- 14) Participate in the MU pediatric radiology case of the month
- 15) Pass a final examination containing 50 cases and 200 cases.

### **III Practice-Based Learning and Improvement:**

GOAL: Residents are expected to investigate and evaluate radiologic practices and to appraise and assimilate clinical information to make appropriate patient management decisions. They should learn to improve their care of any given condition as they learn more about the condition they are treating through the month.

1. Prepare a “case of the day” to be presented to the pediatric radiology team each day
2. Be able to demonstrate the ability to quickly access the pediatric radiologic literature to determine best radiologic practices for different pediatric conditions.
3. Consistently evaluate individual performance, identify gaps in knowledge, and target learning to fill these gaps.
4. Demonstrate learning from error.
5. Work well with other learners to enhance the common knowledge.
6. Be able to identify evidence based radiologic tests and treatments for different pediatric conditions.

### **IV Interpersonal and Communication Skills**

GOALS: Residents are expected to consistently demonstrate interpersonal and communication skills that result in effective information exchange and collaboration with colleagues, patients, and their parents. They must be able to approach the patient and families in a patient-centered manner.

#### **OBJECTIVES:**

1. Demonstrate empathy and understanding for the concerns patients and families who have renal symptoms, such as enuresis, and conditions requiring intrusive diagnostic tests and treatments.
2. Demonstrate an understanding of the necessity of communicating effectively with referring physicians and, if they differ, primary care physicians.
3. Maintain accurate and timely medical records.
4. Demonstrate excellent communication skills with other members of the care team.

## **V Professionalism**

GOALS: Residents are expected to understand and demonstrate a commitment to carrying out professional responsibilities, adherence to ethical principles, and sensitivity to a diverse patient population.

1. Consistently act in the best interest of the patient and family.
2. Consistently demonstrate a caring and respectful demeanor when interacting with patients and families.
3. Maintain patient/family confidentiality.
4. Demonstrate prudence in the use of expensive radiologic studies .
5. Be sensitive to the child's and family's impression of the child's condition.
6. Be sensitive to the different expectations of patients and families based on ethnic, religious and cultural diversity.
7. Respect the integrity of the child and family and their relative roles in decision making.
8. Demonstrate respect for patient modesty.

## **VI Systems Based Practice**

GOALS: Residents are expected to practice quality health care that is cost-effective and to advocate for patients within the health care system by helping them successfully navigate through it for the best outcomes possible. They should be able to work effectively in a multi-disciplinary team of providers to aid in the best outcomes possible.

1. Consistently advocate for patients and families and help them navigate the healthcare system by assisting them in making appointments, scheduling procedures in a timely manner, and calling other providers to communicate about the patient, when necessary.
2. Appropriately refer and follow up patients, when necessary.
3. Demonstrate appropriate communication and collaboration with the entire team needed for adequate treatment of seriously ill patients—subspecialty consultants, dieticians, nurses, teachers, and social workers.

### **Additional Reading Material**

*Caffey's Diagnostic Pediatric Imaging*, Kuhn and Slovis  
*Imaging the Acutely Ill and Injured Child*, Swischuck

*Pediatric Imaging, The Core Curriculum, Siegel and Coley*  
*Pediatric Sonography, Rumack*  
*Fundamentals of Pediatric Radiology, CD*

## **KNOWLEDGE-BASED OBJECTIVES**

### **Pediatric Radiology**

#### Cardiovascular System

##### Imaging modalities:

- chest radiographs – limitations
- angiocardiology – indications, projections
- echocardiography – standard views
- CT (including ultrafast and helical)
- MR – indications, anatomy
- nuclear cardiology

##### Congenital heart disease:

- congenital heart disease with decreased pulmonary blood flow (right-to-left shunt)

- tetralogy of Fallot
  - Ebstein anomaly
  - tricuspid atresia

- cyanotic congenital heart disease with increased pulmonary blood flow (left-to-right shunt)

- truncus arteriosus
  - transposition of the great arteries
  - single ventricle
  - total anomalous pulmonary venous return
  - endocardial cushion defect

- acyanotic congenital heart disease with increased pulmonary blood flow (left-to-right shunt)

- ASD
  - VSD
  - PDA

#### Gastrointestinal System

##### Imaging modalities:

- plain radiographs
- UGI/SBFT
- enteroclysis
- BE/air enema
- US
- CT
- MR
- ERCP
- nuclear medicine

##### Normal variants

Biliary system:

- congenital
  - biliary atresia
  - neonatal hepatitis
  - choledocal cyst
- acquired miscellaneous
  - cholelithiasis
  - hydrops of the gallbladder

Liver:

- infection
  - pyogenic abscess (including chronic granulomatous disease of childhood)
  - ascending cholangitis
- tumors and tumor-like conditions
  - benign
    - mesenchymal hamartoma
    - hemangioendothelioma
  - malignant
    - hepatoblastoma
    - metastases
- trauma
  - lacerations
  - subcapsular hematoma
  - contusion
- portal hypertension
  - cavernous transformation of the portal vein
- miscellaneous
  - portal venous gas
  - glycogen storage disease
  - transplant

Spleen:

- congenital
  - abnormal viscerotrial situs
  - wandering spleen
- neoplasms
  - benign
    - lymphangioma
  - malignant
    - lymphoma/leukemia
- trauma
  - laceration
  - contusion
  - shattered spleen
  - subcapsular hematoma
- splenic infarction
  - sickle cell disease

Pancreas:

- congenital
  - pancreas divisum
  - cystic fibrosis
- pancreatitis (and pseudocyst)
  - trauma
  - congenital anatomic abnormalities
    - pancreas divisum
    - choledocal cyst
- familial pancreatitis

Pharynx and esophagus:

- congenital and developmental anomalies
  - esophageal atresia and TE fistula
- inflammatory lesions
  - retropharyngeal abscess/cellulitis
- trauma
  - foreign body
  - iatrogenic pharyngeal perforation (due to NG or ET tube)
- miscellaneous
  - GE reflux

Stomach:

- congenital
  - duplications
  - antral webs
- gastric outlet obstruction – acquired
  - HPS
- inflammatory
  - corrosive ingestion
  - chronic granulomatous disease
- miscellaneous
  - bezoars
  - spontaneous rupture of the stomach (neonates)
  - volvulus

Small bowel:

- congenital
  - malrotation (including preduodenal portal vein)
  - duodenal, jejunal, and ileal stenosis and/or atresia
  - annular pancreas
  - meconium ileus
  - meconium peritonitis
  - mesenteric and omental cysts
  - duplication cysts
  - Meckel diverticular (including jomphalo-mesenteric band)
  - omphalocele, gastroschisis

- hernias
- neoplasms
  - benign
  - malignant
    - lymphoma
- malabsorption
  - CF
  - cow's milk allergy
  - intestinal lymphangiectasis
- miscellaneous
  - necrotizing enterocolitis
  - ischemic bowel
  - intussusception
  - Ileoch-Schonlein purpura

Colon:

- congenital
  - imperforate anus
  - duplications
  - colonic atresia
- functional disorders
  - Hirschprung disease
  - meconium plug/neonatal small left colon syndrome
- infection/inflammatory
  - appendicitis
- neoplasms
  - benign
  - malignant
    - lymphoma

Miscellaneous:

- lines and catheters
  - umbilical arterial catheter
  - umbilical venous catheter
- pneumoperitoneum (signs on plain radiographs)

Genitourinary System

Imaging modalities:

- plain radiographs
- IVU
- VCUG
- retrograde urethrogram
- nephrostogram
- retrograde ureterogram
- US
- Ct
- MR

nuclear medicine  
interventional techniques  
genitography

## Normal variants

### Kidneys:

- congenital anomalies
  - UPJ
  - duplication
  - multicystic dysplasia
  - agenesis
  - hypoplastic kidney
  - ectopia
    - ptosis
    - pelvic
    - crossed ectopia
  - relationship of congenital renal anomalies with other congenital anomalies (i.e., VATER association, spinal dysraphism, etc.)
  - cystic renal disease
    - autosomal recessive
    - autosomal dominant
    - cysts associated with malformation syndromes
- inflammatory
  - acute pyelonephritis
  - reflux nephropathy
- neoplasms
  - Wilms and Wilms variant
  - nephrogenic rests
  - mesoblastic nephroma
  - multilocular cystic nephroma
  - leukemia/lymphoma
- trauma
  - subcapsular hematoma
  - laceration (including those communicating with the collecting system)
  - contusion
  - avulsion of the renal pedicle
  - UPJ avulsion or laceration
- miscellaneous
  - renal vein thrombosis
  - urolithiasis/nephrocalcinosis
  - renal transplantation
  - renovascular hypertension

### Adrenal gland:

- neoplasms
  - neuroblastoma
- trauma

hemorrhage and adrenal calcification

Bladders, ureters, and urethra:

congenital

- posterior urethral valves
- ureterovesical junction obstruction
- primary megaureter
- bladder diverticuli
- ureteral duplication
- ureterocele
- urachal abnormalities
- hypospadias
- epispadias/exstrophy
- prune belly syndrome
- urologic sequelae of ano-rectal anomalies

inflammatory/infectious

- urinary tract infection
- viral cystitis

neoplasms

- rhabdomyosarcoma

miscellaneous

- vesicoureteral reflux
- neurogenic bladder
- dysfunctional voiding

Male genital tracts:

testicular torsion

inflammatory/infectious

- epididymitis/orchitis

neoplasms

- germ cell tumors
- germ cell plus stroma cell tumors
- gonadal stromal tumors

Female genital tracts:

congenital

- congenital vaginal occlusion (hydrometrocolpos, etc.)
- fusion anomalies of the mullerian ducts (uterus didelphys, etc.)
- cloacal anomalies

neoplasms

ovaries

- ovarian cysts (including torsion)
- germ cell tumors

uterus and vagina

- rhabdomyosarcoma
- clear cell adenocarcinoma

miscellaneous

- differential diagnosis of intralabial masses
  - prolapsing ectopic ureterocele
  - obstructed paraurethral gland
  - imperforate hymen with hydrometrocolpos
  - urethral prolapse
  - sarcoma botryoides
- intersex states
  - differential diagnosis
  - work-up

## Neuroradiology

Imaging modalities:

- plain radiographs
- CT
- MR
- sonography
- myelography
- angiography

Normal variants

Skull:

- congenital
  - craniofacial syndromes
  - congenital dermal sinus
  - premature craniosynostosis
- inflammatory
  - osteomyelitis
- trauma
  - caput succedaneum
  - subgaleal hemorrhage
  - cephalohematoma
  - fractures

Spine:

- congenital
  - absence or hypoplasia of the odontoid
  - os odontoideum
  - segmentation anomalies
  - Kippel-Feil anomaly
  - Sprengel deformity
  - VATER association
  - butterfly vertebrae
  - spinal dysraphism
  - diastematomyelia
  - sacral agenesis (including caudal regression syndrome)

- partial absence (including Currarino triad)
- inflammatory
  - discitis
  - tuberculosis spondylitis
- neoplasms
  - Ewing sarcoma
  - aneurysmal bone cyst
  - osteoblastoma
  - osteoid osteoma
  - Langerhans cell histiocytosis of bone
  - metastases (including leukemia and lymphoma)
- trauma
  - fractures/dislocations
  - atlanto-dens and atlanto-occipital injuries
  - spondylolysis/spondylolisthesis
- miscellaneous
  - Scheurmann disease
  - scoliosis
  - intervertebral disc calcification

Brain:

- congenital
  - migrational disorders
    - lissencephaly
    - pachygyria
    - schizencephaly
    - heterotopic gray matter
    - polymicrogyria
  - holoprosencephaly
  - anomalies of the corpus callosum
  - hydra-encephaly
  - Dandy-Walker malformations
  - Chiari malformations
  - cephaloceles
  - neurocutaneous syndromes
  - vein of Galen malformation
  - aqueductal stenosis
- inflammatory
  - bacterial infections (including meningitis, cerebritis, and abscess)
  - tuberculosis infections
  - viral infections (encephalitis)
    - TORCH infections
    - AIDS
- neoplasms
  - posterior fossa
    - medulloblastoma
    - ependymoma
    - brainstem glioma

- supratentorial
  - pineal region tumors
  - cranipharyngioma
  - astrocytoma
  - oligodendroglioma
  - PNET
  - choroid plexus tumors
- cerebral infarction/ischemia
  - arteritis
  - sickle cell
  - carotid occlusion
  - venous sinus thrombosis
  - hypoxic/ischemic injury in the newborn
    - intracranial hemorrhage
    - periventricular leukomalacia
- trauma (including shaken baby syndrome)
  - cerebral injury (including shearing injuries and concussion)
  - subdural hematoma
  - epidural hematoma
  - subarachnoid hemorrhage
- metabolic brain disorders
  - leukodystrophies

#### Spinal Cord:

- congenital
  - myelomeningocele/meningocele
  - lipomyelomeningocele
  - diastematomyelia
  - tethered cord
  - dermal sinus
  - intradural lipoma
  - hydrosyringomyelia
- tumors
  - neurofibroma
  - astrocytoma
  - ependymoma
  - metastases
  - neuroblastoma, ganglioneuroblastoma, ganglioglioma
  - sacroccygeal teratoma

#### Chest and Airway

##### Imaging modalities:

- plain radiographs
- CT (including high resolution)
- bronchography
- sonography
- fluoroscopy

esophagography  
MR

Normal variants

Upper airway:

congenital

- cystic hygroma
- branchial cleft cyst
- thyroglossal duct cyst
- tracheomalacia/bronchomalacia
- laryngeal stenosis, atresia, web
- laryngomalacia
- choanal atresia

inflammatory

- tonsillar enlargement/adenoidal hypertrophy
- croup
- epiglottitis

neoplasm

- juvenile angiofibroma
- subglottis hemangioma
- laryngeal papilloma

trauma

- foreign body
- acquired subglottic stenosis

Chest:

congenital

- agenesis/hypoplasia
  - venolobar syndrome
- bronchial atresia
- bronchopulmonary foregut malformation
  - sequestration
  - bronchogenic cyst
  - cystic adenomatoid malformation
  - congenital lobar emphysema
- tracheal bronchus
- lymphangiectasia

inflammatory

infections

- bacterial pneumonia (including streptococcus, staphylococcus, pertussis, chlamydia, mycoplasma, H. influenza) including pneumonia, abscess, and post-infectious pneumatocele
- viral pneumonia (including RSV, varicella, measles)
- tuberculosis
- pneumocystis infection
- fungal infections

AIDS

- reactive airways disease
- bronchiectasis
- cystic fibrosis (including immotile cilia syndrome)

neoplasms

- mediastinal neoplasms
  - lymphoma/leukemia
  - teratoma
  - thymoma
  - neurogenic tumors
- primary lung tumors
  - adenoma
  - hamartoma
  - hemangioma
  - mesenchymal sarcoma
    - (and their association with developmental cystic lesions of the lung)
  - metastatic lung neoplasms
  - chest wall neoplasms (including Askin tumor)

trauma

- contusion
- airleak
  - pneumothorax
  - pneumomediastinum
  - pulmonary interstitial emphysema
  - bronchopleural fistula
  - fracture of the tracheobronchial tree
  - airway foreign body
  - post-traumatic bronchial stenosis
  - post-traumatic diaphragmatic hernia
  - complications of tubes and lines

unique problems in the neonate

- hyaline membrane disease
- transient tachypnea of the newborn
- neonatal pneumonia
- congenital diaphragmatic hernia
- bronchopulmonary dysplasia
- meconium aspiration syndrome
- persistent fetal circulation
- ECMO therapy and its complications
- chylothorax
- airleak in the neonate

miscellaneous

- idiopathic pulmonary hemosiderosis
- collagen vascular diseases
- spontaneous pneumothorax
- cardiogenic and noncardiogenic pulmonary edema (including ARDS)
- histiocytosis

## Musculoskeletal System

### Imaging modalities:

- plain radiographs
- CT
- MR
- ultrasonography
- nuclear medicine
- arthrography
- angiography

### Normal variants

### Congenital

- bone dysplasias
  - osteochondrodysplasias affecting growth of tubular bones and spine (identifiable at birth)
    - thanatophoric dysplasia
    - chondrodysplasia punctata
    - achondroplasia
    - asphyxiating thoracic dystrophy
  - osteochondrodysplasias affecting growth of tubular bones and spines (identifiable in later life)
    - metaphyseal chondrodysplasias
    - multiple epiphyseal dysplasia
  - osteochondrodysplasias with disorganized development of cartilage and fibrous components of the skeleton
    - multiple cartilagenous exostoses
    - enchondromatosis
    - polyostotis fibrous dysplasia
    - neurofibromatosis
  - abnormalities of density of cortical diaphyseal structure & metaphyseal modeling
    - osteogenesis imperfecta
    - osteopetrosis
    - pyncodysostosis
    - diaphyseal dysplasia
    - metaphyseal dysplasia
- limb reduction anomalies
  - (including proximal focal femoral deficiency & radial ray anomalies)
- amniotic band syndrome
- congenital bowing deformities and pseudoarthroses
- congenital foot deformities
  - pes planus
  - talipes equinovarus
  - pes cavus
  - metatarsus adductus
- skeletal abnormalities associated with Down syndrome

skeletal abnormalities associated with mucopolysaccharidoses and mucopolipidoses  
developmental dysplasia of the hip  
skeletal abnormalities associated with neuromuscular diseases  
meningomyelocele  
cerebral palsy  
musculodystrophy

Infection/inflammatory:

pyogenic osteomyelitis  
septic arthritis  
toxic synovitis of the hip  
tuberculosis  
syphilis  
juvenile rheumatoid arthritis  
hemophilic arthropathy

Neoplasm:

benign  
osteochondroma  
unicameral bone cyst  
aneurysmal bone cyst  
nonossifying fibroma/fibrous cortical defect  
fibrous dysplasia  
Langerhans cell histiocytosis of bone  
osteoid osteoma  
osteoblastoma  
chondroblastoma  
chondromyxoid fibroma  
malignant  
Ewing sarcoma  
osteogenic sarcoma  
metastases (including leukemia/lymphoma)

Trauma:

fractures  
accidental trauma (including Salter-Harris, greenstick, bowing, and buckle fractures)  
non-accidental trauma (battered child syndrome)  
slipped capital femoral epiphysis  
thermal injury

Metabolic/endocrine:

rickets  
renal osteodystrophy  
hyperparathyroidism  
hypoparathyroidism  
hypophosphatasia  
scurvy

bone age determination

Osteochondroses

Legg-Perthes disease

Kohler disease

Freiberg disease

osteochondritis dissecans

Blount disease and physiologic bowing