I. **PEDIATRIC ULTRASOUND**

All ultrasound examinations may be ordered with or without Doppler studies. All ultrasound examinations may be performed portably or intraoperatively. Ultrasound guided aspiration, biopsy, or drainage may be obtained for most body parts. All ultrasound examinations may be tailored for any specific body part.

All examinations may need to be modified for individual patient, but this section is to be used as the general guide to performing pediatric US studies.

II. **OVERVIEW OF AVAILABLE EXAMINATIONS**

A. **PEDIATRIC NEUROLOGIC SYSTEM:**
   EXAMS: [with or without Doppler, aspiration, biopsy, or drainage]
   1. Cranial [head] [generally, available only for the first year of life images are obtained through the anterior and posterior fontanelle or later if a cranial burr hole or other windows are available]
   2. Spine [generally, available for the first month of life only]

B. **PEDIATRIC CARDIO-PULMONARY SYSTEM:**
   EXAMS: [with or without Doppler, aspiration, biopsy, or drainage]
   1. Chest – pleura
   2. Thymus
   3. Chest wall
   4. Diaphragm

C. **PEDIATRIC GASTRO-INTESTINAL SYSTEM:**
   EXAMS: [with or without Doppler, aspiration, biopsy, or drainage]
   1. Abdominal – liver, spleen, gallbladder, bile ducts, pancreas, kidneys, bladder, includes a survey for free fluid, adenopathy, IVC, aorta, SMV/SMA relationship and bowel wall thickening.
   2. RLQ – graded compression examinations of the appendix area (a limited study of this area should be performed only if there has been a recent complete abdominal study)
   3. Liver Doppler – duplex examination of the liver (also includes a full abdominal study)
   5. Fluid search- limited exam to look for free fluid

D. **PEDIATRIC GENITO-URINARY SYSTEM:**
EXAMS: [with or without Doppler, aspiration, biopsy, or drainage]
1. Renal – kidneys and bladder
2. Pelvic – uterus and adnexa
3. Scrotal – scrotum and contents

E. PEDIATRIC MUSCULOSKELETAL:
EXAMS: [with or without Doppler, aspiration, biopsy, or drainage]
1. Joint – most joints, especially in the young children, can be imaged
2. Hip – dysplasia: bilateral femoral head and acetabulum, with stress views, effusion
3. Muscle – any muscle or subcutaneous area, including tendons and ligaments
4. Foreign Body – localize & document the presence of a foreign body
Normal showing region for measurements

Effusion with capsular positive if greater than comparing one side with

Normal dual scan with a small, symmetric amount of fluid bilater
Radiograph showing transducer position (solid line) for evaluation of right hip effusion. Transverse imaging plane is shown with dashed line. Static and video clip images of both hips should be obtained in various planes as well as a dual image showing both hips together in the imaging planes. Imaging should be performed with a high frequency linear transducer. Measurements obtained as shown on page 2.

F. **PEDIATRIC NECK:**

EXAMS: [with or without Doppler, aspiration, biopsy, or drainage]

1. Neck – parotid, submandibular and thyroid glands; survey for adenopathy; internal jugular vein and carotid artery as well as specified areas, e.g. neck cyst
2. Thyroid – thyroid gland
G. PEDIATRIC VASCULAR:
EXAMS: [with or without Doppler, aspiration, biopsy, or drainage]
1. Venous – venous duplex & color exam of the central veins
2. Arterial – any large – medium vessel, exclusive of the thoracic aorta

III. SYSTEM SPECIFIC PROTOCOLS

A. CRANIAL
1. Indication – evaluation of intracranial structures for anatomy, bleed, mass, hydrocephalus, etc.
2. Contraindication – closed fontanelle or lack of acoustic window
3. Preparation – none
4. Transducer – 8.5 MHz vector transducer; linear transducer to evaluate fluid in sub arachnoid space, lower frequency as needed for penetration.
5. Technical – scan through ant fontanelle with light contact; posterior fontanelle and through squamosal suture as indicated.
6. Views-Anterior Fontanelle:
   a. Coronal
      (1) From above orbit
      (2) @ frontal horns and cavum septum pellucidum
      (3) @ foramen or Monroe/ @ 3rd ventricle
      (4) @ ant cerebellum & 4th vent
      (5) @ temporal lobe
      (6) above the lateral ventricles
   b. Sagittal
      (1) Midline
      (2) At caudo-thalamic notches bilaterally
      (3) Maximal view of lateral ventricles
      (4) At level of sylvian fissure
   c. Posterior fossa
      (1) sagittal of posterior periventricular WM angled along occipital horn@ lat vent, posterior fossa with color Doppler of the choroid plexus to evaluate for intraventricular hemorrhage
      (2) axial evaluate 4th ventricle and cerebellar vermis
   d. Record cine clip in Coronal and Sagittal planes and axial on posterior fossa
7. Hydrocephalus:
   a. Measure:
      (1) Frontal horns/BPD at foramen of Monroe
      (2) Obtain Doppler waveforms of the anterior cerebral or pericallosal artery with and without compression
8. Extra axial fluid: Use linear transducer with Doppler to evaluate vessels relative to the extra axial fluid

B. SPINE
1. Indication – for evaluation of spine anomalies, dorsal skin lesion
2. Contraindications – lack of acoustic window [especially after 6 months of age]
3. Preparation – None
4. Transducer – Linear transducer cadence frequency of 15MHz or as needed for good visualization. Use a high frequency sector transducer for the craniocervical junction. Use a machine that has perspective for extended field of view imaging
5. Technical – scan through the back in prone (with rolled towel under abdomen) or decubitus position: observe for cord pulsation, document vertebral level position of conus; document prone or decub positioning
6. Views – sagittal from craniocervical junction to coccyx axial conus, filum, thoracic and lumbar cord any areas of interest [sinus tract, skin dimple, tumor] obtain cine clip to document cord pulsatility
7. Measurements – documents position of conus relative to T12 and L5
8. Post procedure – may need to place nipple marker on dorsal skin at conus, and obtain AP spine X-ray.

IV. PEDIATRIC CARDIO-PULMONARY SYSTEM:

A. CHEST – PLEURA
1. Indication – evaluation of pleural or pleural based fluid collection or mass
2. Contraindication – None
3. Preparation – None
4. Transducer – Linear transducer cadence frequency of 15MHz or as needed for good visualization. Use a high frequency sector transducer for the craniocervical junction. Use a machine that has perspective for extended field of view imaging
5. Technical – scan through the back in prone (with rolled towel under abdomen) or decubitus position: observe for cord pulsation, document vertebral level position of conus; document prone or decub positioning
6. Views – sagittal from craniocervical junction to coccyx axial conus, filum, thoracic and lumbar cord any areas of interest [sinus tract, skin dimple, tumor] obtain cine clip to document cord pulsatility
7. Measurements – size of collection, including depth from skin

B. CHEST – DIAPHRAGM
1. Indication – evaluation of diaphragmatic motion
2. Contraindication – unable to breath spontaneously
3. Preparation – None
4. Transducer – 8-4 MHz sector
5. Technical supine scan both leaflets of diaphragm together if possible in transverse as well as individual; cine for max ins/expiratory images. Obtain clips in coronal plane from both right and left as well as a transverse clip from the midline
6. Views – coronal, sagittal and axial in ins/expiration

C. THYMUS
1. Indication evaluation of thymic mass
2. Contraindication-none
3. Preparation-none
4. Transducer High frequency sector and linear transducers
5. Technical scan from a parasternal position
6. Views sagittal and axial with inspiration and expiration

D. CHEST TUBE PLACEMENT
1. Indication – pleural effusions
2. Contraindication – significant loculation or bleeding diathesis
3. Preparation – pre-procedure PT, PTT, CBC, CXR, consent, notify radiology nurse to coordinate sedation with inpatient floor
4. Room prep-percutaneous procedure tray
   [4 clean towels, 4x4 packs, lidocaine, 25 & 19 gauge needles, 18 gauge 2” angiocatheter, 5cc & 20 cc syringes x2, needle driver, 20 gauge spinal needle,
sterile saline, connector tubing 3 way stopcock green access needle, Betadine or equivalent, .035-J guide wire, 8 Fr APD locking catheter, catheter
5. Table position – supine
6. Scout film – CXR [recent]
7. Procedure – mark location, prep skin, administer local lidocaine, adapt procedure as appropriate for size and location
8. Post procedure – orders, note in chart, CXR, stamp appropriate lab slips and carry specimens to the appropriate lab
9. Complication – infection, bleeding, pneumothorax

V. PEDIATRIC GASTRO-INTESTINAL SYSTEM

A. ABDOMINAL – [liver, spleen, gallbladder, bile ducts, pancreas, kidneys, bladder, fluid search, appendix, bowel, urinary bladder, IVC, Aorta, SMA/SMV]
1. Indication – evaluation of abdominal pain, mass, fluid collections, ductal dilation
2. Contraindication – none
3. Preparation –
   a. Babies less than 1 year old should be NPO for 3 hours prior to the examination.
   b. Children are to be NPO 6 hours prior to a procedure they may have clear liquids up to 4 hours prior to the exam.
   c. Children need to be NPO for all RUQ abdominal ultrasounds done on a non-emergent basis and for any exam requiring sedation.
4. Transducer-
   a. 0 – 1 years: 8.5 MHz sector or less for adequate penetration ; 8 MHz convex.
   b. 1 – 5 years: 6 MHz convex or less as needed for adequate penetration.
   c. 5 and >: 4 MHz convex
   d. Lower frequencies and the Vector 4 probe should be reserved for very large patient or when access is particularly difficult eg. Multiple dressings.
   e. Linear transducer with cadence at 10 MHz for evaluation of bowel wall; a convex transducer may also be used for this purpose if the patient is too large for adequate penetration with the linear transducer.
f. Harmonics should not be used unless image quality with a 4 MHz transducer with optimal dynamic range, focal zone and total gain is insufficient for good visualization.

5. Technical – supine and decubitus views; may use prone for renal evaluation in infants.

6. Views
   a. Liver
      (1) Transverse
         a. @ hepatic veins (all 3 hepatic veins in on view when possible),
         b. @ portal veins (please include bifurcation showing both right and left portal veins in liver),
         c. @ inferior R lobe, RPV, LPV
      (2) Longitudinal
         a. @ L lobe,
         b. @ caudate,
         c. @ IVC
         d. @ Aorta
   b. Gallbladder – trans and long, neck, body and fundus in supine and decubitus positions
   c. Bile ducts - @ common hepatic, PCBD, DCBD
   d. IVC long & trans (at level of crus of diaphragm)
   e. Aorta long & trans (at level of crus of diaphragm)
   f. Pancreas – head and body, tail if visible in trans; head in long as duct enters
   g. Kidney
      (1) – trans @ upper, mid & lower pole
      (2) - long @ medial & lateral
      (3) – one longitudinal view of each kidney must include either liver or spleen
      (4) – one longitudinal view of the kidney must be taken from a posterior approach to fully outline lower pole.
      - one longitudinal and one transverse clip of each kidney from best acoustic window
   h. Spleen – trans & long [include renal pole on same view]
   i. Paracolic gutters – transverse views bilaterally
   j. Pelvis- to include bladder, uterus and ovaries if female
   k. Bowel sweep entire abdomen to evaluate for bowel masses, wall thickening or adenopathy
   l. Bladder

7. Measurements:
   a. Long – liver [at MCL], spleen [max at hilum], kidney [longest], bladder
   b. Trans – bile ducts, pancreatic head, bladder

B. **RLQ**- to be done in addition to complete abdominal ultrasound unless recent full abdominal study performed at UNC.
   1. Indication – r/o appendicitis, r/o Crohn, pain
2. Contraindication – none
3. Preparation – not to void prior to study; full bladder preferable.
4. Transducer – 15-5 MHz linear
5. Technical – graded compression examination of the appendix area
6. Views:
   a. Oblique along right iliac vessels
   b. Transverse and long of appendix with and without compression
   c. Sub-hepatic, sub-diaphragmatic, pelvic area to r/o abscess
   d. Color Doppler of portal veins to document patency if study positive
   e. If appendix not seen, exam should be repeated with an empty bladder
7. Measurements:
   a. Appendix in cross-section
   b. Kidneys – as above
   c. If female, pelvis

C. **PERITONEAL**
   1. Indication – evaluation of peritoneal cavity for free fluid, debris or pneumatosis
   2. Preparation – recent KUB
   3. Transducer – 7 MHz sector, 7 MHz linear
   4. Technical – graded compression exam in real time
   5. Views – variable with areas of suspicion
   6. Measurements – fluid cavities, if present

D. **LIVER DOPPLER**
   1. Indication – evaluation of liver vascular supply native or transplant
   2. Contraindication – none
   3. Preparation – none
   4. Transducer – high frequency convex transducer
   5. Technical – color Doppler and duplex examination of the liver
   6. Views – color IVC, portal vein right, left and main, splenic vein, superior mesenteric vein, hepatic veins, main right and left hepatic artery [follow work sheet] Indicate whole or type partial liver and date of transplant on the worksheet
   7. Measurements – Sizes liver, spleen, MPV, ducts, kidneys, direction of flow, velocity, SAT, RI, wave form [follow work sheet]
   8. Search for collateral circulation: longitudinal color Doppler view of aorta at gastro-esophageal junction; transverse view of left lobe of liver at expected site of umbilical vein; transverse view of gastric fundus and lesser curvature of stomach, splenic hilum and left renal hilum.

E. **PYLORUS**
   1. Indication – to assess for pyloric stenosis.
   2. Contraindication – none
   3. Preparation – none (NPO if possible) bottle with glucose water/Pedialyte inform parent of possible need to place NG tube
   4. Transducer – 9MHz linear
5. Technical:
   a. Supine to RPO
   b. Gray scale evaluation of pyloric muscle
   c. Scan to the right of midline at level of pancreatic head
   d. Place NG or feed water if antrum not distended with water or if stomach
      needs decompression

6. Views:
   a. Magnified long and trans of pylorus
   b. Long & trans of kidneys & gallbladder
   c. Trans SMA/SMV orientation below the level of the pancreas; transverse clip
      of SMA/SMV starting at pancreas and lower

7. Measurements:
   a. Pyloric muscle in trans & long [single wall]
   b. Pyloric channel length
   c. Renal lengths

VI. **PEDIATRIC GENITO-URINARY SYSTEM:***

A. **RENAL**

1. Indication – evaluation of kidneys and bladder
2. Contraindication – none
3. Preparation – hydration and distended bladder if possible, wait until patient 1
   week old if possible
4. Transducer
   a. 0 – **1 years:** 8.5 MHz sector or less for adequate penetration; 8 MHz
      convex.
   b. **1 – 5 years:** 6 MHz convex or less as needed for adequate penetration.
   c. **5 and >:** 4 MHz convex
   d. Lower frequencies and the Vector 4 probe should be reserved for very
      large patient or when access is particularly difficult eg. Multiple
      dressings.
   e. Harmonics should not be used unless image quality with a 4 MHz
      transducer with optimal dynamic range, focal zone and total gain is
      insufficient for good visualization.

5. Technical:
   a. Supine , decubitus and prone views
   b. Do post void if patient able to void spontaneously
   c. Add post void collecting system measurements, if collecting system was
      dilated on the pre void or if the history is neurogenic bladder
   d. Obtain RI of interlobular artery measurements if new hydronephrosis
   e. Evaluate the adrenal in infants

6. Views:
   a. Long medial, mid, and lateral kidneys, bladder, ureters if visible (include
      on longitudinal view of kidney with liver and spleen)
   b. Trans upper, mid [include renal pelvis], lower pole kidneys
c. Bladder – upper, mid & trigone ureters if visible
d. Longitudinal and transverse clips of the kidneys in window of best visualization. Bladder clips transverse and long

e. Measurements:
   (1) Long kidneys & bladder
   (2) Trans renal pelvis at the hilum,
   (3) Proximal and distal ureter if dilated
   (4) Bladder for estimated volume pre & post void

B. PELVIC
1. Indication – for evaluation of the uterus and adnexa if pain in RLQ will need appendix exam as well
2. Contraindication – no trans-vaginal in non-sexually active
3. Preparation – PO hydration (as much as tolerated) or IV hydration to fill bladder
4. Transducer – 3-8 MHz convex transducer
5. Technical:
   a. Supine, bladder distended
   b. Scan kidneys if pelvic mass present
   c. Demonstrate arterial & venous flow with Doppler if ovarian torsion considered
6. Views:
   a. Trans – uterus, vagina, ovaries
   b. Long – uterus, ovaries, iliac vessels
7. Measurements:
   a. Volume of ovaries
   b. Long & trans of uterus

C. SCROTAL
1. Indication – for evaluation of scrotum and contents
2. Contraindication – none
3. Preparation – none
4. Transducer – 10 MHz linear
5. Technical:
   a. Gray scale, color Doppler, power Doppler. Duplex Doppler required if history is r/o torsion or if power or color Doppler exam abnormal
b. Set PRF to lowest setting
c. **Do not** change setting between sides
d. Patient supine
e. Place towel under scrotum for support
f. Scan inguinal canal and pelvis if no intrascrotal testes
g. Scan inguinal canal and pelvis for mass evaluation
h. Scan inguinal canal to evaluation cord if question is torsion
i. Scan kidney and gonadal vein if varices present to rule out mass
j. Scan retroperitoneum if scrotal mass present to rule out adenopathy
k. Demonstrate arterial & venous flow with duplex Doppler when history is r/o torsion

6. Views:
   a. Trans & long of both scrotum (3 views each plane) include views of epididymis, cord, testes
   b. One trans view with both testes on same view, with color Doppler & without
   c. Obtain clips in both projections for both testes

7. Measurements:
   a. Testes & epididymis in long and trans

VII. **PEDIATRIC MUSCULOSKELETAL:**

D. **HIP**

1. Indication – evaluation of femoral head and acetabulum for DDH risk, scan generally performed at 1 month of age
2. Contraindication – significant ossification of femoral head [~6 months]
3. Preparation – none
4. Transducer – Linear
5. Technical:
   a. Decubitus
   b. May scan in harness
   c. May scan in cast prone
   d. Scan with and without stress in trans/ and coronal
   e. Identify labrum, femoral head, and greater trochanter
   f. Evaluate for pulvinar, perfusion of head with color Doppler
6. Views:
   a. Long & trans of acetabular cavity and position of femoral head
   b. May scan with hip flexed or extended
   c. Obtain transverse stress views unless in cast or in harness
7. Measurements:
   a. % femoral head coverage by bony acetabulum on long view, alpha angle
   b. Mm posterior displacement with stress

E. **JOINT**

1. Indication – evaluation of joint for fluid, tendons & ligament
2. Contraindication – none
3. Preparation – none
4. Transducer – 7-15 MHz linear
5. Technical:
   a. Scan in partial flexion for most joints
   b. Pronation and hyperextension for shoulder
   c. Leg extended for knees with views from suprapatellar region, patellar ligament, quadriceps tendon, medial in sagittal plane, lateral in sagittal plane and posterior axial and longitudinal.
   d. Scan normal side first
   e. Consider scan during motion
6. Views – long and trans of appropriate areas
7. Measurements – effusion depth

F. JOINT ASPIRATION
1. Indication – r/o infection
2. Contraindication – no access
3. Preparation:
   a. NPO for sedation
   b. Sterile towels
   c. Probe cover with sterile gel
   d. Betadine
   e. Lidocaine
   f. 20g spinal needle (2)
   g. 19g 25g hypodermics
   h. 5 cc syringe (3)
   i. Connector tubing
   j. Band-Aid
   k. Sterile 4 x 4s
   l. Lidocaine
   m. Neut
   n. Room preparation for aspiration
4. Transducer – 7-5 MHz linear, may use sector for limited window or guided taps
5. Technical:
   a. Perform diagnostic scan and document effusion and location
   b. Sedation for most children
   c. Lidocaine for local anesthesia
   d. Insertion of needle in to effusion and aspiration

D. MUSCLE
1. Indication – evaluation of muscle for inflammation, tear, hemorrhage, foreign bodies, etc.
2. Contraindication – none
3. Preparation – none
4. Transducer – 10-15 MHz linear
5. Technical:
a. Scan in relaxed and contracted for most
b. Scan normal side first
c. Consider scan during motion of muscle
6. Views- long and trans of appropriate areas

VII. PEDIATRIC NECK

A. NECK
   1. Indication-evaluation of soft tissues of neck
   2. Contraindication- none
   3. Preparation- none
   4. Transducer- high frequency sector and 10-15 MHz linear
   5. Technical:
      a. Supine
      b. Place rolled towel behind neck for hyperextension
      c. Document flow in carotid and jugular
      d. Evaluate any mass with color flow Doppler and duplex
   6. Views-
      1. long and trans bilaterally of parotid and submandibular glands;
      2. transverse view of thyroid.
      3. Longitudinal views of carotid and jugulars.
      4. Cervical adenopathy or masses.
   7. Measurements- mass if present trans and long

B. THYROID
   1. Indication – evaluation of thyroid mass
   2. Contraindication – none
   3. Preparation – none
   4. Transducer – 10-15 MHz linear
   5. Technical:
      a. Review thyroid nucs scan first, if obtained
      b. Slight hyperextension of neck with rolled towel
   6. Views – trans and long of thyroid, including isthmus
   7. Measurements – long (lateral and medial) and trans (upper, mid and lower) of each lobe, any solid or cystic areas

VIII. PEDIATRIC VASCULAR

A. VENOUS
   1. Indication:
      a. R/o thrombosis or document course of vessels, for central line
      b. Placement or to r/o pericatheter thrombus
      c. Upper: evaluate central veins, jugular veins, and as much of SVC as possible
      d. Lower: evaluate vessels from groin (or catheter entrance) to the diaphragm
   2. Contraindication – none
3. Preparation – none
4. Transducer – 7 -15 MHz linear or sector
5. Technical:
   a. Gray scale and color Doppler
   b. Compression views in all compressible vessels
   c. Follow catheters to the tip
6. Views – long and trans of vessels

B. **ARTERIAL** [any large-medium vessel, exclusive of the thoracic aorta]
1. Indication – evaluate vessels for course and patency, r/o stenosis or occlusion
2. Contraindication – none
3. Preparation – none
4. Transducer – 7 -15 MHz linear or sector
5. Technical – gray scale and color Doppler
6. Views – long and trans