

Paediatric Ultrasound On-Call Guide

(First Edition, June 2020)

Prepared for the BSPR by the
Newcastle team, following the BSPR
ASM of 2020

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General

Introduction to this guide

Ultrasound is the imaging modality of choice for many acute paediatric clinical presentations and you may be required to perform this examination out of hours to assist our paediatric colleagues with diagnosis and subsequent patient management. We are aware that as registrars your prior exposure to paediatric ultrasound may be limited and variable. So, we have created this guide to give you an overview of what may be expected OOH with a framework and systematic approach to assist you. Look out for the top tips along the way to help you get the most information from the examination.

We hope you find it useful.

Good luck!

Before you start

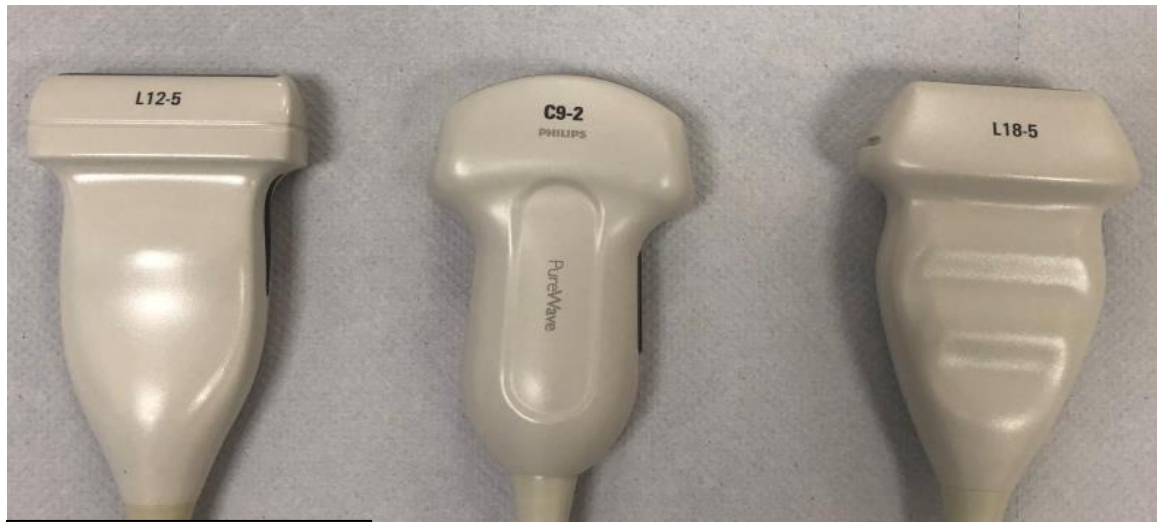
Try and use distractions in the form of lights and toys, parents' mobiles phones can also be a great help! For babies, sucrose can be used to help pacify.

If doing a portable scan, remember to take sterile gel sachets. When you arrive, remember to introduce yourself to the nurse/team looking after the patient and ask for their help moving the patient to optimise patient exposure for the examination.

If you are not clear on the clinical question, discuss with the referring senior registrar or consultant. If the examination is expected to be complex, consider performing with one of the medical team in attendance at the time of the examination.

Probe selection

Feel confident to use a curvilinear and linear on most things and try different probes when scanning!



<u>Linear 12-5</u>	<u>Curvilinear 9-2</u>	<u>Linear 18-5</u>
Bowel and appendix Baby abdomens Neck Testes MSK	Abdomens (unless babies)	Smaller necks/testes/MSK

Abdomen

Generally, children make good ultrasound subjects due to smaller size and lack of subcutaneous fat. However, taking an accurate clinical history and performing a clinical examination can be challenging. The curvilinear 9-2 probe is used most often and is a good starting point-but don't be afraid to add in the linear 12-5, especially for appendixes, as the detail can be fantastic! It is normal practice to look at the entire abdomen so try and avoid doing a targeted RIF scan for appendicitis because you may miss alternative pathology.

Appendicitis

Technique

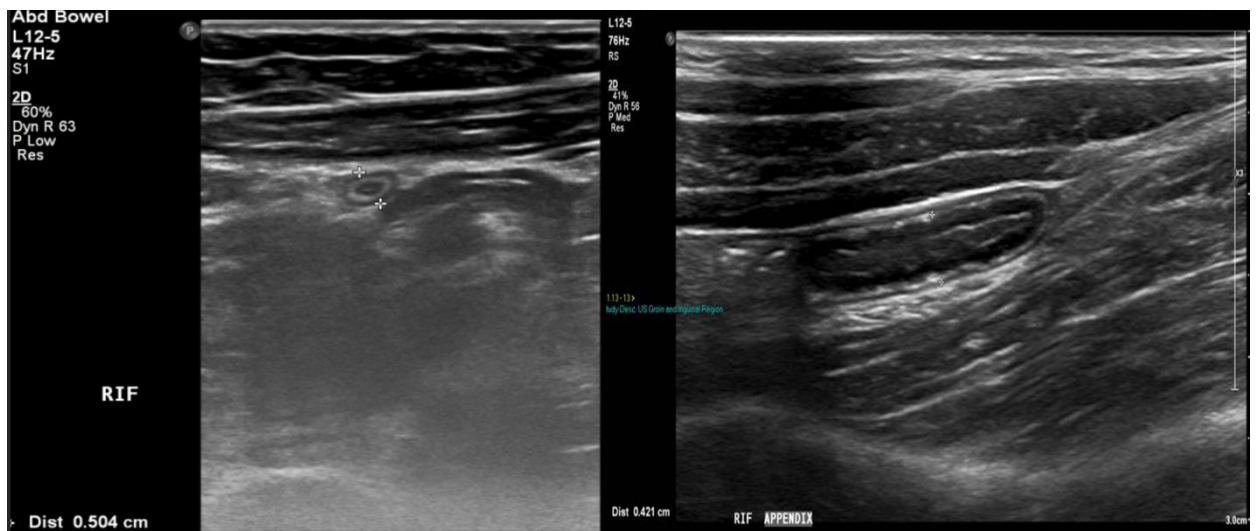
- Curvilinear 9-2 for whole abdomen (PAED ABDO LM setting) followed by linear 12-5 (on bowel setting) for assessment of RIF, appendix and bowel.
- Start with the bladder in paediatric abdominal scanning as this gives a good initial assessment of free fluid in the lower abdomen/pelvis and gives you an initial index of suspicion
- Then scan the entire abdomen as normal before performing a dedicated examination of the appendix/RIF (*empty bladder - see 'Helpful Tips'*)

KEY MARKERS:

- Diameter >6mm
- Non compressible
- Probe tenderness

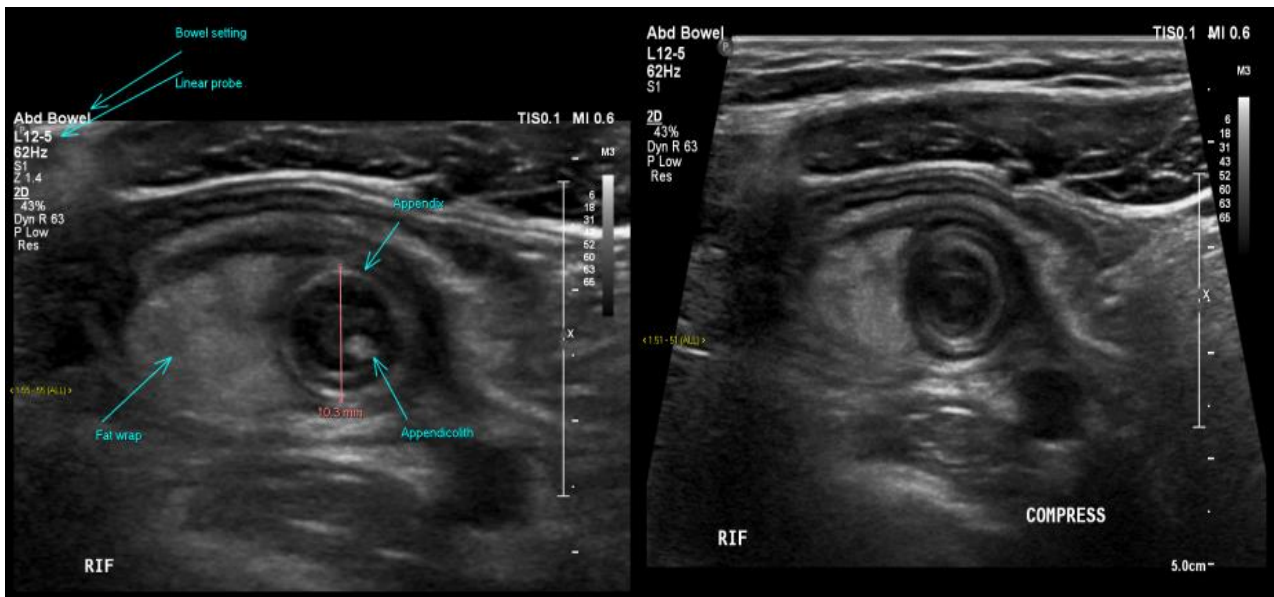
Other features:

Appendicolith/ loss of wall stratification, fat wrap & hyperaemia, free fluid/ collection & lymph nodes



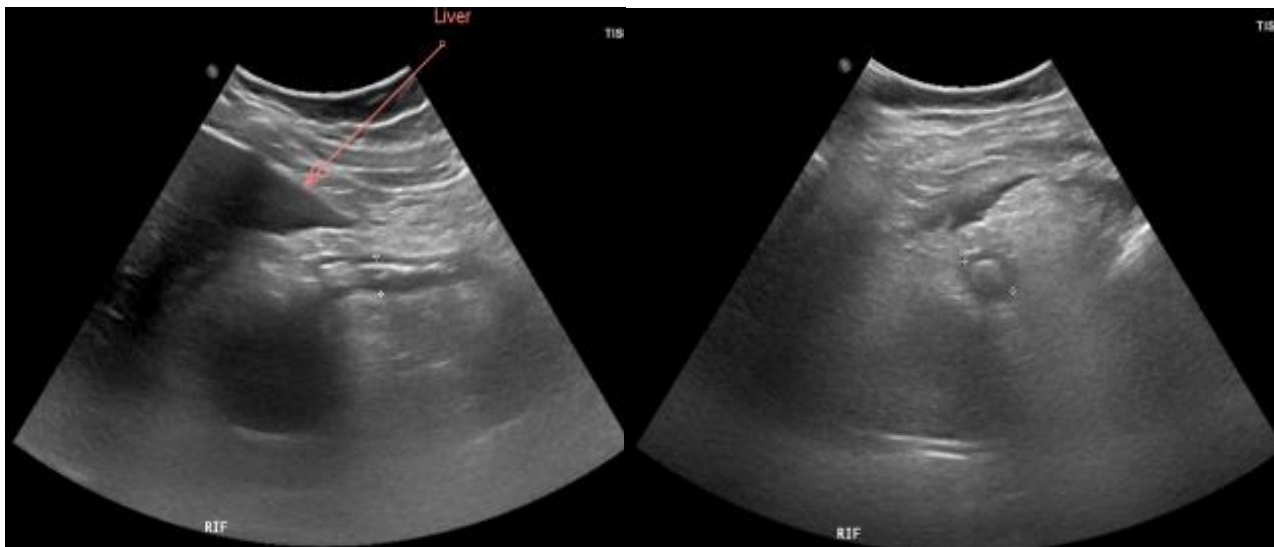
Helpful
Tips

Know what normal looks like on ultrasound - see above transverse and longitudinal views.
Note the lack of surrounding mesenteric fat wrapping and transverse diameter <6mm.



Left: Labelled diagram of appendicitis with associated features. Normal appendix should be smaller than 6mm in cross sectional diameter.

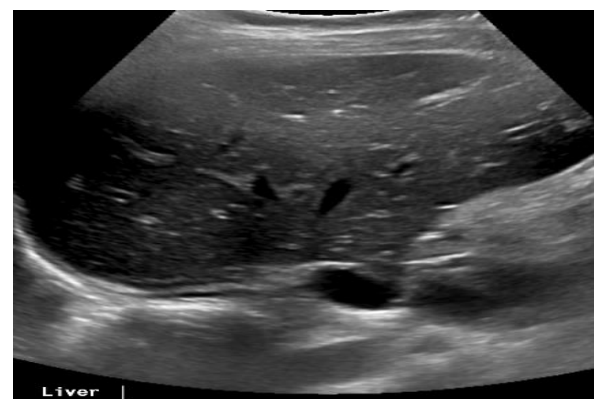
Right: Demonstrating the incompressible nature of the distended appendix. This will be painful, but pressure is sometimes necessary in this scenario in order to make a confident diagnosis.



Appendixes can hide in funny places.

Left: Appendicitis with surrounding inflammatory fat wrap and localised collection seen just inferior to the liver. This was best seen with the patient lying on their left-hand side.

The 'starry sky' liver appearance: bright echogenic dots on background of relatively hypoechoic liver parenchyma. Associated with intra-abdominal inflammation, most commonly appendicitis in children (although can be seen in other pathologies)



Helpful
Tips

*Don't say you have seen a normal appendix unless you are certain that is what you are looking at as this will potentially falsely reassure clinicians.
If the bladder is distended ask the child to go the toilet and perform RIF US. The bladder can displace the surrounding bowel and make appendix difficult to see, so give yourself the best chance to demonstrate it.*

Mesenteric Adenitis

This is the most common alternative condition in paediatric patients presenting with RIF pain. It is a benign inflammation of the ileocolic lymph nodes.

Technique

- Entirely the same as above

What does it look like?

- Prominent RIF mesenteric lymph nodes
- Absence of features of appendicitis



Pyloric Stenosis

Symptoms of non-bilious projectile vomiting start from 3 weeks of life and typically presents at 6-12 weeks of age. May have a family history, palpable olive mass (remember the stenosis is due to hypertrophy of the pylorus) and a metabolic alkalosis. Treatment is surgical via a pyloromyotomy.

Diagnostic sizes/features:

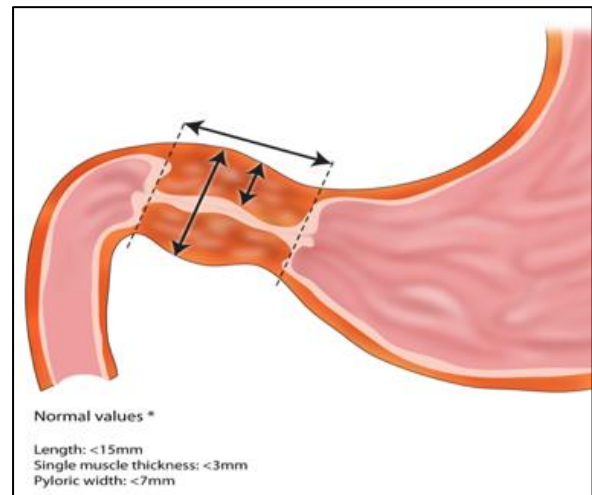
- Single muscle thickness >3mm
- Canal length > 15mm
- Failure to see traversing gastric content

Technique

- Linear probe 12-5 on abdo bowel setting
- Place in epigastric region and move medial from the level of the porta. Probe orientation varies depending on patient, but start in transverse and orientate once pylorus identified

What does it look like?

- Appearances are classical
- Look for antral shouldering and cervix sign from indentation of pylorus into fluid filled antrum of stomach (see below)
- Common teaching is a canal length >15mm and single muscle thickness >3mm (see below for where to place callipers to measure)
- If not sure, when you see the pyloric channel keep the probe in a static position over the pylorus and wait to see if it opens and whether gastric content passes



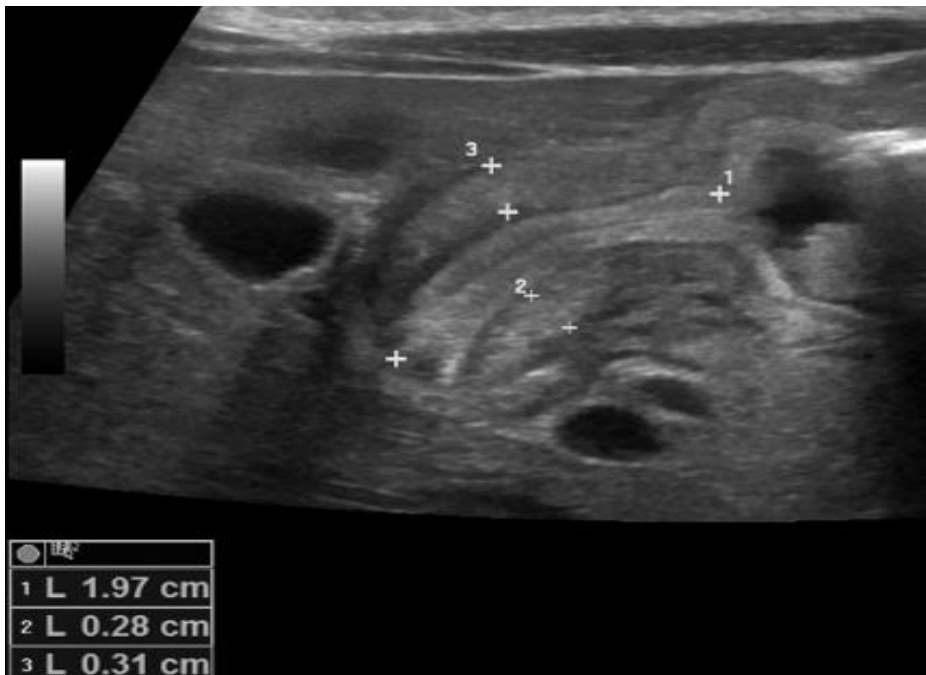
through. If it does, it's **not** pyloric stenosis. In difficult/equivocal cases, a test feed/ fluid can be given (at surgeon's request) PO or through NG tube and then the patient turned in the right anterior oblique position (right side down) to see if there accentuated antral shouldering and to assess for pyloric opening. It is often not critical but generally the surgical team need a decision within 24 hrs.

Helpful
Tips

Pylorospasm – prominent pylorus but doesn't exceed the quoted measurements – can evolve into pyloric stenosis and could consider a re-scan in 24 hrs if clinical concern persists.

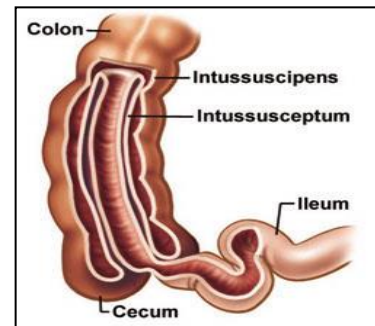


Above: Pyloric stenosis. Measurement 1 is canal length and measurements 2 and 3 are single muscle thickness.
Below: Pyloric stenosis. Note antral shouldering and cervix sign post test feed with no opening of pyloric canal



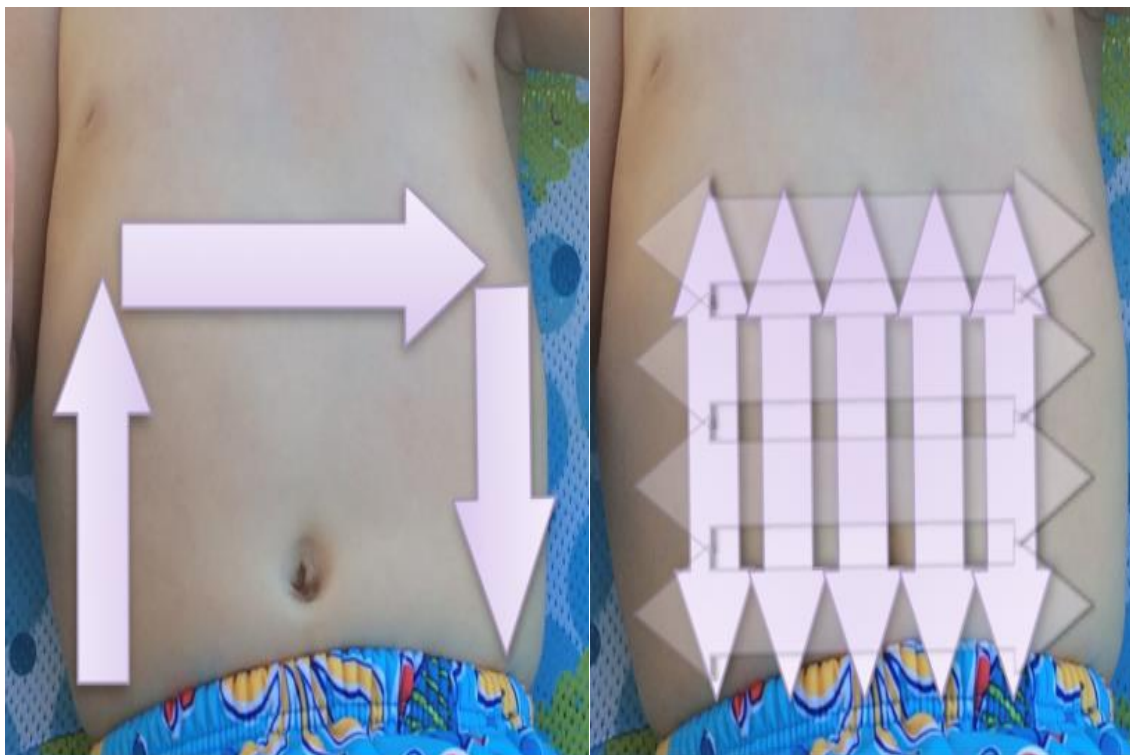
Intussusception

This is a type of acute intestinal obstruction in children typically between 3 months and 3 years of age, where a proximal segment of bowel invaginates into a more distal segment. It can be ileocolic (90%), colocolic or ileoileal and it is important to differentiate between each as small bowel intussusceptions DO NOT require a pneumatic reduction attempt and are usually self-limiting and spontaneously resolve.



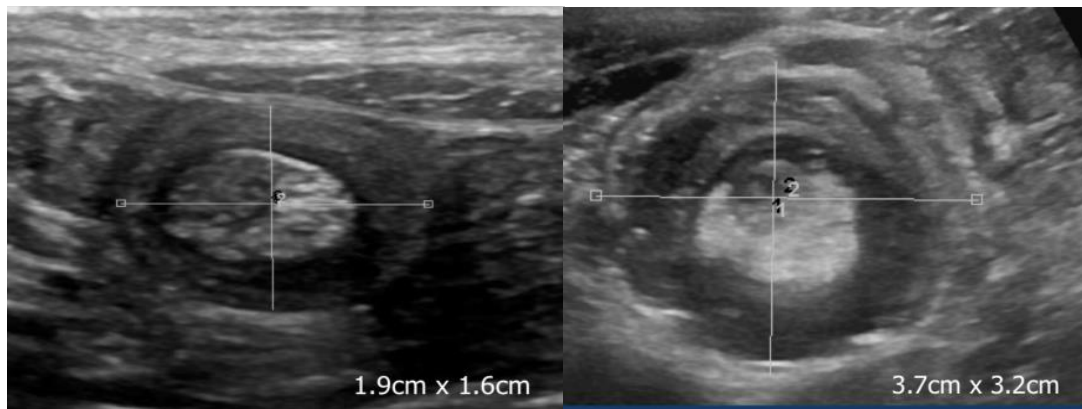
Technique

- Ensure surgical team attend if they are concerned. If the scan is positive, then the patient will require resuscitation/ antibiotics and informed consent prior to pneumatic reduction
- Perform full abdominal ultrasound (standard technique as before) to exclude other pathology with 9-2 probe. Then use linear 12-5 probe on Ped Abd or Abd Bowel
- Start in RIF and localise caecum (if you can). Then trace along the colon as shown in the below left picture from right to left. After that “mow the lawn” as shown in the below right picture to screen the rest of the bowel. Take your time

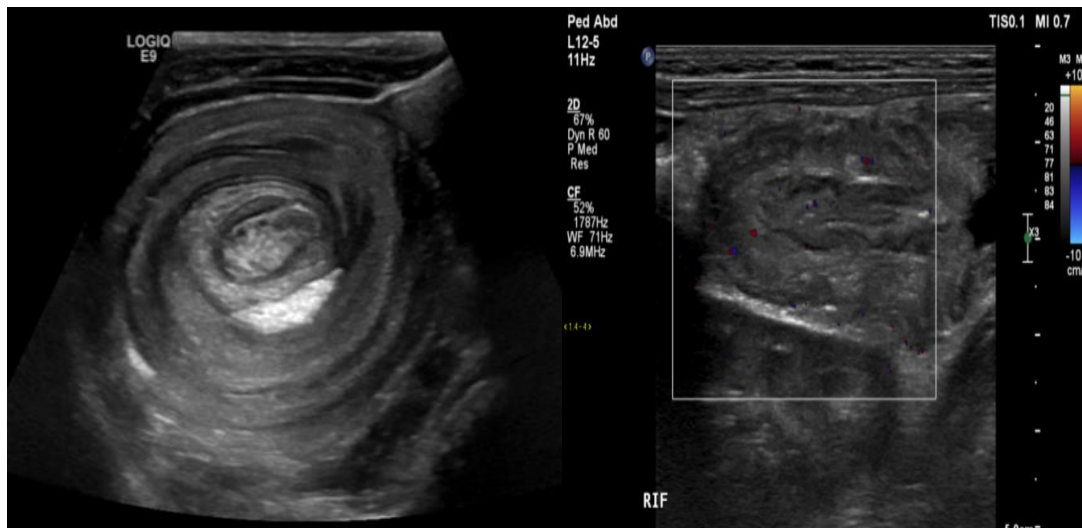


What does it look like?

- Described as the ‘pseudokidney’ sign or ‘doughnut’
- Look for concentric rings
- ? Presence of fluid ? colour flow – these can be used as prognostic indicators for success of reduction but to be honest, if it is ileocolic or colocolic diagnosed on US then attempted pneumatic reduction is needed
- Small bowel vs small-large vs large-large bowel
 - Look at location of probe
 - Size >3cm suggests ileocolic or colocolic, whereas <2.5cm is ileoileal
 - Small bowel intussusceptions are usually transient and may resolve on graded compression during scanning



Using size to help differentiate a small bowel intussusception (left) from an ileocolic intussusception (right)



Left: Trans view through an intussusception demonstrating the concentric rings
Right: Long section

Veno-occlusive disease

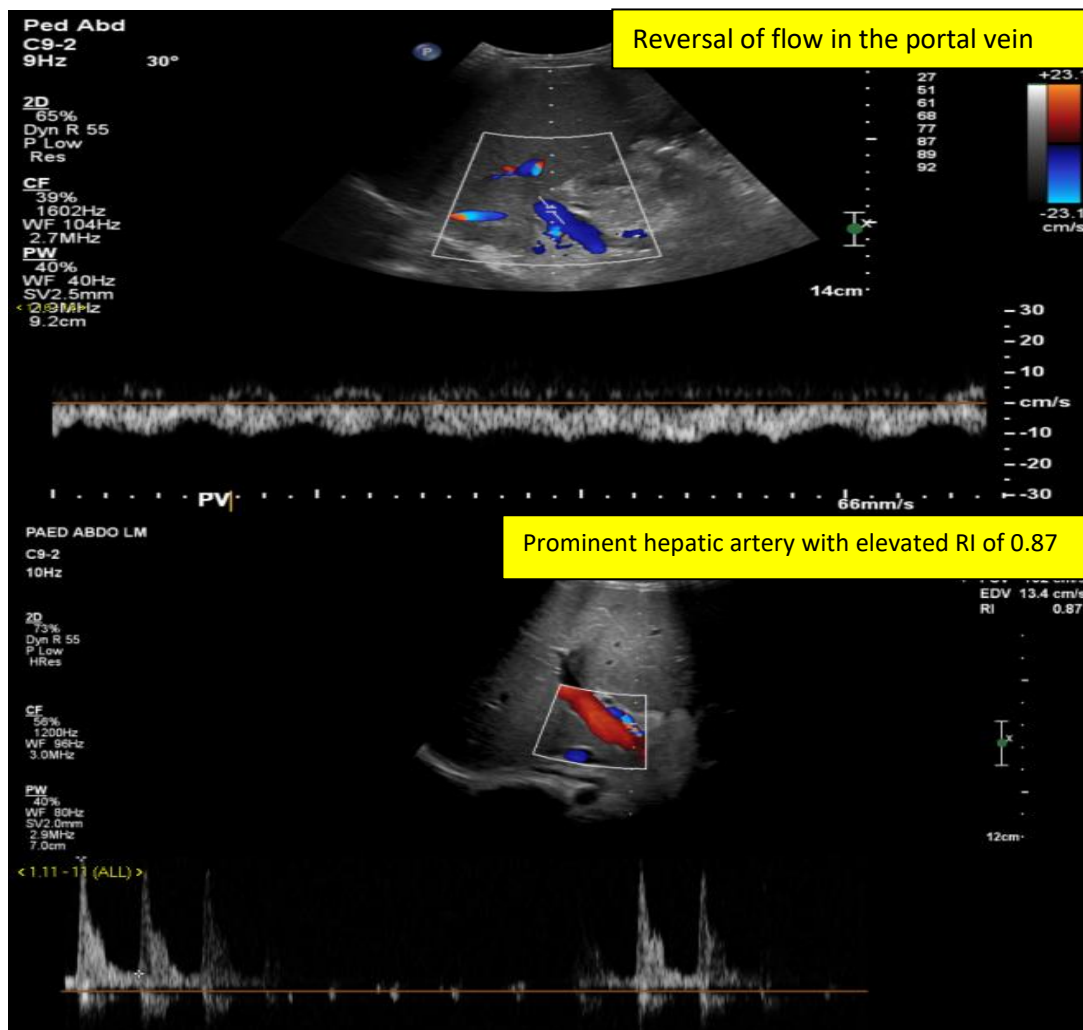
Sinusoidal obstruction syndrome (SOS), previously known as hepatic veno-occlusive disease (VOD), is a condition arising from the occlusion of hepatic venules. This can be caused by chemotherapeutic agents or seen post bone-marrow transplant, which are the typical patients for whom ultrasound is requested to assess for this. Damage to the hepatic venules essentially causes hepatic congestion, and it is signs of this that are assessed on ultrasound. It is treated medically with anticoagulation and supportive care.

Technique

- Standard curvilinear 9-2 examination of the abdomen

What does it look like?

- Hepatomegaly/splenomegaly
- Portal vein occlusion/reversal of flow
- Ascites
- Gallbladder wall thickening (>7mm)
- Prominent hepatic arteries with elevated RI (>0.8)



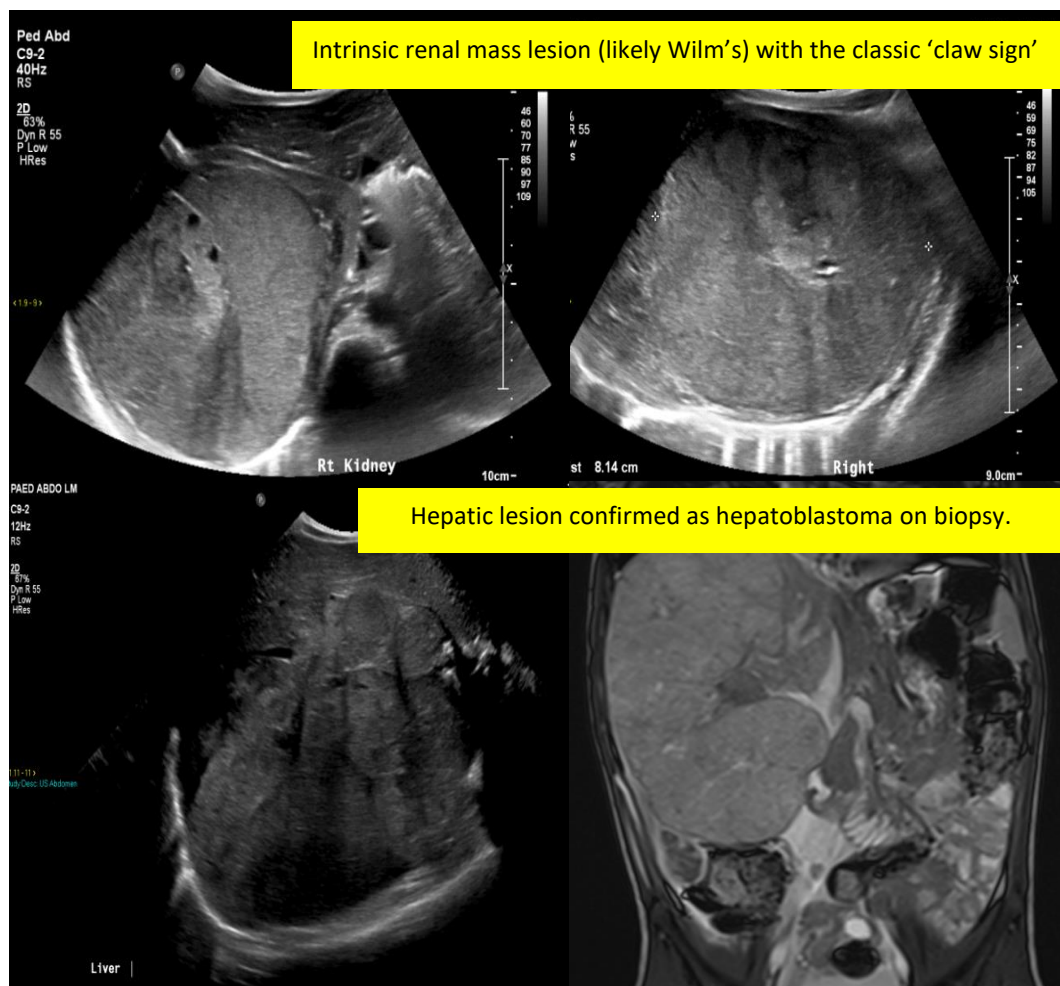
Masses

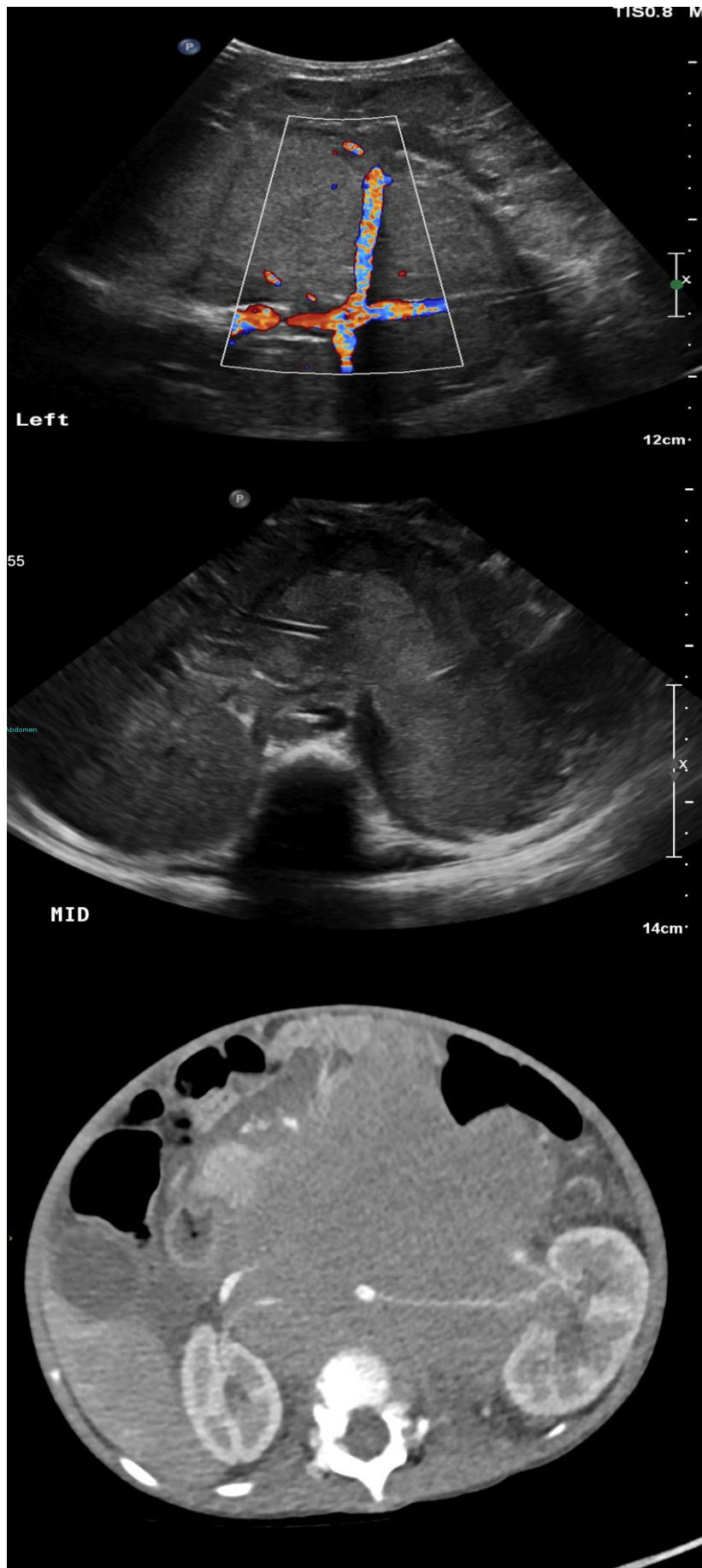
Occasionally you may be asked to scan a child with a new abdominal mass. You should approach these as any other abdominal examination and use the same technique as already described. No one expects you make the correct histological diagnosis (although the clinicians do try to push for one). These patients will always require cross sectional imaging but sometimes a great deal of information can be gleaned from the ultrasound alone.

What does it look like/how to assess?

- Try to establish organ of origin – this can be done via a process of elimination by seeing which normal organs you can see in their entirety separate to it
- Size
- Presence of fluid/collection/ adenopathy
- Cystic/solid
- Vessels – encasement vs displacement. Always use colour flow

Examples





These images demonstrate a neuroblastoma. This encases vessels and typically (but not always) arises from a suprarenal location.

Renal

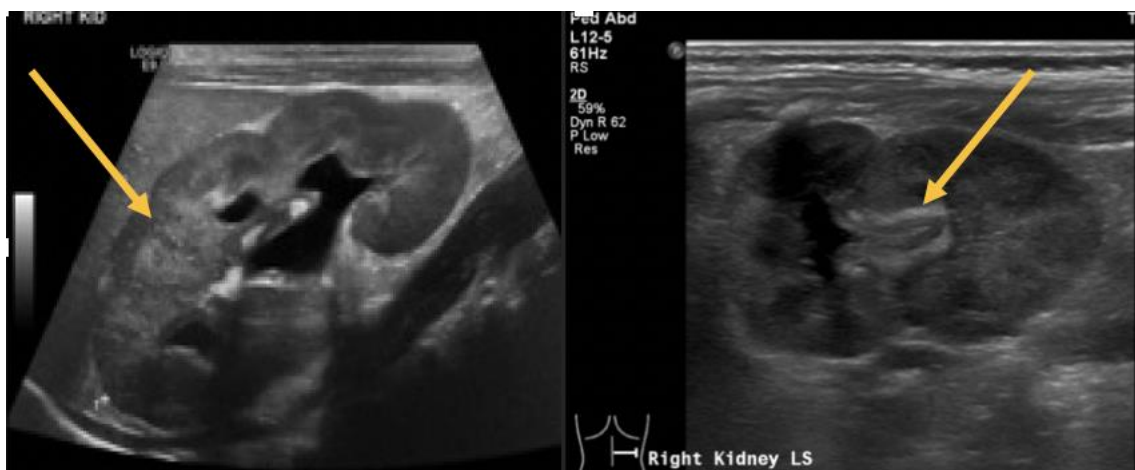
Technique

- Standard curvilinear 9-2 examination of the abdomen (or in babies linear 12-5 with baby lying prone)
- Scan bladder first (young children tend to pee during examination)

Renal pathologies e.g. pyelonephritis, calculi and hydronephrosis will have similar imaging appearances in both children and adults and therefore will not be covered in this booklet.

Look for:

- Presence/absence of hydronephrosis -? clot? calculus? mass
- Pyonephrosis – echogenic and sometimes layering debris in a dilated collecting system
- Urothelial thickening – can be due to infection/inflammation or chronic obstructive uropathy
- Cysts – unusual to see cysts in paediatric patients however document size and +/- vascularity
- Perinephric inflammatory change/collection
- Loss of corticomedullary differentiation with bright echogenic linear stripes is the classic appearance of pyelonephritis +/- abscess formation



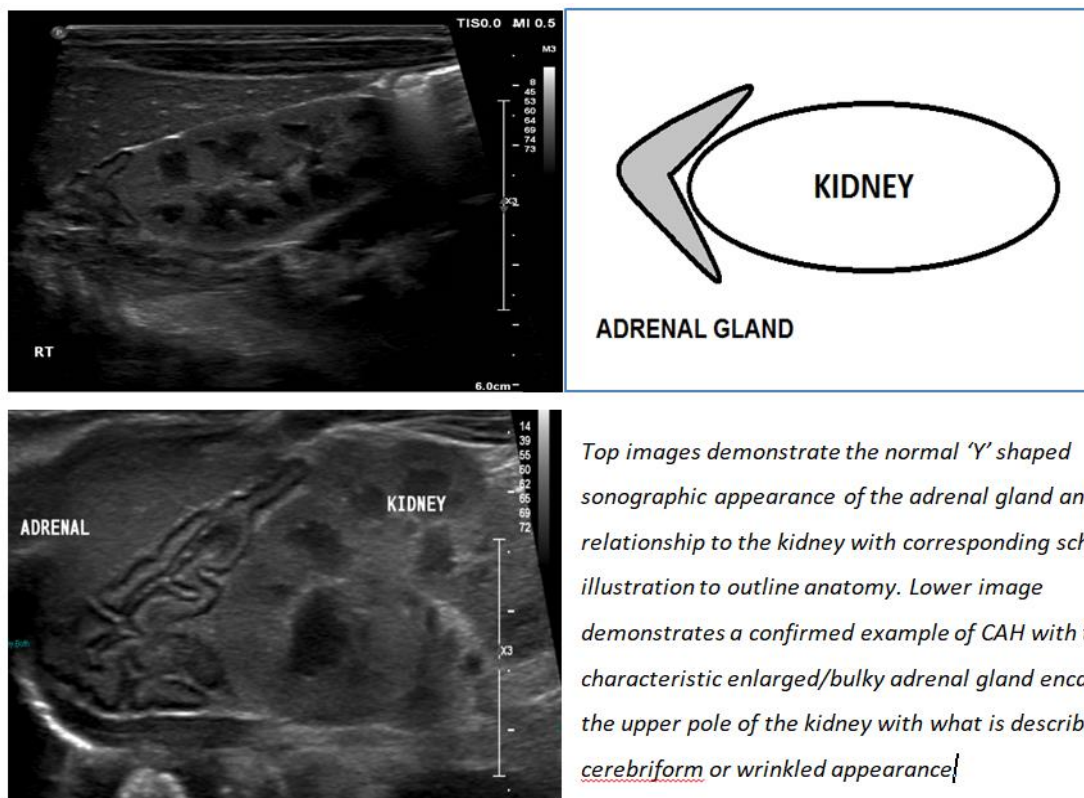
Examples of pyelonephritis and secondary renal changes. Note the loss of corticomedullary differentiation on the left image and urothelial thickening on the right image.

Adrenal

Rarely, you will be asked to assess the adrenal glands in a neonate. By far the commonest abnormality is adrenal haemorrhage secondary to birth trauma. The changes involute on US over a 4-week period and may leave some residual calcification.

However, you may be asked to assess for congenital adrenal hyperplasia (CAH). This is an emergency as can lead to a salt wasting crisis. The findings on US are fairly characteristic (see below). Do not worry about being 100% sure in your findings as the endocrinologists have a fundamental idea of the imaging findings so try to provide suprarenal images and some measurements where possible (linear probe advised).

Measurements can be difficult with some debate about diagnostic sizes: Bilateral adrenal enlargement (>4mm limb width & > 20mm limb length) is suggestive of the diagnosis.

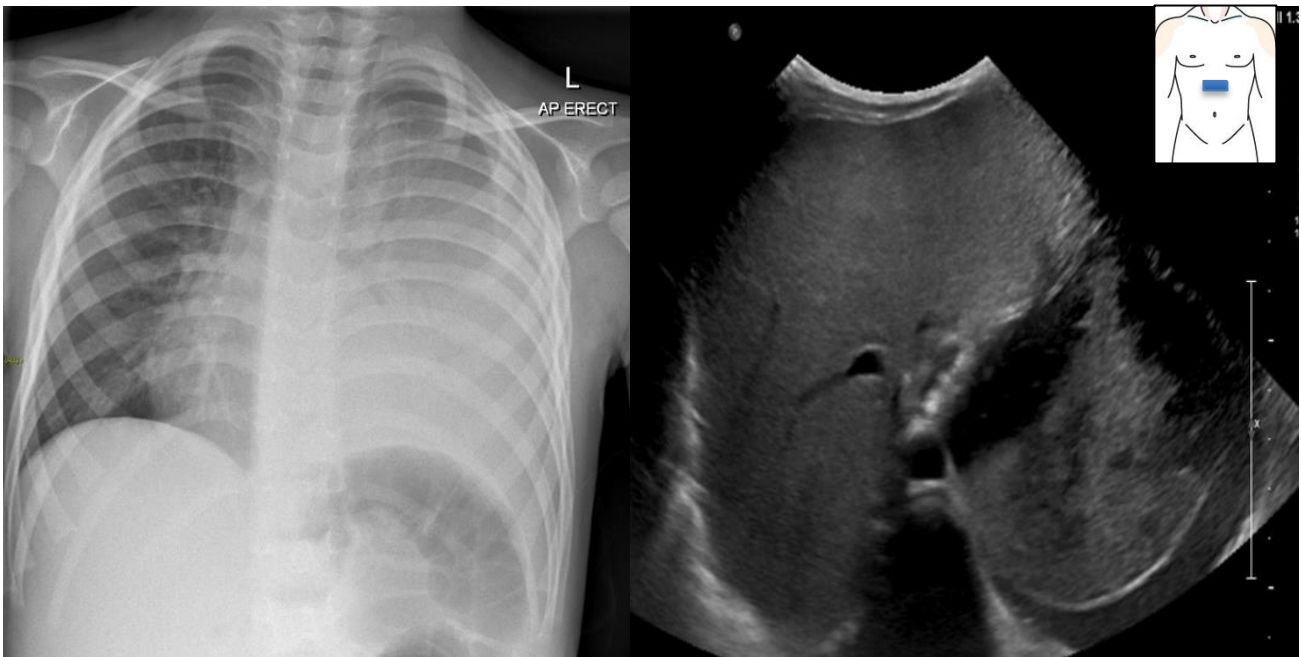


Chest

Occasionally you will get a request to assess for an effusion. In general, the clinical concern will be? empyema and this is extremely important as confirmation on US may cause clinicians to expedite transfer to the Freeman for treatment by decortication. Ultrasound is elegant at differentiating a simple effusion from a chylothorax/empyema.

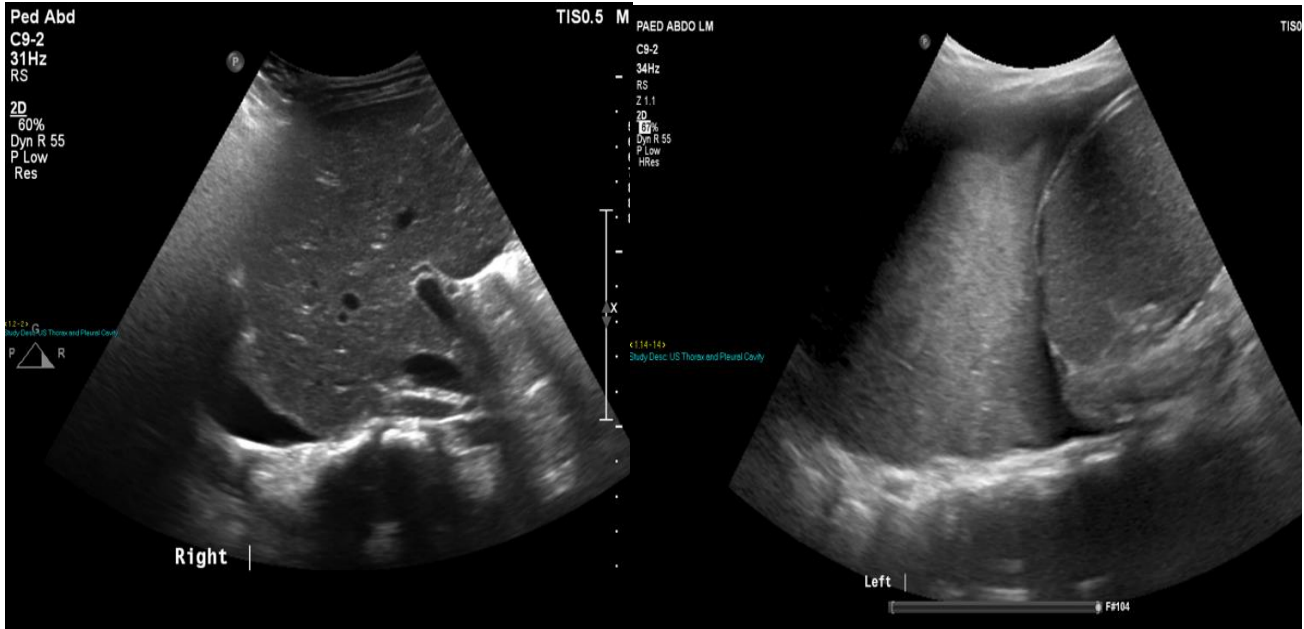
Technique

- Curvilinear 9-2 or linear 12-5 probe (if small child)
- Start in the mid axillary line of the affected side and locate the crus of the diaphragm and see if you can see fluid – remember the lung maybe difficult to see as it is an air-filled structure. If effusion present, try and trace this as high as you can
- Assess effusion
 - Simple; anechoic
 - Complex; suggested by presence of debris, fibrinous stranding, septations, thick rind
- Assess underlying lung for collapse, consolidation or intraparenchymal abscess

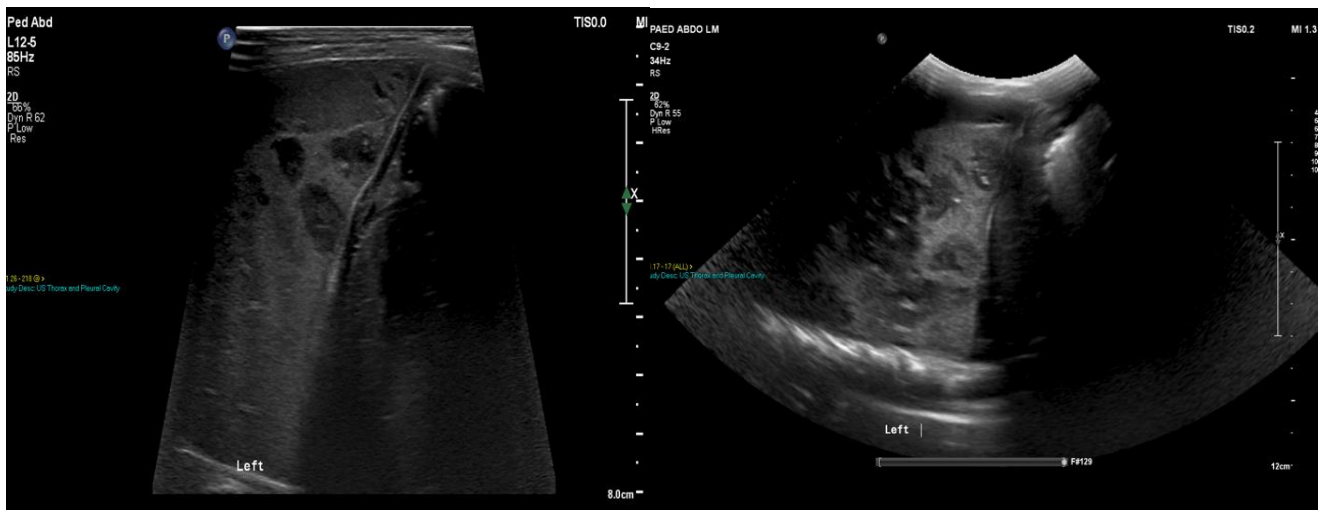


Left: CXR demonstrating large left sided pleural effusion and volume loss

Right: Midline transverse epigastric view demonstrating normal lung on the right adjacent to the liver/right hemidiaphragm and effusion on the left adjacent to the left hemidiaphragm (imaged with 9-2 probe on PAEDS ABDO LM)



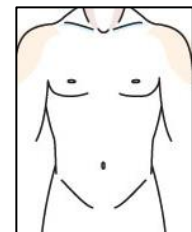
Left: Small, simple effusion lying dependently, with normal aerated lung seen anteriorly
 Right: Consolidated lung with rim of complex fluid anteriorly.



Both images: Complex effusion lying anteriorly with densely consolidated lung containing multiple hypoechoic foci with echogenic centres – US appearances are consistent with intraparenchymal necrosis/abscess.



Don't be afraid to move the patient (in PICU/SCBU setting remember to ask for help first) as you will really struggle to do this scan all with the patient in a fully supine position. A midline epigastric view (see diagram) as above is often a very useful overview to compare the 2 sides.



Testes (The Acute Scrotum)

We are aware this is a topical issue. Traditionally, ultrasound should not be used to “rule out” torsion. However, you are here to assist your clinical colleagues, so don’t be obstructive.

Technique

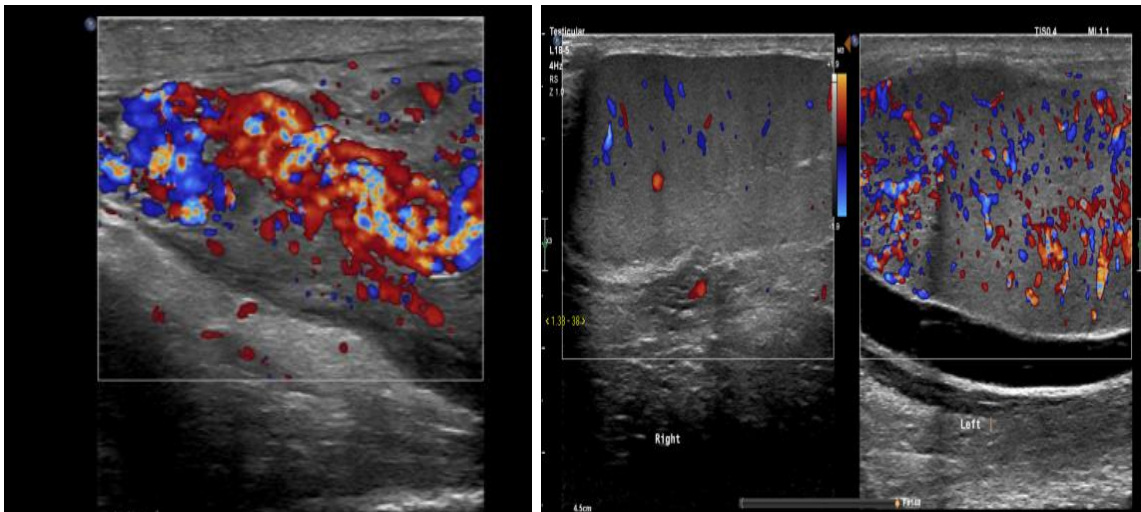
- Linear 12-5 for older children or 18-4/5 for younger ones (testes setting)
- Always compare both sides & always check the groins

Epididymitis

This is inflammation of the epididymis and is common in children. This may or may not affect the testis as well (epididymo-orchitis). Orchitis in isolation is much less common. The clinical spectrum ranges from mild tenderness to a severe febrile process with acute unilateral scrotal pain.

What does it look like?

- Increased size of epididymis/testis/both
- Increased vascularity of epididymis/testis/both
- Altered echogenicity – can be increased, decreased or heterogeneous
- Commonly reactive hydrocele and scrotal wall thickening are also present



Epididymo-orchitis: Increased epididymis vascularity on the left image and increased left testis vascularity on the right image (made easier by direct comparison to contralateral testis). Also note small hydrocoele.

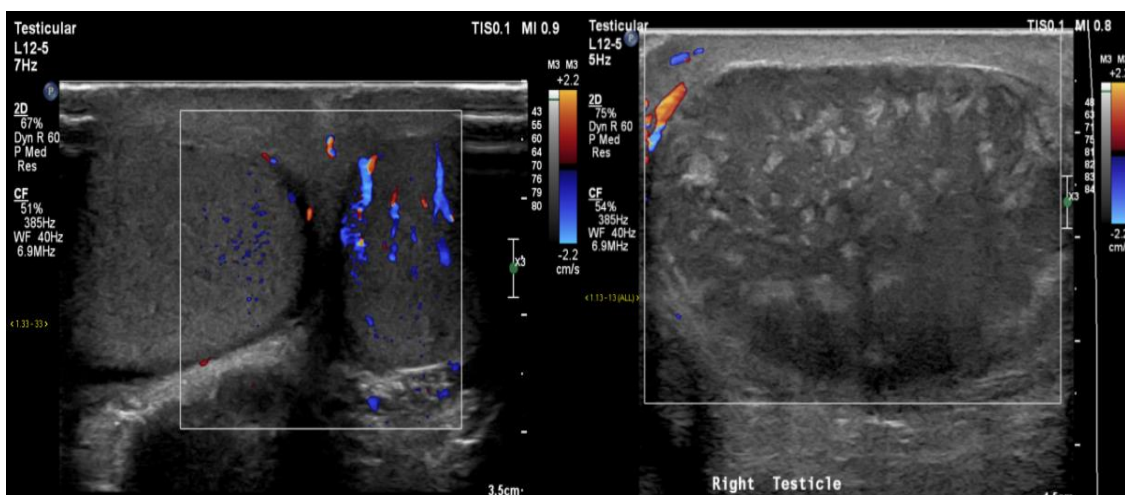
Testicular Torsion



This is most common in adolescents, but can occur at any age. Clinical presentation can be scrotal pain or pain centred on the groin or lower abdomen. This is a surgical emergency and should be fixed within 6-12 hours for a good chance of testicular viability and therefore ultrasound is not performed in cases with high index of suspicion. The difficulty arises for atypical presentations, delayed presentations or maldescended testes, which are the typical scenarios when the surgeons request an ultrasound. In these scenarios it is reasonable to perform a scan, but feel free to write “ultrasound cannot rule out testicular torsion” at the end of your report.

What does it look like?

- Increased size of the testis and epididymis
- Altered vascularity (initially can increase before decreasing)
- Altered echotexture (homogenous at first, heterogeneity implies necrosis)
- Twisting of the spermatic cord producing the “whirlpool” sign on Doppler
- Reactive hydrocoele and scrotal oedema commonly accompany it



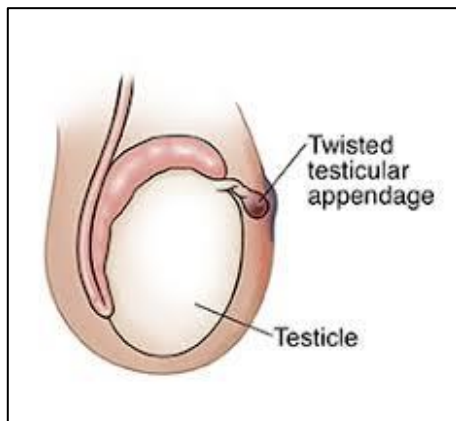
Torsion: Left image was salvageable at surgery (note direct comparison image). Right image was not (note heterogeneity suggestive of necrosis).



SIDE BY SIDE imaging by clicking dual screen allows direct comparison and is extremely helpful in these scenarios.

Undescended testes are more likely to tort, so if you do not see convincing testis/testes in the scrotum, have a search!

Torsion of the Testicular Appendage



Otherwise known as the hydatid of Morgagni, the appendix testis is an embryological remnant located between the superior testis and the epididymal head (see picture). When normal, it is approximately 1-4mm in length, oval/pedunculated in shape and difficult to appreciate on ultrasound.

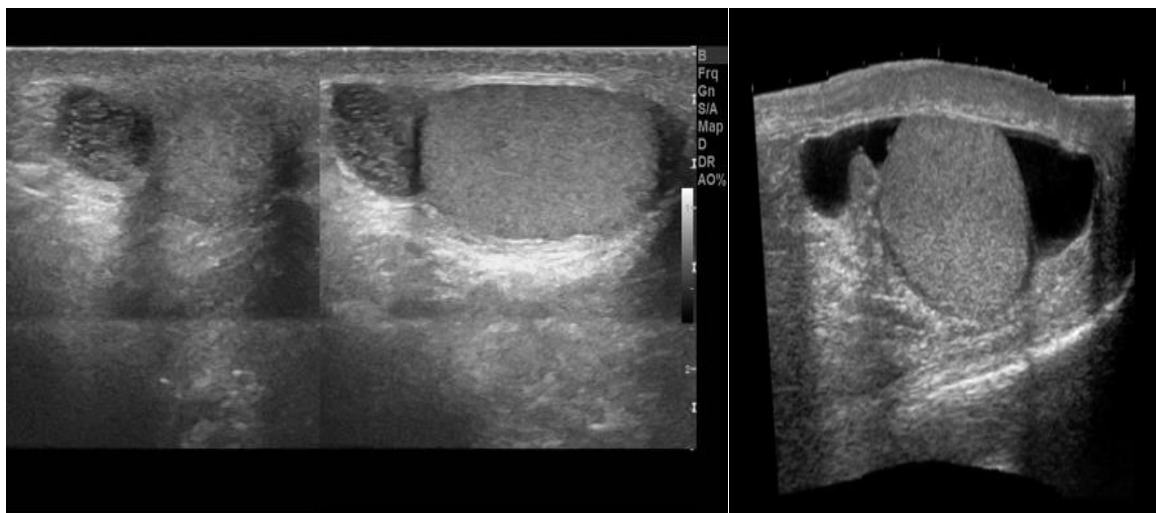
Torsion typically affects boys just before puberty. Occasionally, the torted appendage can be seen or felt (blue dot sign), however scrotal oedema sometimes prevents this from being clinically evident, which causes diagnostic

uncertainty and then an ultrasound may be requested.

The main point is that it is managed conservatively, not operatively, so do not call it if you are unsure, as this diagnosis will potentially preclude a child being taken to theatre!

What does it look like?

- Appendage visible and spherical in shape
- No internal vascularity (although this may be technically difficult to elicit anyway)
- Frequently accompanied by hydrocele and scrotal wall thickening.



Two examples of torsion of the testicular appendage. Note the accompanying hydrocele and scrotal wall thickening on the right image

Scrotal Trauma

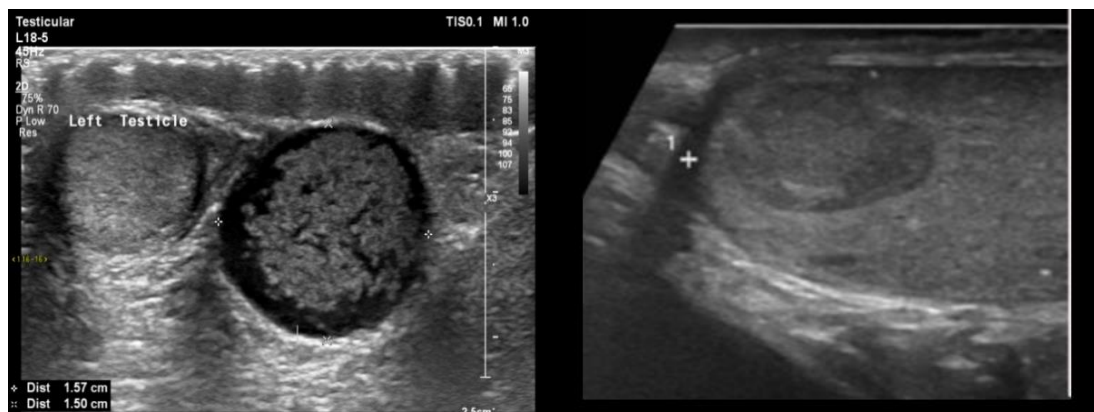
This is not seen commonly, so won't be covered in much detail. Clinical history is very helpful here, but this is sometimes difficult with children. However, trauma can cause serious complications such as testicular rupture and ischaemia/infarction.

What does it look like?

Rupture: Haematocoele usually present. Look for disrupted tunica albuginea (smooth echogenic line around the testis)

Testicular ischaemia/infarct: Heterogeneous testis and features similar to torsion (see above)

Haematoma: These are iso/hyperechoic initially and become hypoechoic as they resolve. Importantly there is no internal vascularity, to distinguish it from a testicular neoplasm. All of these will need follow up imaging to assess for resolution!



Left image: Haematoma separate to the left testis. Heterogenous appearance with no internal vascularity. There was no history of trauma so this was removed due to diagnostic uncertainty and was a pathology proven haematoma.

Right image: Another haematoma, which without Doppler imaging looks identical to a neoplasm. All these patients should receive follow up imaging.

Hernia

Inguinal hernias in children are almost always indirect and due to a patent processus vaginalis. They are more common in boys on the right side and in premature infants. Reducible hernias do not need urgent imaging. However out-of-hours there is often the question about irreducible hernia vs hydrocele or other scrotal pathology.

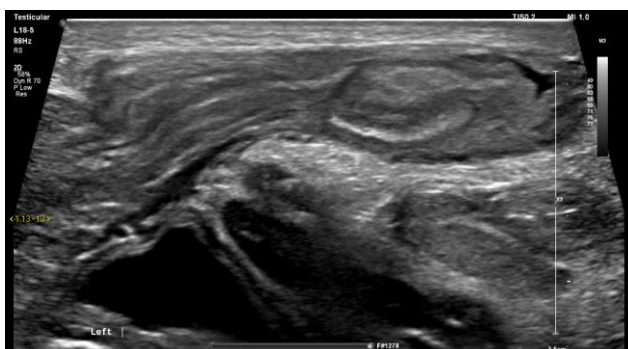
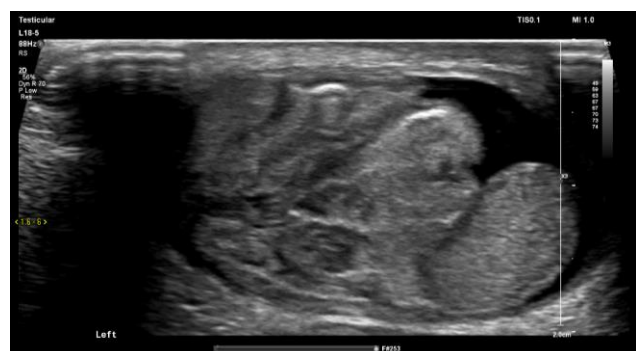
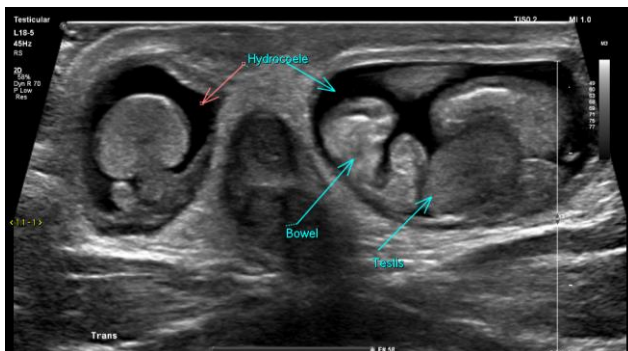
What to look for?

- Use 12-5 linear or 18-4 if small child
- Start with a full testes ultrasound as normal
- Then scan along the spermatic cord from testis to the inguinal ring to assess for any extra tissue tracking along beside it. A hydrocele and a hernia can co-exist (both due to patent processus vaginalis), so always do this step even you see a hydrocele on initial scan
- Again, comparing sides is invaluable here



Hernias do not always contain bowel. An echogenic structure behaving like a hernia is likely a hernia containing omental fat.

Remember that hernias move with intra-abdominal pressure (unless completely irreducible). If a child is crying; look for movement of the hernia when they take a breath. If not; get them to cough or stand up/hold upright and look for movement that way



Bowel containing inguinoscrotal hernia
Top left: Trans mid view through scrotum
Top right: Long view through left hemiscrotum
Bottom left: long view including inguinal ring

Neck

Neck lumps in children are a very common indication for ultrasound. Usually, this can be done in hours, however it may be requested out of hours if significant clinical concern.

Cervical lymphadenitis

Acute lymphadenitis is essentially inflammation of the lymph nodes, which causes them to enlarge. This is common in childhood, is self-limiting and usually the result of a preceding upper respiratory infection.

Sometimes, this lymphadenitis is the result of a bacterial infection. This is usually treated in the first instance by antibiotics, but on occasion they fail to respond and as a result can form localised abscess and require an operative procedure.

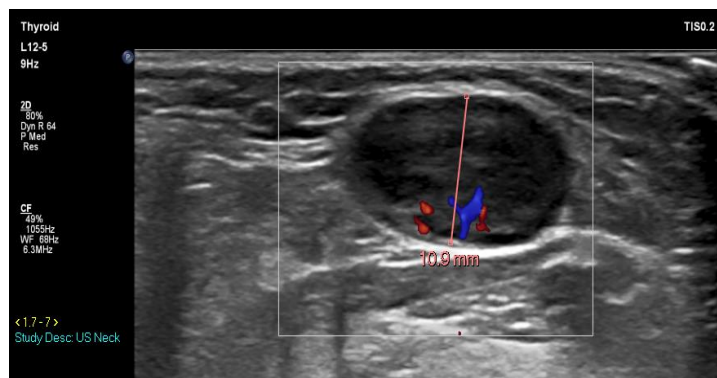
Therefore, the main question for ultrasound is whether there is evidence of suppurative (pus forming) lymphadenitis and whether this is associated with an abscess.

Technique

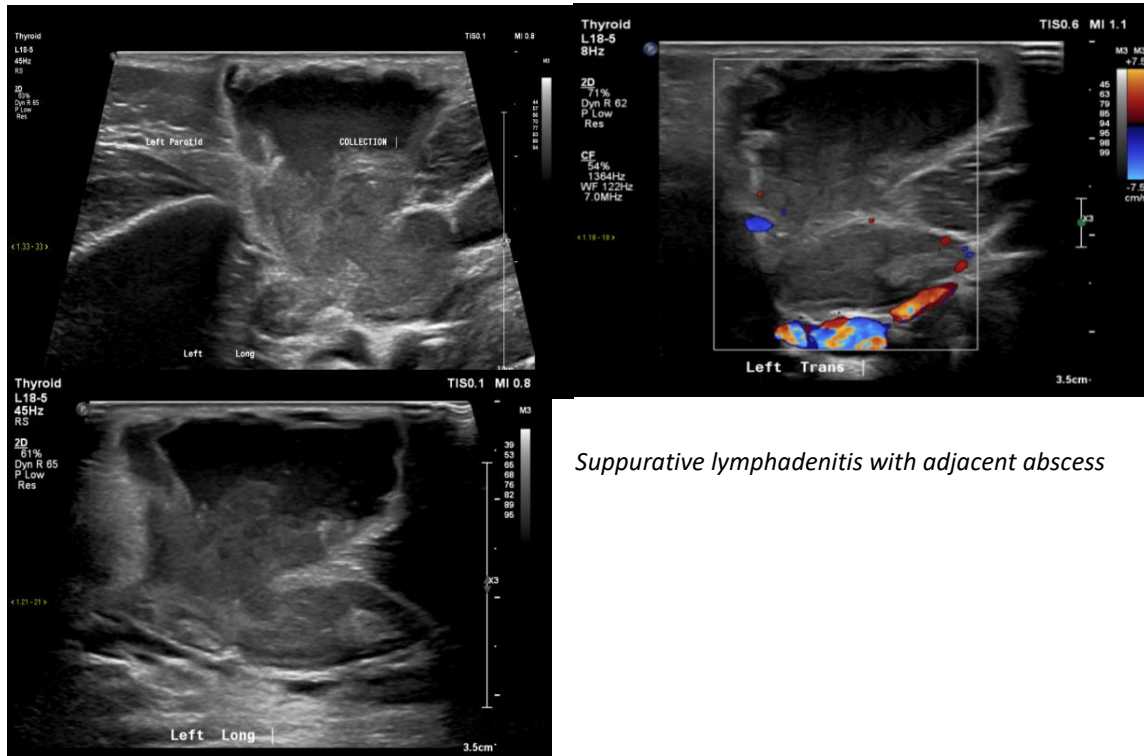
- Linear 12-5 or 18-5 probe
- If child is non-cooperative, try scanning with child on parents knee
- Put colour on to look for flow – abnormal lymph nodes may well have internal vascularity, but abscess will not
- Always image the whole neck to look for lymphadenopathy elsewhere and check IJV patency (remember Lemierre's syndrome – presence of IJV thrombus!)

What does it look like?

- Simple viral associated lymphadenitis will just look like enlarged lymph nodes. Usually these are multiple and on both sides of neck, with normal lymph node architecture.



- Liquefaction/pus within the lymph node causes it to lose its' normal architecture. Look for loss of internal vascularity, heterogeneous appearance/debris within it, cortical disruption and associated abscess.

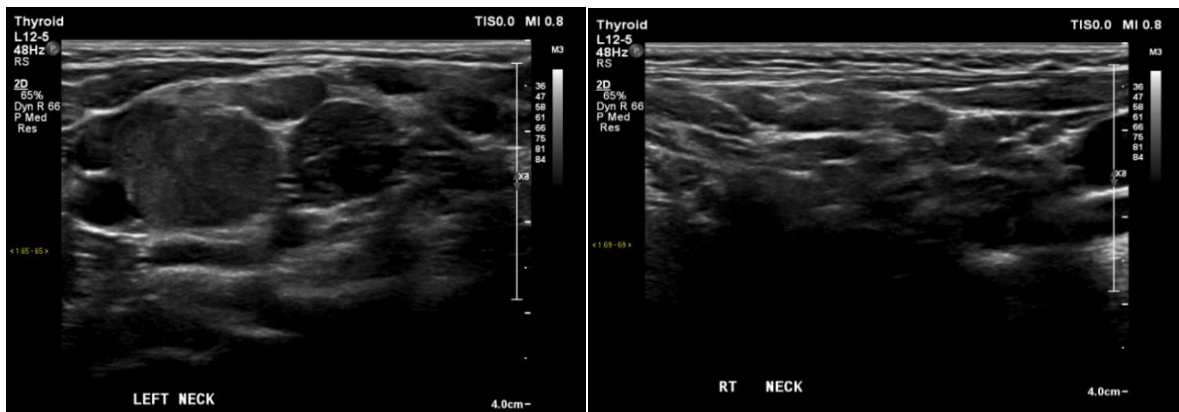


Suppurative lymphadenitis with adjacent abscess



Remember that the jugulodigastric node can be up to (approx.) 1cm and this is normal.

Malignancy can present in children as cervical lymphadenopathy (e.g. lymphoma), so the imaging findings must be taken into clinical context and follow up if not responding to expected clinical course.



This is malignant lymphadenopathy from neuroblastoma. Note the normal appearing nodes in the right neck and abnormal nodes on the left, demonstrating the importance of comparison.

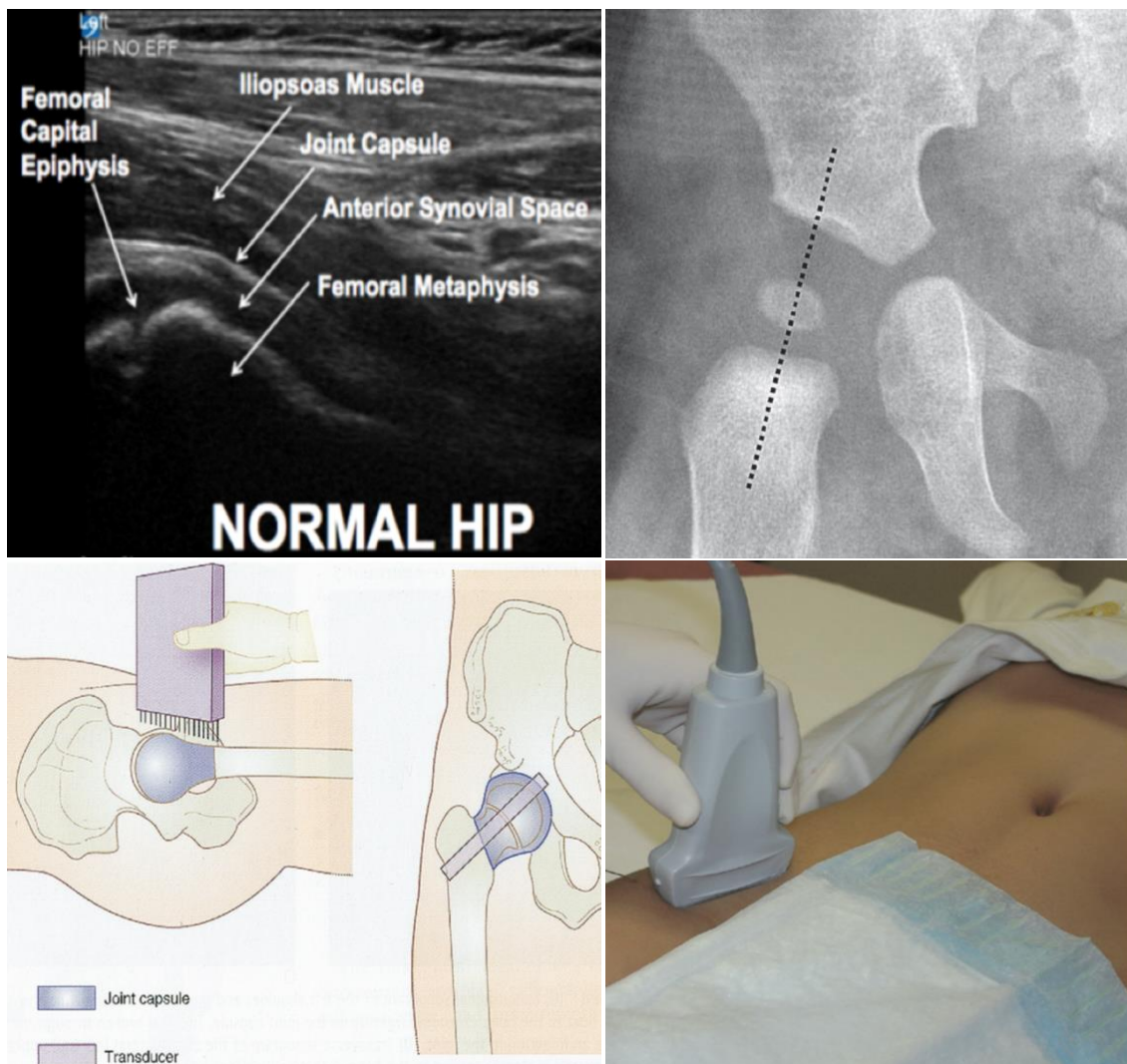
MSK

There are very few scenarios requiring MSK ultrasounds out of hours, but one that may come up is imaging of the hip in the context of a limping child.

Hip

Transient synovitis is the commonest cause of a limping child – typically 2-8yrs old.

The presence of an effusion cannot exclude septic arthritis but US as part of an extended clinical examination may be helpful in determining whether the joint requires aspiration.



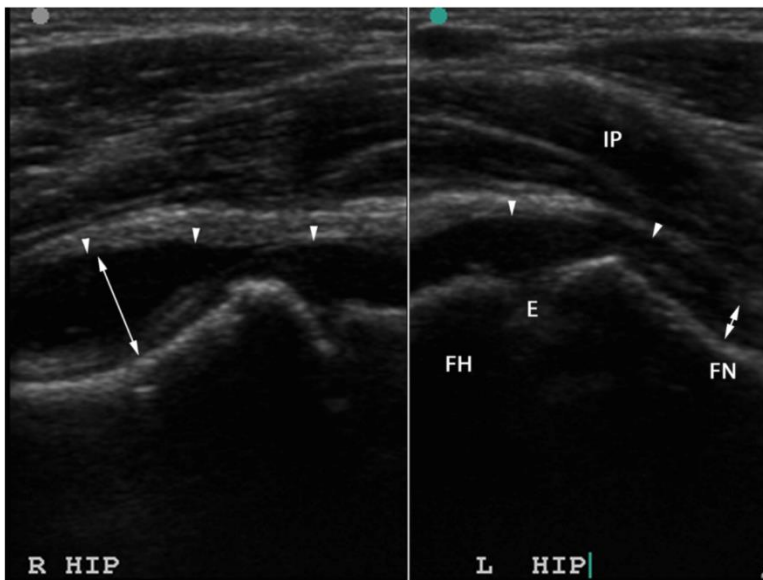
Technique

- Linear 12-5 probe on MSK gen setting
- See images on previous page for probe position
- Always compare both hips and use dual screen if possible
- Have a look around the adjacent soft tissues to make sure you aren't missing an abscess or obvious soft tissue abnormality nearby

What does it look like?

Criteria for a pediatric hip effusion is:

- A capsular-synovial thickness of 5 mm measured at the concavity of the femoral neck, from the anterior surface of the femoral neck to the posterior surface of the iliopsoas muscle
- OR a 2-mm difference compared to the asymptomatic contralateral hip



Right hip effusion, normal left hip, arrow heads – joint capsule, IP – iliopsoas

Helpful Tips

Be aware that the normal synovium is hypoechoic, as you can see in the above picture, this does not mean it is fluid. Cartilaginous (non-ossified) portions of the bone are hypoechoic and NOT focal abscess.

Look for the bulge in the anterior capsule, which suggests underlying fluid and a size discrepancy when compared with the other side.

Final thoughts

We hope you find this handbook useful while on call and even use it for paediatric rotations.

Remember, be methodical and always ask for help when needed.

If you would like to share your opinion of this guide, particularly suggestions for improvement or corrections please contact the BSPR at BSPR.office@gmail.com

GOOD LUCK



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