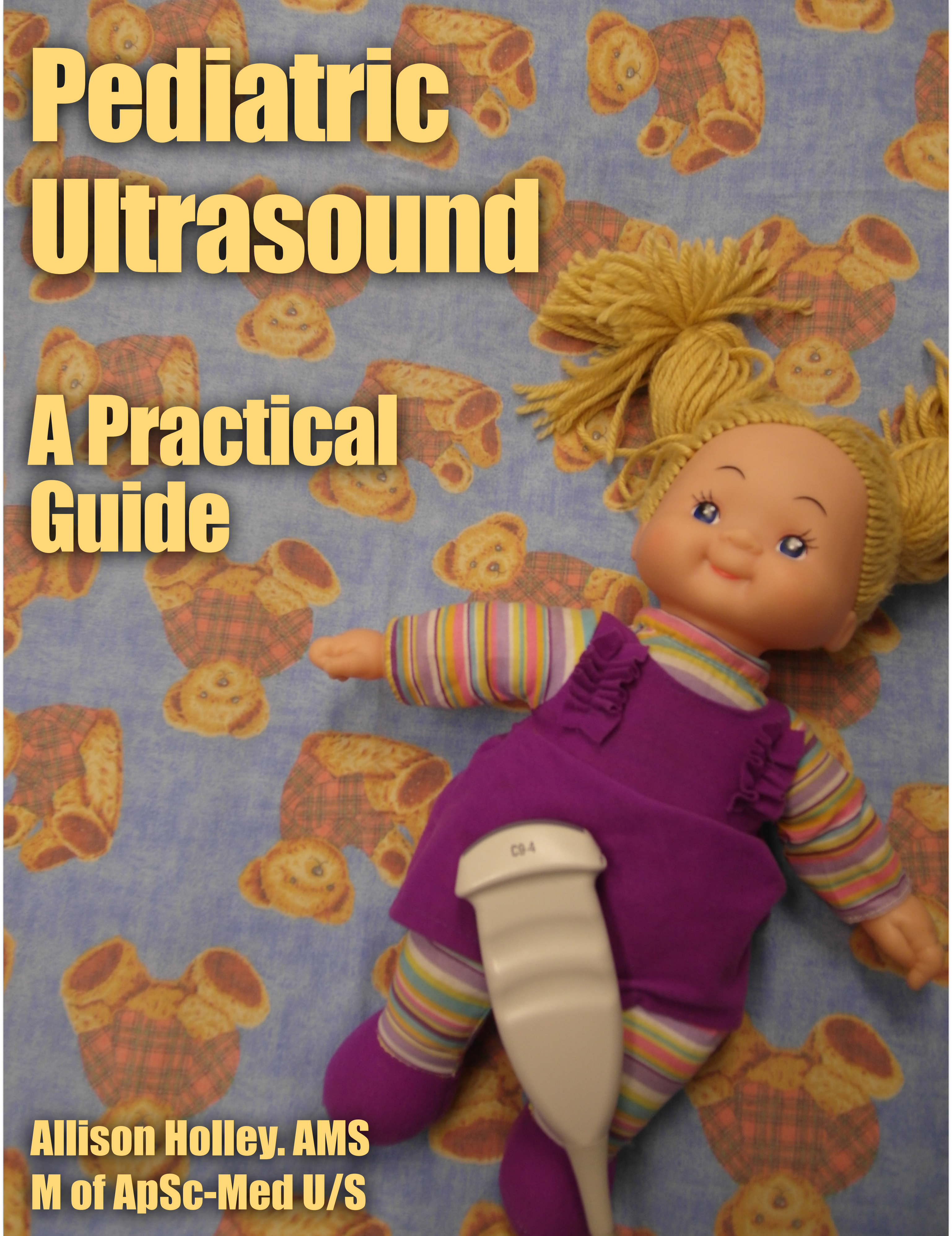
# Pediatric Ultrasound

## A Practical Guide

Allison Holley. AMS
M of ApSc-Med U/S



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pediatric_ultrasound@yahoo.com.au

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This book is intended for use as a medical educational tool and not as a basis for diagnosis or treatment. Every effort has been made to provide accurate and up to date information that complies with current best practice at the time of publication. The publisher and author assume no responsibility for any diagnosis or treatment undertaken on the basis of this product.

# Preface

With pediatric ultrasonography continuing to progress towards a subspecialty, the need for amalgamation of the available information and resources becomes apparent. This book is the second edition of a handbook that was written by a sonographer, for sonographers, using a quick, easy access, reference format. It gives a concise review of ultrasound examination technique for pediatric patients and it is hoped to be of value to sonographers of all levels of experience.

The content of the handbook has been drawn both from clinical experience in a pediatric ultrasound department and a comprehensive literature review. The literature review has been included to enable discussion of ideas and access to further reading on the topics. The information is presented in point form under appropriate headings. Each type of ultrasound examination creates a new chapter and gives patient preparation for various age groups, contraindications, equipment and organs examined for that particular procedure. Each chapter will provide scanning technique and for specific pathology examinations e.g. pyloric stenosis, descriptions of the ultrasonic features of that pathology. Examples of normal measurements and the correct level for taking these measurements are also included.

Each chapter contains a series of ultrasound images giving examples of a film series for that type of examination and demonstrating specific anatomy, or scan planes through a particular organ. Accompanying every ultrasound image is a corresponding line drawing which labels anatomy and identifies relevant pathology or ultrasound specific landmarks. These drawings have been included to help sonographers gain a better understanding of the ultrasound image they are viewing and enable a more informed interpretation of the dynamic examination when viewed in real time.

For the experienced sonographer in a non-pediatric department, the book aims to provide a quick reference to information not often used e.g. the appropriate patient preparation for a specific age group, or a reminder of measurement criteria for diagnosing pathology. For the remote or solo sonographer, the aim is to provide backup, giving examples of images of examination specific pathologies, and the measurements or criteria for diagnosing the pathology. The student sonographer will find the basics have been described, from which probe to use, to the overall scanning technique.

There are many ultrasound pathology books on the market, this is not one of them. This book is about ultrasound technique and producing diagnostically responsible images; not diagnosis.

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Chapter 1

# Dealing with the pediatric patient and their parents

Sonography is an ideal way to examine pediatric patients as it is painless, has no known risks, and there are no injections or ionizing radiation. Nevertheless, a visit to an ultrasound department can be a traumatic experience for both the child and their parents. A combination of factors must be taken into account to minimize the anxiety of the child and their family (1,2).

Section 1

# Dealing with the pediatric patient and their parents

**P**reparation
**E**nvironment
**D**arkness
**I**nformation
**A**nxiety
**T**oys
**R**ewards
**I**nitiative
**C**ontrol
**S**peed

## Introduction

Sonography is an ideal way to examine pediatric patients as it is painless, has no known risks, and there are no injections or ionizing radiation. Nevertheless, a visit to an ultrasound department can be a traumatic experience for both the child and their parents. A combination of factors must be taken into account to minimize the anxiety of the child and their family (1,2).

Ideally, the best results are achieved with a cooperative patient and it is to the sonographer's benefit to work towards achieving this. Sonographers working with children must develop the art of blending gentleness and understanding with the firmness that is required to achieve the optimum images (2). There is no single answer or simple solution as each child responds differently to the situation and a combination of several techniques may be needed for any one patient.

There are a variety of things to consider when deciding the best approach to your pediatric patient. These are summarized in the acronym “pediatrics”.

## Preparation

Children have a very short attention span and even the best of children will only cooperate for a short period of time. So that the best behavioral time is used for scanning the patient, the ultrasound room should be fully prepared to receive the child before the child actually enters the room. The patient details should be entered, the application chosen and the transducer activated. The request should have already been read and previous films reviewed. The sonographer at this stage should have a basic plan of the examination in their head ready to make active. Any available pediatric aids should be placed within arms reach. The sonographer’s total undivided attention should be devoted to the child on their arrival.

## Environment.

Ideally, the ultrasound room should be brightly colored with lots of pictures on the walls and ceiling. The pictures should be age appropriate with objects or characters that children instantly recognize. The examination table and ultrasound equipment can look frightening with all their mechanical parts. Try disguising this with brightly colored linen. Separating the parents from the child due to a lack of space or room setup should be avoided as it raises both patient and parental anxiety. The room setup should include a centrally located examination table to allow the parents to sit next to the child and assist by holding their hand or talking to them throughout the examination.The room should not only be child friendly; but child safe. Ensure the hazard waste container and any interventional equipment is stored safely and out of the child’s reach.

## Darkness.

Many children are afraid of the dark so turning the lights down should be minimized. The room should be as well lit as is practical to scan in so that the child does not enter a dark room. The light level should be set before the child enters the room. Sonographers habitually work in semi lit rooms but this is not necessary and lighter rooms do not affect the images nor the sonographer’s ability to view and interpret them. If light levels are not adjustable, consider using a lamp angled to the ceiling as a nightlight.

## Information.

Spend a couple of minutes gaining the child's confidence. Children are less afraid if they know what to expect and in the older age group, what is expected of them. Conversations should always start with a neutral and non-threatening topic, such as the child's toy, the clothes they are wearing or their favorite TV shows. Using the child's responses, gradually expand the conversation to what you are going to do (3). Relate the scan procedure to things familiar to the child such as the monitor being similar to a TV and the machine being like a big computer. Provide as much information to both parents and patient as possible. Attempt to answer any questions as directly as you can. If departmental policy does not allow discussion of findings, explain this at the beginning and offer to make someone available to them who is able to discuss the findings. Unfortunately, this policy may give the impression that something is being hidden, and parents may assume the worst causing great stress over what is often a normal result.

## Anxiety.

It is important to remember that parents may be anxious about their child's illness or the results of the examination. On arrival, the initial greeting should be relaxed and friendly. A smile goes a long way towards establishing a relationship and reducing both the patient and parents anxiety. Invite the parents to stay with the child during the examination and to play an active role in gaining the child’s cooperation during the examination. Encourage the parents,

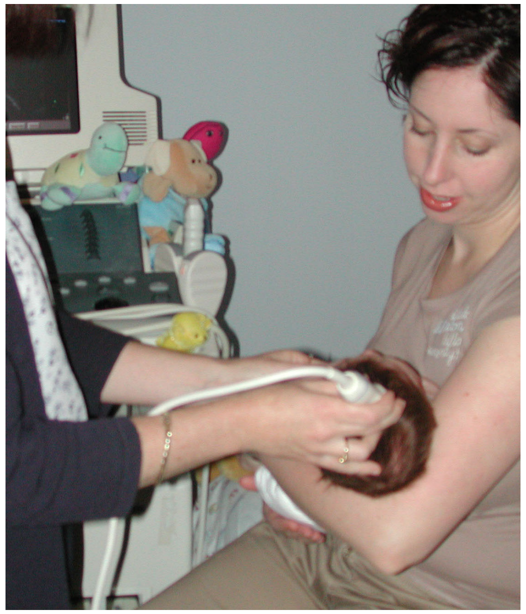
or accompanying adult, to talk the child through the examination. Reassure the child that they are 'OK' and that everything is alright. Make allowances for stress and peoples behaviors and reactions.

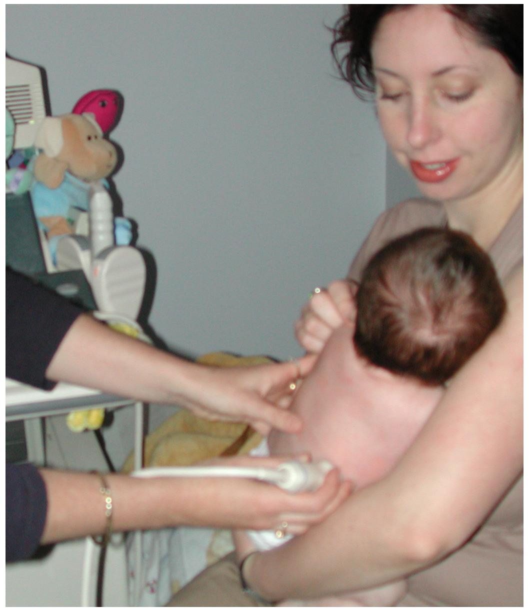
## Toys.

During the examination the child's ability to hold still for a significant amount of time varies according to the age group and the individual. To overcome this, keep the child distracted and entertained with a variety of age appropriate toys, musical devices, and images. Encourage the parent to actively engage the child to elongate cooperation.

## Rewards.

For the older child, offer a reward for remaining still and cooperating. Give a sticker or certificate for being brave which they can take to school or show their friends. Parents will often expand on this technique by offering the child's favorite food or a special treat at the end of the examination. At the end of the examination congratulate the child on being so good. Reinforce that there was nothing to be scared of and that next time they will know all about ultrasound and they can be brave. Always provide any rewards that were promised during the examination by way of a sticker on their top or a certificate with their name on it to take to school. See the child off and wave good bye as they leave the department.





## Initiative

Sonographers will often need to use their initiative to capture the required images. If the child is becoming distressed stop scanning and allow the child to be comforted and cuddled by the parents for a few minutes until they settle; then try again. If the child is distraught and unable to be settled the sonographer may need to adapt to the situation by allowing the child to stand or sit on the table if they wish. A cuddle from a parent can be useful and allows access to the child's back. Access to the child's abdomen and chest can be obtained with a parent sitting on the examination table nursing the child on their lap. The same position, but with the parent standing, will allow access to the child's pelvis and for cranial work the infant may be nursed with the baby's head stabilized by the parent's arm.

## Control

Allow the child to feel involved and in control of what is happening. Always address the child directly and by name. Do not speak across the child to the parents as if the child was not there. Always explain what you are about to do to the child in age appropriate language and then ask permission to do it. Any further explanation should be addressed to the parents. Use positive reinforcement throughout the examination. Allow the child to put the gel on their own skin and offer to let them feel the probe with their hand so they know it does not hurt and that they won't feel anything. Let them be the first to smear the gel around on their skin and always use warm gel so the child does not become distressed by the cold gel.

## Speed

Even with the most cooperative of children the sonographer will only have a small window of opportunity to gain the necessary images for the diagnosis. Use this time efficiently, work as quickly as practical to gain the require information and stop when necessary to attempt to gain further cooperation with a different approach.

Working with pediatric patients is very demanding but it can also be very rewarding. Gaining the child's confidence and letting them feel that they have some control over what is happening goes a long way towards achieving a cooperative patient and obtaining optimum images. Irrespective of how the child behaves or the parents respond, the sonographer must always maintain a friendly and optimistic demeanor and provide an efficient, professional service.

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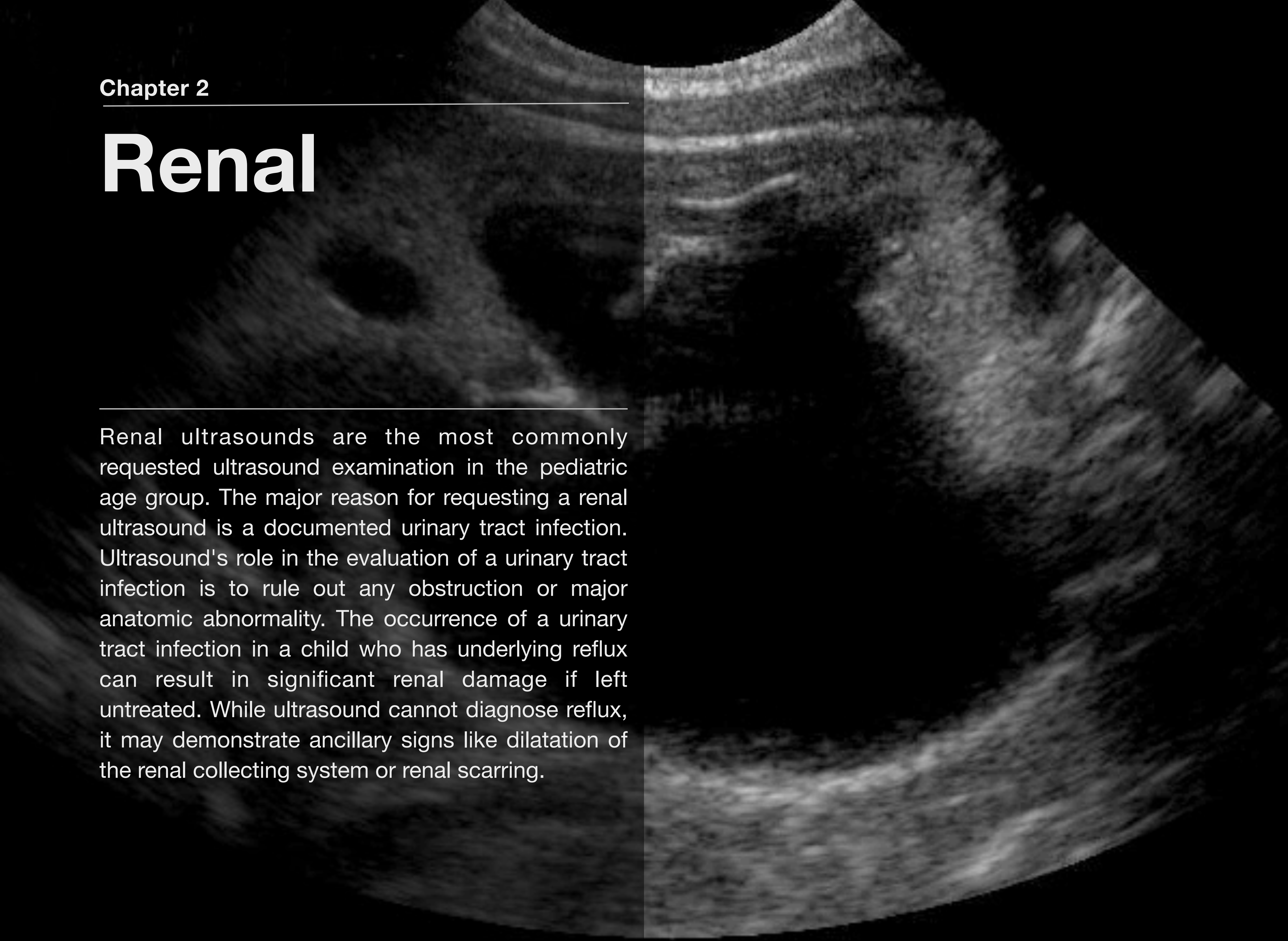


Chapter 2

# Renal

Renal ultrasounds are the most commonly requested ultrasound examination in the pediatric age group. The major reason for requesting a renal ultrasound is a documented urinary tract infection. Ultrasound's role in the evaluation of a urinary tract infection is to rule out any obstruction or major anatomic abnormality. The occurrence of a urinary tract infection in a child who has underlying reflux can result in significant renal damage if left untreated. While ultrasound cannot diagnose reflux, it may demonstrate ancillary signs like dilatation of the renal collecting system or renal scarring.

# Scanning Technique: Renal

**Other Names:** Kidneys and bladder, Kidneys/ureters /bladder (KUB).

**Preparation:**

- Children under 2 years:
  Feed normally and encourage child to drink extra fluid in the hour prior to the examination.
- Children between 2 - 8 years:
  Child to drink 2 glasses of any fluid (not milk) in the hour before the examination and if possible, the child should not empty the bladder in this hour.
- Children over 8 years:
  Child to drink 3 glasses of any fluid (not milk) in the hour prior to the examination and if possible, the child should not empty the bladder in this hour.

**Contraindication**: Nil

**Equipment:**
**Probes:**

- Use probes with good penetration and resolution.
- Recommended frequency
  Sector/curved linear 9-4 MHz for neonates/children
  Sector/curved linear 5-2 MHz for older children
  Linear 17-5 MHz for trauma (subcapsular),
  for urachal remnants

**Organs covered by procedure:**

- Right kidney and adrenal
- Left kidney and adrenal
- Both pelviureteric junctions (PUJ)
- Both vesicoureteral junctions (VUJ)
- Bladder
- Ureters - if dilated
- Space of Retzius - urachal anomalies

**Scanning Technique:**
**Reason for preparation;**
The children are given fluid to fill their bladder to aid visualization of the distal ureters and ureteric jets, to detect ureteroceles and to establish residual bladder volumes. The bladder does not have to be full. Care is needed as bladder distention and increased urine outflow due to over hydration can result in a false positive diagnosis of hydronephrosis. (1)

**NOTE: Antenatally diagnosed hydronephrosis**
Infants referred for postnatal follow-up of antenatally diagnosed severe hydronephrosis should be examined as soon as possible after birth. This reduces the risk of renal damage and allows for surgical intervention if required. If the hydronephrosis was noted to be mild or moderate antenatally then the follow-up scan should be delayed for at least three days in order to allow the infant to be hydrated adequately. Neonates may be dehydrated due to relative oliguria in the first few days after birth and this may cause mild or moderate degrees of hydronephrosis to be missed. (2,3,4)

**Patient Position:**

- The child is placed supine to start the examination and the bladder is examined first.
- The child is then rolled into a decubitus position with the side of interest raised to examine each kidney in turn.

**Technique:**

- Adjust the time gain compensation(TGC) to provide a homogenous texture through the liver.
- In neonates and infants the bladder is scanned first as the pressure of the probe on the abdomen and the removal of the baby's clothes often causes spontaneous voiding. In older children the bladder is examined first and then the child asked to void before scanning the kidneys. This results in a more cooperative patient who is not uncomfortable with a distended bladder.
- Commence scanning the bladder in a longitudinal plane in the midline and scan to the right and left of midline to examine the whole organ. Look for distended ureters situated posterior to the bladder. *Image 4.1*
- Rotate the probe 90$^{o}$ into a transverse plane and scan the bladder from inferior to superior. Examine posterior to the bladder for dilated ureters and examine the cranial aspect of the anterior bladder wall for indication of a urachal remnant *Image 4.2.*

- Examine the trigone of the bladder with power Doppler to visualize ureteric jets entering the bladder with peristalsis. Document the patency of the ureters.
- The child is asked to void, or those with neurogenic bladders to catheterize themselves, to obtain an empty bladder. They are then rescanned to assess the bladder residual volume in longitudinal and transverse planes.
- For neonates and infants, if spontaneous emptying of bladder does not occur continue on to examine the kidneys. Make a note that the kidneys were not scanned post void so that misinterpretation of images does not occur.
- Coronal, longitudinal and transverse scanning of the kidney is recommended to adequately examine the renal parenchyma and collecting systems.
- These planes can be achieved with the patient in supine, prone or lateral decubitus positions. If achievable, the lateral decubitus position is best as it allows access to coronal, transverse and both the anterior and posterior longitudinal windows without disturbing the child.
- Raise the right side into a lateral decubitus position to scan the right kidney.
- Scan the kidney in a longitudinal plane along its long axis. Angle the probe from medial through to lateral; use both the anterior and posterior windows. If the anterior approach is obscured by gas, the posterior approach can be very useful due to a lack of lumbar musculature in children. *Image 4.3*
- From a coronal plane on the right flank, rescan through the long axis of the kidney angling from anterior to posterior. *Image 4.4*
- If the upper and lower poles of the kidney cannot be shown in the one image due to rib shadows, examine the upper and lower poles of the kidney separately making sure the entire organ is evaluated.
- Scan the kidney in a transverse section. Use both lateral flank and anterior approaches. Angle the probe from inferior to superior through the kidney. *Image 4.5*
- Raise the child's left side into a lateral decubitus position.
- Examine the left kidney as for the right kidney using all 3 planes where possible.
- For neonates and infants who had not spontaneously voided previously, recheck their bladder and if micturition has occurred, assess residual volume.

**Optional views**

1 Renal Mass - malignant / benign

- Using color Doppler, examine the mass to establish the degree of vascularity. Locate the main feeding vessels where possible as this will aid in surgical resection if required.
- Examine the aorta, inferior vena cava, renal veins and right atrium (where possible) for invasion or extrinsic compression due to the mass. Check for evidence of compromised blood flow or echogenic tumor / thrombus in the vein lumen. Differentiation between tumor extension into the inferior vena cava and tumor compression around the inferior vena cava may help differentiate between a Wilm's tumor (intrarenal) and a neuroblastoma (extrarenal). These are the two most common abdominal pediatric masses.
- Examine the liver for metastatic spread to aid in staging if the mass is malignant.
- Observe the mass with quiet respiration to determine if the mass moves with respiration or is fixed. Movement of the mass relative to the organ should also be assessed.

2 Renal trauma

- Examine the affected kidney with color Doppler or power Doppler. Move the color Doppler sample box across the entire kidney to check for presence of blood flow. Scan the adjacent liver or spleen for blood flow or evidence of trauma.
- Use a linear probe to image the superficial subcapsular region of the kidney to obtain better definition of small collections or hematomas.
- Scan using a sector or curved linear probe and examine Morrison’s pouch, right and left paracolic gutters, the rectovesical pouch in males and the pouch of Douglas in females for fluid collections.

3 Urachal anomalies

- Examine the cranial aspect of the anterior bladder wall for evidence of a urachal remnant. If a hypoechoic / anechoic area is identified, switch to a linear probe for better delineation and follow to the umbilicus in longitudinal and transverse.

**Variations in normal pediatric renal anatomy**

1. The ultrasonic appearance of neonatal and older children's kidneys may vary dramatically. The normal kidney of a newborn has an echogenic renal cortex equal to that of the liver and often demonstrates prominent hypoechoic renal pyramids with a lack of echogenicity in the renal sinus. These neonatal features are present until approximately six months of age. *Image 4.6* The kidney gradually changes to present the features of an adult kidney by approximately 10 years of age (4,5,6,7).

2. Fetal lobulation indenting the renal cortex may often be seen, especially in the lower pole. It is a normal variation and the regularity and location between the pyramids differentiates these from focal renal scars which occur over the base of the pyramids.

3. The interrenicular junction may appear as an oblique echogenic line of hilar tissue, seen most frequently on the right kidney. It defines the linear remnants of interlobar grooves and should not be mistaken for renal scarring (4,8).

**Measurements: (***Diagram 4.0***)**
Evidence of changing renal size may precede changes in renal echotexture and provide an early indication of disease (9,11,12). There are several methods of monitoring renal growth but the most important feature is sustained growth along the same curve. Nomograms provide objective evidence of renal size and allow for normal variation. Comparing renal length to age is the easiest, most practical approach.

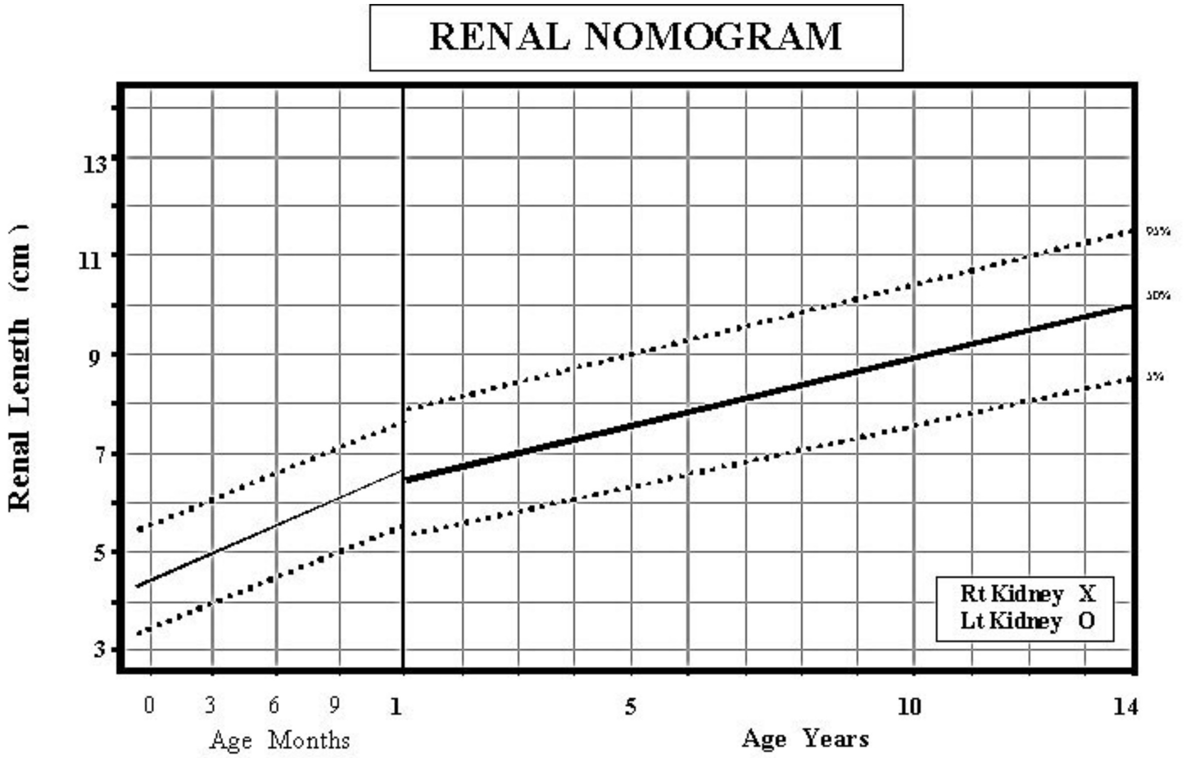
The entire kidney is usually best seen in the coronal plane. Take two measurements of the kidney in its longest plane. The largest measurement is plotted on the nomogram against the child's age.

To calculate a residual bladder volume
(Length x Breadth x Width x 0.5cc).

**Exam Documentation:**
Using the three scanning planes coronal, longitudinal and transverse, to achieve maximum information, a routine image series should include documentation of the following:

- Document the bladder in longitudinal and transverse.
- Demonstrate the distal ureters, vesicoureteral junction and ureteric jets entering the bladder in transverse.
- Calculate pre and post void bladder volumes where possible.
- Document both kidneys in longitudinal, coronal and transverse.
- Demonstrate the adrenals where appropriate.

**Diagram 4.0** Example of renal nomogram



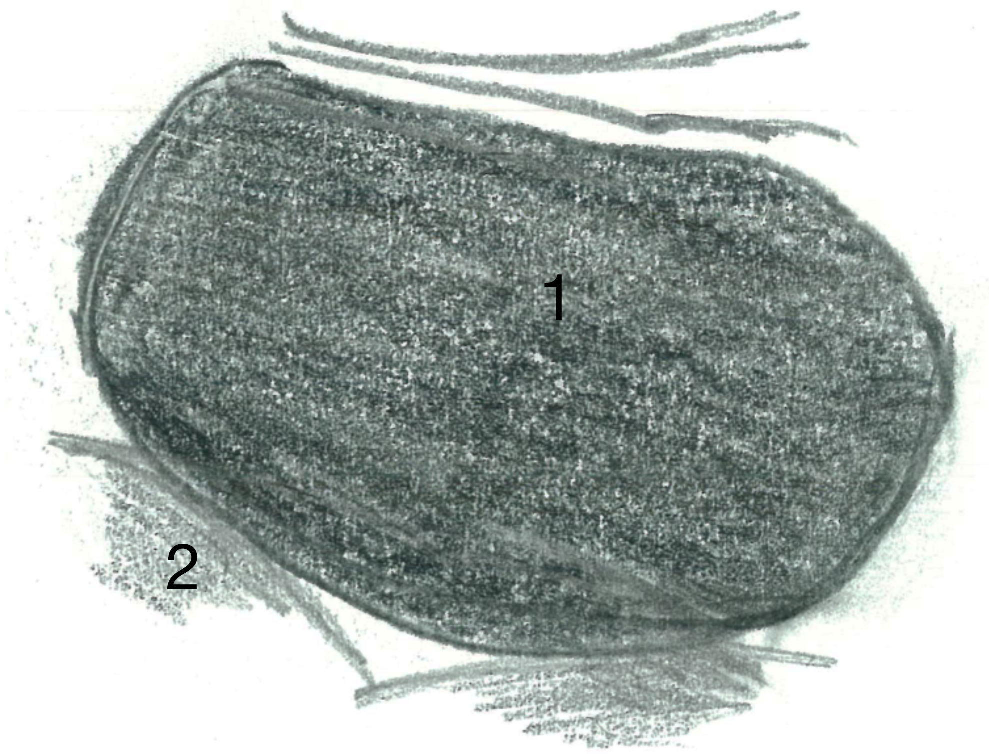

Extracted from . Han B K, Babcock D S. Sonography of kidneys in children. AJR 1985.145 611-616

This is an example of a nomogram used for monitoring renal size. (19)

To use-
Draw a vertical line through the child's age
Using a "X" and "O" to represent the Rt and Lt kidney respectively; mark the longest renal length for each kidney along the vertical line drawn through the child's age.

# Images and Line Drawings

**Diagram 4.1** Bladder - longitudinal




1. Bladder
2. Bowel gas

**Image 4.1** Bladder - longitudinal

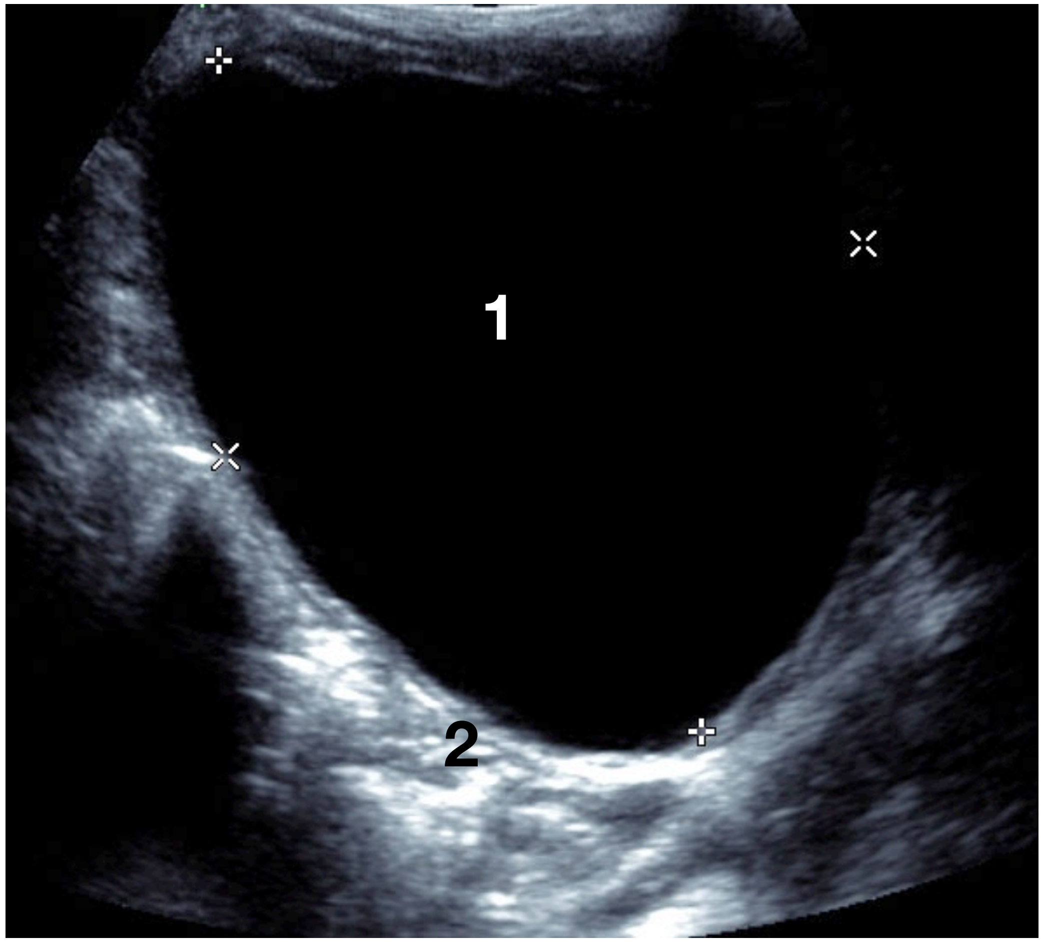
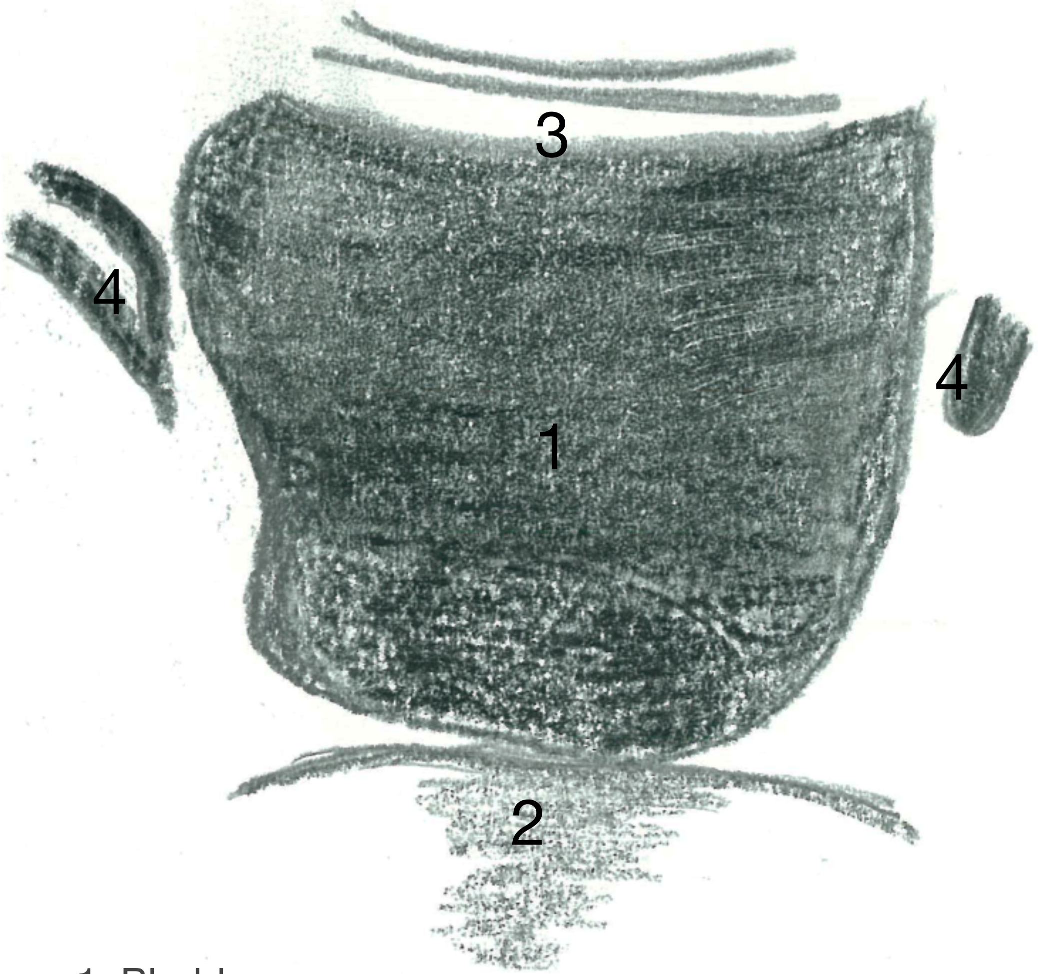


**Diagram 4.2** Bladder - transverse




1. Bladder

2. Bowel gas

3. Anterior bladder wall

4. Iliac vessels

**Image 4.2** Bladder - transverse

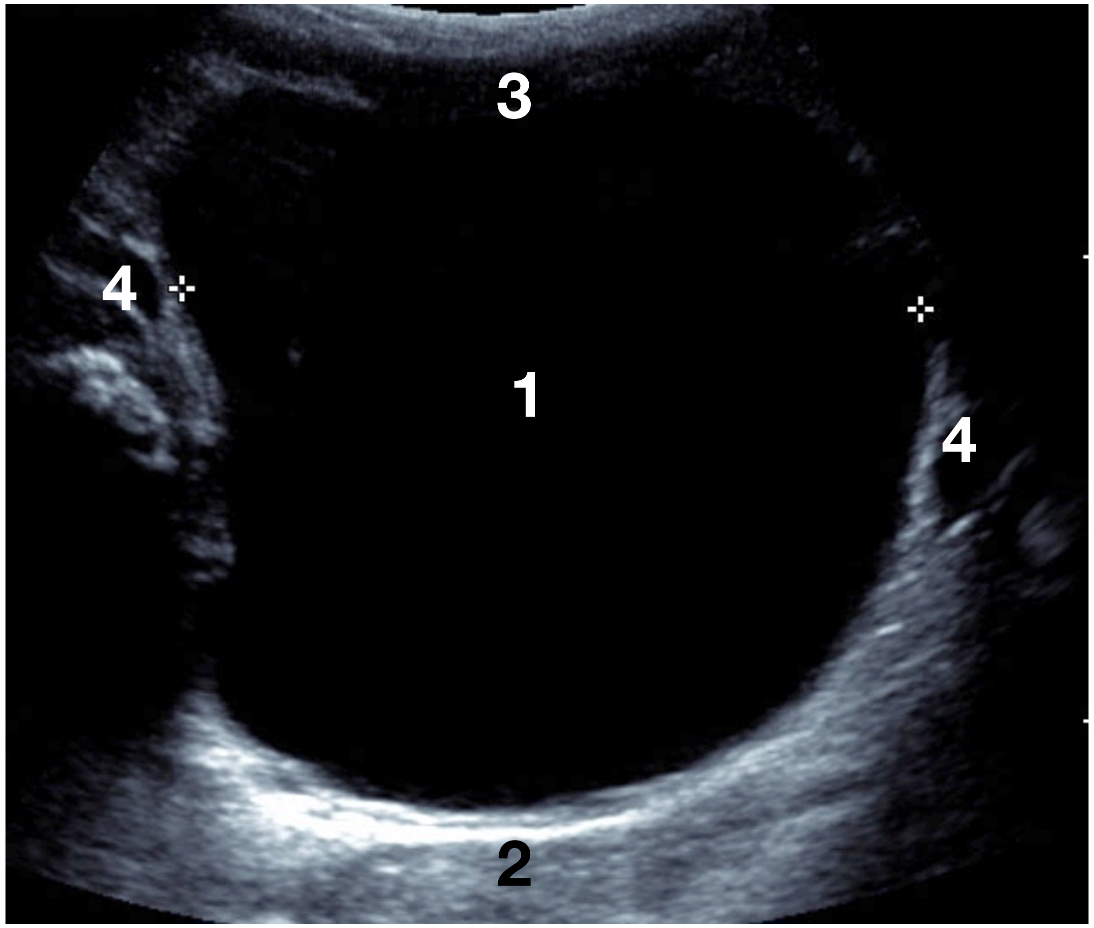


**Diagram 4.3** Longitudinal kidney

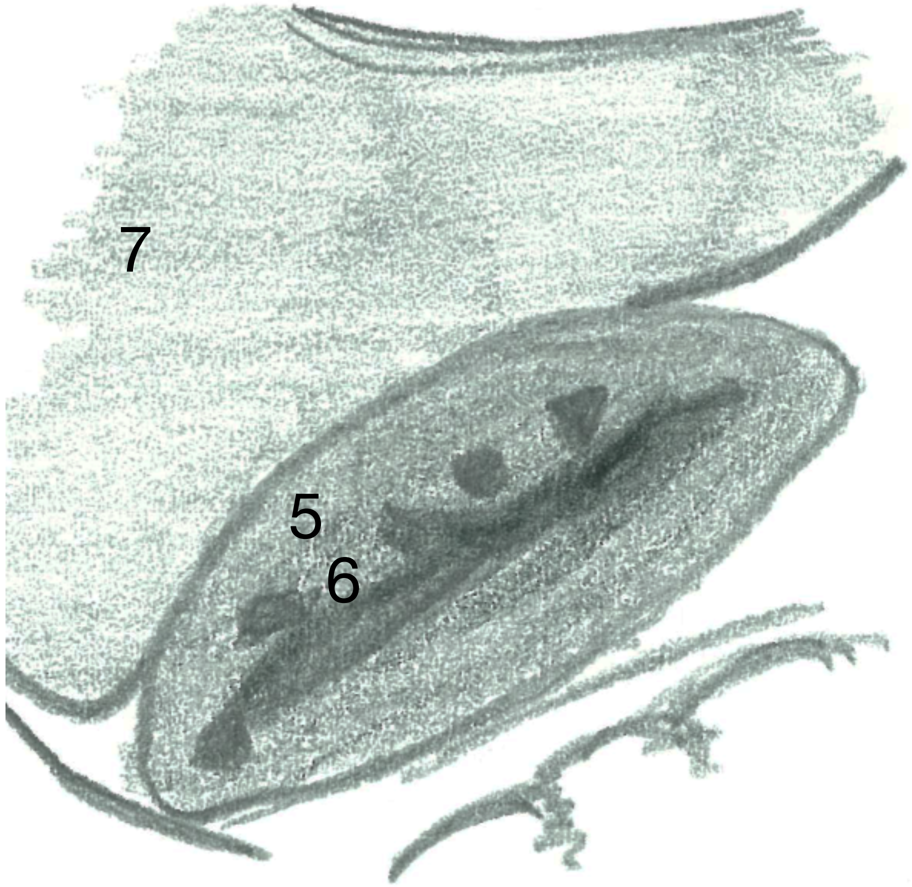
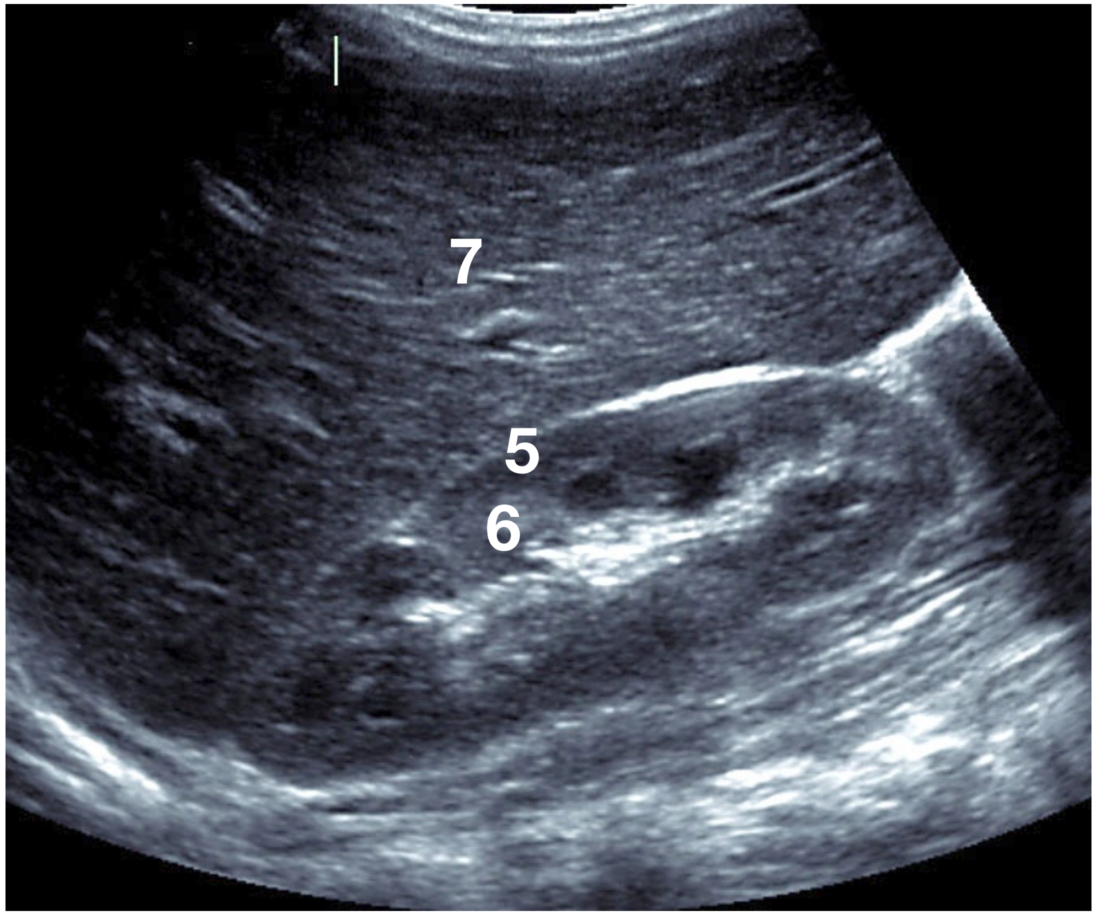



**Image 4.3** Longitudinal kidney

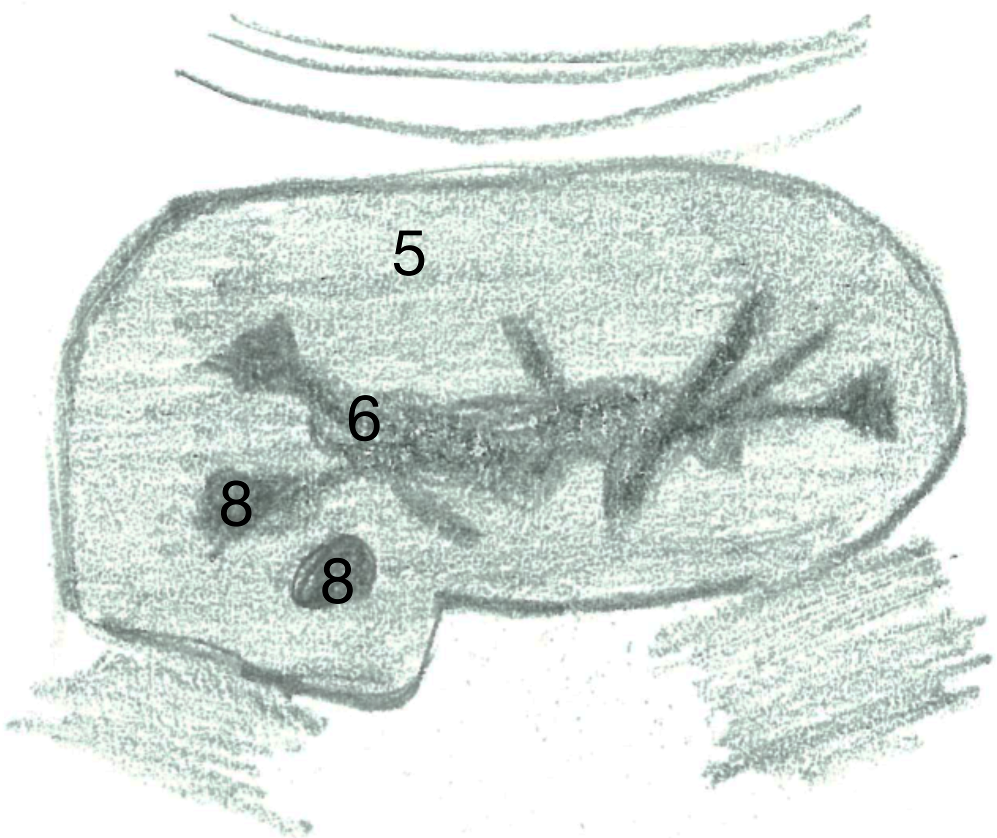



5. Renal cortex

6. Renal medulla

7. Liver

**Diagram 4.4** Coronal kidney




5. Renal cortex

6. Renal medulla

8. Renal pyramids

**Image 4.4** Coronal kidney

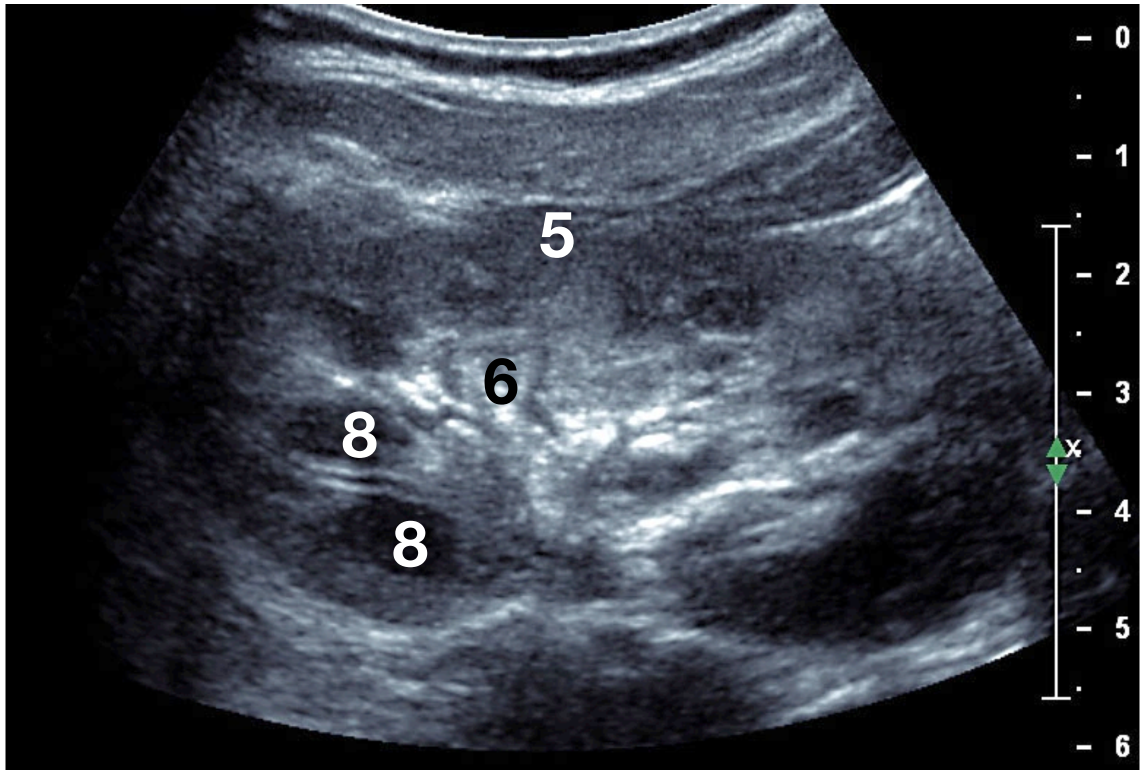
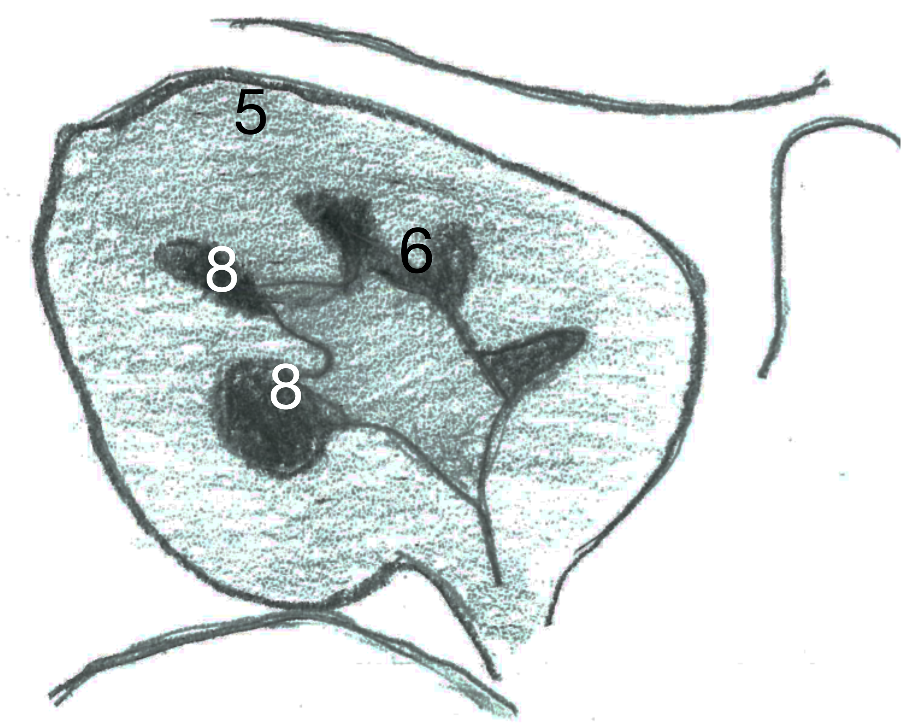


**Diagram 4.5** Kidney - transverse




5. Renal cortex

6. Renal medulla

8. Renal pyramids

**Image 4.5** Kidney - transverse

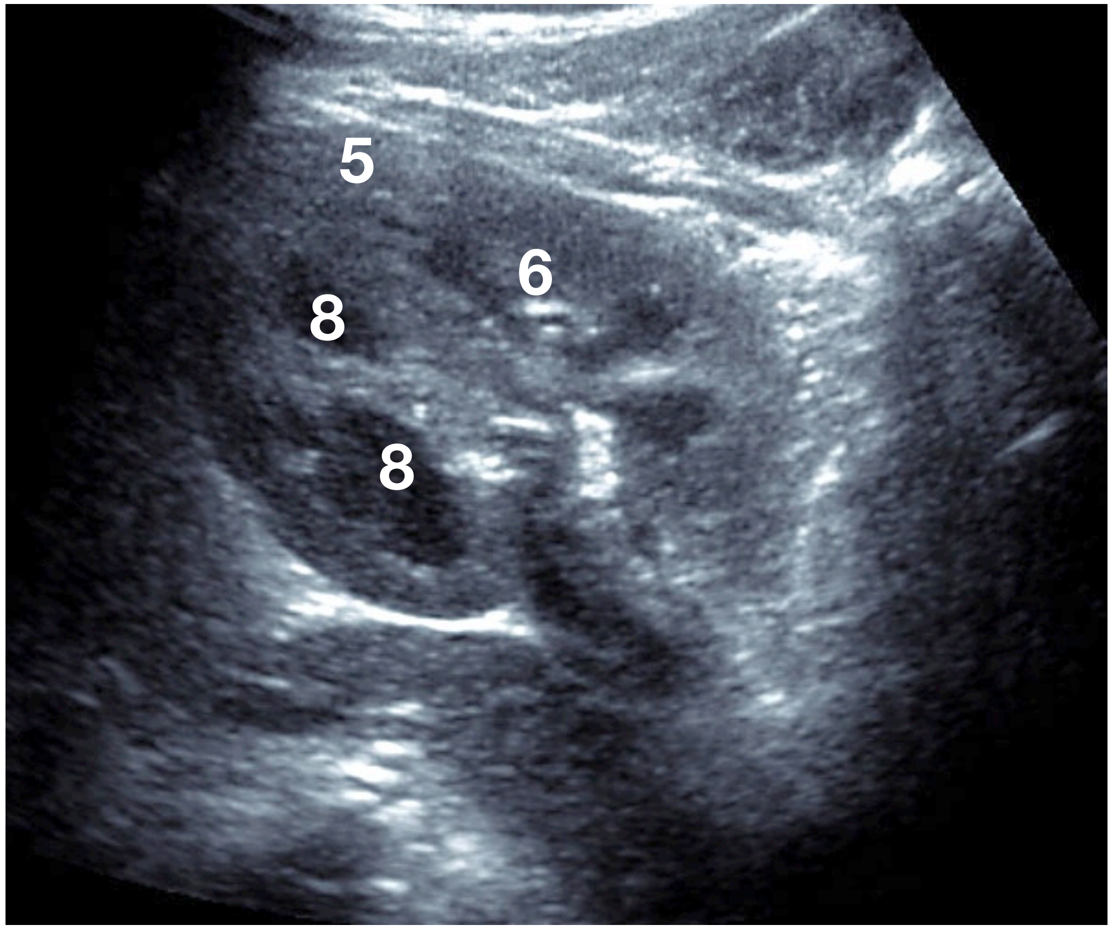
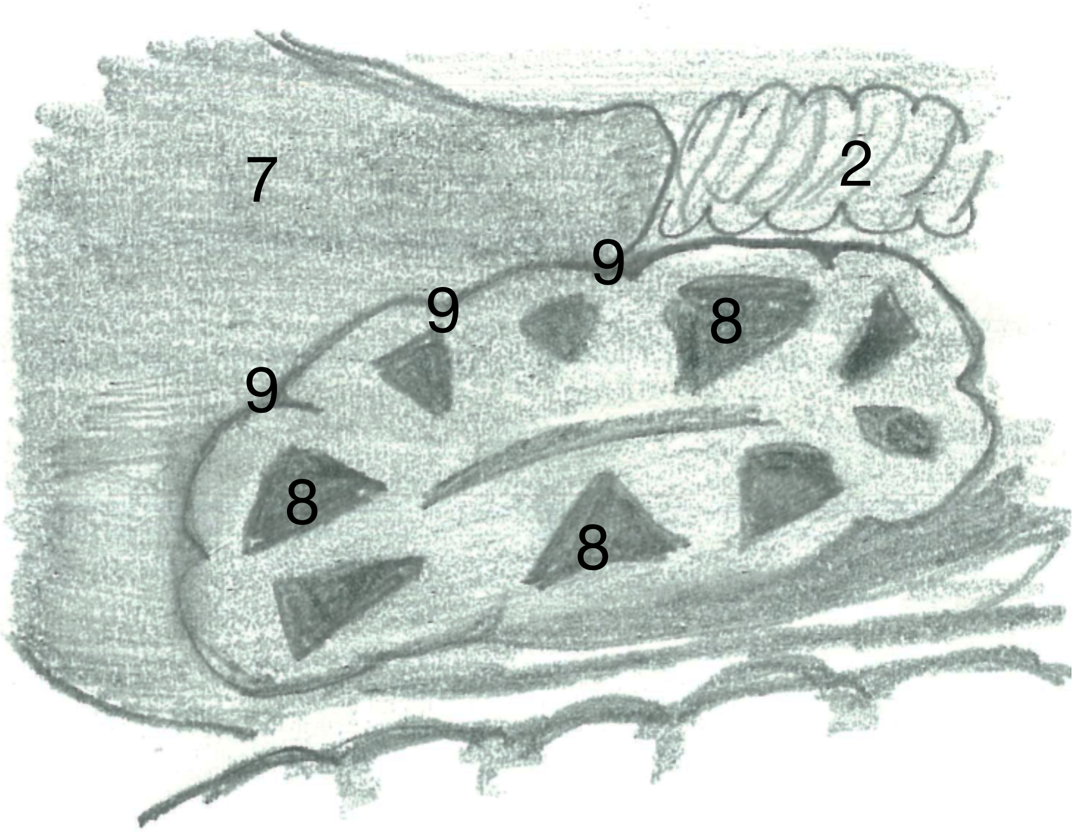


**Diagram 4.6** Neonatal kidney - longitudinal



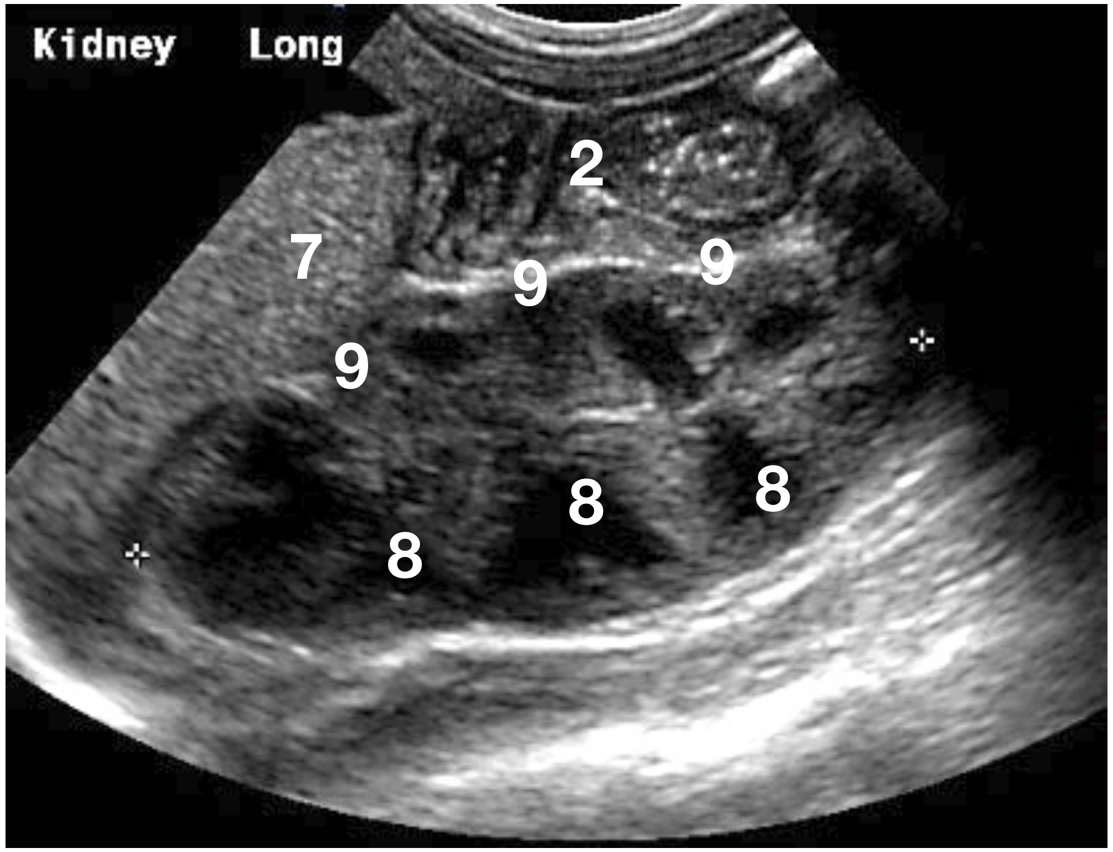

2. Bowel gas

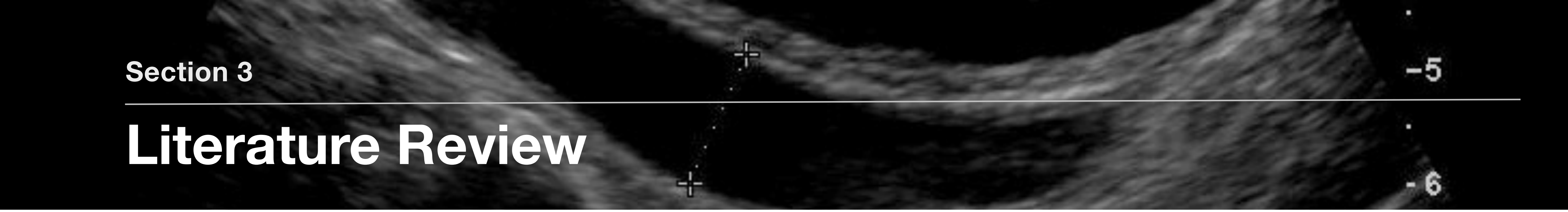
7. Liver

8. Renal pyramids

9. Fetal lobulations

**Image 4.6** Neonatal kidney - longitudinal






Section 3

# Literature Review

**Introduction**

Renal ultrasounds are the most commonly requested ultrasound examination in the pediatric age group. Ultrasound enables examination of the urinary tract without the use of contrast media, sedation or ionizing radiation and is therefore safer and less traumatic for the child. The major reason for requesting a renal ultrasound is a documented urinary tract infection. Urinary tract infections are common in childhood and are most frequent in those under one year of age (1). Ultrasound's role in the evaluation of a urinary tract infection is to rule out any obstruction or major anatomic abnormality. The occurrence of a urinary tract infection in a child who has underlying reflux can result in significant renal damage if left unmonitored and untreated for a period of time. While ultrasound cannot diagnose reflux, it may demonstrate ancillary signs like dilatation of the renal collecting system or renal scarring. An ultrasound finding of hydronephrosis, asymmetric or small renal size or duplex kidneys correlates to a higher prevalence of vesicoureteral reflux and warrants further investigation and monitoring. (13)

**Anatomy and Pathology**

The ultrasonic appearances of neonatal kidneys vary dramatically from that of older children. The normal kidney of a newborn has an echogenic renal cortex equal to that of the liver (9). Authors (9,10) suggests that this is the result of an increase in the number of acoustic interfaces in the neonatal cortex. The glomeruli occupy a larger portion of the cortex in neonates than in adults, and this provides the multiple acoustic interfaces. The neonatal kidney also demonstrates prominent hypoechoic renal pyramids and good corticomedullary differentiation. There is a lack of echogenicity in the renal sinus and this is thought to be secondary to an absence of renal sinus adipose tissue (9). It is felt that these neonatal appearances are present up to six months of age, and then gradually change to present the features of adult kidneys by two years of age (4,9,11,12). Vade (14) disagrees with the majority of authors, suggesting that these neonatal appearances can persist longer, and that even at ten years of age only 90% of children demonstrate the adult renal pattern.

Fetal lobulations are indentations in the renal cortex caused by interlobular grooves. These grooves fuse progressively during infancy resulting in the renal cortex becoming smoother with age. Occasionally these grooves persist and fetal lobulation is demonstrated. It is a normal variant and the regularity and location between the calyces differentiate them from focal renal scars (4,5).

When complete duplex renal systems are detected the Weigert-Meyer rule applies. The rule states that the ureter from the upper moiety of the kidney will insert into the bladder medial and inferior to both its normal insertion and to that of the other ureter. This may result in the upper moiety developing a ureterocele and obstructive hydronephrosis where the lower moiety ureter will typically reflux due to a short insertion. (15)

The urachus is located superficially in the anterior abdominal wall in the space of Retzius. It connects the dome of the bladder to the allantois inutero and should close at birth to become the medial umbilical ligament. Urachal remnant anomalies can be divided into four categories dependent on where the failure to close has occurred. Scanning the midline anterior abdominal wall, ultrasound is able to identify a patent urachus, a urachal sinus which opens at the umbilical end, a urachal diverticulum which opens at the bladder end or a urachal cyst where both ends have closed leaving a residual length of patent duct between. (15,16,17)

**Measurements**

Evidence of changing renal size may precede changes in renal echotexture and provide an early indication of disease (6,7) Many articles have been written on renal measurements, describing which parameters to measure and what best to correlate them with. While the importance of renal measurements in the detection of early renal disease is not questioned by authors, the most reliable and accurate method is still debated. Many authors use the renal length to evaluate the kidneys (6,7,8,18) but the comparative parameters used varies. Some authors (6,18,19) recommended comparing the renal length to nomograms. Nomograms provide an objective evaluation of renal length taking into account the physiological scatter found in individuals. Rosenbaum (18) and Cremins (5) both support the use of nomograms because it also absorbs the inaccuracy in the renal length measurement caused by the fact that the upper pole of the kidney is more medial than the lower pole and there are no internal landmarks for locating the true renal axis. Using a nomogram that compares the renal length to age is the easiest, most practical approach to monitoring renal growth, with the most important feature being sustained growth along the same curve. The renal length is the easiest parameter to assess and comparing it to age avoids having to weigh or measure the height or body length of each child as part of the examination. The renal length is the longest bipolar measurement of the kidney in long axis from a coronal or longitudinal plane in a supine or lateral decubitus position. The patient position is thought to affect the length measurement with prone longitudinal measurements yielding shorter measurements then supine or lateral decubitus positions (20).

Teele recommends measuring the renal pelvis to diagnose hydronephrosis (2). Measurements are taken across the distended renal pelvis of a transverse kidney in the AP plane. While 5mm is the upper limit of normal, it is felt that distention does not become clinically relevant until reaching 1cm. Follow-up monitoring of interval changes and trending are more relevant than the actual measurement value.

Kadioglu (20) recommends measuring parenchymal thickness in cases of hydronephrosis. The thickness is measured at the mid third of the kidney from the apex of the pyramids to the capsular edge forming a line that is perpendicular to the renal length measurement. This is an indication of cortical thinning with the lowest limit of normal at any age being 8mm. Bis (21) measures bladder volumes to monitor voiding disorders especially neurogenic abnormalities. Measurements are taken of the greatest superior to inferior and AP dimensions on the sagittal plane and the greatest transverse dimension in transverse plane. Jequier (22) suggests that bladder wall thickness varies mostly with the state of bladder filling and only minimally with age and gender. The bladder wall measurements should be taken in the area of the bladder floor, posterolateral to the trigone with less than 3mm as normal with adequate bladder distention (16,17,23).

Berrocal (15) states that normal ureters are usually less than 5mm in AP diameter and suggests measurement greater than 7mm in AP diameter are indicative of a megaureter. Leroy (24) also uses 5mm as the upper limits of normal and suggests ureteral dilation may be a useful ultrasonic indicator of reflux.

**Discussion**

As there is a wide variability in the ultrasound appearances of children’s kidney there is the potential to over diagnosis. Daneman (25) warns of the potential to misinterpret the normal neonatal appearances of large hypoechoic pyramids as dilated calyces or renal cystic disease and the appearances of a thin hyperechoic cortex as cortical scarring. While the normal neonatal kidney should have an echogenic renal cortex equal to that of the liver, children over two years of age should have a hypoechoic renal cortex when compared to the renal medulla and liver. An echogenic renal cortex in adults is used as an indicator of renal disease but Wiersma (26) warns detection of a hyperechoic renal cortex with echogenicity greater than or equal to the liver in children over two may not be clinically relevant. In children who present with an acute abdominal illness, Wiersma describes this as a non-specific transient finding that will resolve with time.

It is not uncommon to demonstrate a small amount of fluid in the renal pelvis, usually due to over hydration, or a full bladder causing mild upper tract stasis. Hayden (4) does not consider this to be of any significance as the renal pelvis is a potential space and when challenged by over-distention of the bladder or diuresis it will distend a little. Only when the pelvis is distended and there is branching of the renal pelvis into calyces is it considered pathological. Hayden (4) found that over 75% of all newborns have small amounts of fluid in their renal pelvis, either unilaterally or bilaterally.

Neonates may be dehydrated due to a relative oliguria and a low glomerular filtration rate in the first few days after birth. It is recommended that if hydronephrosis was diagnosed as mild or moderate antenatally then the follow-up scan should be delayed for at least three days in order to allow the infant to be hydrated properly. In a dehydrated state, mild or moderate degrees of hydronephrosis may be missed or under called. (2,3,4). If the infant was diagnosed with severe hydronephrosis antenatally, the ultrasound should be performed as soon as possible after birth to reduce the risk of renal damage and allow for surgical intervention if required.

**Conclusion**

It is recognized that a number of diseases can affect renal size and that this change in size can precede changes in echotexture, so evidence of changing renal size can provide early indication of renal disease and warn of pending renal damage (6,7). The most important feature of normal renal growth in a child, irrespective of their height, weight or age, is sustained growth along the same curve. While there are many documented methods of monitoring renal growth, nomograms provide objective evaluation of renal size while allowing for individual variation. The nomographic comparison between renal length and the patient's age is the easiest, most practical approach to monitoring renal growth. As ultrasound is a fast, noninvasive examination and does not use ionizing radiation, it enables regular monitoring of children with renal abnormalities, neurogenic abnormalities and recurrent urinary tract infections.

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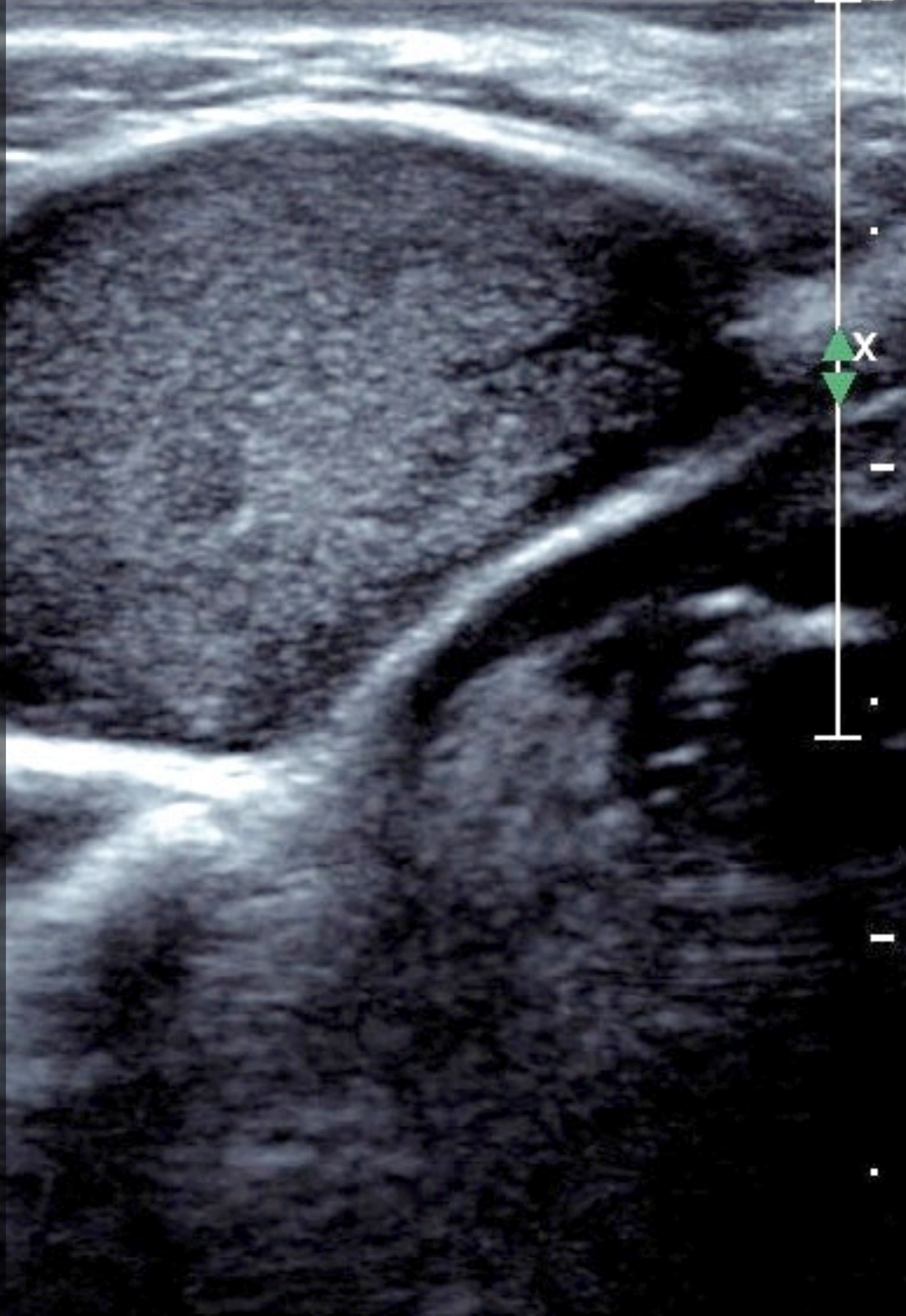
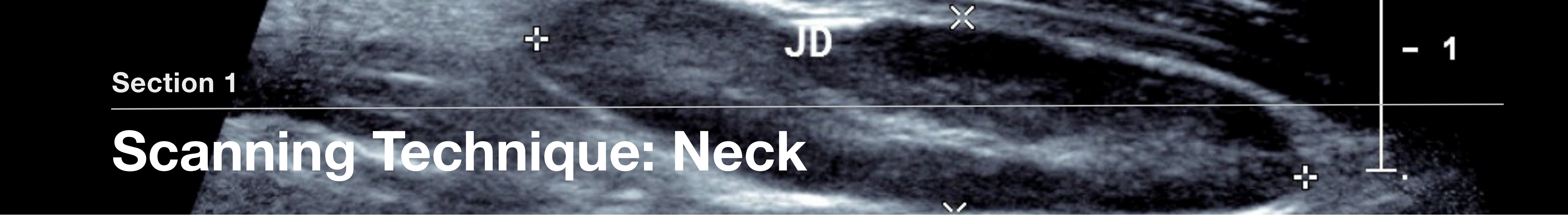
Chapter 3

# Neck

Ultrasound is the imaging modality of choice for the investigation of palpable neck masses in children. Ultrasound enables reliable evaluation without the use of radiation or sedation. When combined with clinical history and presentation, ultrasound is able to give a definite diagnosis for many of the common neck masses, particularly the congenital lesions. The information on a soft tissue mass's size, location, internal consistency and vascularity can easily be obtained and may help facilitate the clinical management of the child.






Section 1

# Scanning Technique: Neck

**Other Names:** Lump, lymph nodes, thyroid, region of interest, soft tissue neck, sternocleidomastoid muscles, thyroglossal duct, branchial cleft.

**Preparation:** Nil

**Contraindication:** Nil

**Equipment:**
**Probes:**
- Use a probe with a high frequency, small footprint and good resolution in the near field**.**
- Recommended frequency - Flat Linear or Hockey stick 17 - 5 MHz

**Organs covered by procedure:**
- Region of interest soft tissues
- The contralateral area of interest to establish a normal baseline
- Cervical lymph nodes
- +/-Thyroid
- +/-Sternocleidomastoid muscles

**Scanning Technique:**
**Patient Position:**
- The patient is positioned to allow easy access to the area of interest.
- Extend the child's neck to enable access with the linear probe to the area. In infants, hyperextend the neck by placing the child supine over a rolled up towel positioned at the shoulder level.
- In infants with short necks, where access is not possible, use the stand-off gel pad to fill the area between the chin and shoulder / chest.

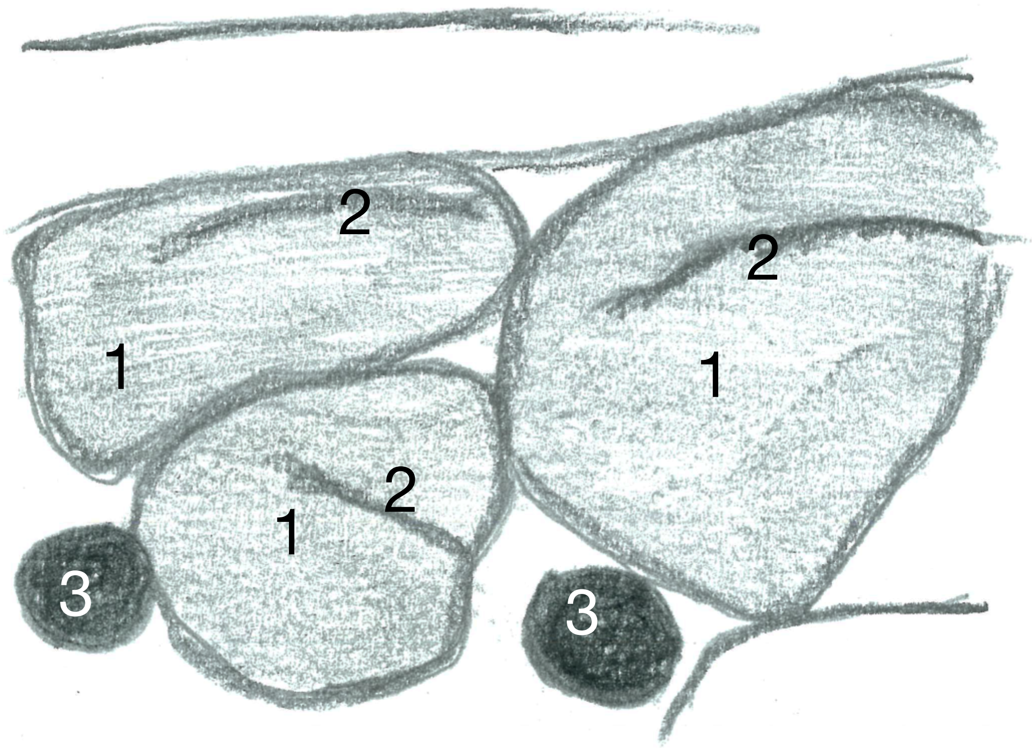
**Technique:**
- Adjust TGC to provide a homogenous texture through the area of interest.
- As this examination is area specific, first scan the contralateral area of interest to obtain comparative views of the local anatomy and normal echotexture in longitudinal and transverse planes.
- Scan the area of interest in longitudinal and transverse and examine the location, shape, and internal consistency of the mass or region of interest.
- Examine the region of interest with color or power Doppler to establish vascularity.
- Examine the surrounding anatomy to identify vascular landmarks and fixed anatomical structures to determine their relationship with the mass.

**Measurements:**
- Measure the region of interest's length, width and depth.

**Exam Documentation:**
- Document the region of interest in longitudinal and transverse planes.
- Document color or power Doppler to demonstrate vascularity.
- Comparable views of the area of interest and its contralateral area should be documented to establish both normal and abnormal anatomy. Use a split screen function where available.

# Images and Line Drawings

**Diagram 12.1** Cervical lymph nodes - transverse




1. Lymph nodes
2. Hilum of lymph nodes
3. Blood vessels

**Image 12.1** Cervical lymph nodes - transverse

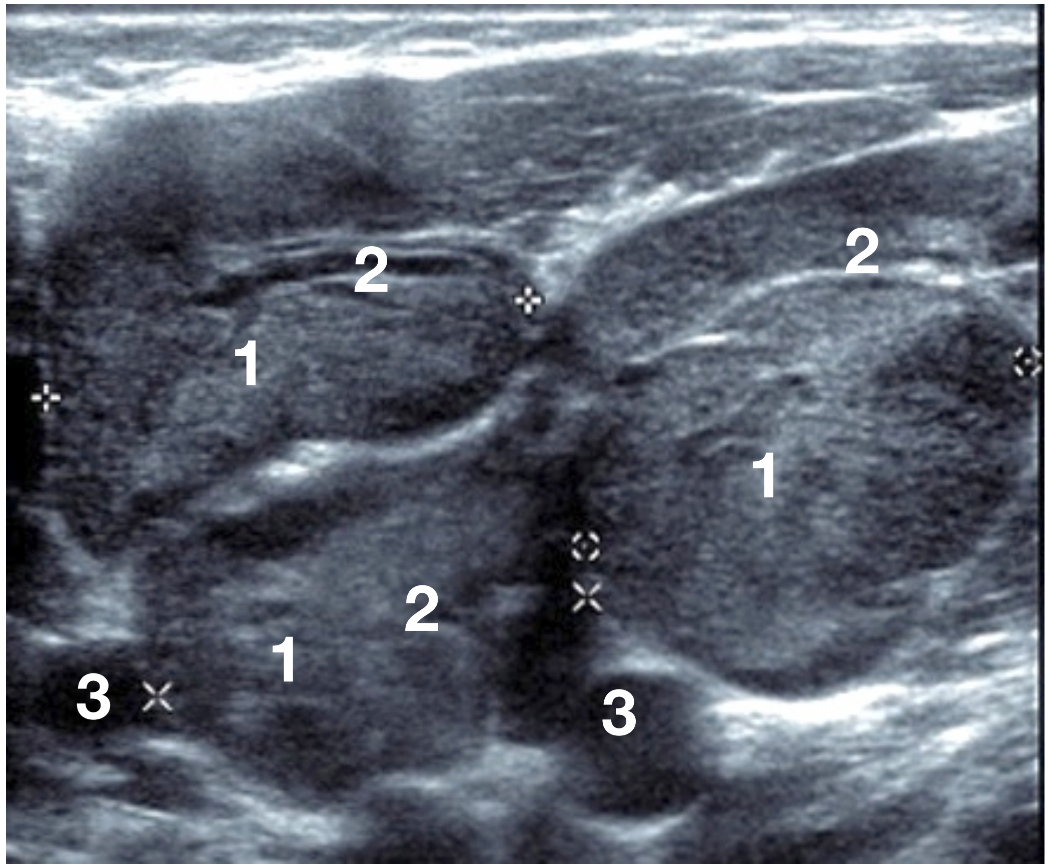
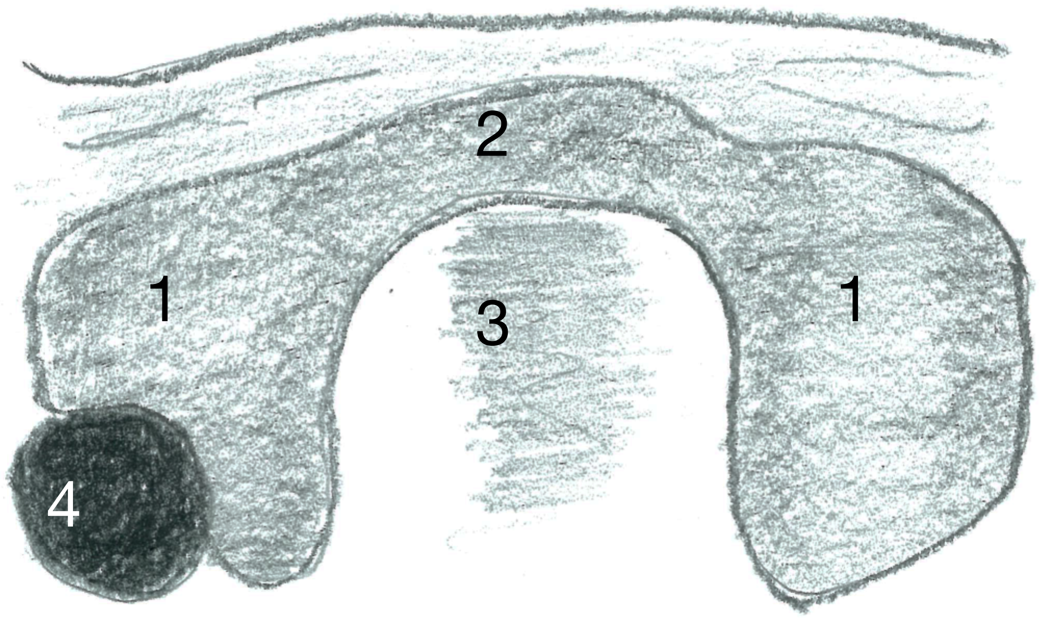


**Diagram 12.2** Thyroid - transverse




1. Thyroid lobes
2. Isthmus of thyroid
3. Trachea
4. Carotid artery

**Image 12.2** Thyroid - transverse

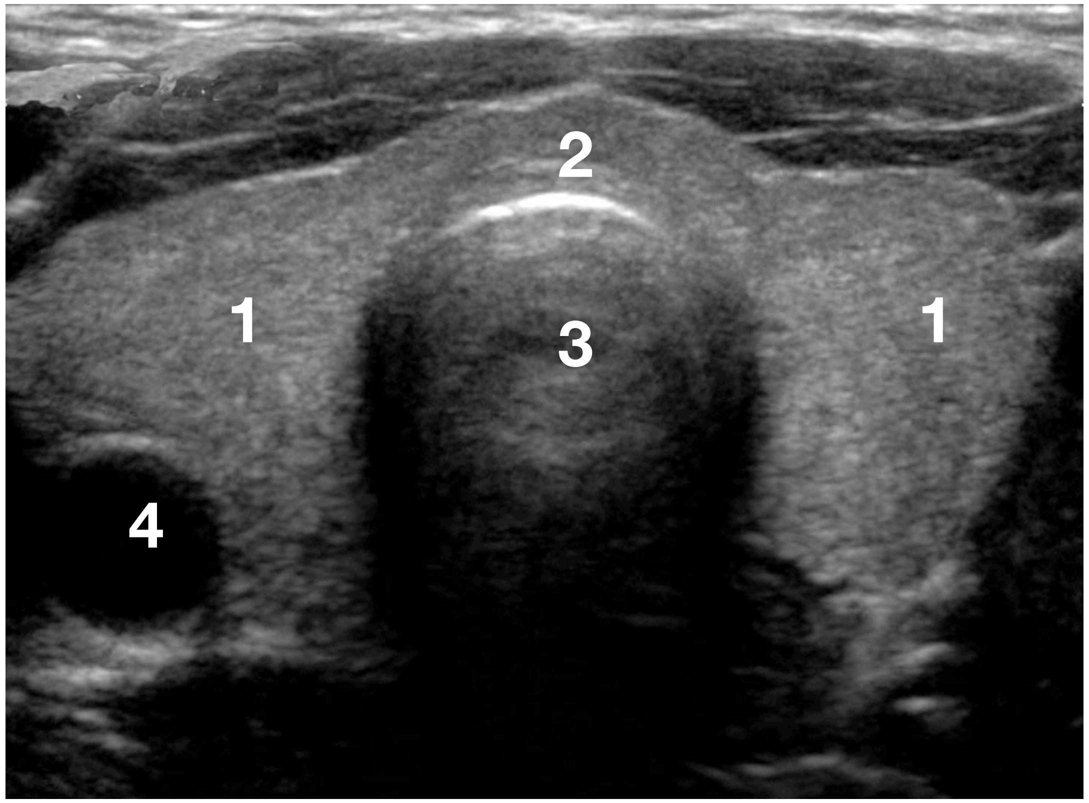
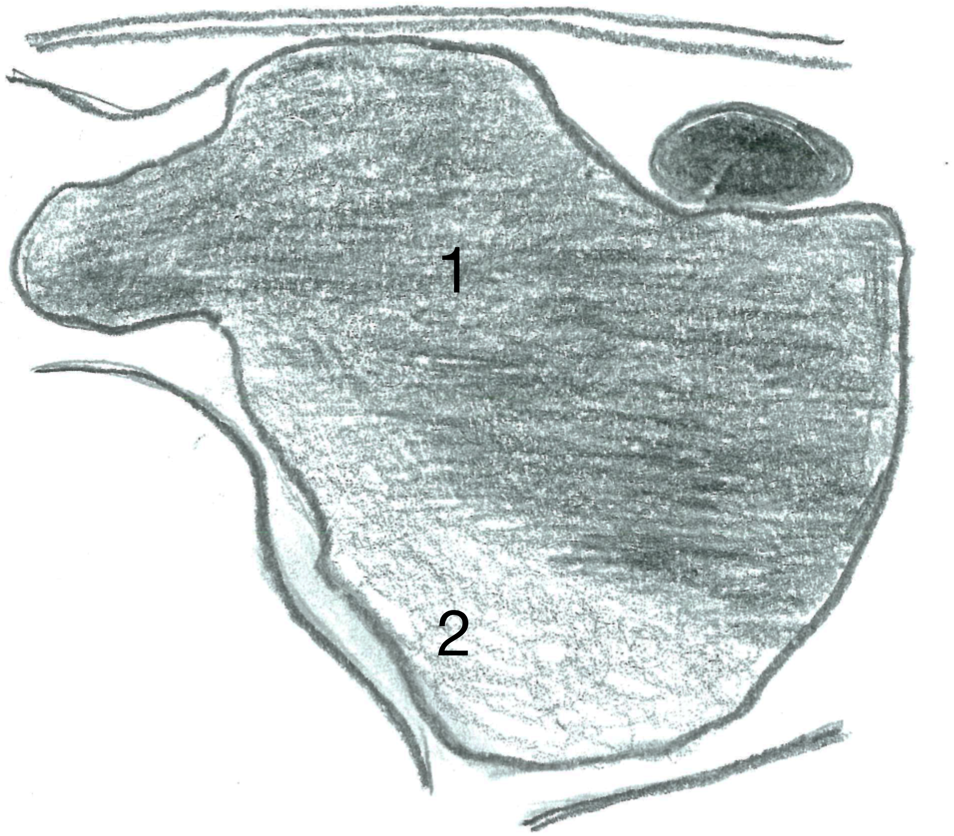


**Diagram 12.3** Lymphatic malformation




1. Lymphatic fluid collection

2. Particulate matter within fluid

**Image 12.3** Lymphatic malformation

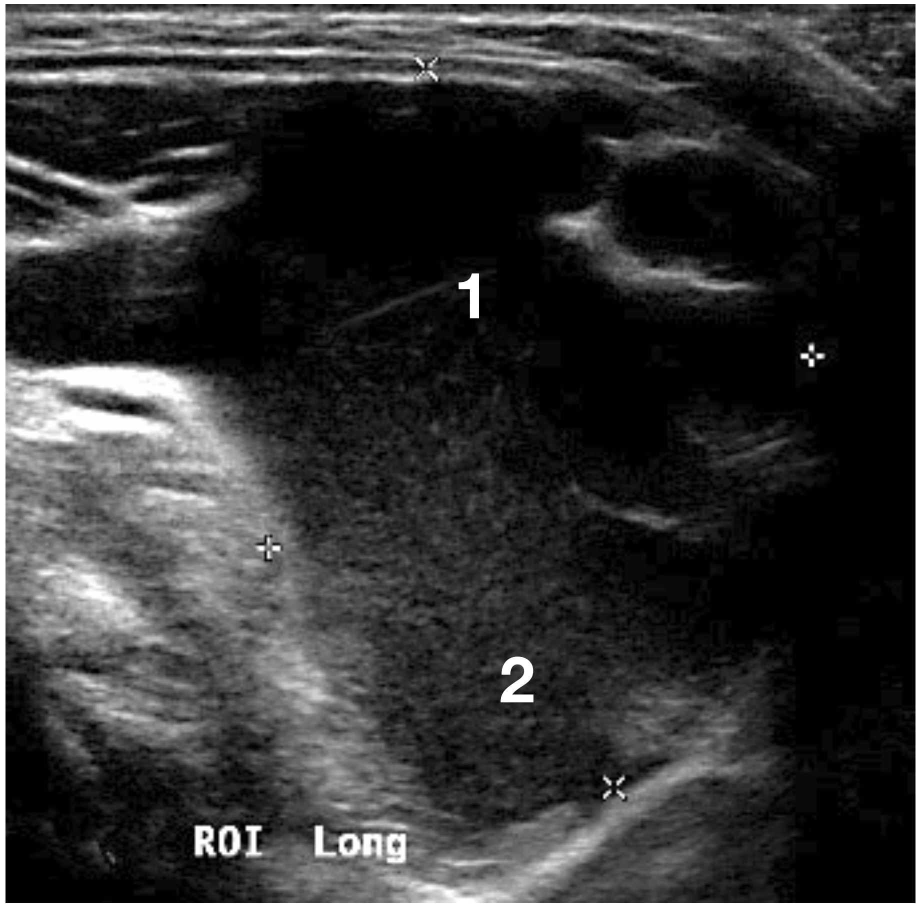
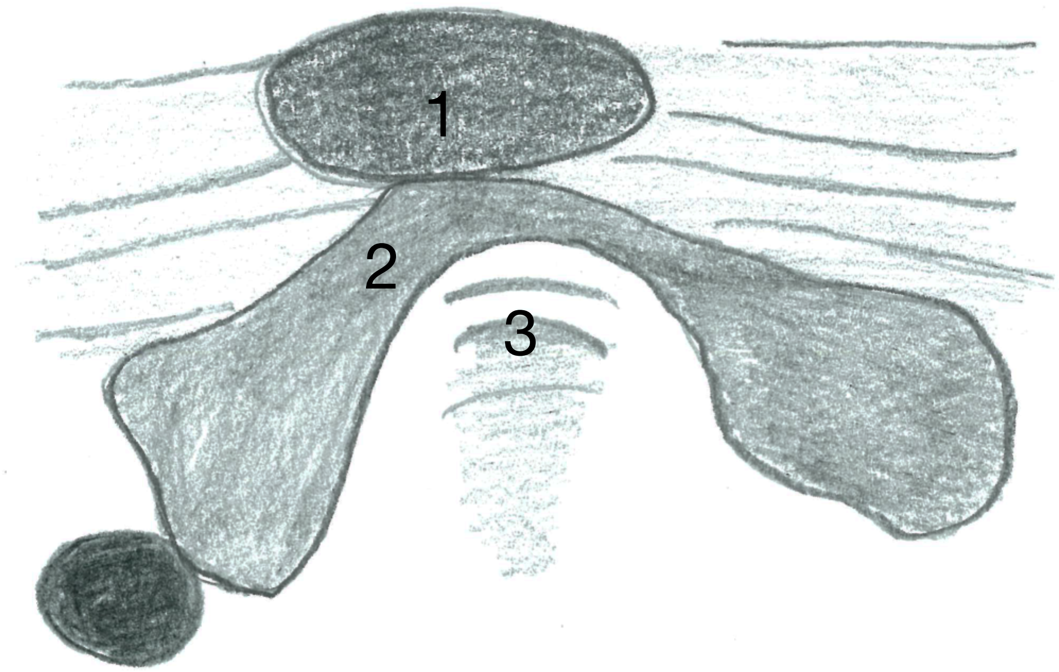


**Diagram 12.4** Thyroglossal cyst - transverse




1. Thyroglossal cyst

2. Thyroid

3. Trachea

**Image 12.4** Thyroglossal cyst - transverse

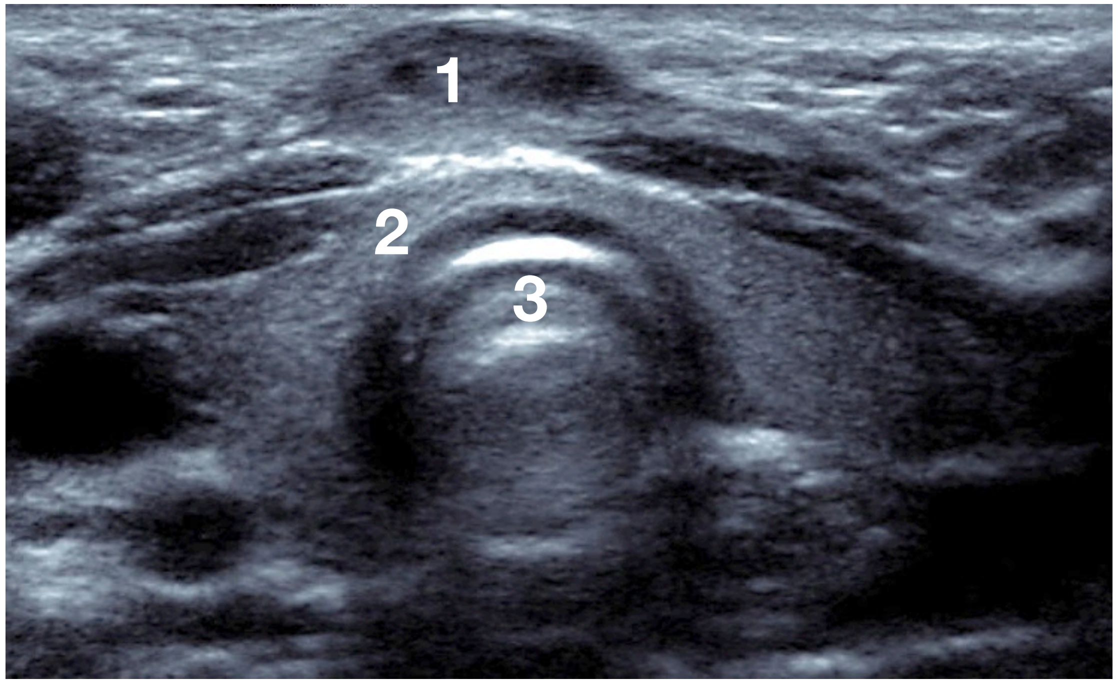
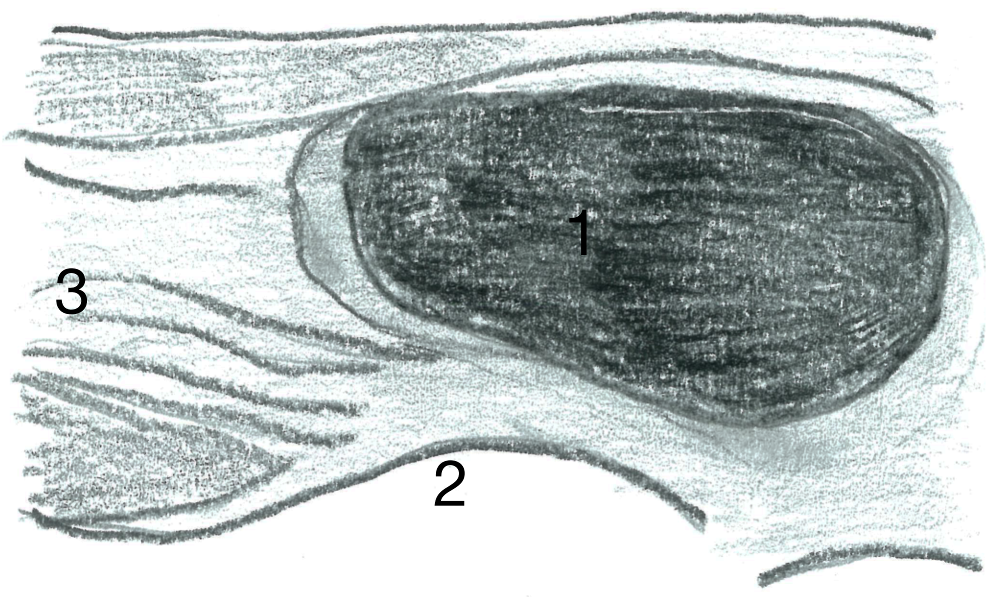


**Diagram 12.5** First branchial cleft cyst




1. Brachial cyst

2. Angle of mandible

3. Subcutaneous facial tissue

**Image 12.5** First branchial cleft cyst

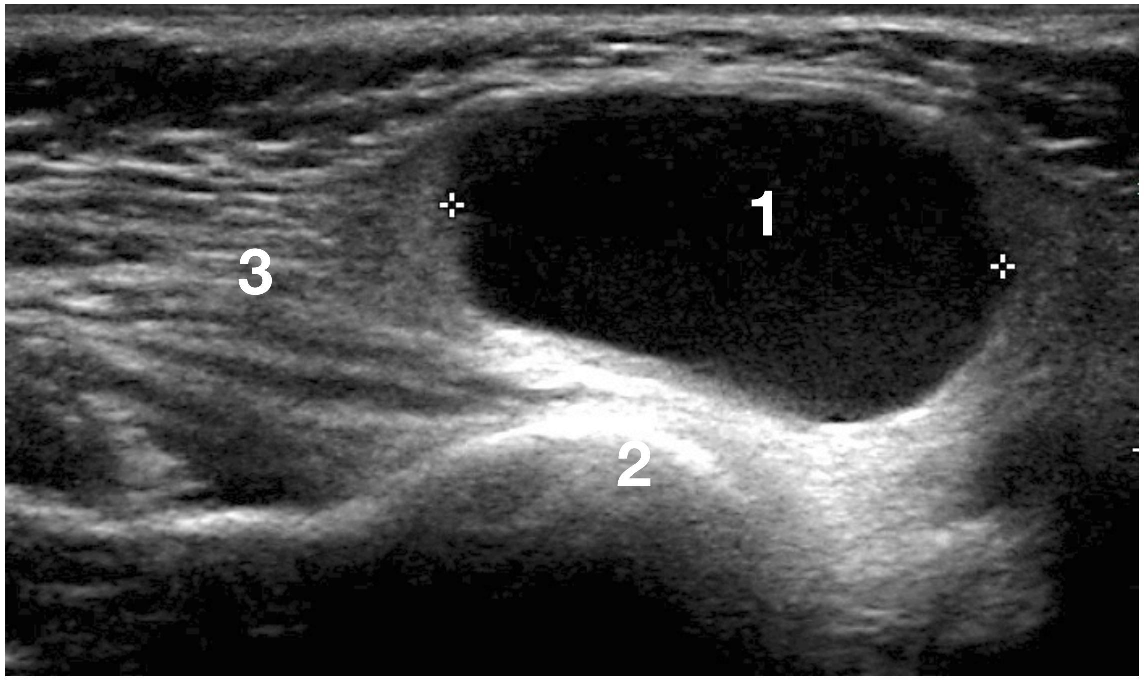
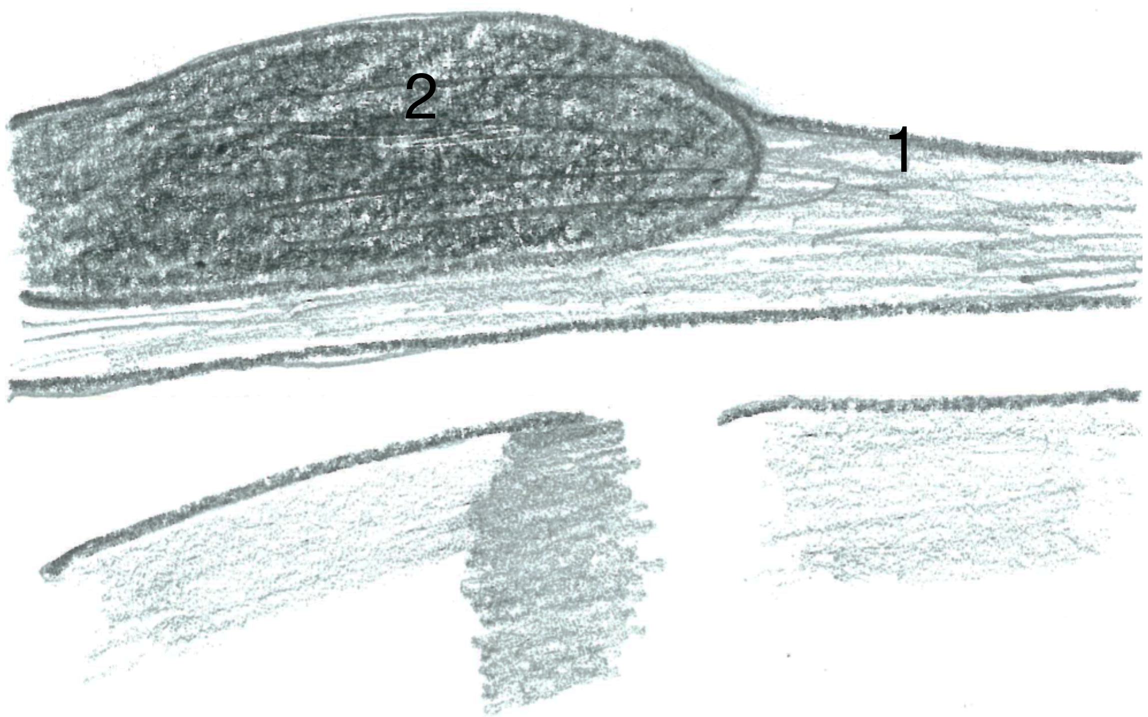


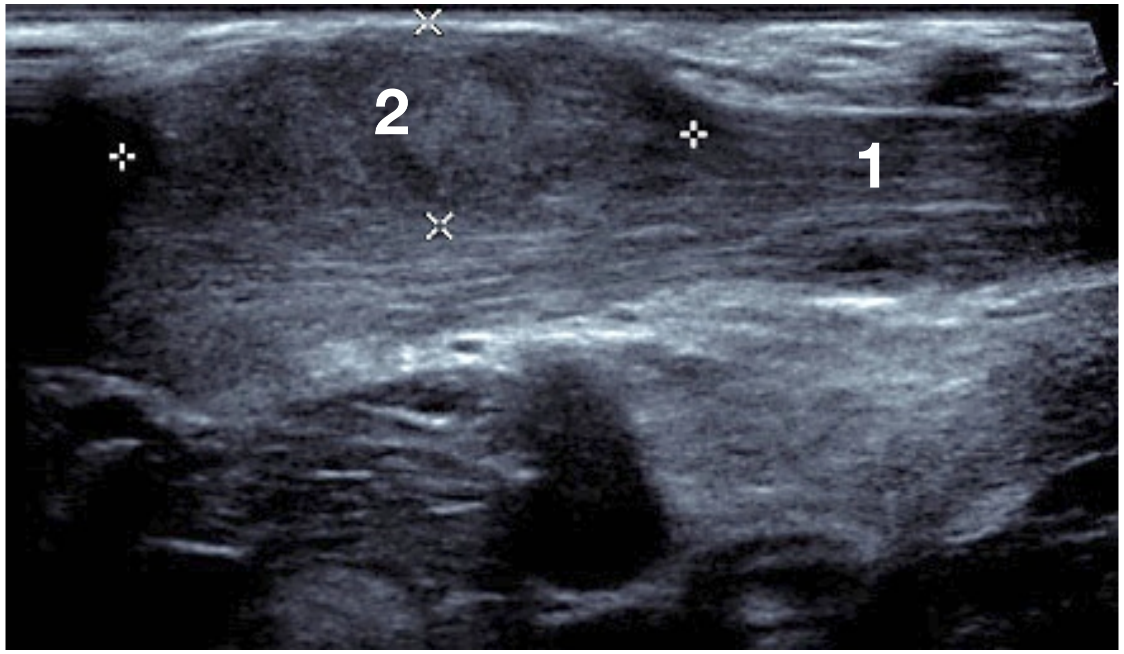
**Diagram 12.6** Sternocleidomastoid muscle
- longitudinal

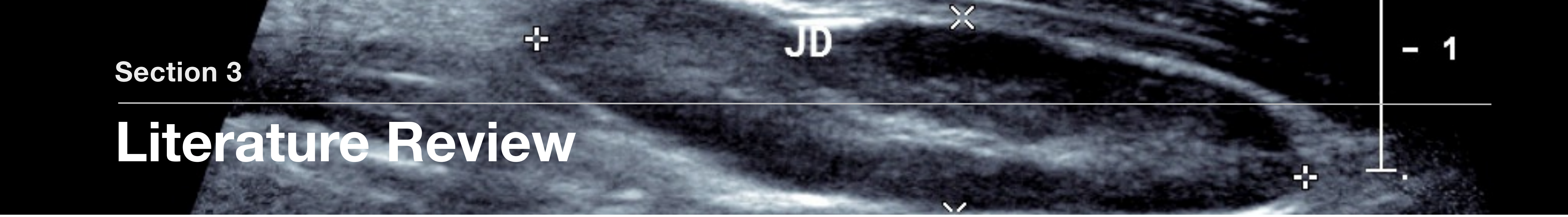



1.Sternocleidomastoid muscle

2. Fusiform mass within sternocleidomastoid muscle belly

**Image 12.6** Sternocleidomastoid muscle
- longitudinal






Section 3

# Literature Review

**Introduction**

Ultrasound should be the initial imaging modality for the investigation of soft tissue neck masses in children. Ultrasound can illustrate normal anatomy, identify vascular structures relative to the area of interest and provide information regarding the size, location, internal consistency and extent of the mass (1). Palpable neck masses are a common clinical presentation in the pediatric age group and ultrasound enables reliable evaluation without the use of radiation or sedation. When combined with clinical history and presentation, ultrasound is able to give a definite diagnosis of many of the common neck masses, particularly the congenital lesions.

**Cervical Lymph Nodes** *Image 12.1*

Palpable lymph nodes are the most common soft tissue masses in the pediatric neck. The most common cause of lymph node enlargement is reactive hyperplasia in response to a local inflammatory process. Ultrasound can be used to depict the presence and distribution of cervical lymph nodes and to differentiate between lymphadenitis and an abscess, which can be clinically difficult.(2) Screaton (3) states that while neck lymphadenopathy is common in both benign and malignant disease, significant pathology is uncommon in children. Lymphadenopathy is described as multiple discrete, ovoid, hypoechoic masses along the cervical lymphatic chain. Siegel (4) states multiple lymph nodes with AP diameters less than 5mm are common in asymptomatic children and should be considered normal as long as they appear flattened or oval and have an echogenic hilum. Rumack (5) agrees stating 80-90% of children aged between 4 - 8yrs will have palpable reactive hyperplastic lymph nodes without current viral infection or systemic illness.

Clinically relevant adenopathy is described as multiple painful round nodes with diameters over 5mm and increased central vascularity. (4). These criteria should not be used on the jugulodigastric lymph node as it is commonly much larger and may have an AP diameter of up to 10mm and still be within normal range (6). Rumack (5) suggests that enlargement should not be considered until a lymph node has a maximum dimension over 10mm or a ratio of length to AP diameter of greater than 1:2.

Koischwitz (6) emphasized that differential diagnosis by absolute measurements of the cervical lymph node is not accurate and should not be used. Papakonstantinou (7) agrees and suggests that a combined ultrasound criteria may improve specificity in pediatric cervical lymphadenopathy and help select nodes where biopsy may be appropriate. Papakonstantinou (7) suggests that while all pathologies will present with nodal enlargement, reactive lymph nodes will present as oval masses with well circumscribed margins, wide echogenic hilum and a longitudinal hilar vessel. Infectious lymphadenopathy appears similar but the nodes are considerably larger, round and hypervascular, exhibiting a radial pattern. Acute unilateral lymph node enlargement is most commonly bacterial. (8) Lymphomatous lymph nodes are typically hypoechoic but have an absent or slit-like hilum and firm, non-mobile, painless enlarged lymph nodes are suggestive of neoplastic involvement.(9)

**Thyroid** *Image 12.2*

The ultrasound technique for examining the thyroid in children is the same as in adults as is the imaging criteria for disease diagnosis. Ultrasound has been established as a useful initial examination when hormone levels are abnormal or when enlargement is considered. The pediatric thyroid should have a homogenous mid-level echo texture and moderate vascularity. It should be more echogenic than surrounding musculature (10). Achieving longitudinal images of the thyroid can be difficult in neonates, the young and uncooperative children due to the limited space between the chin and chest and an inability to make contact with the probe.

While papers (10,11) have been published establishing the normal range for pediatric thyroid volumes practically achieving these measurements is often difficult. Yasumoto (12) proposes creating a ratio between the thyroid and the trachea as it does not rely on achieving good longitudinal images. By measuring each of the thyroid lobes at their widest in a transverse plane and adding these together a ratio can be created with the widest tracheal measurement taken in the same transverse plane. A ratio between 1.7 and 2.4 is considered normal at any age.

There are a variety of congenital anomalies that may involve the thyroid so if the thyroid is unable to be located the examination should be extended superiorly to the level of the base of the tongue to exclude ectopic thyroid tissue and thyroglossal remnants.

**Soft Tissue Masses**

Soft tissue masses are common in children especially in the neck region and are usually benign and either congenital or inflammatory in nature. (4,13) Hayden (14) describes ultrasound as very useful for delineating the relationship of the mass to adjacent structures, especially vascular structures, and it provides vital information as to whether the mass is cystic or solid. Sherman (15) uses ultrasound to obtain information on the mass's size, shape, location and internal consistency and then correlates the sonographic characteristics with the clinical information to determine the differential diagnosis. Kraus (16) suggests that while it is nonspecific, the presence of calcification in the soft tissue mass is highly suggestive of a neoplastic lesion. Kraus (16) states that certain neck masses have classical ultrasound appearances and these can be diagnostic when supported by clinical history.

**Lymphatic Malformations** *Image 12.3*

Cystic hygroma or lymphangioma are outdated terms for this common congenital mass. They present in children under two as a painless soft mass, 75% of which are situated in the neck. Ultrasound appearances may be either focal or diffuse and are typically thinned walled, multicystic lesions containing septum and no vascularity. They are more common on the left side and in the posterior triangle or oral cavity. The lesion has the potential to rapidly enlarge and the fluid may become hypoechoic or echogenic if complicated by infection or hemorrhage. Lymphatic malformations may regress spontaneously but often require surgical intervention. This is often difficult due to the invasive nature of the lesion surrounding vital structures and ultrasound may be requested to assist in surgical planning (4,5).

**Thyroglossal Duct Anomalies** *Image 12.4*

Thyroglossal duct cysts are the most common congenital abnormality in the neck. They are caused by the embryonic thyroglossal duct failing to close and can be located anywhere along the duct from the base of tongue to the isthmus of the thyroid. The cyst develops when the epithelial lining starts to secrete. Presentation occurs in the first decade of life as a firm lump and is usually located midline or slightly off to the left of midline. If the cyst is suprahyoid in location it will move with the tongue. Poking the tongue out will cause the cyst to move superiorly. (5) Surgical removal is recommended due to risks of infection and the potential for malignant regression.(4). They are well circumscribed, thin walled lesions but internal consistency can have a variable ultrasound appearance due to infection, hemorrhage or high protein contents of the secretions. (10,11). A solid echogenic mass identified in close association with a thyroglossal cyst may represent ectopic thyroid tissue. If this thyroid tissue is the patients only functioning thyroid tissue and it is removed with the thyroglossal cyst, the patient will be permanently hypothyroid. Consequently the thyroid should always be identified in cases of thyroglossal cysts to exclude an ectopic thyroid as the reason the duct remains open (4,8).

**Branchial Cleft Anomalies** *Image 12.5*

The branchial network is a series of six paired mesodermal arches that give rise to the major neck structures. Branchial cleft anomalies may take the form of cysts, sinuses or fistulas and result from the failure to close of the embryonic pathways. Branchial cleft cysts are the most common of the cleft anomalies with the second branchial cleft being the most commonly occurring location. First branchial anomalies occur in locations from anterior to the external auditory canal and posterior to the parotid gland to inferiorly at the angle of mandible. Second branchial anomalies lie in the anterior triangle of the neck, usually anterior to the sternocleidomastoids. Third and fourth branchial anomalies are rarely detected by ultrasound. (4,5)

Presentation usually occurs later in childhood as a soft fluctuant painless mass in the lateral neck. The ultrasound appearances may be consistent with a cyst but more commonly are homogeneously echogenic due to cellular debris and cholesterol crystals within the fluid, or due to complications of infection or hemorrhage (6). Branchial cleft cysts are able to be differentiated from thyroglossal cysts by their lateral location.

**Sternocleidomastoid Muscle** *Image 12.6*

Fibromatosis colli or a pseudotumor of the sternocleidomastoid, a term no longer used, is a benign, self-limiting mass within the sternocleidomastoid muscle belly caused by birthing trauma. The etiology is unclear but results in fibrosis and shortening of the muscle fibers causing a soft fusiform mass within the sternocleidomastoid muscle. Presentation is within the first month of life, most commonly with a right sided torticollis resulting in an ipsilateral head tilt and palpable mass. It will usually regress over four to six months and requires conservative management. Ultrasound of the sternocleidomastoid muscle will demonstrate a hypoechoic focal or diffuse enlargement of the muscle with disruption of the echogenic linear muscle fibers (4,5). On dynamics, the mass will move with the muscle (8). Color Doppler examination will help exclude other neoplastic lesions.

**Conclusion**

Soft tissue masses are a common clinical indication for performing ultrasound examinations of the neck in children. Ultrasound evaluation of neck provides information using a quick, non-ionizing, non-invasive technique. The information on a soft tissue mass's size, location, internal consistency and vascularity can easily be obtained using ultrasound. Information on the lesions involvement with surrounding structures may also be provided. In the vast majority of cases the sonographic appearances are characteristic and provide enough data to proceed with a definitive therapy or biopsy of the soft tissue mass. It is therefore a valuable examination and may help facilitate the clinical management of the child.

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