Sonographic Pictorial Review of Benign Palpable Paediatric Lumps: Head to Foot

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INTRODUCTION
This pictorial review illustrates the ultrasound (US) features of commonly encountered benign palpable paediatric lumps in our clinical practice. For ease of description, we have classified them as head and neck lumps and trunk and extremity lumps (Table I). Some lumps however like vascular malformations, lipomas, nerve sheath tumours, lymphadenopathy, abscesses and epidermal inclusion cysts commonly overlap in both locations.

LUMPS IN THE HEAD AND NECK
Palpable paediatric head and neck lumps may be inflammatory or non-inflammatory in nature. Many of these lesions are site specific and their location in conjunction with clinical history and US characteristics help to reach the correct diagnosis.

Haemangiomas and vascular malformations
Vascular lesions are the most common paediatric soft tissue masses. They are classified into haemangiomas and vascular malformations. Infantile haemangiomas are true neoplasms that proliferate and then involute. Vascular malformations are congenital developmental anomalies that continue to grow proportionately with the child. The diagnosis of these lesions is often clinical. Imaging is used to characterise the lesion and assess deeper extent prior to therapy.

Infantile haemangioma is the most common vascular tumour in infants. It is commonly seen in the face and neck (60%) with a particular predilection for the parotid gland. It appears as a red lobulated cutaneous lesion akin to a strawberry surface. On grey scale US, it is usually seen as a well defined solid hypoechoic mass. Colour Doppler shows high vessel density typically more than 5/sq.cm and on spectral Doppler, peak arterial shifts of more than 2kHz are usually noted. On follow up imaging, the mass usually diminishes in size and appears less vascular, in keeping with the natural history of fibrofatty involution.

Vascular malformations can present as high flow lesions such as arterio-venous malformations and arterio-venous fistulae or low flow lesions like venous, capillary and veno-lymphatic malformations. High flow vascular malformations tend to show high vessel density and peak arterial shifts similar to haemangiomas (Fig 1). Venous tumours usually show anechoic compressible vascular spaces, low vascular density and low Doppler flow (Fig 2). Phleboliths if present, confirm the diagnosis of venous malformations.

Lymphatic malformations / cystic hygromas
Lymphatic malformations are a subtype of slow flow vascular malformations. The ones with large cystic spaces (usually >1 cm) are called cystic hygromas. These lesions involve the head and neck in 48% cases and are usually found at the posterior triangle. It is estimated that 90% of patients present by the age of 2. Patients commonly present clinically with a painless mass that may be compressible or transilluminant. On grey scale US, uncomplicated cystic hygromas are seen as large, multilocular anechoic lesions with thin intervening septae. They are often transpatial and do not cause mass effect. Mild vascularity may be demonstrated within the septae on colour Doppler. Complications such as infection and haemorrhage may lead to acute increase in the size of the lesion with internal echoes or fluid-debris level within the cysts. MRI is necessary to delineate the deep extent of the lesion when sclerotherapy is considered for treatment. US can then be used to assess for post-therapy response in selected cases.

Thyroglossal duct cyst
Thyroglossal duct cysts (TDC) result from failure of thyroglossal duct regression. They account for about 70% of congenital neck masses in the paediatric population. TDCs are often located in the midline and often seen in close association to the hyoid bone. The relationship with the hyoid bone varies with the majority of TDCs occurring at the infrahyoid region. About 50% of patients present before age 10 with a painless midline neck mass and often with history of previous incision and drainage. An uninfected TDC is typically seen on US as a midline, unilocular, anechoic and avascular lesion with posterior acoustic enhancement. It characteristically moves with tongue protrusion and swallowing. Infected TDC may show debris and septae. They may rarely appear pseudo-solid due to high proteinaceous content. Some TDCs may show a track leading to the hyoid on US. It is essential to look for a solid nodule within a TDC, though rare it may indicate malignant transformation. Midline dermoids may mimic TDCs. Off-midline TDCs may be confused with branchial cleft cysts. In these cases, the relation of TDC with the hyoid bone and the mobility of the lump is crucial in its identification.
Branchial cleft cyst
Branchial cleft cysts are the most common non-inflammatory lateral neck masses seen in children. About 95% of these arise from the second branchial apparatus. A second branchial cleft cyst is typically seen high in the lateral neck along the anterior border of the sternocleidomastoid. It lies superficial to the common carotid artery and internal jugular vein but deep to the submandibular gland. Occasionally, the cyst may be associated with a tonsillar fossa fistula or sinus tract to the anterior border of sternocleidomastoid. A typical branchial cleft cyst will sonographically appear as a unilocular, well-defined, anechoic lesion without internal debris or vascularity. Posterior acoustic enhancement may be seen. Complications such as infection or haemorrhage may result in thickened walls, internal debris and septae. Cystic metastases from papillary thyroid carcinoma may mimic a complicated branchial cleft cyst. Fine needle aspiration of the cyst and evaluation of the thyroid gland is recommended in these cases. CT or MRI is usually performed to assess deeper pharyngeal involvement prior to surgical excision.

Dermoid cyst
Dermoid cysts are rare congenital cystic lesions with an incidence of 7% in the head and neck. They frequently present as midline lumps in the floor of the mouth, suprasternal notch, forehead, orbits and nasal cavities. They are lined by epithelium and contain skin appendages. Dermoid cysts on US appear pseudosolid with mixed internal echoes due to their cellular and fat content. They are avascular. Posterior acoustic enhancement is uncommon. Osseous-dental structures if present, appear as echogenic foci with dense posterior acoustic shadowing. Fat globules within the lesion give rise to the ‘sac of marbles’ appearance on CT or MRI that helps to confirm the diagnosis.

Fibroma
A rosy red, firm nodule is the most common variant seen in children. It is typically firm and moves with the neck. Minimal vascularity may be seen on colour Doppler although calcification is uncommon. Gradual regression can be assessed by serial follow-up US.

Lymphadenopathy
Reactive or suppurative nodes are common inflammatory neck masses in children. Enlarged lymph nodes in children are mostly reactive and represent a transient response to local or systemic inflammatory process. Chronic lymphadenopathy however may have infective (viral, bacterial, fungal, protozoal) or malignant aetiology (lymphoma, leukaemia, metastases). Cervical lymph nodes measuring less than 1 cm in diameter are considered normal in children under 12 years of age. Reactive lymph nodes on US appear ovoid with fatty hilum and prominent hilar vascularity. Their short to long axis ratio is less than 0.5.

Pathological nodes have some typical US features such as round contour, absence of echogenic hilum, intranodal necrosis, calcifications, matting and adjacent soft tissue oedema. Intranodal necrosis and calcifications may be seen in tuberculous nodes and nodal metastases from papillary thyroid carcinoma. Matting of nodes and adjacent soft tissue oedema are common in tuberculous lymphadenopathy. Mixed or peripheral vascularity is abnormal and commonly seen in malignant nodes. US is often the only modality needed for assessment and follow-up of reactive lymphadenopathy post treatment. It can also be used for guided fine needle aspiration of suspicious nodes and drainage of lymph nodal abscesses.

Lumps in the trunk and extremities:
Unlike neck lumps, palpable lumps of the trunk and extremities are not very specific to any particular site. They vary in aetiology with some also seen in the head neck region.

Lipoma
Lipomas are the most common benign mesenchymal tumours and account for two thirds of all paediatric adipocytic tumours. They are typically subcutaneous, however intra-and intermuscular locations may be seen. They commonly occur in the upper back, neck and proximal extremities. Lipomas present clinically as soft, painless, mobile masses. They may be solitary or multiple. Lipomas on US usually appear as encapsulated elliptical subcutaneous masses parallel to the skin surface. They are typically homogeneous and hypoechoic relative to adjacent soft tissue. They may contain echogenic lines parallel to the skin surface. Lipomas can appear isoechogenic and hypoechoic less frequently. They tend to displace rather than infiltrate surrounding structures and are often compressible. Posterior acoustic enhancement is not seen in most cases. Lipomas are typically avascular on colour Doppler. Intralesional vascularity may suggest sarcomatous transformation of the lipoma.

Nerve sheath tumours
The most common type of benign peripheral nerve sheath tumours are neurofibromas and schwannomas. These lesions are often asymptomatic and malignant transformation is
Table I: Summary of the different benign palpable paediatric lumps according to their location. Note that vascular malformations, lipomas, nerve sheath tumours, lymphadenopathy, abscesses and epidermal inclusion cysts can overlap in locations

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Typical locations</th>
<th>Typical ultrasound findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemangiomas</td>
<td>Anywhere</td>
<td>Solid hypoechoic lesion with high vessel density that involutes with time</td>
</tr>
<tr>
<td>Vascular malformations</td>
<td>Anywhere</td>
<td>Ill or well defined lesions with vascular channels that show high or low velocity flow</td>
</tr>
<tr>
<td>Lymphatic malformation/cystic hygroma</td>
<td>Posterior triangle of the neck</td>
<td>Multiloculated transpatial anechoic cystic lesion</td>
</tr>
<tr>
<td>Thyroglossal duct cyst</td>
<td>Midline neck, infrahyoid</td>
<td>Well defined, unilocular, anechoic, avascular cystic neck lesion; moves with tongue protrusion or swallowing. Posterior acoustic enhancement may be seen.</td>
</tr>
<tr>
<td>Branchial cleft cyst</td>
<td>Along anterior border of sternocleidomastoid muscle</td>
<td>Well defined, unilocular, anechoic, avascular cystic lesion. May have sinus draining along the anterior border of the sternocleidomastoid muscle</td>
</tr>
<tr>
<td>Dermoid cyst</td>
<td>Junction of dermatoms, periorbital, midline</td>
<td>Well defined, pseudosolid, mixed echogenic avascular lesion at the head and neck</td>
</tr>
<tr>
<td>Simple ranula</td>
<td>Floor of mouth above the mylohyoid</td>
<td>Well defined, unilocular, anechoic avascular lesion</td>
</tr>
<tr>
<td>Dermoid cyst</td>
<td>Sternocleidomastoid muscle</td>
<td>Focal fusiform mass or diffuse enlargement</td>
</tr>
<tr>
<td>Lymphadenopathy</td>
<td>Lateral neck, axillary, inguinal</td>
<td>Ovoid, hypoechoic enlarged nodes with fatty hilum and prominent hilar vascularity</td>
</tr>
<tr>
<td>Lipoma</td>
<td>Anywhere – subcutaneous layer</td>
<td>Ill to well defined, subcutaneous or intramuscular avascular echogenic lesions parallel to skin surface</td>
</tr>
<tr>
<td>Nerve sheath tumour</td>
<td>Adjacent to nerve</td>
<td>Well defined, ovoid hypoechoic lesion. Nerve passes central or peripheral to mass vascularity</td>
</tr>
<tr>
<td>Hematoma</td>
<td>Anywhere</td>
<td>Initially ill defined echogenic lesion that undergoes interval decrease in size and echogenicity with temporal evolution</td>
</tr>
<tr>
<td>Abscess</td>
<td>Anywhere</td>
<td>Ill to well defined, hypo-anechoic lesion with shaggy walls and rim vascularity; “dirty” internal echoes</td>
</tr>
<tr>
<td>Ganglion cyst</td>
<td>Periarticular adjacent to tendons</td>
<td>Well defined, anechoic and avascular cyst lesion, posterior acoustic enhancement and communication to joint may be seen</td>
</tr>
<tr>
<td>Herniae</td>
<td>Inguinal, scrotal and periumbilical</td>
<td>Distended internal inguinal ring measuring &gt;4 mm in width and presence of fluid, omentum or organs within the inguinal canal</td>
</tr>
<tr>
<td>Epidermal inclusion cyst</td>
<td>Subcutaneous regions</td>
<td>Well defined, anechoic cyst lesion within the skin and subcutaneous tissue; pseudosolid appearance and sinus track to skin surface may be seen</td>
</tr>
</tbody>
</table>

Benign palpable paediatric lumps

Head and neck
- Haemangioma & vascular malformation
- Lymphatic malformation
- Thyroglossal duct cyst
- Brachial cleft cyst
- Dermoid cyst
- Ranula
- Fibromatosis colli
- Lymphadenopathy

Trunk and extremity
- Lipoma
- Nerve sheath tumours
- Haematoma & abscess
- Ganglion cyst
- Herniae
- Epidermal inclusion cyst
Fig. 1: 1 year old girl with left facial lump. (a) Grey scale US shows an ill-defined, hypoechoic subcutaneous mass in the left cheek. Few anechoic vascular channels are seen within (arrows). (b) Colour Doppler shows high vascular density within the lesion (c) Spectral Doppler shows pulsatile arterial flow within the vessels. US confirmed clinical suspicion of AVM. Child treated conservatively and on regular US follow up.

Fig. 2: 13 year old boy with suspected venous malformation on the left side of the neck. (a) Grey scale US shows an ill defined mass with anechoic serpiginous vascular spaces (arrow). (b) Doppler shows very low amplitude flow within the vascular spaces in keeping with a low flow vascular malformation. (c) Echogenic phleboliths (arrows) within the vascular spaces confirm the diagnosis of venous malformation. The lesions is stable in appearance and size on follow up US.

Fig. 3: 8 month old boy with fluid filled lump in the neck. (a) Grey scale US shows a transpatial multilocular cystic lesion. (b) Colour Doppler shows minimal vascularity within the thin intervening septae. These features in the given clinical setting are characteristic for a cystic hygroma. Patient was later treated with sclerotherapy.

Fig. 4: 8 year girl with midline neck lump. Grey scale US shows well circumscribed anechoic cystic lesion in the midline of the neck, anterior to the thyroid cartilage (arrow), that moves with tongue protrusion. The cyst shows internal echogenic debris and posterior acoustic enhancement. Thyroglossal duct cyst was confirmed on surgical excision.

Fig. 5: 11 year old girl with midline neck lump. Grey scale US shows a well circumscribed hypoechoic lesion at the midline of the neck with small track leading to the hyoid bone (arrow). The lesion was excised surgically and histologically proven to be thyroglossal cyst.

Fig. 6: 13 year old girl with lateral neck lump. Grey scale US shows a large cystic lesion located anterior to the common carotid artery (annotation). Internal echogenic debris suggests a complicated cyst. Fine needle aspiration was performed to exclude metastatic lymphadenopathy that was negative. The lesion was excised surgically and histologically proven as branchial cleft cyst.
Fig. 7: 8 year old girl with midline neck lesion. (a) Grey scale US shows well circumscribed hypoechoic lesion with no relation to the hyoid bone. The lesion does not move with tongue protrusion. (b) Colour Doppler shows absent vascularity. The lesion was surgically excised and histologically proven to be dermoid.

Fig. 8: 10 year old boy with painful right submandibular swelling. Grey scale US shows the bulk of the well defined cystic lesion in the right submandibular space, adjacent to the submandibular gland (arrow). The clinical presentation in combination with sonographic findings are in keeping with plunging ranula. Surgical marsupialization was performed.

Fig. 9: 2 week old boy with torticollis. (a) Grey scale US shows an oval, slightly hypoechoic mass within the sternocleidomastoid muscle (b) Colour Doppler shows some patchy vascularity within the mass. The US features appear consistent with fibromatosis coli. The lesion gradually involuted on follow up US.

Fig. 10: 6 year old boy with right sided painful neck lump. Colour Doppler shows an enlarged, ovoid hypoechoic node with prominent fatty hilum and prominent hilar vascularity in keeping with reactive lymphadenopathy.

Fig. 11: 14 year old girl with prominent supraclavicular lump. Colour Doppler shows a round hypoechoic enlarged lower cervical node with mixed hilar and peripheral vascularity. The node was biopsied under US guidance and diagnosis of lymphoma was confirmed.
Fig. 12: 13 year old boy with a large lump over the anterior abdominal wall. (a) Grey scale US shows a well encapsulated, elliptical subcutaneous lesion with echogenic lines parallel to the skin surface. (b) Colour Doppler shows absence of vascularity. The features are consistent with lipoma and no further follow up imaging was performed.

Fig. 13: 9 year old girl with right forearm lump. (a) Grey scale US shows a well defined, solid hypoechoic lesion with tail-like appearance representing the exiting nerve (arrow) in keeping with schwannoma. (b) Colour Doppler shows no internal vascularity. Surgical excision was performed and histological analysis confirmed schwannoma.

Fig. 14: 11 year old boy with recent trauma and swollen right thigh. Grey scale US shows a poorly circumscribed organizing hyperechoic avascular mass in the right thigh. Diagnosis of hematoma was made and the child was followed up with US until complete resolution.
Fig. 15: 14 year old boy with painful red wrist lump. (a) Grey scale US shows an anechoic liquefied abscess with dirty internal echoes and shaggy walls. (b) Colour Doppler shows peripheral vascularity within the walls of the abscess. Surgical incision and drainage was performed.

Fig. 16: 12 year old boy with non tender right wrist lump. Grey scale US shows a well circumscribed anechoic cystic lesion dorsal to the extensor tendons of the right wrist. Internal debris and posterior acoustic enhancement noted. The features were consistent with ganglion cyst and the patient is being followed up with US.

Fig. 17: 2 year old girl with painful right groin lump. (a) Grey scale US of the right inguinal region shows a well defined structure with internal cystic areas within. The features appear characteristic for a herniated ovary with numerous follicles within (b) Colour Doppler shows intact vascularity of the pedicle. No other imaging was performed and child underwent surgical exploration and repair. Herniated right ovary identified intra-operatively.
rare. US is poor at distinguishing between neurofibromas and schwannomas. Both commonly appear as well defined, ovoid or fusiform, homogeneous and hypoechoic masses (Fig 13). Posterior acoustic enhancement and ‘target’ appearance i.e. hyperechoic centre with hypoechoic periphery may be occasionally visualized. The nerve is seen to pass through the centre of the mass in neurofibromas whereas the nerve is related to the periphery of the mass in a schwannoma. Schwannomas may appear cystic and more vascular than neurofibromas.

Haematoma and Abscess
Haematomas and abscesses are common in the extremities. Clinical history is crucial to distinguish between the two as they have similar sonographic features. The sonographic appearance of haematoma changes with time. Acute haematoma is usually ill defined and hyperechoic whilst chronic haematoma reduces in echogenicity and size (Fig 14). Vascularity is often absent in a haematoma. An infected haematoma can progress onto an abscess.

An abscess on US usually appears as an ill to well defined hypo or anechoic lesion with shaggy walls. It may show ‘dirty’ internal echoes, fluid-fluid levels, septae and rim vascularity on colour Doppler (Fig 15). An abscess is frequently associated with adjacent oedematous subcutaneous tissue and enlarged reactive regional nodes. US may be used for guided aspiration and follow up till resolution.

Ganglion cyst
About 50-70% of soft tissue masses in the wrist region are ganglion cysts. They are less common at the shoulder, elbow, hip, knee and ankle. A wrist ganglion on US typically appears as a well defined, anechoic and avascular lesion, lying dorsal to the extensor tendons (Fig 16). Posterior acoustic enhancement is common. Some ganglions may be compressible. Lobulations, septations and internal echoes may be seen. An anechoic duct leading to the joint may be visualized. An infected ganglion can mimic a solid mass and appear heterogeneous with internal echoes.

Herniae
Congenital indirect inguinal herniae are the most common external herniae in children. These usually contain omental fat, bowel loops and peritoneal fluid. Unusual sac contents may include the vermiform appendix, part of the urinary bladder and ovaries and/or fallopian tubes in female infants.
A herniated ovary if detected on US must be differentiated from a round ligament cyst. Torsion of the ovarian vascular pedicle must be ruled out in all cases of herniated ovary [Fig 17]. US criteria that have been described for paediatric inguinal herniae include internal inguinal ring greater than 4 mm in diameter and presence of fluid or organs in the inguinal canal at rest or during straining. Herniated omental fat appears hyperechoic whilst bowel loops will demonstrate peristalsis [Fig 18]. Bowel viability must be assessed in all cases by evaluating for peristalsis, reducibility and mucosal vascularity. Valsalva manoeuvre and examination in the standing position helps to assess sliding motion and reducibility of herniae in older cooperative children.

**Epidermal inclusion cyst**

Epidermal inclusion cyst results from the implantation of epidermal components into the dermis. The aetiology may be congenital (secondary to misplacement of the remnant ectodermal tissues during embryogenesis) traumatic or post-surgical. They usually occur in the back, neck, scalp and extremities. Patients commonly present with a palpable nodule that discharges oily material through a punctum. An intact epidermal cyst on US appears as a well defined, anechoic lesion within the skin or subcutaneous tissue. Some cysts may show a sinus track leading to the skin surface. They may sometimes appear pseudo-solid with bright internal echoes (pseudotestis appearance) due to their keratin content. A ruptured cyst may show irregular margins, rim vascularity and adjacent inflammatory changes. Both intact and ruptured epidermal cysts may show posterior acoustic enhancement.

**CONCLUSION**

US along with Doppler is a safe and reliable first line modality for the evaluation of palpable paediatric lumps. Accurate clinical history and awareness of the specific US characteristics of these lesions helps in correct diagnosis. The commonly encountered benign palpable lumps in children along with their common locations and typical US characteristics have been summarized in Table II. US also plays an important role in follow up of benign paediatric lumps, imaging guided needle aspiration for cytology and drainage of abscesses and collections.

**REFERENCES**

Multiple Choice Questions

1. What is the commonest location of a TDC?
   A. Suprahyoid
   B. Infrahyoid
   C. Submental
   D. Submandibular
   E. Posterior triangle

2. Which space shows the bulk of a plunging ranula on US?
   A. Submental space
   B. Submandibular space
   C. Anterior triangle
   D. Masticator space
   E. Parapharyngeal space

3. US features of benign reactive nodes include:
   A. Intranodal necrosis
   B. Intranodal calcifications
   C. Fatty hilum with hilar vascularity
   D. Peripheral vascularity
   E. Round shape

4. What is the commonest location of a ganglion cyst?
   A. Wrist
   B. Hip
   C. Shoulder
   D. Ankle
   E. Knee

5. What are the common US imaging features of a cystic hygroma?
   A. Solid hyperechoic lesion
   B. Multilocular anechoic lesion
   C. Pseudotestis appearance
   D. Shaggy walls with dirty internal echoes
   E. High vessel density