Impact of Ultrasound in Diagnosis of Pediatric Superficial Masses in Head and Neck

Ahmed Farid, Ahmed Shalaan, Shirin Khedr

Department of Radiology, Benha faculty of medicine, Benha University, Egypt

Correspondence to: Shirin Khedr, department of Radiology, Benha faculty of medicine, Benha University, Egypt.

Email:

shirinkhedr2020@gmail.com

Received: 19 July 2020

Accepted: 15 August 2020

Abstract:

Background: Neck masses are frequently encountered in pediatric medicine, and can present a diagnostic dilemma for the clinicians involved. **Aim:** to determine the impact of ultrasound in diagnosis of superficial masses in head and neck in pediatric. **Methods:** This is a review article. The search was performed using MEDLINE, Embase, Pubmed and CINAHL Plus in the same date range with the following medical terms: “Ultrasound; Pediatric; mass; head; neck”, including articles from 2000 to 2019. **Results:** In this review, the US findings are described for a variety of common and uncommon pediatric head and neck masses diagnosed in our practice. Specifically, the entities covered include neonatal scalp hematoma, craniosynostosis, dermoid and epidermoid cysts, Langerhans cell histiocytosis, lymph nodes and their complications, fibromatosis colli, thyroglossal duct cyst, branchial cleft cyst, cervical thymus, congenital goiter, thyroid papillary carcinoma, parathyroid adenoma, hemangioma, lymphangioma, jugular vein phlebectasia, acute parotitis, leukemia and/or lymphoma, neurogenic tumor, and rhabdomyosarcoma. **Conclusion:** Duplex US has emerged as the first-line imaging modality for the evaluation of superficial pediatric masses. Without the use of ionizing radiation, iodinated contrast material, or sedation and/or anesthesia, this safe, quick, and cost-effective imaging modality allows rapid evaluation and characterization of masses.

Keywords: Ultrasound; Pediatric; mass; head; neck

Introduction

Superficial palpable masses of the head and neck are common in the pediatric population, with the vast majority of the lesions ultimately proven to be benign (1).

Neck masses are frequently encountered in pediatric medicine, and can present a diagnostic dilemma for the clinicians involved. There are several means by which neck mass in children can be subdivided, for example by age at presentation, anatomical location including compartments and fascia of the neck, their classical appearance when imaged, or by etiology. When imaging children the clinicians must be mindful of radiation exposure and as such ultrasound (US) is often attempted first (2).

A wide variety of scalp lesions are identified as palpable masses or as incidental findings on radiologic studies. They represent a challenge, for that may lead to diagnostic mistakes. Correct interpretation of a scalp mass may lead to reduced mortality and morbidity and may guide physicians toward the most appropriate management (3).

The US findings are described for a variety of common and uncommon pediatric head and neck masses diagnosed in our practice. Specifically, neonatal scalp hematoma, craniosynostosis, dermoid and epidermoid cysts, Langerhans cell histiocytosis, lymph nodes and their complications, fibromatosis colli, thyroglossal duct cyst, branchial cleft cyst, cervical thymus, congenital goiter, thyroid papillary carcinoma, parathyroid adenoma, hemangioma, lymphangioma, jugular vein phlebectasia, Lemierre syndrome, acute parotitis and parotid abscess, leukemia and/or lymphoma, neurogenic tumor, and rhabdomyosarcoma (2).

Ultrasound is the second most common method of imaging carried out in hospitals worldwide after plain-film radiography. Modern high-resolution ultrasound has excellent spatial and contrast resolution for the near field, ultrasound plays an increasingly important role in head and neck imaging (4).

Improved developments in digital ultrasound technology and the use of high-frequency broadband transducers make ultrasound (US) imaging the first screening tool in investigating superficial tissue lesions. US is a safe (no ionizing radiation), portable, easily repeatable, and cheap form of imaging compared to other imaging modalities. US is an excellent imaging modality to determine the nature of a mass lesion (cystic or solid) and its anatomic relation to adjoining structures. Masses can be characterized in terms of their size, number, component, and vascularity with US (5).

This study aimed to determine the impact of ultrasound in diagnosis of superficial masses in head and neck in pediatric.

Methods

This is a review article. The search was performed using MEDLINE, Embase, Pubmed and CINAHL Plus in the same date range with the following medical terms: "Ultrasound; Pediatric; mass; head; neck", including articles from 2000 to 2019. Excluded articles from review are those of language other than English. Key words: Ultrasound; Pediatric; mass; head; neck.

Results

Head Masses

Neonatal Scalp Hematoma

US is used to evaluate for superficial hematomas when there is clinical concern regarding the differential diagnosis, as well as to determine if higher-tech imaging is required. Precise knowledge of the relevant scalp anatomy is essential in the evaluation of neonatal scalp collections. The scalp is divided into skin, connective tissue, the aponeurosis, also known as the galea aponeurotica, and the pericranium (periosteum), which covers the skull. Although many types of neonatal scalp hematomas exist, this review focuses on utilization of US for assessment of suspected cephalohematomas and subgaleal hematomas (6).

Craniosynostosis

Although the diagnosis of craniosynostosis can often be made on the basis of the findings at physical examination because of the cosmetic and/or calvarial deformity, US can be helpful in more subtle cases. At US, there is loss of the normal hypoechoic appearance of a segment of normal skull suture secondary to fusion of the suture. It may be quite challenging, in the presence of patient motion and/or excess scalp hair, to follow the entire course of the sutures to confirm their patency. Both a lack of suture patency and ridging of the sutures are characteristic of craniosynostosis. Although US is a good screening modality for craniosynostosis, definitive diagnosis and surgical planning require advanced imaging (CT) with three-dimensional reconstruction (7).

Dermoid and Epidermoid Cysts

At US, dermoid and epidermoid cysts are generally well circumscribed, avascular, and hypoechoic, compared with subcutaneous fat, and occasionally contain hyperechoic foci because of the presence of calcification, fat, mucoid, and/or purulent material or soft tissue. To confirm the origin of the cyst, it is imperative to demonstrate whether the cyst is covered by periosteum or is superficial to the periosteum, figure 1. (8)

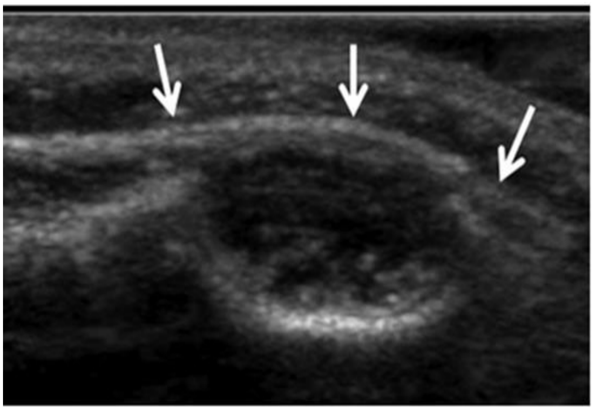

Figure 1: Epidermoid cyst in a 9-month-old female infant presenting with a small hard immobile right frontal mass: Transverse gray-scale US image shows a hypoechoic avascular well-defined complex cystic mass containing debris, which arises from the right frontal bone. The periosteum (arrows) is draped over the mass. (Morrow Ms and Oliveira AM., 2014)

Langerhans Cell Histiocytosis

On radiographs, the bone lesions of Langerhans cell histiocytosis are typically described as "punched-out" lytic lesions without periosteal reaction or reactive sclerosis. In patients with Langerhans cell histiocytosis, asymmetric destruction of the inner and outer tables of the skull results in a beveled appearance. At US, Langerhans cell histiocytosis manifests as a solid mass with minimal vascularity, extending from the diploic surface. Because the differential diagnosis includes leukemia and/or lymphoma as well as other neoplastic processes that cannot be excluded with US alone, cross-sectional imaging is required for more precise tissue characterization and to assess the extent of the lesion, especially with regard to invasion of the bone, dura, meninges, and/or cerebral cortex (9).

Neck Masses

Normal Cervical Lymph Nodes

At gray-scale US, normal lymph nodes will be well defined and appear hypoechoic when compared with the adjacent musculature. A flattened or oval configuration is typically depicted, with distinct borders and a short axis–to–long axis ratio of less than 0.5. By the end of the 1st decade of life, normal cervical lymph nodes will measure up to 10 mm in size when measured in the short axis, with nodes larger than 10 mm considered enlarged. During the 1st decade of life, the short axis of normal lymph nodes generally measures 5 mm or less. A hyperechoic linear fatty hilum should be able to be identified in a normal lymph node. The vasculature courses through the hilum before radially branching from the central lymph node. This pattern of central vascular flow may be demonstrated at color Doppler US. The perinodal soft tissues will be distinct, with well-defined planes separating the dermis, subcutaneous fat, and muscle (10).

Malignant lymphadenopathy is also a consideration in a child presenting with cervical lymphadenopathy. Malignant lymphadenopathy in the setting of metastatic disease or primary lymphoma and/or leukemia will often manifest differently, with nodal enlargement being painless, hard, and non-mobile .If lymphadenopathy persists after a trial of antibiotic therapy, tissue sampling is often the next step in the workup, to look for malignancy. Please refer to the “Leukemia and/or Lymphoma” section for further discussion of the US appearance of lymphomatous and leukemic nodes (11).

Fibromatosis Colli

US imaging is the first step in the workup to evaluate for fibromatosis colli and will demonstrate either focal (most commonly in the lower two-thirds of the muscle) or diffuse enlargement of the sternocleidomastoid muscle. The affected fibrotic regions may have a variable appearance, often demonstrating an ellipsoid region of thickening that is uniformly hyperechoic or hypoechoic compared with the adjacent unaffected muscle. The swollen belly of the sternocleidomastoid muscle will smoothly blend with the unaffected muscle fibers without evidence of a focal well-defined primary mass (12).

At real-time US, the mass will move synchronously with the remaining sternocleidomastoid muscle, confirming the location of the mass and its relationship to the muscle. Uncommonly, hyperechoic foci with acoustic shadowing may be depicted, owing to calcification, a finding that is likely the sequela of prior hemorrhage. Pertinent associated findings, such as adjacent lymphadenopathy, extension of the mass beyond the muscle planes, or irregular mass margins, should be reported to prompt further workup, because these suspicious characteristics would not be expected in fibromatosis colli figure 2. (12).

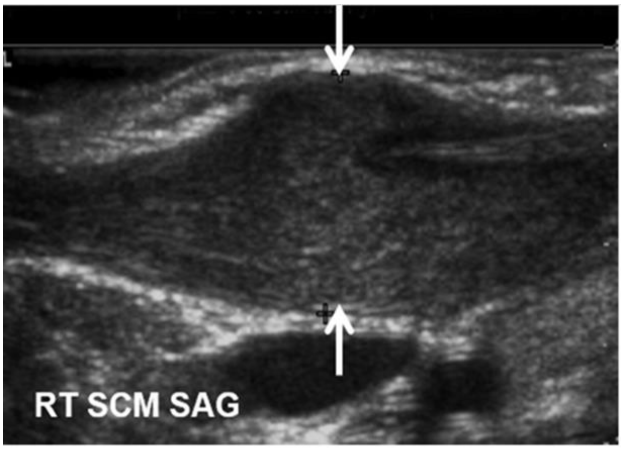

Figure 2: Fibromatosis colli in a 3-week-old female newborn presenting with a right neck mass. Sagittal gray-scale US images of the right (27) and left (28) sternocleidomastoid muscles show an enlarged right sternocleidomastoid muscle (arrows on 27), compared with the uninvolved corresponding left muscle (arrows on 28).(Lyshchik A et al.,2005)

Thyroglossal Duct Cyst

At US evaluation, TDCs will be a well-circumscribed hypo- or anechoic cystic structure with posterior acoustic enhancement.

Imaging features of internal complexity, such as septa and debris or internal echoes from proteinaceous material, may be depicted in the absence of infection. In the setting of an infected TDC, additional US findings such as a thickened and irregular cyst wall with increased peripheral vascularity may be present. A soft-tissue mass associated with a TDC may represent ectopic thyroid rests or, rarely, a carcinoma—with papillary thyroid carcinoma diagnosed in most cases (>80%) at histopathologic examination.

Given this small potential for malignant transformation, as well as the potential for infection and the challenge of differentiating infection from tumor in the presence of hypervascular wall nodules and calcifications, elective resection is recommended. Before surgical removal, the presence of a properly positioned thyroid gland must be confirmed, because the ectopic thyroid rests may potentially be the only functional thyroid tissue in the body (13). (figure3).

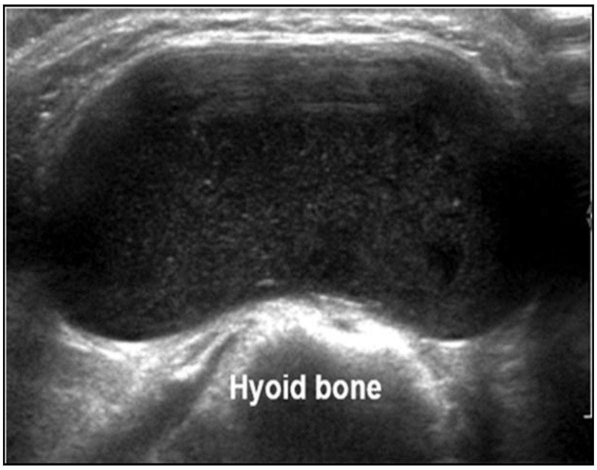

Figure 3: Transverse gray-scale US image of the midline anterior part of the neck at the level of the hyoid bone in a 12-year-old girl shows a 3.9-cm avascular cystic lesion with internal debris, findings compatible with a minimally complex TDC.(Kollars J etal.,2005)

Branchial Cleft Cyst

At US evaluation, BCCs are well-circumscribed round or oval hypo- or anechoic cystic structures with posterior acoustic enhancement. A common location for BCCs is the anterior triangle of the neck, located anterior to the sternocleidomastoid muscles. These cysts lie anterolateral to the great vessels of the neck and may be adherent to the internal jugular vein or possibly protrude between the internal and external carotid arteries. A variable complex cystic appearance and peripheral hypervascularity may be seen in the setting of superimposed infection. When imaging a BCC, it is important to look for a concurrent branchial cleft sinus or branchial fistulas, because resection of these tracts is necessary to prevent recurrence of the cyst. Those patients with a branchial cleft sinus or branchial fistulas will often present earlier and have more symptoms than those with a BCC, owing to external and/or internal mucosal drainage and an increased risk of superinfection. Often, the entire tract will be difficult to delineate but will be proven to be present at surgical resection. (1)

Cervical Thymus

At US, a cervical thymus will demonstrate the same characteristics as normally positioned thymic tissue, thereby helping to confirm the diagnosis. Multiple linear hyperechoic septa and discrete homogeneously distributed hyperechoic foci give the thymus a speckled appearance. Continuity with the dominant thymic mass may be seen by way of the thymopharyngeal duct, a finding that may also aid in diagnosis, (14), figure 4.

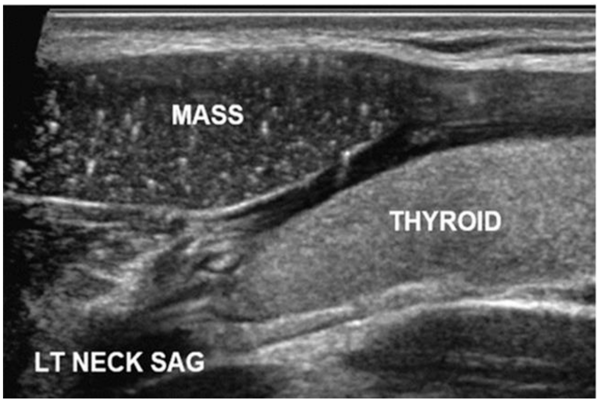

Figure 4: Cervical thymus in a 19-year-old man presenting with a left anterior neck mass that had been unchanged for the previous 3 years. Sagittal gray-scale US image of the neck left of midline shows a painless well-defined hypoechoic heterogeneous compressible avascular structure containing a myriad of tiny bright hyperechoic foci with comet tail artifacts. The superior margin of the structure is adjacent to the undersurface of the body of the hyoid bone, and the inferior margin overlies the upper third of the thyroid anteriorly. (Ridgway JM etal.,2010)

Congenital Goiter

Antenatal US evaluation is difficult, but investigators have attempted to use US findings to help correlate whether a fetal goiter is associated with thyroid dysfunction.

It is determined by identifying a diffusely and homogeneously enlarged thyroid gland with a circumference or diameter that is greater than the 95th percentile for gestational age on the basis of normative values.

Once a goiter is identified, color Doppler US may be used in conjunction with other findings, such as bone maturation and fetal heart rate, to help determine the cause of the fetal goiter. Peripheral vascularity is thought to be suggestive of an enlarged but inactive thyroid gland, whereas central vascularity is suggestive of an overactive thyroid gland, although these findings are not exclusive to their diagnoses. Postnatal US evaluation will also demonstrate a diffusely and homogeneously enlarged thyroid gland that may show mass effect and narrowing of the adjacent airway. The findings at physical examination may include neck hyperextension, and the birth history may include a difficult vaginal delivery owing to cervical dystocia (15)

Thyroid Papillary Carcinoma

At US evaluation, malignant thyroid nodules are predominantly solid and hypoechoic, compared with the adjacent normal thyroid parenchyma, with prominent perinodular and/or intranodular vascular flow. The borders of malignant thyroid nodules may be irregular or microlobulated, but the presence of smooth well-defined borders does not preclude the diagnosis.

In addition to suspicious-appearing thyroid nodules, a diffusely enlarged thyroid gland with multiple microcalcifications should be managed similarly, and cases should be followed up with fine needle aspiration (16).

Parathyroid Adenoma

In the presence of a parathyroid adenoma, one or more parathyroid glands will enlarge and appear as round solid masses that are hypoechoic compared with the adjacent thyroid parenchyma.

This decreased echogenicity is thought to correlate with the dense cellularity of the adenoma seen at histopathologic examination. As the adenoma enlarges, it will adopt an oval and flattened shape as it grows between the tissue planes. At color Doppler US, there will be prominent peripheral hypervascularity with a feeding artery, which may or may not be identified (17). (Figure 5).

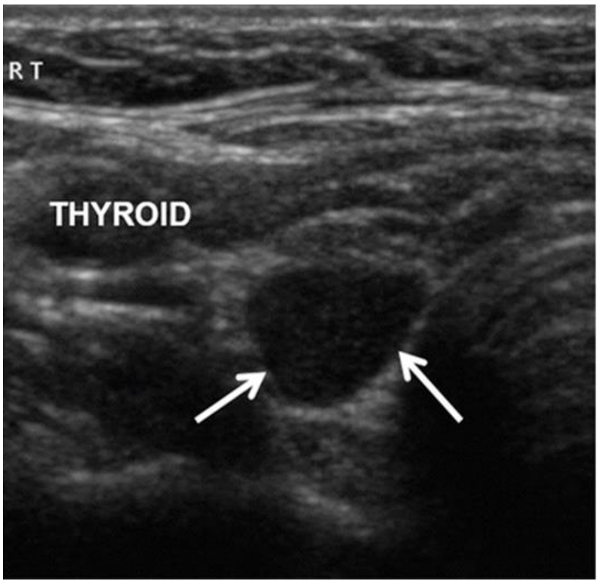

Figure 5: Parathyroid adenoma in a 14-year-old female adolescent presenting with hyperparathyroidism. Sagittal gray-scale (38) and color Doppler (39) US images of the inferior aspect of the right thyroid lobe show a well-circumscribed hypoechoic mass (arrows on 38) with minimal vascularity.(Heul C etal.,2009)

Hemangiomas

At US, hemangiomas appear as discrete cutaneous or subcutaneous soft-tissue masses with prominent internal vascularity. Both arterial and venous flow can be demonstrated within the masses, with high-velocity arterial waveforms and low-resistance venous waveforms (18) (Figure 6).

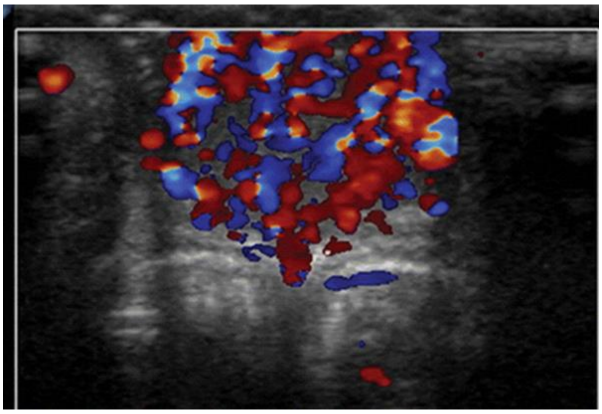

Figure 6: Hemangioma in a 6-month-old female infant presenting with a compressible bluish mass on her upper lip that had appeared at 3 months of age: Transverse gray-scale (40) and color Doppler (41) US images of the mid upper lip show a 1.2-cm hypoechoic hypervascular well-defined compressible mass (marked by calipers on 40). (Massimi et al., 2012)

Lymphangioma

At Doppler US imaging, arterial or venous flow may be seen in the septa. Large lymphangiomas tend to occupy more than one space in the neck and insinuate between normal structures. CT and MR imaging are useful for evaluation of deeper extension into the neck or chest. On CT images, lymphangiomas are hypoattenuating compared with adjacent muscle; and on MR images, they are usually T1 hypointense and markedly T2 hyperintense, unless complicated by hemorrhage. Enhancement is demonstrated in cyst walls and septa but not in central fluid components (19).

Jugular Vein Phlebectasia

Dynamic US of the neck with and without a Valsalva maneuver can help confirm the diagnosis of phlebectasia when the affected vein dilates during a Valsalva maneuver to a diameter approximately twice the diameter at rest. Color Doppler US is useful to demonstrate the presence of blood flow and to exclude thrombus and is the reference standard for the diagnosis of jugular vein phlebectasia (14).

Parotitis

At US, the parotid gland appears enlarged and heterogeneous in both viral and bacterial parotitis, with increased vascularity at color Doppler US. In the bacterial form of parotitis, the parotid gland demonstrates hypoechoic nodular areas that represent intraparotid lymph nodes. In severe cases, avascular hypoechoic areas of suppuration or discrete abscesses may develop. US may also reveal dilated tubular areas compatible with dilated obstructed salivary ducts that may contain hyperechoic calculi (20).

Leukemia and/or Lymphoma

Considerable overlap exists between the US appearance of benign and malignant lymph nodes. In lymphoma, US generally demonstrates enlarged nodes that appear hypoechoic.The nodes tend to be round with absent hila and increased central and peripheral vascularity. Lymphomatous nodes have been shown to have internal reticulation—a micronodular appearance—as well as elevated values for the resistive index and the pulsatility index at spectral Doppler US. The nodes can become confluent, matted, and mass like. In leukemia, cervical nodes are clustered and appear slightly enlarged. The nodes can maintain their borders or may become more confluent, mimicking lymphoma (21). (Figure 7).

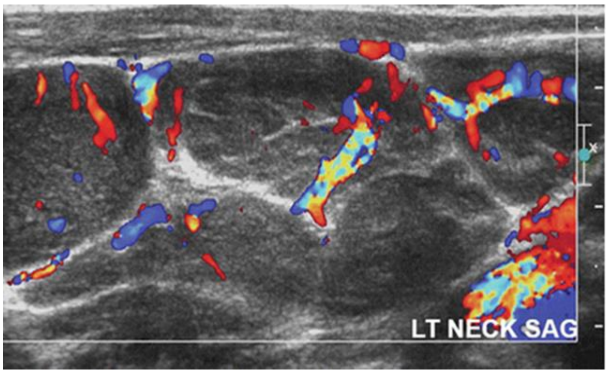

Figure 7: Hodgkin lymphoma in a 4-year-old girl presenting with swollen glands that had been present for the previous 2 months: Sagittal Doppler US image of the left lateral part of the neck shows multiple large hyperemic architecturally abnormal lymph nodes with a reticulated hypoechoic appearance, which lack the expected fatty hilum.(Morris LM 2016)

Neurogenic Tumors

Schwannomas and neurofibromas generally appear well circumscribed, homogeneous, and hypoechoic, with posterior acoustic enhancement. Some schwannomas may demonstrate prominent internal vascularity, which can be easily compressed with gentle pressure on the transducer. It can be difficult to differentiate schwannomas from reactive lymph nodes, which may have a similar appearance; however, identification of an associated nerve can be used to reliably distinguish schwannomas from nodes. (22).

Neurofibromas appear well circumscribed and are hypoechoic, with posterior acoustic enhancement, and may demonstrate a target appearance—peripherally hypoechoic and centrally hyperechoic. Plexiform neurofibromas demonstrate diffuse peripheral nerve involvement rather than a focal mass. On CT and MR images, plexiform neurofibromas appear as multilobulated masses along the expected course of a nerve trunk, with extension along nerve branches, creating the appearance of a bag of worms. A split fat sign may be seen, with a rim of fat around the lesion; and a target sign can be seen on MR images, with central T2 hypointensity against a background of T2 hyperintensity (23).

Malignant peripheral nerve sheath tumor (MPNST) is a high-grade sarcoma that can arise from a plexiform neurofibroma or from prior irradiation or can arise spontaneously. MPNST affects approximately 5% of patients with neurofibromatosis type 1. MPNST is difficult to distinguish from neurofibroma at US, although some MPNSTs may demonstrate hyperemia. Radionuclide imaging with gallium 67 citrate can show increased radiotracer uptake in MPNST, compared with that in neurofibroma; and MR imaging may demonstrate altered MR signal intensity in MPNST, compared with that in benign lesions (23).

Neuroblastoma is the third most common malignant neoplasm in children, with a rate of occurrence of one in 10 000 live births. Of these cases, 25% appear to be congenital, usually occurring in children nearing 18 months of age. Cervical neuroblastoma accounts for less than 5% of all neuroblastoma cases.It presents as a non-tender lateral neck mass, usually with symptoms related to compression of adjacent structures, such as cranial nerves (Horner syndrome), the esophagus (swallowing difficulty), and the airway (stridor), as well as heterochromia iridis (difference in right and left eye colors). At US, neuroblastoma appears as a solid complex or hypoechoic mass, sometimes with shadowing calcifications, arising posterior to the carotid sheath, with displacement or encasement of the carotid artery and internal jugular vein (23).

Rhabdomyosarcoma

US is particularly valuable in the evaluation of more superficial rhabdomyosarcomas, as well as in the identification of suspicious adjacent lymph nodes. At US evaluation, rhabdomyosarcomas also resemble neuroblastomas in echotexture and often demonstrate low to medium echogenicity, with variable internal vascularity at color Doppler US. The US appearance also resembles fibrosarcoma, malignant fibrous histiocytoma, angiosarcoma, and neurofibrosarcoma. Cross-sectional imaging with MR imaging is required, because the assessment of disease extent and staging is limited with US alone, and tissue sampling is required for a final diagnosis. At MR imaging, rhabdomyosarcoma is usually iso-intense to slightly hyperintense on T1-weighted MR images and T2 hyperintense, with marked contrast enhancement, and possible intralesional hemorrhage or necrosis. Treatment is based on the extent of the disease as well as primary tumor localization, with orbital and non-parameningeal head and neck locations associated with a better prognosis. Chemotherapy is the first line of treatment for rhabdomyosarcomas, with radiation therapy and surgery being the mainstay for local tumor control (24).

Discussion

Ultrasound is the second most common method of imaging carried out in hospitals worldwide after plain-film radiography. Modern high-resolution ultrasound has excellent spatial and contrast resolution for the near field, and the development of 3D technology, extended field-of-view or panoramic imaging, and color flow and power Doppler applications has led to great improvements in its diagnostic utility and accuracy. The technology involves no ionizing radiation, is readily available in most centers, and is relatively inexpensive compared with CT, MRI, and PET (4).

Color flow imaging is now a routine part of the ultrasound examination. Systems should ideally offer high-sensitivity color-flow imaging and power Doppler functionality. Equipment used for functional imaging should be calibrated to depict slow-flowing vessels in the head and neck without artifacts or background noise caused by oversensitivity. The lingual artery in the floor of mouth is a useful and practical vascular landmark for calibration (25).

The following major parameters should be determined: echogenicity, contour, margin, composition, size, related surrounding tissue in grayscale ultrasonography, the grading of CDUS, and resistive index (RI) in spectral Doppler. Many more specific patterns can be observed, including phleboliths, cellulitis-like changes, to-and-fro flow pattern, hyperechoic fat lobules, parallel echoic lines, C-shaped cysts, pannus, echogenic rim, gas bubbles, tortuous tubular structures, compressibility, and central necrosis. These patterns are not seen in each lesion but are diagnostic when they appear. (26)

We suggest the use of a high-frequency probe (>10MHz) for small superficial lesions and 5–10MHz for larger lesions. A curved probe (3–5 MHz) should be used for deeply located lesions. Each ultrasound machine should be equipped with a color Doppler function. (27)

Duplex US is the first-line modality of choice for the evaluation of superficial head and neck masses. Without use of ionizing radiation, iodinated contrast material, or sedation and/or anesthesia, US is able to provide quick and cost-effective acquisition of information, including the location, size, shape, internal contents (solid or cystic), and vascularity of the mass, as well as its relationship to nearby vessels. Moreover, if indicated, US can also be used for guidance during interventional procedures for the purpose of diagnosis (i.e. tissue sampling and biopsy) and/or treatment (i.e. drainage) (23).

Superficial lesions are sometimes very small and located on the dermis or in the subcutaneous layer. We would like to emphasize the importance of gentle scan technique, such as using extra jelly on the skin and holding the probe with only slight skin contact to avoid compressing the lesion. It is not necessary to apply any pressure on the skin or lesion to detect small vessels and low-velocity signals with CDUS and spectral analysis (28).

The examination should be performed with the patient in the sitting or supine position and the neck in extension. A systematic examination should be completed according to the preference of the physician performing the ultrasound procedure as long as it is standardized and thorough. For a right-handed examiner, the console should be located next to the patient's right shoulder. If a focal lesion is identified on physical examination, the ultrasound procedure may concentrate on that area. However, in every circumstance, a basic thyroid assessment and examination of the neck should be performed, as this is a unique opportunity to detect occult pathology with a simple screening evaluation.

Conclusion

Superficial palpable masses of the head and neck are extremely common in the pediatric population, with most of these lesions ultimately proven to be benign. Duplex US has emerged as the first-line imaging modality for the evaluation of superficial pediatric masses. Without the use of ionizing radiation, iodinated contrast material, or sedation and/or anesthesia, this safe, quick, and cost-effective imaging modality allows rapid evaluation and characterization of masses.

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To cite this article: Ahmed Farid, Ahmed Shalaan, Shirin Khedr. Impact of ultrasound in diagnosis of pediatric superficial masses in head and neck. BMFJ 2020; 37 (Radiology):63-76. DOI: 10.21608/bmfj.2020.36406.1292