

# Ultrasonography of Neck Lymph Nodes in Children

M YING, YYP LEE, KT WONG, VYF LEUNG, AT AHUJA

## Abstract

Ultrasound is an ideal imaging tool for initial assessment of cervical lymph nodes in children. Grey scale ultrasound helps to evaluate the morphology of cervical nodes, whereas power Doppler ultrasound assesses the nodal vasculature. On grey scale ultrasound, useful sonographic features that help in identifying pathologic nodes include round contour, absence of echogenic hilus, intranodal necrosis, calcification, ill-defined borders, matting, and adjacent soft tissue oedema. On power Doppler ultrasound, evaluation of vascular pattern of lymph nodes helps to differentiate malignant and benign nodes. Ultrasound-guided fine-needle aspiration cytology is becoming popular in paediatric patients, and ultrasound-guided core biopsy is also possible in this group of patients under local anaesthesia. This article reviews these topics to provide an overview of ultrasonography of cervical lymphadenopathy in children.

## Key words

Neck lymph nodes; Paediatric; Ultrasound

## Introduction

Palpable neck lymph nodes are common in children. This is because reactive hyperplasia of lymph nodes is strongly associated with inflammatory processes commonly seen in children. It has been reported that up to 90% of children aged 4-8 have palpable neck nodes.<sup>1</sup> Cervical lymphadenopathy is also a clinical manifestation of

malignancy. Cervical lymph node metastases are often found in children with head and neck cancers, and neck nodes are also a common site of lymphomatous involvement. The differential diagnosis of cervical lymphadenopathy is different in children because of the higher incidence of congenital abnormalities and infectious diseases, and the relative rarity of malignancies in that age group. Common causes of cervical lymphadenopathy in children include: bacterial, viral, protozoal and fungal infections, malignancies (lymphoma, leukaemia and metastases), systemic lupus erythematosus (SLE), Rosai-Dorfman disease (sinus histiocytosis with massive lymphadenopathy) and Kawasaki disease.<sup>2-9</sup>

Ultrasound is a useful imaging tool for initial evaluation of cervical lymph nodes because it has a high sensitivity (98%) and specificity (95%) particularly when combined with fine-needle aspiration cytology (FNAC).<sup>10</sup> Ultrasound has a higher sensitivity than palpation in detection of cervical nodes (96.8% and 73.3% respectively).<sup>11</sup> Computed tomography (CT) and magnetic resonance imaging (MRI) can also be used to evaluate cervical lymph nodes. However, CT involves ionizing radiation, and sedation may be needed for children undergoing MRI examinations. Therefore, ultrasound examination is more acceptable for this group of patients.

Department of Health Technology and Informatics,  
The Hong Kong Polytechnic University, Hung Hom,  
Kowloon, Hong Kong, China

M YING (應天祥) *PhD*

Department of Diagnostic Radiology and Organ Imaging,  
Prince of Wales Hospital, The Chinese University of Hong  
Kong, Shatin, N.T., Hong Kong, China

YYP LEE (李艷萍) *FRCR, MBChB*

KT WONG (黃嘉德) *FRCR*

VYF LEUNG (梁懿芳) *PhD, RDMS, RVT*

AT AHUJA (區皓智) *FRCP*

Correspondence to: Dr AT AHUJA

**Normal Anatomy**

There are about 300 lymph nodes located along the lymphatic channels of the neck. Each cervical lymph node has a cortex and medulla, and is covered by a fibrous capsule.<sup>12,13</sup>

The cortex consists of lymphocytes which are densely packed together to form spherical lymphoid follicles. The medulla is composed of medullary trabeculae, medullary cords and medullary sinuses. The paracortex is an intermediate area between the cortex and the medulla, where lymphocytes return to the lymphatic system from the circulating blood. In the medulla, the medullary trabeculae compose of dense connective tissue and act as a framework extending from the capsule, and guide blood vessels and nerves to different regions of the lymph node. The medullary cords contain mainly plasma cells and small lymphocytes, whereas the medullary sinuses are filled with lymph and are part of the sinus system of the lymph node.<sup>12,13</sup>

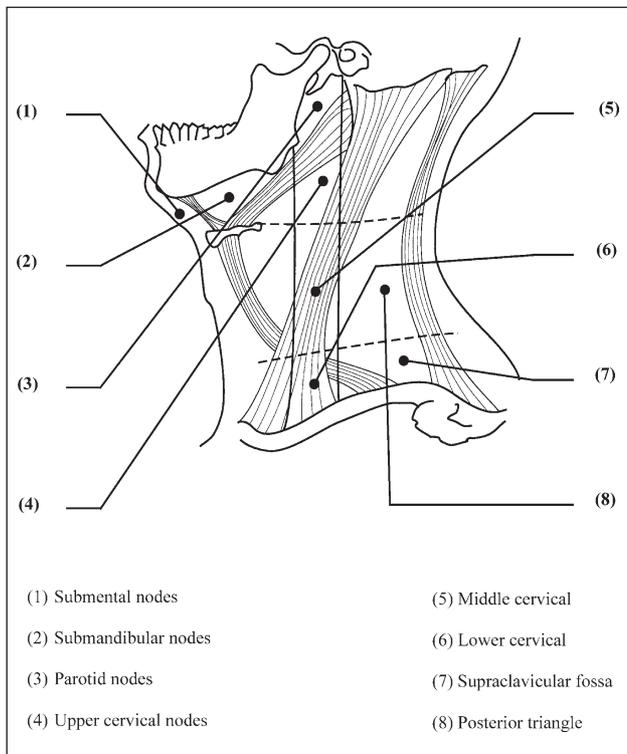
Cervical lymph nodes also contain blood vessels, and the main artery enters the lymph node at the hilus, which

then branches into arterioles. Some of the arterioles supply the capillary bed in the medulla and others run along the medullary trabeculae to the cortex where the arterioles further branch into capillaries and supply the lymphoid follicles. The remaining arterioles run along the trabeculae to the capsule where they anastomose with other branches.<sup>12-14</sup> The venous system has a route similar to the arterial system. The venules converge to form small veins in the cortex. The small veins run along the trabeculae of the lymph node and reach the medulla where they further converge to form the main vein, and leave the lymph node at the hilus.<sup>12-14</sup>

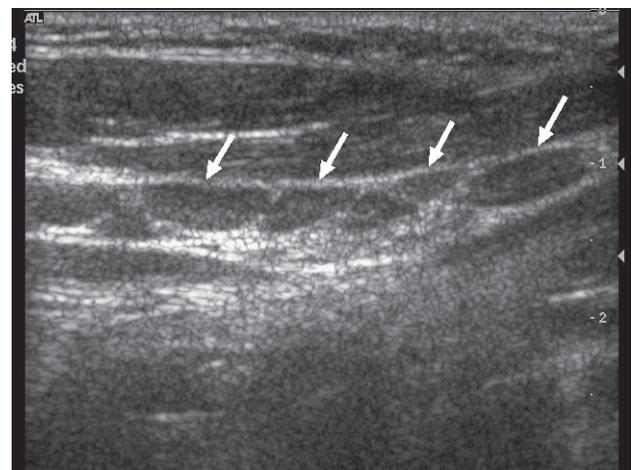
**Sonographic Appearance of Lymph Nodes**

**Distribution**

Although there is no previous report about the distribution of normal neck nodes in children, normal cervical lymph nodes are usually found in the submandibular, parotid, upper cervical and posterior triangle regions of the neck in adults (Figures 1 and 2).<sup>15</sup> It has been reported that palpable lymph nodes in the anterior cervical region are common in healthy children.<sup>3</sup> The finding of the laterality of reactive hyperplasia in children is controversial. Niedzielska et al<sup>9</sup> found that 70% of the paediatric patients showed unilateral reactive lymphadenopathy whereas 30% of them presented with



**Figure 1** Schematic diagram of the neck showing the classification of the cervical lymph nodes.



**Figure 2** Longitudinal sonogram showing multiple normal lymph nodes (arrows) in the posterior triangle of a 9-year-old child. Note the lymph nodes are well-defined, hypoechoic and oval-shaped.

bilateral reactive nodes. However, Papakonstantinou et al<sup>16</sup> reported that 91% of the children with reactive lymph nodes showed bilateral involvement. Unlike reactive hyperplasia, bacterial and tuberculous lymphadenitis tend to be unilateral (100%).<sup>16</sup> It has been reported that nontuberculous mycobacterial lymphadenitis is commonly found in submandibular (87%), preauricular/parotid (9%) and submental (3%) nodes, and 98.6% of patients had unilateral lymph node involvement.<sup>6</sup> Kawasaki disease is an acute febrile illness of unknown cause that occurs primarily in infants and young children. Unilateral nodal involvement is more common than bilateral involvement in Kawasaki disease.<sup>7</sup>

### Size

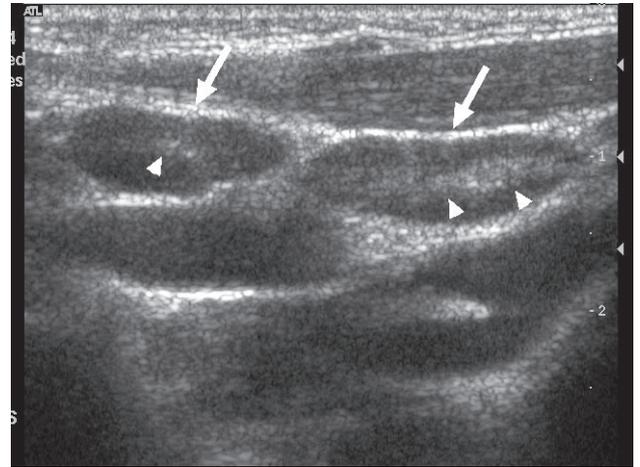
Cervical lymph nodes less than 1 cm in diameter are considered to be normal in children younger than 12 years old, and small lymph nodes in the anterior cervical region are usually benign in this group of patients.<sup>1</sup> Reactive hyperplasia is a common cause of cervical lymph node enlargement in children. Although reactive nodes tend to be smaller than infectious or bacterial lymphadenitis and lymphoma,<sup>16</sup> size of lymph nodes alone cannot be used as the sole criterion in the differential diagnosis of cervical lymphadenopathy in paediatric patients. It has been reported that cervical lymph nodes in Kawasaki disease, bacterial lymphadenitis and acute Epstein-Barr virus infection are similar in size.<sup>7</sup> Furthermore, there is no significant difference in the size of lymph nodes infected with different types of nontuberculous mycobacterial lymphadenitis.<sup>6</sup>

### Shape

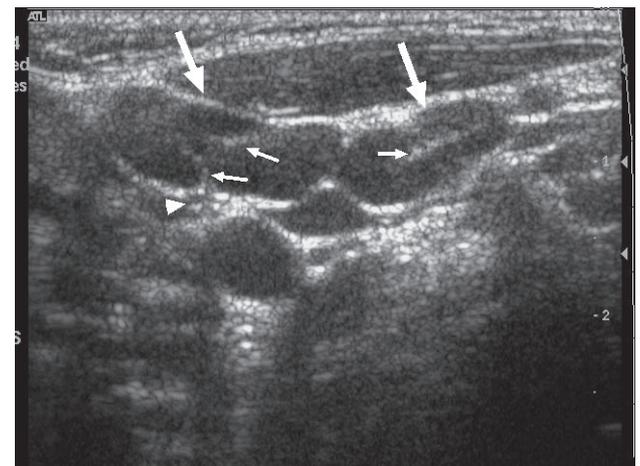
Nodal shape is a common assessment criterion in the sonographic evaluation of cervical lymphadenopathy. Similar to the adults, reactive lymph nodes in paediatric patients tend to be long or oval in shape with a short axis to long axis ratio (S/L) smaller than 0.5 (Figures 3 and 4), whereas lymph nodes involved with infectious mononucleosis, bacterial lymphadenitis, lymphoma, cat-scratch disease and Kawasaki disease tend to be round with a S/L ratio greater than 0.5 (Figure 5).<sup>7,9,16</sup> Therefore, although nodal shape may be helpful in differentiating reactive nodes from other infectious and lymphomatous nodes, it has limited value in distinguishing between infectious and malignant diseases.

### Echogenic Hilus

The echogenic hilus is predominantly associated with the medullary sinuses of lymph nodes, which act as multiple acoustic interfaces and partially reflect the ultrasound waves to produce an echogenic structure, whilst fatty infiltration



**Figure 3** Longitudinal sonogram showing multiple reactive lymph nodes (arrows) in the posterior triangle of a 3-year-old child. The lymph nodes are hypoechoic, oval-shaped and maintain their echogenic hilus (arrowheads).



**Figure 4** Transverse sonogram showing multiple reactive upper cervical nodes (large arrows) in a 2-year-old child. The lymph nodes are hypoechoic and oval in shape. Echogenic hilus (small arrows) is shown in both lymph nodes and is continuous with adjacent fat (arrowhead).

in the medulla makes the hilus sonographically more obvious.<sup>17-19</sup> On ultrasound, the echogenic hilus appears as an hyperechoic linear structure and is continuous with the adjacent fat (Figures 3 and 4).<sup>17,19,20</sup> In the normal neck of adults, about 90% of nodes with a maximum transverse diameter greater than 5 mm show an echogenic hilus.<sup>21</sup> In paediatric patients, reactive lymph nodes (94%) and infectious mononucleosis nodes (100%) tend to have an echogenic hilus whereas lymphoma and bacterial lymphadenitis either show a narrow / irregular hilus or do not present with an echogenic hilus (100%) (Figure 5).<sup>16</sup>

### Intranodal Necrosis

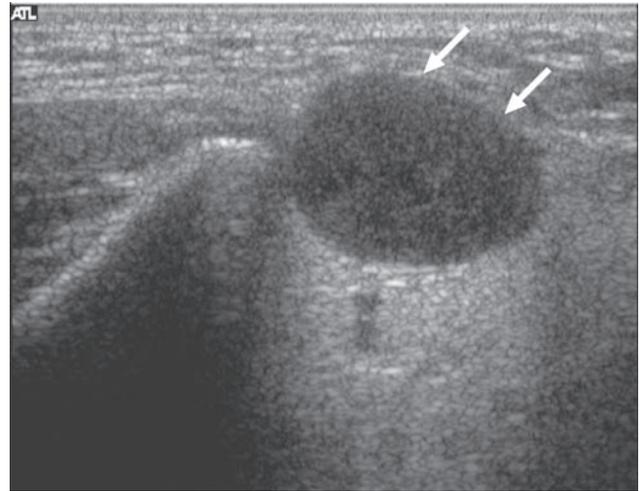
Lymph nodes with intranodal necrosis, regardless of their size, are pathologic.<sup>22</sup> In paediatric patients with nontuberculous mycobacterial cervical lymphadenitis, involved lymph nodes tend to have intranodal cystic necrosis (92%) which appears as an echolucent area within the lymph nodes<sup>6</sup> (Figure 6). In cervical atypical mycobacterial lymphadenitis, lymph nodes with heterogeneous echopattern incorporating intranodal echolucent areas may indicate abscess formation.<sup>8</sup> Intranodal cystic necrosis may also be found in cervical metastatic nodes from the papillary carcinoma of the thyroid in children,<sup>23</sup> which is similar to the metastatic nodes from the same type of carcinoma in adults.<sup>24</sup>

### Intranodal Calcification

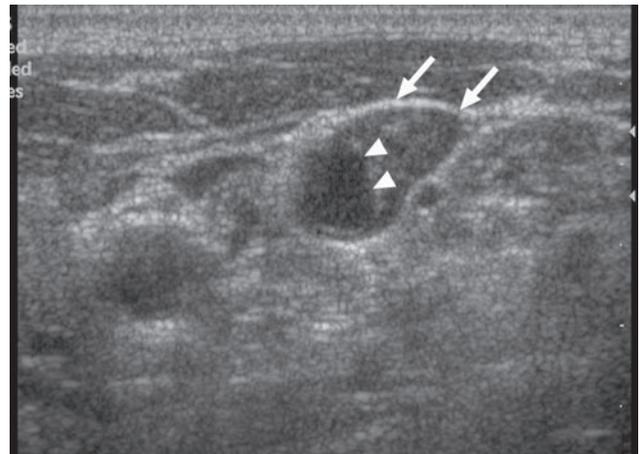
Calcification within lymph nodes is uncommon. However, in paediatric patients, intranodal calcification may be found in atypical mycobacterial lymphadenitis and is predominantly seen in patients late in the course of the infection (Figure 7).<sup>8,25</sup> Similar to adult patients, calcification may also be found in metastatic nodes from papillary carcinoma of the thyroid in children.<sup>23,24</sup>

### Nodal Borders

Malignant lymph nodes tend to have sharp borders because tumour infiltration causes an increase in the difference in acoustic impedance between intranodal and surrounding tissues.<sup>26</sup> In paediatric patients, reactive and lymphomatous lymph nodes, and lymph nodes involved with infectious mononucleosis tend to have sharp borders



**Figure 5** Longitudinal sonogram showing a lymphomatous node in the submandibular region (arrows). The lymph node is hypoechoic, round in shape and without an echogenic hilus.



**Figure 6** Transverse sonogram showing a lymph node involved with mycobacterial lymphadenitis (arrows). Note the intranodal cystic necrosis which appears as a hypoechoic area within the lymph node (arrowheads).

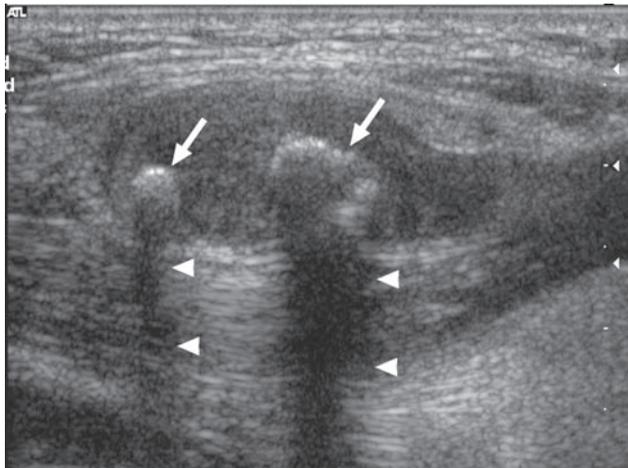
(100%, 82% and 100% respectively) (Figure 8), whereas bacterial or tuberculous lymphadenitis and cat-scratch disease usually present with ill-defined lymph nodes (79%, 60% and 80% respectively; Figure 9).<sup>16</sup> The unsharp nodal borders in lymphadenitis and cat-scratch disease may be related to the associated periadenitis.<sup>27,28</sup>

### Ancillary Features

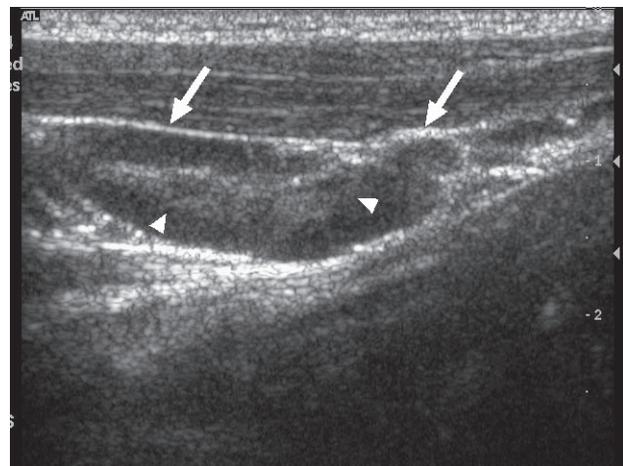
Ancillary features that help in the ultrasound evaluation

of cervical lymphadenopathy are nodal matting and adjacent soft tissue oedema.<sup>29</sup> Lymph nodes affected by mycobacterial lymphadenitis (tuberculous and nontuberculous) tend to have adjacent soft tissue oedema<sup>6,30</sup> (Figure 10). However, adjacent soft tissue oedema is not commonly seen in cervical lymphadenopathy in cat-scratch disease.<sup>31</sup>

Matting or clumping of lymph nodes is common in paediatric patients with Kawasaki disease, infectious mononucleosis, bacterial and tuberculous lymphadenitis



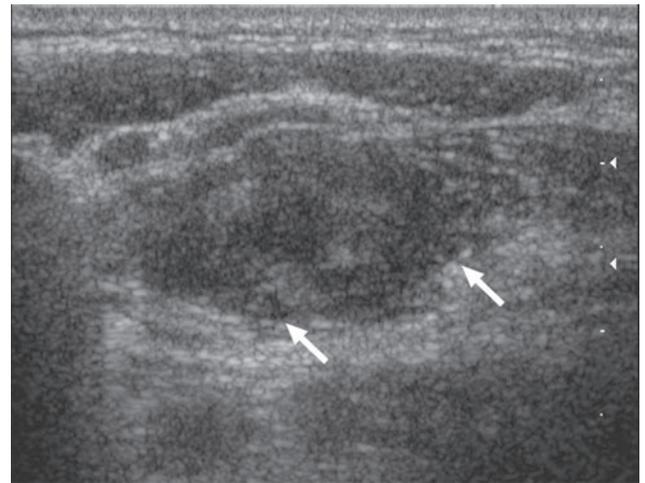
**Figure 7** Longitudinal sonogram showing a lymph node involved with mycobacterial lymphadenitis. The lymph node is hypoechoic and with dense intranodal calcification (arrows). Distal acoustic shadowing (arrowheads) is a common ultrasound artifact associated with dense calcification.



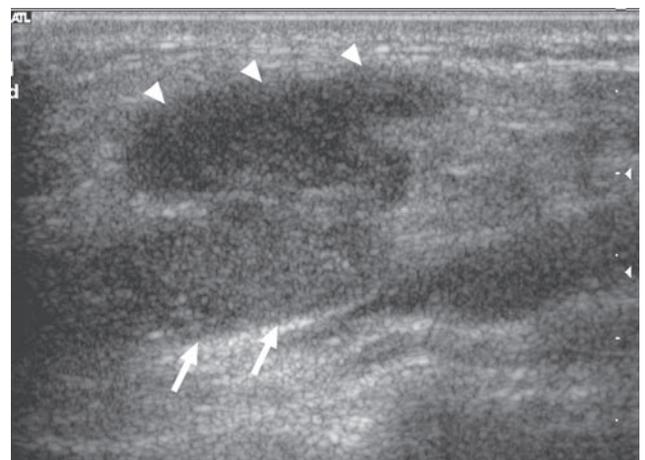
**Figure 8** Longitudinal sonogram showing a reactive posterior triangle node (arrows) in a 3-year-old child. The lymph node is well-defined, hypoechoic, oval in shape and has an echogenic hilus (arrowheads).

(Figure 11).<sup>6,7,9,16</sup> The high incidence of matting in these pathologic lymph nodes is considered to be the result of periadenitis and adjacent soft tissues oedema.

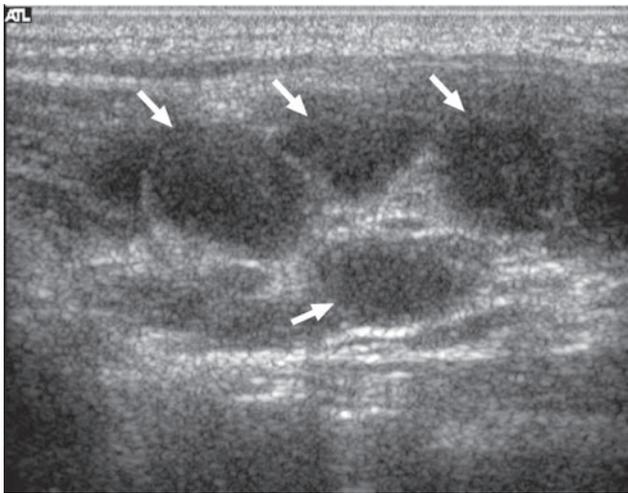
The presence of matting of lymph nodes in cat-scratch disease is debatable. Ridder et al<sup>31</sup> found that 83% of patients with cat-scratch disease do not present with matting of lymph nodes. However, another study showed matting of lymph nodes in 60% of patients with cat-scratch disease.<sup>16</sup> The difference may be due to variation in sonographic features of involved lymph nodes relative to the duration of the illness, as matting occurs late in the course of the disease.



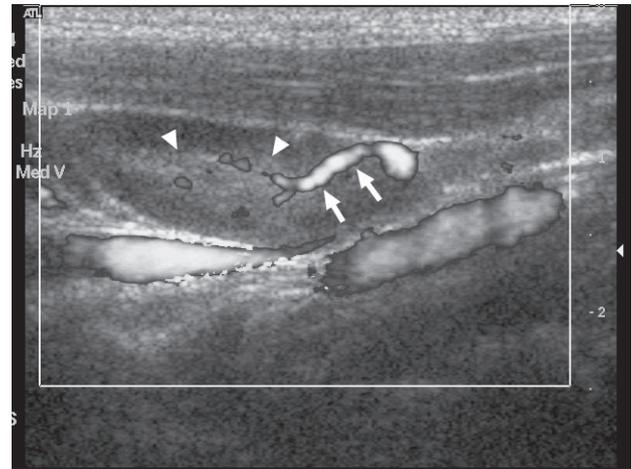
**Figure 9** Longitudinal sonogram showing a tuberculous lymph node with ill-defined borders and is hypoechoic (arrows).



**Figure 10** Longitudinal sonogram showing a tuberculous node (arrows) with adjacent soft tissue oedema which is hypoechoic and ill-defined (arrowheads).



**Figure 11** Longitudinal sonogram showing multiple tuberculous nodes clump together (arrows). Note the lymph nodes are hypoechoic, round and without echogenic hilus.



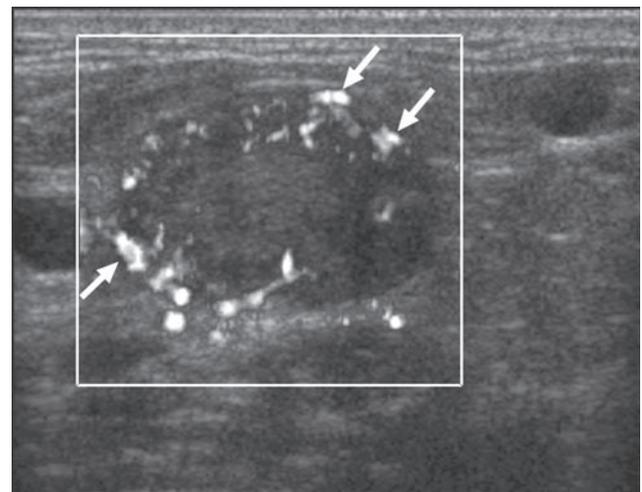
**Figure 12** Power Doppler sonogram of the same lymph node as in Figure 8 showing the hilar vascularity (arrows) which is superimposed on the echogenic hilus (arrowheads) of the node.

**Vascular Pattern**

Evaluation of the intra-nodal vascular pattern of normal and abnormal cervical lymph nodes using power Doppler ultrasound has been reported to be reliable, with a repeatability of 85%.<sup>32</sup> Previous research showed that small normal lymph nodes (maximum transverse diameter <5 mm) usually do not show vascular signals, whereas hilar vascularity is found in larger nodes (maximum transverse diameter >5 mm).<sup>21</sup> With the use of newer high-sensitivity power Doppler equipment, the sensitivity of the detection of intra-nodal vascularity has increased.<sup>33</sup> Hilar vascularity is usually found in reactive nodes (Figure 12), whereas peripheral or mixed vascularity are common in malignant nodes (Figure 13).<sup>34-38</sup> Therefore, the presence of peripheral vessels in lymph nodes is suspicious of malignancy. However, evaluation of vascular pattern of lymph nodes may not distinguish between different benign nodal diseases as their vascular patterns vary with the duration of illness.<sup>9,16</sup>

**Ultrasound-guided Needle Aspiration and Biopsy**

Fine-needle aspiration cytology (FNAC) is well-established in adults and is becoming popular in children.<sup>2,39</sup> Ultrasound-guided FNAC has been shown to be an accurate method in evaluating cervical lymphadenopathy with a high



**Figure 13** Power Doppler sonogram showing a round, hypoechoic malignant lymph node. Note the presence of peripheral vascularity (arrows) is common in malignant nodes.

sensitivity (89-98%), specificity (95-99%) and accuracy (95-98%).<sup>10,40,41</sup> Although ultrasound-guided FNAC is useful in the majority of cases, surgical excision of the lymph nodes and histology are usually considered when cytologic findings are inconclusive for the diagnosis or for bulky and symptomatic lesions.<sup>4</sup> It has been reported that ultrasound-guided core biopsy of neck masses can be performed in paediatric patients under local anaesthesia, and that the procedure is well tolerated.<sup>42</sup> Ultrasound-guided core biopsy therefore avoids unnecessary surgical procedures in this group of patients.

## Conclusion

Ultrasound is a useful imaging tool for the initial investigation of cervical lymphadenopathy in children. Useful sonographic features for identifying pathologic nodes include round contour, absence of echogenic hilus, intranodal necrosis, calcification, ill-defined borders, matting, and adjacent soft tissue oedema. Evaluation of vascular pattern of lymph nodes is useful to differentiate malignant and benign nodes. Ultrasound-guided FNAC or biopsy may still be necessary for confirmation if the ultrasound findings are equivocal.

## References

1. Park YW. Evaluation of neck masses in children. *Am Fam Physician* 1995;51:1904-12.
2. Umapathy N, De R, Donaldson I. Cervical lymphadenopathy in children. *Hosp Med* 2003;64:104-7.
3. Twist CJ, Link MP. Assessment of lymphadenopathy in children. *Pediatr Clin North Am* 2002;49:1009-25.
4. Ruggiero A, Attinà G, Maurizi P, et al. Rosai-Dorfman disease: two case reports and diagnostic role of fine-needle aspiration cytology. *J Pediatr Hematol Oncol* 2006;28:103-6.
5. Boi F, Baghino G, Atzeni F, Lai ML, Faa G, Mariotti S. The diagnostic value for differentiated thyroid carcinoma metastases of thyroglobulin (Tg) measurement in washout fluid from fine-needle aspiration biopsy of neck lymph nodes is maintained in the presence of circulating anti-Tg antibodies. *J Clin Endocrinol Metab* 2006;91:1364-9.
6. Lindeboom JA, Smets AM, Kuijper EJ, van Rijn RR, Prins JM. The sonographic characteristics of nontuberculous mycobacterial cervicofacial lymphadenitis in children. *Pediatr Radiol* 2006;36:1063-7.
7. Tashiro N, Matsubara T, Uchida M, Katayama K, Ichiyama T, Furukawa S. Ultrasonographic evaluation of cervical lymph nodes in Kawasaki disease. *Pediatrics* 2002;109:E77-7.
8. Haber HP, Warmann SW, Fuchs J. Cervical atypical mycobacterial lymphadenitis in childhood: findings on sonography. *Ultraschall Med* 2006;27:462-6.
9. Niedzielska G, Kotowski M, Niedzielski A, Dybiec E, Wieczorek P. Cervical lymphadenopathy in children--incidence and diagnostic management. *Int J Pediatr Otorhinolaryngol* 2007;71:51-6.
10. Baatenburg de Jong RJ, Rongen RJ, Verwoerd CD, van Overhagen H, Lameris JS, Knegt P. Ultrasound-guided fine-needle aspiration biopsy of neck nodes. *Arch Otolaryngol Head Neck Surg* 1991;117:402-4.
11. Baatenburg de Jong RJ, Rongen RJ, Lameris JS, Harthoorn M, Verwoerd CD, Knegt P. Metastatic neck disease. Palpation vs ultrasound examination. *Arch Otolaryngol Head Neck Surg* 1989;115:689-90.
12. Castenholz A. Architecture of the lymph node with regard to its function, In Grundmann E, Vollmer E (Eds): *Reaction patterns of the lymph node. Part 1. Cell types and functions.* New York: Springer-Verlag, 1990, p1-32.
13. Hall FG. The functional anatomy of lymph nodes, In Stansfeld AG, d'Ardenne AJ (Eds): *Lymph node biopsy interpretation.* London: Churchill Livingstone, 1992, p3-28.
14. Papadimitriou CS, Kittas CN. Normal structure and function of lymph nodes, In Pangalis GA, Polliack A (Eds): *Benign and malignant lymphadenopathies.* Chur: Harwood Academic Publishers, 1993, p113-30.
15. Ying M, Ahuja A, Brook F. Gray scale and power Doppler sonography of normal cervical lymph nodes: comparison between Chinese and white subjects. *J Ultrasound Med* 2002;21:59-65.
16. Papakonstantinou O, Bakantaki A, Paspalaki P, Charoulakis N, Gourtsoyiannis N. High-resolution and color Doppler ultrasonography of cervical lymphadenopathy in children. *Acta Radiol* 2001;42:470-6.
17. Rubaltelli L, Proto E, Salmaso R, Bortoletto P, Candiani F, Cagol P. Sonography of abnormal lymph nodes in vitro: correlation of sonographic and histologic findings. *Am J Roentgenol* 1990;155:1241-4.
18. Vassallo P, Edel G, Roos N, Naguib A, Peters PE. In-vitro high-resolution ultrasonography of benign and malignant lymph nodes. A sonographic-pathologic correlation. *Invest Radiol* 1993;28:698-705.
19. Evans RM, Ahuja A, Metreweli C. The linear echogenic hilus in cervical lymphadenopathy--a sign of benignity or malignancy? *Clin Radiol* 1993;47:262-4.
20. Sakai F, Kiyono K, Sone S, et al. Ultrasonic evaluation of cervical metastatic lymphadenopathy. *J Ultrasound Med* 1988;7:305-10.
21. Ying M, Ahuja A, Brook F, Metreweli C. Vascularity and grey-scale sonographic features of normal cervical lymph nodes: variations with nodal size. *Clin Radiol* 2001;56:416-9.
22. Som PM. Lymph nodes of the neck. *Radiology* 1987;165:593-600.
23. Antonelli A, Miccoli P, Fallahi P, et al. Role of neck ultrasonography in the follow-up of children operated on for thyroid papillary cancer. *Thyroid* 2003;13:479-84.
24. Ahuja AT, Chow L, Chick W, King W, Metreweli C. Metastatic cervical nodes in papillary carcinoma of the thyroid: ultrasound and histological correlation. *Clin Radiol* 1995;50:229-31.
25. Wolinsky E. Mycobacterial lymphadenitis in children: a prospective study of 105 nontuberculous cases with long-term follow-up. *Clin Infect Dis* 1995;20:954-63.
26. Shozushima M, Suzuki M, Nakasima T, Yanagisawa Y, Sakamaki K, Takeda Y. Ultrasound diagnosis of lymph node metastasis in head and neck cancer. *Dentomaxillofac Radiol* 1990;19:165-70.
27. Ahuja A, Ying M, King W, Metreweli C. A practical approach to ultrasound of cervical lymph nodes. *J Laryngol Otol* 1997;111:245-56.
28. Ying M, Ahuja AT, Evans R, King W, Metreweli C. Cervical lymphadenopathy: sonographic differentiation between tuberculous nodes and nodal metastases from non-head and neck carcinomas. *J Clin Ultrasound* 1998;26:383-9.
29. Ahuja A, Ying M. Sonography of neck lymph nodes. Part II: abnormal lymph nodes. *Clin Radiol* 2003;58:359-66.
30. Ahuja A, Ying M, Evans R, King W, Metreweli C. The application of ultrasound criteria for malignancy in differentiating tuberculous cervical adenitis from metastatic nasopharyngeal carcinoma. *Clin Radiol* 1995;50:391-5.
31. Ridder GJ, Richter B, Disko U, Sander A. Gray-scale sonographic evaluation of cervical lymphadenopathy in cat-scratch disease. *J Clin Ultrasound* 2001;29:140-5.

32. Ying M, Ahuja A, Brook F. Repeatability of power Doppler sonography of cervical lymph nodes. *Ultrasound Med Biol* 2002; 28:737-44.
33. Stramare R, Tregnaghi A, Fittà C, et al. High-sensitivity power Doppler imaging of normal superficial lymph nodes. *J Clin Ultrasound* 2004;32:273-6.
34. Wu CH, Chang YL, Hsu WC, Ko JY, Sheen TS, Hsieh FJ. Usefulness of Doppler spectral analysis and power Doppler sonography in the differentiation of cervical lymphadenopathies. *Am J Roentgenol* 1998;171:503-9.
35. Steinkamp HJ, Maurer J, Cornehl M, Knobber D, Hettwer H, Felix R. Recurrent cervical lymphadenopathy: differential diagnosis with color- duplex sonography. *Eur Arch Otorhinolaryngol* 1994;251:404-9.
36. Na DG, Lim HK, Byun HS, Kim HD, Ko YH, Baek JH. Differential diagnosis of cervical lymphadenopathy: usefulness of color Doppler sonography. *Am J Roentgenol* 1997;168:1311-6.
37. Arijji Y, Kimura Y, Hayashi N, et al. Power Doppler sonography of cervical lymph nodes in patients with head and neck cancer. *Am J Neuroradiol* 1998;19:303-7.
38. Ahuja AT, Ying M, Ho SS, Metreweli C. Distribution of intranodal vessels in differentiating benign from metastatic neck nodes. *Clin Radiol* 2001;56:197-201.
39. Ramadan HH, Wax MK, Boyd CB. Fine-needle aspiration of head and neck masses in children. *Am J Otolaryngol* 1997;18: 400-4.
40. Lo CP, Chen CY, Chin SC, et al. Detection of suspicious malignant cervical lymph nodes of unknown origin: diagnostic accuracy of ultrasound-guided fine-needle aspiration biopsy with nodal size and central necrosis correlate. *Can Assoc Radiol J* 2007;58:286-91.
41. Robinson IA, Cozens NJ. Does a joint ultrasound guided cytology clinic optimize the cytological evaluation of head and neck masses? *Clin Radiol* 1999;54:312-6.
42. Bain G, Bearcroft PW, Berman LH, Grant JW. The use of ultrasound-guided cutting-needle biopsy in paediatric neck masses. *Eur Radiol* 2000;10:512-5.