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Original Contribution

The use of point of care ultrasound in the evaluation of pediatric soft tissue neck masses

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ABSTRACT

Objective: Most soft tissue neck masses represent benign inflammatory or infectious processes; however, in some cases the diagnosis is not clear and a broader differential must be considered. The aim of this study was to compare point-of-care ultrasound (POCUS) to radiology department imaging (RDI) in the diagnosis of soft tissue neck masses.

Methods: This prospective pilot study involved a convenience sample of patients ranging in age from 1 month to 18 years of age presenting to the Pediatric Emergency Department (PED) with a soft tissue neck mass. All children who presented to the PED with soft tissue neck mass at times when an investigator was in the department, and who were candidates for enrollment, underwent a POCUS. The managing pediatric emergency medicine (PEM) provider determined whether RDI was indicated. The results of the POCUS sonologist and radiologist were compared. The kappa statistic was used to analyze agreement with $p < 0.05$ denoting statistical significance.

Results: Twenty-seven patients were enrolled into the study. Twenty-two received radiology ultrasound (RUS), 3 patients received CT, and 2 patients received both RUS and CT. There was agreement between POCUS and RDI diagnoses in 21/27 cases (78%). Accordingly, overall concordance between POCUS and RDI diagnoses was good: the kappa statistic comparing diagnoses obtained by POCUS versus RDI was 0.69 ($p < 0.001$).

Conclusion: This prospective pilot study describes the reliability of POCUS as an imaging modality in the management of patients with undifferentiated soft tissue neck masses. POCUS demonstrated good agreement with RDI as a bedside imaging tool in the evaluation of pediatric soft tissue neck masses.

1. Introduction

Neck masses in children are a commonly encountered chief complaint in pediatric emergency care. While the vast majority of these masses are caused by benign inflammatory or infectious conditions [1,2], the differential diagnosis of a soft tissue neck mass is vast and other diagnoses must be considered. In broad terms, the causes of soft tissue neck masses can be divided into infectious, inflammatory, congenital, and malignant etiologies.

History and physical examination represent important elements that contribute to the medical decision-making in pediatric patients with soft tissue neck masses. Laboratory and radiological evaluation are performed at the discretion of the managing provider. Many children with signs and symptoms consistent with lymphadenitis are managed with a trial of antibiotics without additional testing [2]. Children in whom the diagnosis is less clear or who have concerning symptoms including high fever, severe pain with palpation of the neck mass, or torticollis, will often undergo laboratory tests and radiological imaging to help guide patient management.

Ultrasound is frequently utilized as the initial imaging modality of choice for the evaluation of palpable neck masses in children [3,4]. Ultrasound has the noted benefits of sparing patients radiation exposure and requiring no sedation, making this an ideal imaging modality for the initial evaluation of these masses [3,5]. Additionally, the neck is particularly amenable to sonographic interrogation since the pathology is often found in a relatively superficial location.

Point of care ultrasound (POCUS) is an emerging field within pediatric emergency medicine. The premise of point of care ultrasound is to answer a targeted question at the bedside, which can help in medical decision making in real time. Several prospective studies have evaluated how POCUS can improve medical decision making in the care of pediatric patients with soft tissue infections, although none of these previous studies have evaluated patients with neck masses [6,7]. The objective of this study was to evaluate the accuracy of POCUS among patients

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with soft tissue neck masses, with radiology department imaging (RDI) as the comparative gold standard.

2. Materials and methods

This was a prospective pilot study involving a convenience sample of children presenting to the ED with a chief complaint of a neck mass. Our ED is an academic tertiary pediatric emergency department (PED) with an annual census of 37,000 patients. Children deemed candidates for inclusion in this study were <18 years of age with a chief complaint of a soft tissue neck mass. Children who were assessed to have an unstable airway, had any form of hemodynamic instability, or had failed antibiotic therapy, were excluded from this study. The Institutional Review Board at our institution approved this study. Informed consent and HIPAA authorization was obtained from accompanying parent or guardian, with assent obtained from children over the age of 7.

The two primary investigators of this study were fellowship trained in both emergency ultrasound and pediatric emergency medicine (PEM). The division of emergency ultrasound established an agreed upon list of sonographic features of lymphadenitis, phlegmon and abscess based on current literature, and a standardized approach to the sonographic evaluation was employed. The sonographic protocol is described below.

A convenience sample of pediatric patients (1 month to 18 years of age) who presented with a chief complaint of neck mass were screened for enrolment. Inclusion in the study was based on study investigator availability. The PEM attending evaluated the patient and decided on the plan of care on clinical grounds alone. It was at the discretion of the PEM provider whether to obtain diagnostic imaging through the radiology department and/or blood for laboratory evaluation.

Upon completion of the initial PEM evaluation, one of the study investigators performed the POCUS. The investigator then documented a working diagnosis based on the sonographic appearance of the mass.

2.1. Technique and sonographic protocol

Using a high frequency linear probe, L10-6 MHz (Zonare Medical Systems, Mountain View, CA) the investigator imaged the neck mass in both the axial and sagittal planes. Key sonographic details obtained were: overall appearance of the mass, singular lymph node or a conglomeration of lymph nodes, normal lymph node architecture with the long axis being greater than the short axis and presence of internal hilar flow using color Doppler (Fig. 1. Sonographic appearance of a normal lymph node {LN}). Other key findings relayed were whether the mass was more consistent with a phlegmon, abscess, cyst or, if the mass was of unclear etiology. Sonographic features of a phlegmon included LN that lacked internal vascular flow with early disruption of the LN internal architecture, while abscess had an irregular shape, variable degree of echogenicity of internal contents, and lobulated or septated appearance. (Fig. 2. Sonographic appearance of a LN with abscess). Cysts were noted when the mass had a thin wall, anechoic internal contents and posterior acoustic enhancement. Fibromatosis Coli (FMC) sonographically appeared as hypertrophy of the sternocleidomastoid muscle.

The investigator was then required to make a presumptive diagnosis based on the sonographic appearance of this mass. The investigator's impression of the mass was then relayed to the managing PEM provider. The purpose of this step was to ensure that the managing PEM provider could use important information obtained by the POCUS. It was also understood that if there was a plan to obtain radiology imaging, this step should continue regardless of the results of the POCUS. Radiologists were blinded to the results of the POCUS. Children for whom the managing PEM provider deemed no confirmatory imaging necessary were excluded from the statistical analysis. Those children who did not undergo radiology imaging as part of their ED evaluation were contacted 7–10 days following their ED discharge to obtain follow up regarding their clinical course (Fig. 3. Study algorithm).

2.2. Statistical analysis

Categorical variables were described in terms of percent (frequency) while continuous variables were described in terms of median (minimum, maximum).

To determine agreement between the diagnosis on the basis of POCUS versus RDI diagnosis, a Cohen's kappa statistic was performed. A kappa between 0.21 and 0.40 was considered fair agreement, 0.41 to 0.60 moderate agreement, and 0.61 and 0.80 was considered good agreement [8].

All statistical tests were performed using a level of significance $p < 0.05$ and all analyses were carried out using SPSS 23.0 (IBM Inc., Armonk, NY). Based on the assumption of 0.41 being the minimum value of kappa that would allow for a sufficiently reliable level of agreement, we estimated that a sample of 21 patients would allow for at least 80% power with a one sided alpha = 0.05.

3. Results

Forty-five patients were candidates for enrollment in the study; of these, 27 received both point of care and RDI and only these were included in the statistical analysis. Of the 27 patients, 22 (81%) received radiology ultrasound (RUS), 3 received CT (11%), and 2 (8%) underwent both RUS and CT. Patient demographics and clinical characteristics are

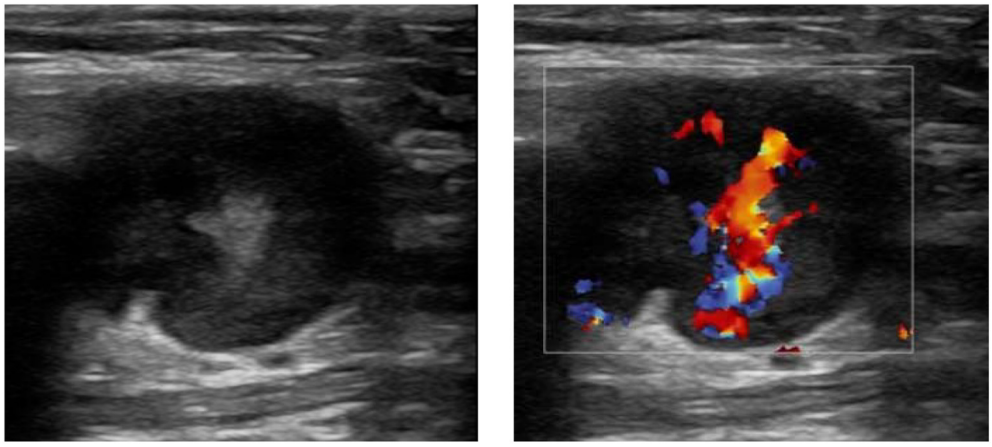

Fig. 1. Sonographic appearance of a normal lymph node.

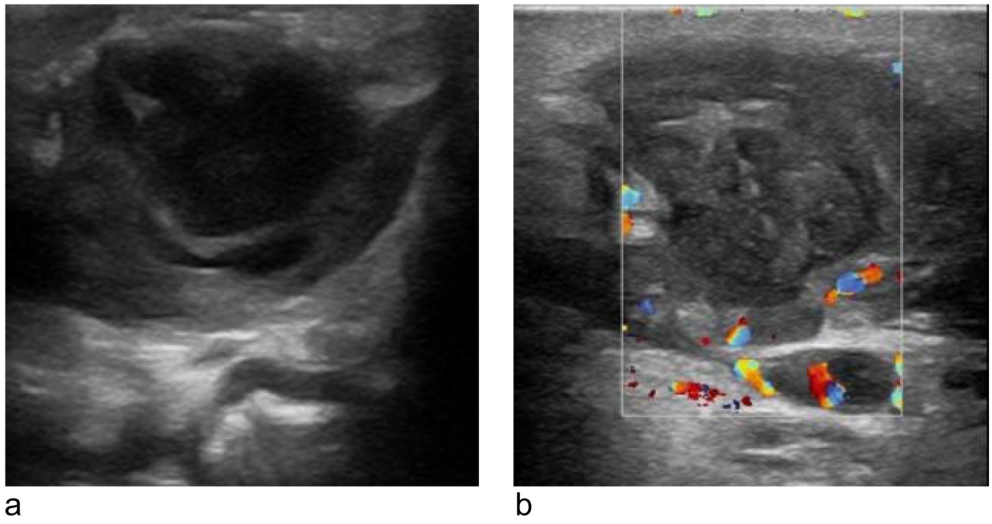

Fig. 2. Sonographic appearance of an abscess in a lymph node.

given in Table 1 with the Radiologists' diagnoses for these patients described at the bottom of Table 1.

Comparison of POCUS assessment to the radiological assessment demonstrated an agreement in 21 (78%) out of 27 cases. The agreement pattern for POCUS diagnoses versus radiological diagnoses is shown in Table 2. The highest rates of agreement for POCUS diagnoses relative to RDI diagnoses were for Lymphadenitis (LAD) (12/13 = 92.3%), Abscess (6/8 = 75%), and (FMC; 1/1 = 100%). Calculation of the kappa statistic for the overall agreement between the POCUS diagnoses and RDI diagnoses showed good concordance; kappa = 0.69 (95% CI 0.44–0.94; $p < 0.001$).

There were 6 cases in which there was a lack of agreement between radiology imaging and POCUS. Of these, 2 cases were interpreted by the emergency sonologist as lymphadenitis but were diagnosed as abscess by the radiologist. Two case were interpreted by POCUS as a soft tissue mass but were diagnosed as abscess and TGD cyst based on radiology imaging. One case was interpreted as an abscess by POCUS, and was diagnosed as a soft tissue mass based on radiology imaging. And one case that was diagnosed as abscess by POCUS and was determined to be LAD by radiology imaging.

18 patients who received POCUS without RDI were managed on clinical grounds alone. On day 7 phone follow up, 16 were compliant with the prescribed management plan and were clinically improving. Of the remaining 2 patients, one patient returned to the ED with worsening soft tissue neck swelling; initially the child had been managed as lymphadenitis, based on PEM provider and sonographic assessment. However, on the return visit the child was diagnosed with soft tissue neck abscess and was managed accordingly. The other patient was lost to follow-up.

In 18 of 27 patients enrolled in this study the investigator was not made aware of the clinical history and pertinent physical exam findings prior to performing the POCUS. For the other 9 patients, the PEM provider and the study investigator were the same person. Subgroup analysis compared the results of this group to the results of the 18 patients in which investigators and the PEM provider were different. No statistically significant difference was found between these 2 groups of patients.

4. Discussion

The vast majority of soft tissue neck masses in children are secondary to inflammatory or infectious causes [4,9]. As the lymphatic system drains infections of the head and neck, there is resultant inflammation of the cervical lymphatic chain, causing enlargement of the associated

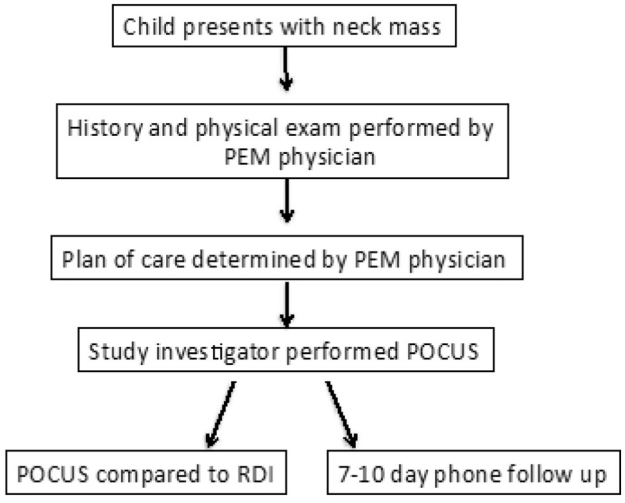

Fig. 3. Study algorithm. PEM-pediatric emergency medicine; POCUS-point of care ultrasound; RDI-radiology department imaging; POCUS-point-of-care ultrasound.

Table 1
Demographic and clinical characteristics of the 26 pediatric patients with neck mass.

Characteristic		
Males		65.4 (17)[a]
Age		5.3 (1 month to 14.8 years)[b]
Temperature		101.6 (98 to 105 °F)[b]
White blood cell count[c]		17.4 (9 to 46 × 10^3/mm^3)[b]
Duration of symptoms		3.5 (1 to 30 days)[b]
Cellulitis		15.4 (4)[a]
Fluctuance		7.7 (2)[a]
Fever		69.2 (18)[a]
Admitted to the hospital		57.7 (15)[a]
Radiological impression	Lymphadenopathy (LAD)	50 (13)[a]
	Abscess	30 (8)[a]
	Phlegmon	7.6 (2)[a]
	Fibromatosis Coli (FMC)	3.8 (1)[a]
	Soft tissue mass	3.8 (1)[a]
	Thyroglossal Duct (TGD) cyst	7.6 (2)[a]

[a] Percent (frequency).
[b] Median (minimum to maximum).
[c] Total N = 19 (7 patients did not have blood drawn).

Table 2
Agreement of POCUS diagnosis relative to RDI diagnosis (kappa = 0.69).

Diagnosis POCUS	Diagnosis RDI					
	Abscess	FMC	LAD	Phlegmon	Soft tissue mass	TGD cyst
Abscess	6 (75.0%)[a]	0	1	0	1	0
FMC	0	1 (100%)[a]	0	0	0	0
LAD	2	0	12 (92.3%)[a]	0	0	0
Phelgmon	0	0	0	1 (50%)[a]	0	0
Soft tissue mass	0	0	0	1	0 (0%)[a]	1
TGD cyst	0	0	0	0	0	1 (50%)[a]
Total number of RDI diagnoses	8	1	13	2	1	2

[a] Frequency of each combination of POCUS versus RDI diagnosis (percent of agreement between POCUS and RDI diagnosis).

lymph nodes [2]. Inoculation of the enlarged lymph nodes with streptococcal or staphylococcal species, often the causative organisms, results in the development of lymphadenitis [2,10]. Lymphadenitis is often distinguished from reactive lymph nodes by the presence of unilateral neck swelling, overlying erythema, and systemic symptoms such as fever [2,11]. Left untreated, the bacteria will cause destruction of the architecture of the lymph node by suppuration, resulting in the development of abscess. While the diagnosis of lymphadenitis is often made on clinical grounds, when the diagnosis is equivocal, ultrasonography has emerged as the imaging modality of choice for interrogation of soft tissue neck masses [3,4,10]. Sonographically, normal lymph node appears as an ovoid, bean shaped structure with its long axis greater than its short axis [4,9,12]. The lymph node is nourished by a blood supply that enters the node by way of its central hilum. Lymphadenitis has a similar sonographic appearance when compared to the uninfected lymph node, while occasionally demonstrating increased peripheral vascular flow [10]. A lymph node with abscess, however, loses its architectural integrity, often appearing more circular, occasionally with variable degrees of internal echoes, and lacking internal vascular flow [10,12]. A phlegmon will occur along the continuum from the intact lymph node structure to the development of an abscess, just before suppuration has developed [10]. Other less common entities encountered include congenital cysts. Congenital cysts are mobile circular lesions with thin walls, have completely anechoic fluid and demonstrate posterior acoustic enhancement [4,10]. Thyroductal gland cysts arise along the midline of the neck from the level of the tongue to the hyoid bone [10]. Branchial cleft cysts are most often located on the lateral aspect of the neck usually along the sternocleidomastoid muscle [1].

Over the last five years, there has been tremendous development in the area of POCUS in pediatric emergency care. Studies have demonstrated that POCUS improves patient care and is also a clinical tool that can be readily adopted by pediatric emergency care providers [13-15]. Additionally, utilization of POCUS has been found to improve patient throughput, allows for expedited medical decision-making and has been linked to improved patient-physician satisfaction [16].

By convention, lymphadenitis is a clinical diagnosis. The history and physical examination alone are usually used to determine whether antibiotics are indicated in the management of soft tissue neck masses. However, in certain clinical cases imaging is obtained via the radiology department. We sought to compare the diagnostic agreement of POCUS to the radiological diagnosis. POCUS was found to be 78% accurate in the sonographic assessment of soft tissue neck masses. This prospective study demonstrated promising results for POCUS as this imaging tool can help in the bedside diagnostic evaluation of soft tissue neck masses.

5. Limitations

The main limitation of this pilot study is the small sample size, but to our knowledge, this is the first study to utilize POCUS in the assessment of undifferentiated soft tissue neck masses. In addition, the study was conducted at a single center, and the investigators of this study were PEM providers with specific expertise in POCUS, so it is unclear whether these results can be generalized to the greater PEM community.

6. Conclusion

POCUS is a useful diagnostic tool when caring for patients who present to the Pediatric Emergency Department with soft tissue neck masses. A larger prospective study would be needed in order to generalize the data to the greater PEM community.

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References

[1] Gujar S, Gandhi D, Mukherji SK. Pediatric head and neck masses. Top Magn Reson Imaging 2004;15(2):95–101.
[2] Gosche JR, Vick L. Acute, subacute, and chronic cervical lymphadenitis in children. Semin Pediatr Surg 2006;15(2):99–106.
[3] Kadom N, Lee EY. Neck masses in children: current imaging guidelines and imaging findings. Semin Roentgenol 2012;47(1):7–20.
[4] Rosenberg HK. Sonography of pediatric neck masses. Ultrasound Q 2009;25(3):111–27.
[5] Turkington JR, Paterson A, Sweeney LE, Thornbury GD. Neck masses in children. Br J Radiol 2005;78(925):75–85.
[6] Marin JR, Dean AJ, Bilker WB, Panebianco NL, Brown NJ, Alpern ER. Emergency ultrasound-assisted examination of skin and soft tissue infections in the pediatric emergency department. Acad Emerg Med 2013;20(6):545–53.
[7] Sivitz AB, Lam SH, Ramirez-Schrempp D, Valente JH, Nagdev AD. Effect of bedside ultrasound on management of pediatric soft-tissue infection. J Emerg Med 2010;39(5):637–43.
[8] Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. Fam Med 2005;37(5):360–3.
[9] Papadopouli E, Michailidi E, Papadopoulou E, Paspalaki P, Vlahakis I, Kalmanti M. Cervical lymphadenopathy in childhood epidemiology and management. Pediatr Hematol Oncol 2009;26(6):454–60.
[10] Friedman ER, John SD. Imaging of pediatric neck masses. Radiol Clin North Am 2011;49(4):617–32 (v).
[11] Tracy Jr TF, Muratore CS. Management of common head and neck masses. Semin Pediatr Surg 2007;16(1):3–13.
[12] Ahuja AT, Ying M. Sonographic evaluation of cervical lymph nodes. AJR Am J Roentgenol 2005;184(5):1691–9.
[13] Riera A, Hsiao AL, Langhan ML, Goodman TR, Chen L. Diagnosis of intussusception by physician novice sonographers in the emergency department. Ann Emerg Med 2012;60(3):264–8.
[14] Sivitz AB, Cohen SG, Tejani C. Evaluation of acute appendicitis by pediatric emergency physician sonography. Ann Emerg Med 2014;64(4):358–64 [e354].
[15] Marin JR, Lewiss RE, American Academy of Pediatrics, C. o. P. E. M., Society for Academic Emergency, M., American College of Emergency Physicians, et al. Point-of-care ultrasonography by pediatric emergency physicians. Policy statement. Ann Emerg Med 2015;65(4):472–8.
[16] Howard ZD, Noble VE, Marill KA, Sajed D, Rodrigues M, Bertuzzi B, et al. Bedside ultrasound maximizes patient satisfaction. J Emerg Med 2014;46(1):46–53.