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Thoracic Mass Nature Determination; What Modality Is Better in Pediatric Age?

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Abstract

Background
The first step in assessing thoracic lesions is chest X-ray, but the optional imaging procedure for the final diagnosis is controversial. We aimed to examine the diagnostic accuracy of imaging modalities in pediatric thoracic masses.

Materials and Methods
This prospective cross-sectional study was conducted from 2017 to 2018 in Dr. Sheikh hospital, Mashhad, Iran. A total of 130 patients with a confirmed pathology report of thoracic masses were recruited in this study. A pediatric radiologist independently evaluated the existing chest X-ray (CXR), ultrasound (US) and CT and reported the probable diagnosis. Imaging reports of CXR, US, and CT were compared with the pathology results.

Results
83 (63.8%) of the patients were boys with the mean age of 72.15 $\pm$ 46 months. The most prevalent site of the thoracic masses was the lung parenchyma with the frequency of 81 (62.3%), and the most frequent mass was hydatid cyst with the frequency of 57 (43.8%). Thoracic CT had the overall sensitivity of 100% for mass localization and 78.2% for nature determination; while US had the sensitivity of (95.4%) for mass localization and 90.9% for the diagnosis of mass nature. The sensitivity of CXR for thoracic mass localization was 89.4 and for mass nature determination was 35.5%.

Conclusion
Based on the results, CXR and US had a similar appropriate sensitivity in localization of thoracic masses. Although CT had the highest overall sensitivity for mass localization, in comparison with US, it was less diagnostic to define mass nature and US had the highest sensitivity for mass nature determination. Hence, US may potentially obviate further imaging such as CT in most of the cases.

Key Words: Chest X-ray, Computed Tomography scan, Pediatric, Thoracic mass, Ultrasound.

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1- INTRODUCTION

Thoracic masses in children may appear in different sites of the chest including the mediastinum, lung parenchyma, pleura or chest wall and they span a wide spectrum from simple cysts to malignant tumors (1). Diagnostic precision is necessary to select treatment strategy. Chest X-ray (CXR), computed tomography (CT), and ultrasound (US) are imaging modalities for diagnostic evaluation of thoracic masses. Currently, CXR is the most prevalent procedure performed in children in order to differentiate thoracic lesions (2, 3). CT and magnetic resonance imaging (MRI) are also used to confirm the diagnosis and to obtain more detailed diagnostic information (4). According to the existing literature, US is considered a useful and low-cost modality in evaluating different thoracic abnormalities without the risk of radiation, compared to CT and MRI. US has been recognized as the first-line procedure to assess pleural, diaphragmatic and chest wall abnormalities (5, 6).

In a study performed by Smereczyński et al, ultrasound should be performed among the initial imaging procedures in detecting chest wall masses (7). Technological advances have also enabled physicians to overcome air and bony thorax using US, in order to evaluate the parenchyma, which was not easily accessible in the past (8). Considering the point that differentiating thoracic masses in children might not be convincing with CXR, US provides further information as a supplementary procedure (9-11). Based on the current evidence, chest ultrasound may be helpful for diagnosing pulmonary hydatid cysts and specifically peripheral cysts (12, 13). Recently, a systematic review conducted by Heuvelings et al. has revealed that chest ultrasound can be used as the first imaging method when pneumonia is doubted in pediatrics and the diagnostic accuracy of this imaging modality has been recommended to be evaluated in various chest diseases (3). Transthoracic ultrasound has been proved to be effective in the evaluation of anterior and posterior mediastinal masses and it may be more beneficial in guiding biopsied compared to CT (14). Ultrasound has been demonstrated to be a reliable diagnostic method to discover the reason for CXR opacities in children (15). Lowering the risk of exposure to ionizing radiation is significantly important in the pediatric field regarding their higher sensitivity to the effects of radiation compared to adults (16, 17). CT radiation carries high risks including brain tumor for children. Therefore, it is essential to perform CT cautiously and adhere to the indications while considering dose adjustment, in order to decrease the adverse effects (18). The purpose of this study, was to evaluate the sensitivity of the imaging modalities in the diagnosis of thoracic masses among pediatric patients.

2- MATERIALS AND METHODS

This prospective cross-sectional study was conducted from 2017 to 2018 in the radiology department of Dr. Sheikh Children's hospital, which is a tertiary center in Mashhad, Iran. A total of 130 pediatric patients admitted with pathology reports of thoracic masses were enrolled in this study. Pathological specimens were extracted by surgery or US guided core needle biopsy. Imaging procedures (CXR, US and CT) were done based on indication during treatment and no additional imaging was requested. Ultrasounds were performed using 1-7 MHz convex transducer and 3-8 MHz linear transducer (Samsung H60, Medison, Korea). CT scans were conducted using a CT scanner (Neuviz 16, Neusoft Medical Systems, P.R., China) at 90 kVp, 40-120 mA, pitch of 1.5, and slice thickness of 1.5 mm. Demographic characteristics including age, sex, location of the sampling, and the final diagnosis reports from the pathology

department were recorded. The existing imaging studies were reviewed by our expert radiologist who had no previous knowledge regarding the final diagnosis and their features were also recorded separately. Overall, 114 CXR, 44 US and 23 CT scans from 130 patients were studied. Thoracic lesions were classified based on their location as pulmonary, mediastinal and chest wall lesions. Eventually, the results of radiology and pathology reports were compared together. This study was carried out after obtaining confirmation from the University Ethics Committee. All patients with thoracic masses who were operated, had a recognized etiology and had available imaging data were included in this study. Children without existing or available imaging reports were excluded.

Data on demographic and clinical features of the patients were analyzed using SPSS software (version 23.0). To describe the data, descriptive statistical methods including central indicators, dispersion and frequency distribution were used. Sensitivity and specificity of all the imaging modalities were calculated using the pathology results of surgery or US guided core needle biopsy as the gold standard. A p-value < 0.05 was considered to be significant in statistical analyses.

3- RESULT

Among 130 children who participated in the current study, 83 (63.8%) were boys and 47 (36.2%) were girls and the mean age of the participants was 72.15 ± 46 months (from 10 days to 158 months). Thoracic masses were stratified based on the chest compartment. The thoracic masses were located in parenchyma in 81 (62.3%) subjects, chest wall in 33 (25.4%) and mediastinum in 16 (12.3%) patients. The most prevalent site of the thoracic masses was the lung parenchyma. The masses were also divided into three groups based on their nature as infectious, congenital and tumors. The mass etiology was infectious in 67 (51.5%), congenital in 12 (9.2%), and tumors in 51 (39.2%) of the subjects. The frequency of pathologies in different lung compartments obtained from the histopathologic findings are demonstrated in **Table.1**. In each group, the most common masses were hydatid cyst, lymphoma and Ewing sarcoma, respectively. Hydatid cyst with the abundance of 57 (43.8%) cases was the most frequent disease detected from the biopsy results (**Table.1**).

In this study, we investigated the diagnostic value of CXR, US and CT in detecting the location and nature of thoracic masses in children, separately. The sensitivity of imaging modalities to define mass location and nature are demonstrated in **Table.2**. Not surprisingly, CT had the highest overall sensitivity for mass localization (100%). However, the highest overall sensitivity for diagnosis of the mass nature was achieved from US results (90.9%). The overall sensitivity of US and CXR for localization of the chest masses was 95.4% and 89.4%, respectively. The overall sensitivity of US and CXR for nature determination of the chest masses was 90.9% and 35.2%, respectively.

CXR had excellent sensitivity for localization and acceptable sensitivity for nature determination of parenchymal masses (98.7% and 48.1%, respectively); but it was limited in localizing the chest wall and mediastinal masses. US had excellent sensitivity for localization of the mediastinal and chest wall masses (100%). CT was the most sensitive modality for localization (100%) with moderate sensitivity (78.2%) in characterization of the thoracic masses.

Table-1: Frequency of the thoracic masses based on their location and etiology.

Number (%)	Mass Type	Mass Location
Lung Parenchyma	Hydatid cyst	57 (43.8)
	Pneumonia	6 (4.6)
	Wilms tumor (metastasis)	4 (3.1)
	Pulmonary Blastoma	4 (3.1)
	Congenital Pulmonary Airway Malformation (CPAM)	3 (2.3)
	Pulmonary sequestration	2 (1.5)
	Abscess	2 (1.5)
	Pulmonary pneumatoceles	1 (0.8)
	Inflammatory Pseudotumor	1 (0.8)
	Renal Clear Cell Sarcoma (metastasis)	1 (0.8)
	Total	81 (62.3)
Chest Wall	Ewing sarcoma	6 (4.6)
	Lymphatic Malformation	5 (3.8)
	Primitive neuroectodermal tumor (PNET)	5 (3.8)
	Dermoid Cyst	5 (3.8)
	Hemangioma	4 (3.1)
	Lipoblastoma	2 (1.5)
	Rhabdomyosarcoma	2 (1.5)
	Osteosarcoma	1 (0.8)
	Osteochondroma	1 (0.8)
	Lipoma	1 (0.8)
	Infantile Myofibroma	1 (0.8)
	Total	33 (25.4)
Mediastinum	Lymphoma	10 (7.7)
	Bronchogenic cyst	2 (1.5)
	Neuroblastoma	2 (1.5)
	Ganglioneuroma	1 (0.8)
	Yolk Sac Tumor	1 (0.8)
	Total	16 (12.3)
Total		130 (100)

Table-2: The sensitivity of imaging modalities based on location and nature of the thoracic masses.

Imaging modality		CXR		US		CT	
Purpose	Sub-groups	Sensitivity for localization (%)	Sensitivity for nature determination (%)	Sensitivity for localization (%)	Sensitivity for nature determination (%)	Sensitivity for localization (%)	Sensitivity for nature determination (%)
Location of mass	Chest Wall	55.0	5.0	100	90.9	100	75.0
	Pulmonary	98.7	48.1	95.8	95.8	100	78.5
	Mediastinum	86.6	6.6	100	77.7	100	80.0
	Total	89.4	35.2	95.4	90.9	100	78.2
Nature of mass	Infectious	98.4	53.8	100	94.7	100	83.3
	Tumor	75.0	7.5	95.8	85.0	100	66.6
	Congenital	88.8	22.2	100	100	100	100
	Total	89.4	35.2	95.4	90.9	100	78.2

CXR= chest X-ray; US= ultrasound; CT= computed tomography.

4- DISCUSSION

The aim of this study was to investigate the diagnostic value of ultrasound in detecting chest masses in children. This method as a non-ionizing imaging procedure has been of great

interest (3). Based on our results ultrasound had a higher sensitivity in defining the nature of thoracic masses in children, compared to the CXR and CT. Thoracic masses in children have various etiologies and they are anatomically located in different parts of the chest (1). The diagnosis of thoracic masses can be quite challenging in children as the adverse effects of radiation exposure should be kept in mind considering the appropriate indication (19). We found that parenchymal masses were the most prevalent thoracic masses, that was inconsistent with other reports from Ranganath et al. and Merten who described the mediastinal masses as the most frequent thoracic masses in children (20, 21). Most of the thoracic masses in this study were infectious in nature and hydatid cyst was the most common mass in the patients. Respiratory infections in children are one of the major reasons leading to hospitalization and child mortality in the developing countries (22, 23). CXR is usually the first line imaging modality for the diagnosis of thoracic abnormalities including masses (24-27).

Current study demonstrated that CXR had an excellent sensitivity for diagnosing the parenchymal and mediastinal masses, especially those with an infectious origin which were highly prevalent. Our findings were in accordance with a prior study performed by Coley, who described CXR as a sufficient procedure to assess the lung parenchyma (5). However, the most significant limitation of CXR was its low sensitivity in characterizing the lesion nature (ranging from 5-53%). In addition, the use of CXR was restricted in the localization of the chest wall masses (sensitivity=55%). Goh and Kapur reported US as the first line procedure in detecting chest wall lesions and it can play a major role in detecting pleural effusions. According to the aforementioned study, US may be helpful for the evaluation of the mediastinum especially the superior mediastinum (11). Once a thoracic mass is detected with CXR, CT imaging is known as the second line of the diagnostic approach (5). High radiation exposure is expensive and not easily available that limit the use of CT imaging. Diagnostic procedures without radiation are extremely important in children, since they are more susceptible to cancers compared to adults. According to the literature, the risk of cancer is higher among children with a previous history of CT radiation (16, 18, 28). Previous studies have shown thoracic US to be a reliable and accurate procedure for assessing pulmonary diseases, such as pneumonia (29, 30). Ambroggio et al. also revealed that US and CXR had similar sensitivity in pneumonia diagnosis compared with CT (31).

Furthermore, this study underpinned that US was superior to CXR in the evaluation of mediastinal and chest wall masses and the sensitivity of US in the diagnosis of infectious masses was nearly the same as CT. Although US has been recently used to evaluate thoracic masses, its usage is not prevalent, particularly in the mediastinum (32, 33). However, it seems that CT may be replaced with US as the second diagnostic evaluation tool of thoracic masses. US is an available, safe and inexpensive procedure (34) and based on our results it was highly sensitive in defining nature of the thoracic masses (90.9%) (**Figure.1**). Thoracic US was found to be superior to CT regarding parenchymal and infectious masses (95.8% vs. 78.2%) and it can be used for a better characterization of CT detected lesions. Pulmonary US has been reported as a useful imaging procedure for diagnosing pulmonary hydatidosis (12). On the other hand, it is worth noting that US is an operator-dependent modality that improves in reliability by training and gaining experience (35). The most important advantage of CT compared to CXR and

US was the excellent sensitivity and complete characterization of the congenital masses. Consequently, CT is considered the modality of choice in solving diagnostic problems faced by CXR and US in more complicated cases, as well as staging and preoperative assessments of lesions (33, 36, 37). One of the limitations of this study was the sampling method. We selected pediatric patients with a pathology report of thoracic masses. However, numerous thoracic masses in children have an infectious origin and they can be cured medically. Non available, unreliable ultrasound reports by less experienced operators, nonperformance of each of the three imaging modalities in all patients were other limitations. It is advisable to investigate further patient with chest masses without our limitations in future studies by researchers.

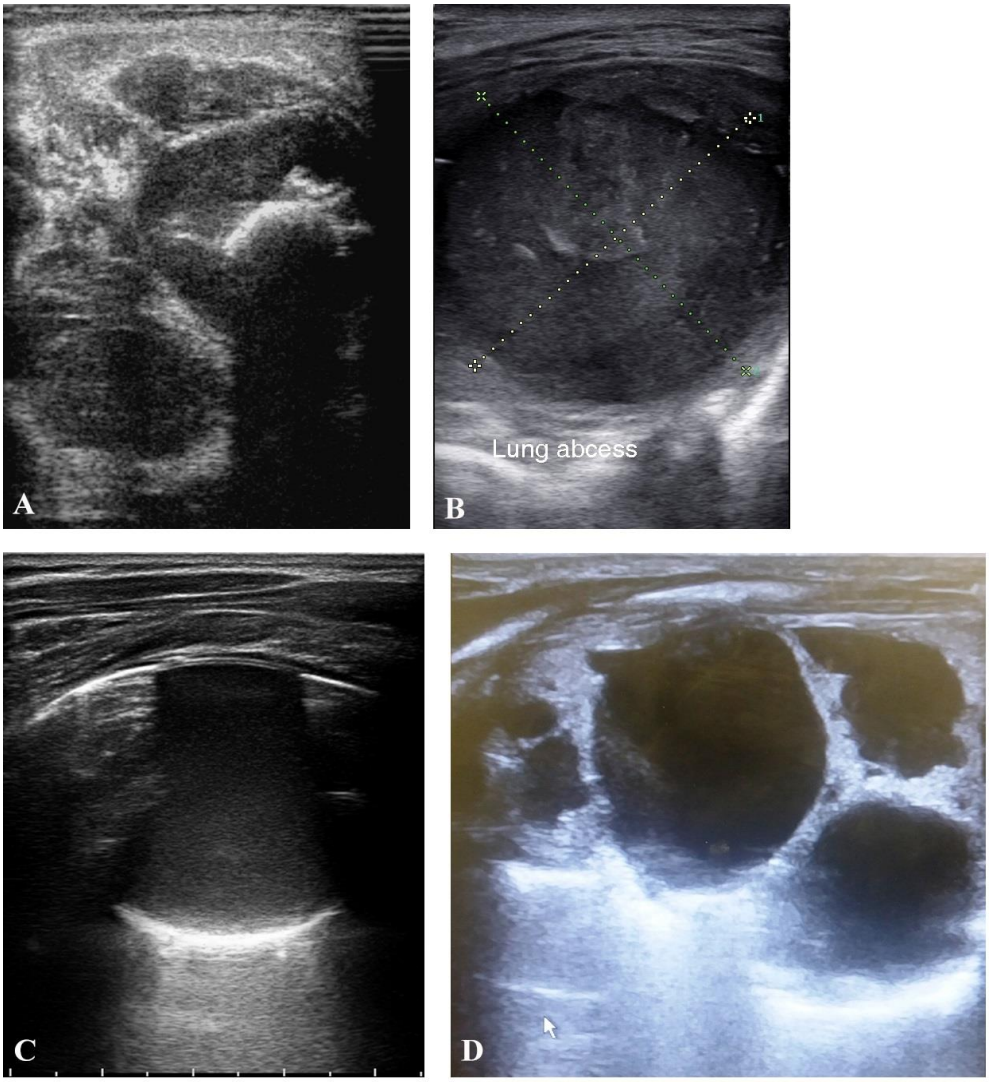

Fig.1: The ultrasound images of thoracic masses. A) Chest wall mass with rib origin as an eccentric heterogeneous mass with rib periosteal reaction. B) Lung abscess as a hypoechoic necrotic oval associated with plural thickening. C) The ultrasonic view of simple hydatid cyst of lung. D) A complex multi-cystic solid lung mass compatible with congenital pulmonary airway malformation (CPAM).

5- CONCLUSION

Based on our results, CXR and ultrasound had a similar appropriate sensitivity in localization of thoracic masses. Although CT had the highest overall sensitivity for mass localization, in comparison with US, it was less diagnostic to define mass nature and US had the highest sensitivity for mass nature determination. Hence, US may potentially obviate further imaging such as CT in most of the cases and prevent additional radiation or sedation. We suggest that the imaging workup of pediatric thoracic masses include CXR and chest US, and chest CT should be set aside for more complicated cases.

6- CONFLICT OF INTEREST: None.

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