# Thoracic Neoplasms in Children

## Contemporary Perspectives and Imaging Assessment

Matthew A. Zapala, MD, PhD[a,*], Victor M. Ho-Fung, MD[b], Edward Y. Lee, MD, MPH[c]

**KEYWORDS**

• Primary lung neoplasm • Primary airway neoplasm • Mediastinal neoplasm • Chest wall neoplasm • Pediatric patients

**KEY POINTS**

- Pediatric thoracic neoplasms are rare and often present with nonspecific symptoms leading to a delay in diagnosis. Imaging evaluation is often first in identifying the unforeseen problem.
- A thorough understanding of the multiple imaging modalities and protocols available to assess pediatric thoracic neoplasms provides the optimal radiologic evaluation necessary for accurate diagnosis and proper surgical/treatment planning.
- Up-to-date knowledge of the typical imaging appearance of pediatric thoracic neoplasms narrows differential diagnoses for optimal clinical management and treatment.

## INTRODUCTION

Radiology plays an increasingly critical role in the evaluation and characterization of thoracic neoplasms in the pediatric population.[1] In recent years, dramatic advances in imaging techniques from various currently available modalities, including digital radiography, ultrasound, multidetector computed tomography (MDCT), and MR imaging, have substantially increased the diagnostic capabilities of radiology and placed radiology at the forefront of clinical decision making.[2–6] Although primary thoracic neoplasms in children are rare, they are clinically challenging to diagnose because they are often asymptomatic.[7] In addition, when affected children do present with symptoms, they are often nonspecific, such as cough, prompting imaging as the initial work-up. Imaging of pediatric patients with thoracic neoplasms offers unique challenges distinct from adult patients. This article reviews the current radiologic work-up for pediatric thoracic neoplasms and provides imaging algorithms with the latest techniques and the characteristic imaging appearance of various thoracic neoplasms unique to the pediatric population.

## IMAGING ALGORITHM

Initial imaging work-up in children with clinically suspected underlying thoracic neoplasm often begins with chest radiographs. Chest radiographs are

Disclosure Statement: All authors certify that there is no actual or potential conflict of interest in relation to this article.

[a] Department of Radiology and Biomedical Imaging, Benioff Children's Hospital, University of California, San Francisco, 1975 Fourth Street, San Francisco, CA 94158, USA; [b] Department of Radiology, The Children's Hospital of Philadelphia, 3401 Civic Center Boulevard, Philadelphia, PA 19104, USA; [c] Department of Radiology, Boston Children's Hospital, Harvard Medical School, 300 Longwood Avenue, Boston, MA 02115, USA
* Corresponding author.
*E-mail address:* Matthew.Zapala@ucsf.edu

Radiol Clin N Am 55 (2017) 657–676
http://dx.doi.org/10.1016/j.rcl.2017.02.008

an excellent first-line modality in providing the radiologist with an overview of the chest and can often identify sizable parenchymal lesions, pleural-based masses, mediastinal masses, and chest wall or bony-based neoplasms.[7] Although most thoracic neoplasms in children eventually require additional cross-sectional imaging for confirmation and further characterization,[6] chest radiographs remain a vital screening component in the initial work-up of pediatric thoracic neoplasms.

Ultrasound also plays an increasingly important role as a first-line screening modality in the assessment of palpable thoracic chest wall masses.[8] Some of these palpable chest wall masses are accurately diagnosed with ultrasound alone, such as vascular malformations.[9] However, chest wall masses without classic imaging features of vascular malformation need to go on to further characterization by CT or MR imaging. Typically, soft tissue chest wall masses that lack bony involvement can best be assessed by contrast-enhanced MR imaging.

MDCT remains the main workhorse in terms of image evaluation of thoracic neoplasms in the pediatric patient population.[6] After initial assessment by chest radiographs, MDCT is the imaging modality of choice given its superior ability to confirm and characterize airway, parenchymal, and pleural-based thoracic neoplastic masses.[10] However, it is important to recognize that, in comparison with chest radiographs, such increased ability to assess the lung parenchyma, pleura, and airways comes with a price of increased radiation dose to the patient. As such, every effort should be made to obtain the MDCT using the ALARA (as low as reasonably achievable) principle with the lowest possible radiation dose to obtain diagnostic quality images for the pertinent indication.[11]

Although MDCT remains the modality of choice for most pediatric thoracic neoplasms, MR imaging still can play an important role in the assessment of chest- and mediastinal-based neoplastic masses.[12] MR imaging is particularly useful in assessing for fat within lesions or for assessing atypical vascular malformations. MR imaging may be most useful in further characterizing isolated chest wall soft tissue masses with nonspecific imaging findings on ultrasound.[13] Although MR imaging lacks ionizing radiation, the increased scan time needed to acquire images may necessitate that pediatric patients be sedated. As such, it is critical that only the appropriate MR imaging sequences be performed to address the underlying specific diagnostic question. Imaging protocols for ultrasound, MDCT, and MR imaging are further discussed in the following sections.

## IMAGING TECHNIQUES AND PROTOCOLS

### *Ultrasound*

Sonographic technique for chest masses is usually reserved for palpable chest masses.[14] For ultrasound to be useful, the thoracic mass needs to be superficial and can usually be imaged with a high-frequency linear transducer (9–15 MHz) to increase image resolution.[15] Lesions may require a standoff pad to visualize appropriately. In addition to gray-scale images, color flow images documenting arterial and/or venous waveforms are critical in the sonographic assessment of chest wall masses. Ultrasound can also be useful for accurately identifying thymus versus other mediastinal masses given the typical sonographic appearance of the thymus in infants and young children. In contrast to superficial masses, a sector probe using a subxiphoid approach is often helpful to assess the mediastinum.[8] The advantages of ultrasound are the lack of ionizing radiation and the ability to image nonsedated pediatric patients in a dynamic and reproducible way.

### *Multidetector Computed Tomography*

MDCT evaluation of neoplastic thoracic masses requires that the pediatric patient remain still and follow instruction. Although sedation can usually be avoided in older patients who can follow instruction, it is usually required for pediatric patients age 5 and younger.[16] MDCT scanning parameters should be adjusted and optimized to the ALARA principle to minimize the overall radiation exposure. This can usually be achieved by varying the kilovoltage peak (kVp) and tube current milliampere (mA) according to the patient's weight and age. Recommended weight- and age-based MDCT protocols are provided online at the Image Gently campaign from the Alliance for Radiation Safety in Pediatric Imaging.

When assessing purely airway-based or lung parenchymal–based lesions, intravenous (IV) contrast may not be necessary. However, when assessing mediastinal masses, lymphadenopathy, and involvement of major vasculature, IV contrast is beneficial. Often, initial evaluations of thoracic neoplastic masses in pediatric patients are evaluated with IV contrast. The recommended dose of contrast is usually 1.5 to 2 mL per kg body weight not to exceed 150 mL of total IV contrast. IV contrast is administered either by hand or mechanically depending on the catheter size and location.[17]

### *MR Imaging*

MR imaging protocols should be indication-based with the field of view and coil selection tailored to