

# Mediastinal Lymph Nodes and Pulmonary Nodules in Children: MDCT Findings in a Cohort of Healthy Subjects

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**OBJECTIVE.** Existing data are very limited on incidentally detected pulmonary nodules or mediastinal lymph nodes in healthy children who undergo chest MDCT. We aimed to evaluate the prevalence, distribution, and average dimensions of these occasional findings in a cohort of otherwise healthy patients.

**MATERIALS AND METHODS.** Two radiologists reviewed in consensus the scans of patients referred for chest MDCT during the preoperative workup for pectus carinatum or pectus excavatum treatments. Exclusion criteria included the presence of any documented malignancy (by date of MDCT or during the 2 years after the examination), history of recent infections, or trauma. Patients' records were assessed after 2 years for the development of any malignancy.

**RESULTS.** A total of 99 individuals (63 boys, 36 girls; mean age, 13.5 years; range, 4–18 years) who fulfilled the study criteria were evaluated. The presence of at least one pulmonary nodule was observed in 75% of the patients, with a mean diameter of 2.8 mm. Of a total number of 225 pulmonary nodules, only 24 (10.7%) were calcified. Mediastinal lymph nodes were also identified in 81% of the cases, with a maximum diameter of 7 mm (smallest axis).

**CONCLUSION.** The presence of pulmonary nodules or mediastinal lymph nodes on the basis of preoperative chest MDCT scans in healthy children is frequent. Given that 95% of the nodules and 100% of the lymph nodes measured less than 6 mm and 7 mm, respectively, we conclude that incidental findings under these limits are very unlikely to be pathologic.

**T**here is current evidence that the incidental detection of either pulmonary nodules or mediastinal lymph nodes during chest imaging examinations of children is no longer an exceptional situation [1–3]. The advent and widespread use of MDCT, by its enabling of better spatial resolution, has increased the diagnostic accuracy for smaller nodules (especially those < 5 mm) and might be considered the main reason for the increasing rate of reported incidentalomas [4, 5].

Although significant efforts have been directed at predicting the nature of a lesion before biopsy or surgery [6], a reliable imaging differentiation is still a constant challenge and tends to be even more unfeasible in young patients [7].

The aim of this study was to assess the prevalence and morphology of lung nodules and mediastinal lymph nodes in healthy children. There are very sparse publications in this field, and the majority of reports had investigated patients with documented extra-

thoracic malignancies or who had experienced high-energy trauma [2, 3, 7, 8].

## Materials and Methods

We conducted an individualized, transversal, retrospective, noninterventional study. We investigated the presence of pulmonary nodules and thoracic lymph nodes in patients referred for chest MDCT during the preoperative assessment of either pectus carinatum or pectus excavatum surgery between January 2007 and December 2013.

Because of radiation exposure, we cannot perform this study in healthy children without a clinical indication. Both pectus carinatum and pectus excavatum surgeries are performed mostly for cosmetic reasons and cosmetic-related psychologic disorders [9]. Diagnostic techniques for pectus surgery include chest MDCT and cardiorespiratory evaluation. Therefore, we believe that this population is the closest we can get to a healthy population.

The exclusion criteria involved any history of the following: malignancy (thoracic or other) documented by the date of MDCT or during the 2 years after the examination, based on the patient's re-

cords at our institution; infection or trauma within 15 days before the MDCT study; and any change in pulmonary or cardiac function tests during the pre-operative evaluation. All medical records were also reviewed to check for the presence of any exclusion criteria. This research followed the guidelines of the Declaration of Helsinki and was approved by our local ethical research review board.

A commercially available CT scanner with 64 detector rows (collimation, 0.625 mm) (Somatom Sensation 64 Systems, Siemens Healthcare) was used for the imaging acquisition and was periodically calibrated as per the manufacturer's recommendation. The exposure and kilovoltage settings were adjusted to patient size and ranged from 40 to 200 mAs and from 80 to 100 kV, respectively. The axial images, with a slice thickness of 0.625 mm, were reconstructed in the craniocaudal direction, and a data matrix of 512 × 512 was chosen. All of the examinations were performed without administration of contrast medium.

Two thoracic radiologists, with 5 and 9 years of experience, reviewed each scan and reached a consensus on the presence of any abnormality. All cases were evaluated in a Leonardo workstation (Siemens Healthcare), with the use of maximum-intensity-projection (MIP) tool in sagittal, coronal, and axial reconstructions. However, all of the measurements were performed by using 0.625-mm slices in the axial view without MIP. Lymph nodes were measured along their shortest axis by using an electronic caliper that was available in the workstation. The following six sites were reviewed for the presence of lymph nodes: upper paratracheal (between the top of the aortic arch and lung apex); prevascular and posterior mediastinal; lower paratracheal (between the top of the aortic arch and the carina); aortopulmonary window; subcarinal; and along the mammary vessels. Finally, the pulmonary nodules were measured along their largest and smallest diameters, and the resulting value from the average of these measurements was considered the nodule size, as previously suggested [10]. We evaluated the location of calcification for each incidentally detected pulmonary nodule. We did not include pulmonary lesions with trapezoid or triangular shapes with the intent to exclude pulmonary lymph nodes. The distribution and size of thoracic lymph nodes were also analyzed but not the presence of calcifications.

Computer software (Excel for Mac 2011, version 14.1.3, Microsoft) was used for data storage and graphics display. Statistical analyses were performed with Stata software (version 12.1, StataCorp). One-way ANOVA or Kruskal-Wallis tests were used for correlative assessment of quantitative data depending on the presence of normal distribution. A Tukey test was chosen for post hoc analysis. A bilateral 0.05 level of significance was established.

**TABLE 1: Lung Nodule Distribution and Size, by Lobe and Age**

Parameter	Site					
	RUL	ML	RLL	LUL	LLL	LL
Total no. <sup>a</sup>	45	18	57 (12)	60 (6)	75 (6)	132 (18)
Mean diameter (mm)	2.9	2.1	3.2	2.6	2.8	2.9
Minimum diameter (mm)	2	2	2	2	2	2
Maximum diameter (mm)	5	3	8	3	5	8
Shortest-axis threshold (mm)						
Age < 10 y	4	3	6	2	4	6
Age ≥ 10 y	5	3	8	3	5	8

Note—RUL = right upper lobe, ML = middle lobe, RLL = right lower lobe, LUL = left upper lobe, LLL = left lower lobe, LL = lower lobes.

<sup>a</sup>Calcified nodules (n = 24) are shown in parentheses.

**TABLE 2: Lymph Node Distribution and Size, by Site and Age**

Parameter	Site			
	SC	UPT	LPT	AW
Mean diameter (mm)	4.60	4.46	4.1	4.05
Minimum diameter (mm)	3	2	2	3
Maximum diameter (mm)	5	6	6	7
Total no.	27	45	48	51
Maximum no.				
Age < 10 y	4	5	6	3
Age ≥ 10 y	5	6	6	7

Note—SC = subcarinal, UPT = upper paratracheal, LPT = lower paratracheal, AW = aortopulmonary window.

**Results**

A total of 99 patients (63 boys, 36 girls [63% male]) with a mean age of 13.5 years (range, 4–18 years) met the inclusion criteria and were evaluated. A total of 225 pulmonary nodules were registered (Fig. 1), resulting in a nodule-per-patient rate of 3.4 (range, 1–21). The mean diameter was 2.8 mm (2–8 mm), and only 24 nodules (10.7%) contained any calcification. The observed 95th percentile was 5.8 mm. In addition, 135 nodules (60%) were located in the left lung. Although most nodules were located at the inferior lobes (132 [59%]), there was no significant difference between the size of a nodule and its respective location. These data are summarized in Table 1.

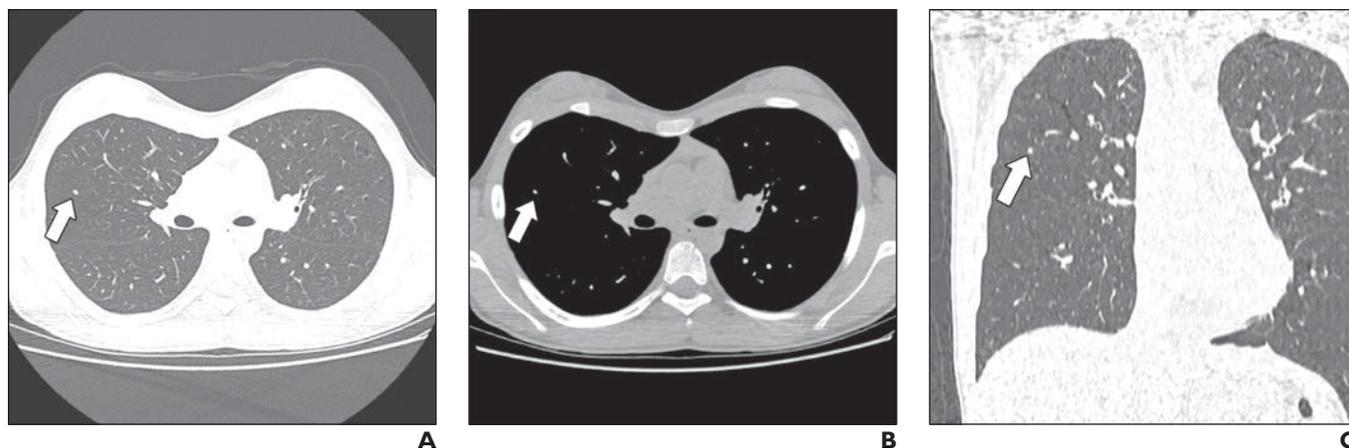
A total of 171 mediastinal lymph nodes were detected. At least one lymph node was identified in 81 patients (82%). The most frequent lymph node stations were both the upper and lower paratracheal and the aortopulmonary window (45, 48, and 51, respectively). Although the largest mean diameter was found at the subcarinal station (4.6 mm), no significant difference was shown between the different stations. These data are displayed in Table 2.

**Discussion**

The results of our research confirm that the detection of at least one pulmonary nodule during chest MDCT studies in children is common and that radiologists should be careful not to misinterpret such findings. In a study by Grampp et al. [1], involving only pediatric patients with initial extrathoracic malignancy, a significant number, 70%, of the lung nodules were benign. Ten years later, assessing another pediatric population with similar characteristics, Silva et al. [7] also showed that most of the lesions up to 5 mm were benign at biopsy (9:1 ratio) but none of the CT features could safely predict the nature of the nodule. To our knowledge, however, this was the first study on the prevalence of pulmonary nodules among completely healthy children (without any documented malignancy and history of recent infection or trauma).

Similarly, the detection of mediastinal lymph nodes in children had previously been reported as a common event. In a recent article, de Jong and Nieuvelstein [3] proposed shortest-axis thresholds of 7 and 10 mm for mediastinal lymph nodes in patients young-

## MDCT of Mediastinum and Chest in Children



**Fig. 1**—12-year-old boy with pectus excavatum.

**A–C**, Axial CT images displayed with pulmonary (**A**) and mediastinal (**B**) windows and coronal CT image (**C**) show small pulmonary nodule (arrow), measuring 3 mm, in right upper lobe.

er than and at least 10 years old, respectively. Our results were found to be consistent with theirs, because none of the 171 identified mediastinal nodes—even those in patients 10 years old or older—exceeded 7 mm along the shortest axis. Therefore, to aid the diagnosis of lymphadenopathy in children, we suggest that the aforementioned limits should still be considered when selecting interventional treatments in this population.

The increasing number of small pulmonary nodules and lymph nodes detected during MDCT evaluation has mainly been attributed to improvements in CT scanners, which have become faster and are now capable of provide thinner slices than in past decades. By contrast, the current need to implement low-dose protocols could possibly decrease the diagnostic accuracy for such findings. A novel study published by Li et al. [11] has shown that a tube exposure dose reduction of 75% would slightly decrease the diagnostic accuracy for small (3–5 mm) nodules. In our study, however, the possible loss of accuracy after reducing tube exposure could not be assessed because the MDCT studies had been performed only once and followed standardized parameters.

Importantly, pulmonary nodules must be distinguished from pulmonary lymph nodes, particularly in pediatric patients. Although pulmonary lymph nodes are generally oval or triangular in shape and located at or close to the pleura, they may exhibit different presentations (e.g., peribronchial or perifissural) [12]. Hence, appropriate attention should be given to this underrecognized differential diagnosis during the investigation of pulmonary nodules.

Some limitations of our study should be noted. First, the sample size could be considered to be relatively small; nonetheless, we believe it to be appropriate when taking into account the exclusion criteria and the ethical implications of radiation exposure in children. Second, the history of malignancy, previous infection, or trauma was assessed by reviewing medical records, which are sometimes inaccurate. Third, we did not use contrast media and thus could have underestimated the prevalence of mediastinal lymph nodes. Fourth, the studied population resides in an area that is endemic for granulomatous diseases; still, our results (in terms of both number and size) were comparable to studies conducted in non-endemic areas. Finally, because no enrolled patient was diagnosed with malignancy after a 2-year follow-up, biopsies were not performed, and histologic results were not available.

In conclusion, we found that the presence of pulmonary nodules and thoracic lymph nodes during thoracic MDCT of healthy children is frequent. Given that 95% of nodules measuring less than 6 mm and all lymph nodes measuring less than 7 mm are very unlikely to be pathologic, we recommend that such limits are reliable thresholds when investigating these incidental findings among pediatric patients.

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