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Visualization of pleural fissures in infants on computed tomography

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ABSTRACT

Purpose For infants with prenatally detected lung lesions, a chest CT is performed prior to surgery. The chest CT is performed as close to the surgery date as possible, because it is presumed that the visualization of lung fissures would be poor in the immediate neonatal setting. However, this presumption has never been formally studied. The purpose of this study is to assess differences in lung fissure visualization on chest CT in different infant age groups.

Methods This was a retrospective study of clinically indicated chest CT approved by the institutional review board performed in infants of different ages. The visibility of pleural fissures was subjectively assessed by three pediatric radiologists who were blinded to age group.

Results In the 0–2 months age group, 80% of all fissure segments were visible versus 92% in the 5–6 months group (p=0.04) and 95% in the 7–9 months group (p=0.01).

Conclusions The ability to visualize pleural fissures on CT increases with infant age. This observation should be taken into consideration when choosing the optimal timing of preoperative CT for asymptomatic congenital lung lesions.

INTRODUCTION

The most common congenital lung lesion in infants is a congenital pulmonary airway malformation, with a reported incidence between 1/2400 and 1/35 000.[1–5] At the authors' institution, preoperative CT for a congenital lung lesion is performed prior to surgical resection. CT is useful for preoperative planning to establish the size and location of the lung lesion, and visualization of the lung fissures helps establish the involved lobe. At the authors' institution, CT is delayed until closer to the surgery date, with the presumption that the visualization of lung fissures would be poor in the immediate neonatal setting, due to smaller patient size. However, this presumption has never been formally studied in infants, as all previous radiology research on pleural fissure anatomy on CT has all been in adults.[6–10] The hypothesis of this study is that the CT visibility of pleural fissures increases in older infants. The results of this study will hopefully assist pediatric surgeons and radiologists in determining the optimal timing of preoperative CT imaging of congenital lung lesions.

METHODS

Study design

This study was a retrospective chart review.

Study population

All patients included in the study were infants who underwent a clinically indicated contrast-enhanced chest CT at a single academic pediatric hospital during an 8-year time period (September 2007 to March 2014). The indications for the CT included, but were not limited to, prenatally detected lung lesions. Three age groups were selected: 0–2 months, 5–6 months, and 7–9 months. There were several reasons for selecting these specific age ranges. First, the 0–2 months group was selected to answer the question: Should preoperative CT of known congenital lung lesions be performed in the inpatient neonatal period, before the patient has been discharged from the neonatal unit? Second, age groups of the 5–6 months and 7–9 months were selected to answer the question: Is it sufficient to perform a preoperative CT a few months before surgery or should the CT be performed closer to the actual surgery date (ie, assuming the surgery is performed at approximately 9 months)? Each CT study represented a unique patient, with no repeat patients or repeat CT examinations used within or between age groups.

Imaging parameters

All studies were performed on a 64-slice multidetector scanner (Discovery CT 750 HD, GE Healthcare, Milwaukee, WI) with the following weight-based settings: (A) 80 kVp and max 240 mA for infants <7.5 kg and (b) 100 kVp and max 135 mA for infants >7.5 kg. The remaining CT parameters were the same for all patients: noise index 14, rotation time 0.5 s, slice thickness 2.5 mm, pitch 1.375. Each CT was performed under

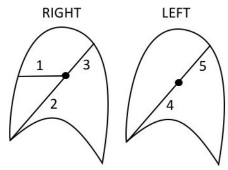

Figure 1 Sagittal sections of the right and left lungs. There were five fissure segments evaluated in each patient, including: (1) right minor fissure, (2) right major fissure anterior segment, (3) right major fissure posterior segment, (4) left major fissure anterior segment, and (5) left major fissure posterior segment.

anesthesia with positive pressure breath hold with patient positioned supine with both arms elevated. All CT scans were performed with intravenous contrast. Iohexol 350 mg/mL intravenous contrast was injected at 2 mL/s at a volume of 2 mL/kg with acquisition obtained 5 s after completion of contrast injection. Lung images were created at 1.25 mm thickness using either adaptive statistical iterative reconstruction (30% blend with filtered back projection) or model-based iterative reconstruction.

Assessment of lung fissures

All assessments were performed on diagnostic quality workstation (Barco, Fremont, CA; Agfa, Greenville, SC) in low-level lighting clinical radiology reading room. Three board-certified pediatric radiologists (postfellowship years of experience: 2, 5, 7) reviewed each case and recorded whether or not a fissure or fissure segment was visible. Fissure segment visibility was scored in a binary fashion: (A) visible or (B) not visible. The radiologists were blinded to patient age. There were five fissure segments evaluated in each patient: (1) right minor fissure, (2) right major fissure anterior segment, (3) right major fissure posterior segment, (4) left major fissure anterior segment, and (5) left major fissure posterior segment (figure 1). The radiologist was allowed to use any available reformat (axial, sagittal, or coronal reformat) to make the assessment of fissure visibility.

Statistical analysis

A fissure segment was counted as visible only if all three radiologists were in agreement. A χ^2 test was performed to compare different proportions of fissure segment visibility between the different age groups. An online calculator was used to generate p values.[11]

RESULTS

Demographics

All patients were seen at a single academic pediatric hospital. During the study period, 124 consecutive CT examinations were identified in the queried age groups. After excluding repeat examinations, repeat patients, technically inadequate CT studies, and non-chest anatomy, a total of 40 unique patients remained: 9 in the 0–2 months group, 16 in the 5–6 months group, and 15 in the 7–9 months group. The patient demographics are summarized in table 1.

Fissure visibility

A total of 200 fissure segments were evaluated in the 40 unique patients (five fissure segments per patient, with 45 fissure segments in the 0–2 months group, 80 fissure segments in the 5–6 months group, and 75 fissure segments in the 7–9 months group). Of the 200 fissure segments evaluated, 181 (91%) were visible to all three radiologists and 1 (0.5%) was *not* visible to all three radiologists. In the remaining 18 (9%) fissure segments, the three radiologists disagreed about the visibility.

The lung fissure segments were more frequently visible (to all three radiologists) in the older infants compared with younger infants (table 2). In the 0–2 months group, 80% of all fissure segments were visible to all three radiologists, compared with 92% of fissure segments in the 5–6 months group (p=0.04) and 95% in the 7–9 months group (p=0.01). When combining all age groups, the right major fissure anterior segment was the most visible segment (seen in 95% of all patients) whereas the right minor fissure was the least visible segment (seen in 80% of all patients); this difference in rate of visibility was statistically significant (p=0.04). The remaining fissure segments were visible in 93% of all patients; however, this rate was not significantly different from the rate of visibility of the right minor fissure (p=0.09). Figure 2 shows an example of an older infant in whom all three radiologists agreed that all of the fissure segments were visible. Figure 3 shows the one example of a younger infant in whom all three radiologists agreed that the right minor fissure was *not* visible.

DISCUSSION

The increased use of routine prenatal ultrasound has resulted in the increased detection of congenital lung

Table 1 Patient demographics

Ages (months)	n	Mean age (months)	Female:male patients (n)	Indications for CT
0–2	9	0.9	6:3	Prenatal chest mass (n=4), chest radiograph abnormality (n=2), extrathoracic neoplasm (n=1), gastrointestinal bleed (n=1), pulmonary hypertension (n=1)
5–6	16	5.4	6:10	Prenatal chest mass (n=7), chest radiograph abnormality (n=4), extrathoracic neoplasm (n=4), congenital heart disease (n=1)
7–9	15	7.6	5:10	Prenatal chest mass (n=7), congenital heart disease (n=3), chest radiograph abnormality (n=2), infection (n=2), extrathoracic neoplasm (n=1)

Age group	Right minor fissure (%)	Right major fissure (anterior) (%)	Right major fissure (posterior) (%)	Left major fissure (anterior) (%)	Left major fissure (posterior) (%)	All fissure segments (%)
0–2 months	6/9 (67)	7/9 (78)	7/9 (78)	8/9 (89)	8/9 (89)	36/45 (80)
5–6 months	13/16 (94)	16/16 (100)	15/16 (94)	15/16 (94)	15/16 (94)	74/80 (92)
7–9 months	13/15 (87)	15/15 (100)	15/15 (100)	14/15 (93)	14/15 (93)	71/75 (95)
All age groups	32/40 (80)	38/40 (95)	37/40 (93)	37/40 (93)	37/40 (93)	181/200 (91)

Table 2 Fissure visibility in different age groups (all three radiologists in agreement)

lesions.[1–4 12] Most surgeons choose to resect radiologically identifiable lung lesions in infants due to the long-term risks of infection and malignancy.[4 5 13–16] Lobectomy is the most common surgical operation for congenital lung lesions.[17 18] Surgery is typically performed acutely in symptomatic patients (usually pneumonia or respiratory distress) and before 10–12 months in asymptomatic patients.[1 5 12 13 17 19] The justifications for performing surgery in asymptomatic patients before 12 months of age are threefold: (A) avoid infection, (B) allow for compensatory growth of the healthy lung, and (C) detect unsuspected malignancy (eg, pleuropulmonary blastoma).[5 12–14 18–22]

Preoperative CT is performed for congenital lung lesions to confirm diagnosis and delineate the relationship between the lung lesion and the normal anatomical structures.[16] The hypothesis of this study was that the CT visibility of lung fissures increases with infant age, and the results of this study supported the hypothesis. In the 0–2 months group, 80% of fissures were visualized compared with 92% and 95% of fissures in the age groups of 5–6 months and 7–9 months, respectively. Nearly all fissures were visible by 5 months of age, with no significant difference between the 5–6 months group and 7–9 months group. The implication of the results is that preoperative CT does not need to be performed in the neonatal setting and can be delayed until later in infancy, at a time that is convenient for the planned surgery.

The authors of this study propose three possible explanations for why the fissures were more difficult to visualize in the 0–2 months group. First, infants are considerably smaller at 0–2 months of age, so the smaller structures at 0–2 months will be less readily visualized or below limits of detectability by CT. A second possible explanation is that fissures are more difficult to see in smaller patients due to their higher respiratory rate. For this study, the CT scanner was a 64-slice detector, and newer generation scanners and techniques might allow for better anatomic detail in smaller patients.[23] A third possible explanation for the results is that, in the absence of a healthy control group, the comparison was confounded by a higher rate of acute pathology in the younger infants. Sicker patients would have more lung opacities and volume loss that could obscure a pleural fissure, as was demonstrated in the patient in figure 3.

There are multiple limitations in this study. This is a single-center study with a small sample size; therefore, the results may not be generalizable to all infant populations. Also, there was no asymptomatic control group and the study groups were not controlled for gender, patient weight, respiratory rate, or clinical indication; therefore, the different rates of fissure visibility may have not have been due to differences in patient age. The imaging findings were not correlated with clinical outcomes; therefore, no clinical conclusions can be drawn. The 0–2 months group had fewer patients than the other groups and was underpowered based on retrospective power analysis. Despite being underpowered, a statistically significant difference in fissure visibility was still detected between the 0–2 months group and the older age groups; this suggests that an adequately powered sample size

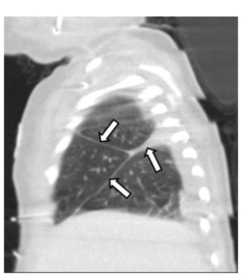

Figure 2 An older female infant (7–9 months group) with a neck abscess underwent a contrast-enhanced chest CT. In this sagittal reformat of the right lung, all three radiologists agreed that the pleural fissures were clearly visible (indicated by arrows). Of note, a pleural effusion was present, which likely enhanced visualization of the fissures, particularly the posterior segment of the right major fissure.

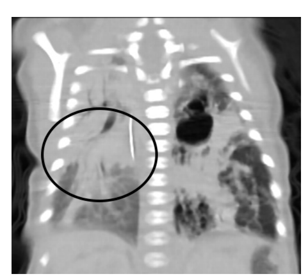

Figure 3 A younger female infant (0–2 months group) with a prenatally diagnosed lung lesion underwent a contrast-enhanced chest CT. In this coronal reformat, all three radiologists agreed that the right minor fissure was not visible (the expected region of the right minor fissure is indicated with a circle). The lack of visibility was, at least in part, due to the mass effect of the left lung lesion resulting in right lung atelectasis.

would have produced the same result. The ages of the patients were not continuous, which might have allowed for a stronger correlation to be drawn between age and fissure visibility. If more patients in different age groups had been evaluated, then a more accurate timeline of fissure visibility could have been elucidated. Lastly, this study did not evaluate for accessory fissures or fissure variants, which have been well described in adults undergoing CT.[9]

Within these limitations, however, we believe the results of this study support the practice of delaying the timing of preoperative CT for asymptomatic congenital lung lesions until closer to the elective surgery date. This delayed imaging approach has the added benefit of avoiding ionizing radiation in the neonatal period, at which time the long-term risks of ionizing radiation are higher.[24] Future studies with larger patient populations using the latest CT equipment and techniques are needed to further validate the observations in this study.

In conclusion, the ability to visualize pleural fissures on CT increases with infant age. This observation should be taken into consideration when choosing the optimal timing of preoperative CT for asymptomatic congenital lung lesions.

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Patient consent Not required.

Ethics approval This study was approved by our institution's committee for human research, and the need for informed consent was waived.

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