

Characteristics of Chest Lesions Missed on Neck CT Interpretations

경부 전산화단층촬영 판독에서 놓친 흉부 병변들의 특징

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Purpose: The purpose of this study was to identify the characteristics of chest lesions that are missed in interpretations of neck computed tomography (CT) scans.

Materials and Methods: A total of 240 consecutive neck CT scans were retrospectively analyzed to determine whether chest lesions were included or not. All missed chest lesions, which had not been described on neck CT reports, were recorded, and classified according to their clinical significance (insignificant, indeterminate, or significant) and awareness (known or unknown) at the time of CT interpretation, and their radiologic patterns were analyzed.

Results: Eighty seven (36.3%) of 240 neck CT scans had 105 chest lesions, and 88 of these were not described on the neck CT reports. Thirty seven clinically known or insignificant lesions were excluded, resulting in a miss rate for chest lesions of 35.2% (37/105), with six of these (5.7%) being potentially significant. The most common location of missed chest lesions was the lung (56/88, 63.6%), and 45 (80.4%) of these missed lung lesions were visualized only with lung window settings.

Conclusion: Chest lesions were common and frequently missed on neck CT interpretations. When reviewing neck CT scans, a special attention should be given to lung lesions by using lung window settings.

Index terms

Diagnostic Errors
Computed Tomography, X-Ray
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INTRODUCTION

With the increasing complexity of radiologic imaging in association with continuous advancement of the technical science, the demands for sub-specialized knowledge within radiology have increased greatly (1). However, in practice, we can't afford to have all radiologic examinations interpreted by specialized radiologists. Occasionally, as in cases of neck or abdominal computed tomography (CT) scans, additional specific sites (i.e., a part of the chest) may inevitably be included and also need to be interpreted correctly. Incidental but potentially important findings outside the area of interest may be present but missed in any radiologic studies (2-6). We have occasionally found chest lesions that were not reported on neck CT interpretations when

follow-up neck or chest CT studies were performed and compared with a previous neck CT study. The authors are unaware of any published study that addresses this issue of chest lesions being missed in interpretations of neck CT scans. Therefore we have attempted to assess the characteristics, such as prevalence, clinical significance, and radiologic patterns, of chest lesions that are missed on neck CT interpretations. This may provide useful information for radiologists interpreting neck CT scans that include areas in the chest.

MATERIALS AND METHODS

Patient Selection

This retrospective study was approved by the Institutional

Review Board, and the requirement for informed consent was waived. Three hundred ninety three (393) consecutive contrast enhanced neck CT scans of 393 patients that were performed from 1 to 31 May, 2014 at our institution were retrospectively reviewed. Of these, 153 neck CT scans of 112 patients who underwent chest CT scans on the same day and 41 patients who had follow-up neck CT scans during the selected study period were excluded. The remaining 240 neck CT scans were included in our study.

CT Imaging Protocol

The CT scans were performed on 64 or 128 multidetector scanners (Light Speed VCT; GE Healthcare, Milwaukee, WI, USA, and Somatom Definition, Somatom Definition AS+, or Sensation 64; Siemens, Erlangen, Germany). The scanning volume covered the area from the skull base to the aortopulmonary window of the mediastinum in the cephalo-caudal direction, with 3-mm collimation, 3-mm reconstruction interval, 120 kVp, and 60 mAs. Enhanced images were acquired with a bolus contrast injection by using a mechanical injector at a rate of 2.5 mL/s, for a total dose of 100 mL.

Imaging Analysis

The patients' clinical information for disease status and management was obtained by reviewing medical charts. To detect chest lesions, neck CT scans were reviewed using both soft tissue and lung window settings. A consensus interpretation was made by two radiologists: one board-certified radiologist with 20 years of experience in reading chest CT scans and one radiology resident with 2 years' experience in chest CT interpretations. Past records of neck CT reports were checked to determine whether those chest lesions were described or not. The original reports of neck CT scans were made by four board-certified radiologists with 5–20 years of experience in reading neck CT scans, or by radiology residents with 1–4 years of experience in reading neck CT scans with secondary confirmation by board-certified radiologists.

Missed (not described) and detected (described) chest lesions were recorded and classified according to their clinical significance (insignificant, indeterminate, or significant) and clinical awareness (known or unknown) at the time of the original neck CT interpretation. In addition, radiologic patterns, such as ana-

tomic location, radiologic characteristics, and suggested disease were analyzed.

Clinical significance of the chest lesions was judged by the interpreting radiologists. Chest lesions requiring no further evaluation, treatment, or follow up were categorized as insignificant lesions. These included old tuberculosis (TB) scars, small subsegmental linear atelectasis, and small lung nodules with a high likelihood of benignity. Lesions requiring later radiological or clinical follow-up were categorized as indeterminate lesions. These included mild to moderate emphysema, mild bronchiectasis, indeterminate lung nodules, small pleural effusion, and nonspecific enlargement of mediastinal lymph nodes. Lesions requiring immediate further evaluation, treatment, or close follow-up were categorized as pneumonia, suspicious active TB, severe emphysema, pulmonary thromboembolism, or suspicious metastatic nodule. The anatomic locations of the chest lesions were classified as lung, pleura, mediastinum including cardiovascular system, or chest wall.

Clinical awareness of chest lesions at the time of the original neck CT interpretations was defined by whether those lesions were mentioned either in the previous imaging reports or in the medical chart.

The frequencies, anatomic locations, CT findings of the missed chest lesions were analyzed. The frequency of missed lung lesions that were visualized only with a lung window setting was also analyzed.

Statistical Evaluation

All data were entered into an Excel spreadsheet (Microsoft Office Excel 2007, Redmond, WA, USA), and descriptive statistical analyses were performed. A chi-square (χ^2) test was used to compare incidences in anatomic distributions of missed chest lesions between patients with and without head and neck cancers. A *p* value of 0.05 or less was considered to indicate a statistically significant difference.

RESULTS

There were 111 men and 129 women, and patients' ages ranged between 19 and 89 with a mean age of 57. Underlying conditions which led to neck CT scans of these patients were malignancies (*n* = 97) including head and neck cancers (*n* = 66),

acute and chronic infection or inflammation of neck ($n = 57$), cervical lymphadenopathy ($n = 32$), and other various symptoms and signs ($n = 54$).

Of the total 240 neck CT scans, 87 scans showed 105 chest lesions (87/240, 36.3%) (Table 1). Among those 105 chest lesions, 88 (88/105, 83.8%) had not been described on the CT reports, and 50 (50/88, 56.8%) of these missed chest lesions were clinically unknown at the time of CT interpretation (Table 1). When clinically known lesions ($n = 38$) and unknown insignificant lesions ($n = 13$) were excluded from the 88 missed (not described) lesions, the miss rate of chest lesions was 35.2% (37/105). Seven (6.7%) of 105 chest lesions were clinically significant and previously unknown, and six (5.7%) were missed. These six included suspicious active TB ($n = 2$) (Fig. 1), bullous emphysema ($n = 1$) (Fig. 2), suspicious adenocarcinoma of the lung ($n = 1$) (Fig. 3), pulmonary thromboembolism ($n = 1$), and diffuse bony sclerosis associated with leukemia ($n = 1$).

Clinical, anatomic, and radiologic characteristics of all the chest lesions missed on neck CT scans are listed in Table 2. The most common location of the missed chest lesions was the lung (56/88, 63.6%), followed by the mediastinum including cardiovascular system, pleura, and chest wall (24/88, 27.3%; 5/88,

5.7%; 3/88, 3.4%, respectively). Three most commonly missed lung lesions were nodules ($n = 13$, 23.2%), emphysema ($n = 14$, 25.0%), and postinflammatory scarring ($n = 16$, 28.6%). Most (45/56, 80.4%) of the missed lung lesions were visualized only with lung window settings (Table 3, Fig. 3). The sclerotic bone lesion was seen only with a bone window setting.

There were 23 missed chest lesions in neck CT scans of 66 patients with head and neck cancers. These were comprised of fourteen pulmonary lesions, six mediastinal lesions, two pleural lesions, and one chest wall lesion. When these 23 missed chest lesions are compared to 65 missed chest lesions in 174 patients without head and neck cancers, the incidence of missed chest lesions is similar for the two groups (34.8% vs. 37.4%, respectively). Among the 23 missed chest lesions in patients with head and neck cancers, four were lung nodules: two were known metastatic nodules; one was an unknown indeterminate nodule; and one was a known benign nodule. The percentage of lung nodules in all missed chest lesions in patients with head and neck cancers was similar to that in patients without head and neck cancers [17.4% (4/23) vs. 13.8% (9/65), respectively]. In addition, the anatomic distributions of the missed chest lesions were not statistically different between the two groups with and

Table 1. Clinical Conditions of the 105 Chest Lesions Visualized on 240 Neck CT Scans

Clinical Significance	Clinical Awareness				Total
	Unknown		Known		
	Missed	Detected	Missed	Detected	
Insignificant	13	1	8	1	23
Indeterminate	31	5	18	3	57
Significant	6	1	12	6	25
Total	50	7	38	10	105

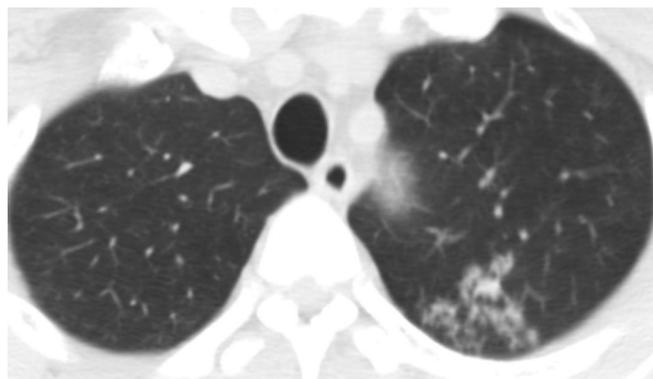


Fig. 1. Neck CT image at the level of lung apex in a 42-year-old man presenting with tongue discomfort. Multiple clustered, centrilobular nodules are noted in the left upper lobe, raising the possibility of pulmonary tuberculosis, which were missed on neck CT interpretation.

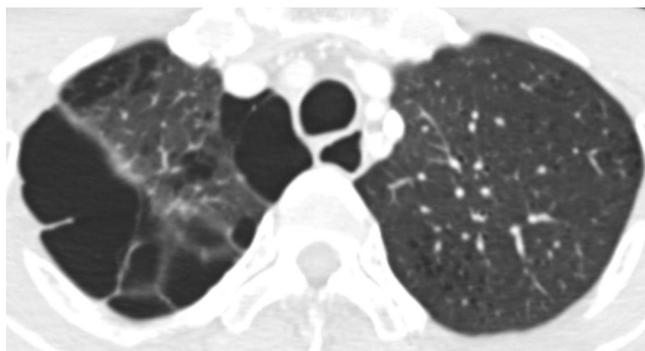


Fig. 2. Neck CT at the level of lung apex in a 53-year-old man with peritonsillar abscess. CT image with lung window setting shows multiple variable sized bullae in the right lung apex, which was not described in neck CT report. Minimal centrilobular emphysema is also noted in the left upper lobe.

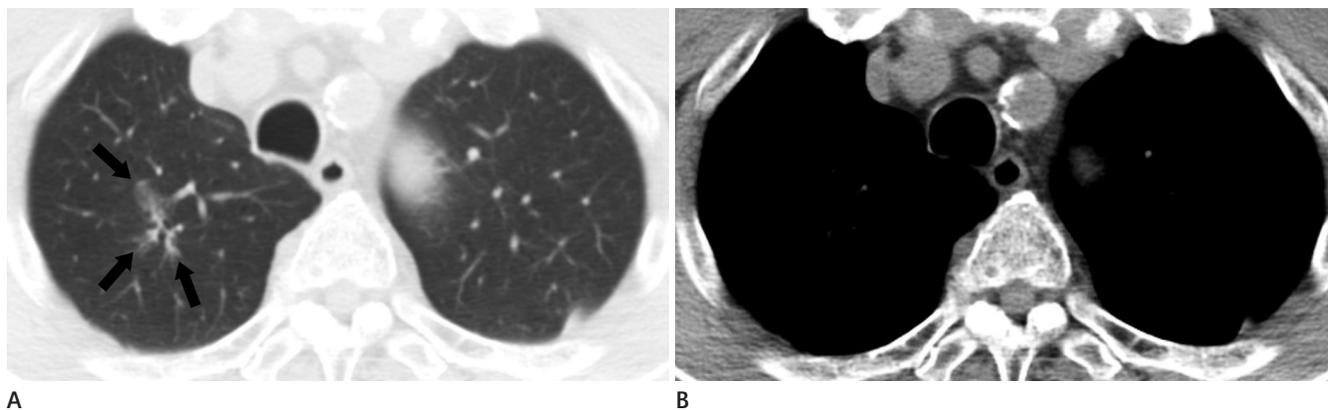


Fig. 3. Missed and significant chest lesion on neck CT in an 80-year-old man with thyroid cancer. The lower part of neck CT image with lung window setting **(A)** shows an irregular shaped peribronchovascular ground-glass opacity nodule (arrows) in the right upper lobe, suggesting adenocarcinoma of the lung. On mediastinal window setting **(B)**, this lesion is not seen.

Table 2. Clinical, Anatomic, and Radiologic Characteristics of the Chest Lesions Missed on Neck CT Interpretation

Clinical Significance	Location	CT Findings	Clinical Awareness		Total
			Unknown	Known	
Significant	Lung	Metastatic nodule		3	12
		Suspicious lung cancer	1	1	
		Suspicious active TB	2	1	
		Severe emphysema	1	1	
		Pneumonia		1	
		Interstitial lung disease		1	
	Mediastinum & cardiovascular system	Metastatic lymphadenopathy		2	4
		Pulmonary thromboembolism	1		
		Pulmonary arterial dilatation		1	
Chest wall	Bony sclerosis associated with leukemia	1		2	
	R axillary metastatic lymphadenopathy		1		
Indeterminate	Lung	Indeterminate nodule	1	1	23
		TB with indeterminate activity		1	
		Mild emphysema	10	2	
		Mild bronchiectasis	1	3	
		Fibroatelectasis	2	1	
		Mild pulmonary edema	1		
	Pleura	Small pleural effusion	4		5
		Pleural thickening		1	
	Mediastinum & cardiovascular system	Reactive lymphadenopathy	7	1	20
		Probable thymic hyperplasia	2		
		Suspicious bronchogenic cyst	1		
		Atherosclerosis or dilatation of aorta	2	6	
		Coronary artery stent		1	
	Chest wall	Injection granulomas in breasts		1	1
Insignificant	Lung	Benign nodule	5	3	21
		Old TB scar		2	
		Linear atelectasis or scarring	8	3	

TB = tuberculosis

without head and neck cancers (Table 4).

DISCUSSION

Errors during radiologic imaging studies are not uncommon and have long been recognized. These errors may lead to suboptimal management and consequently seriously impact a patient's outcome (7, 8). Since most errors occur during image interpretation, and perceptual misses (i.e., false-negative errors) are the most common misinterpretation made by radiologists (2, 9, 10), we specifically focused on these false-negative missed chest lesions on neck CT scans.

Several articles have emphasized the importance of analyzing recurrent and common patterns of errors, to reduce or prevent repetition of the same error (7, 8, 11). Other studies have reported that if the first radiologist misses a finding, the next radiologist will likely miss it as well (8, 12). There are only a few studies which investigated common errors in the interpretation of head and neck CT scans, none of which focused on missed chest lesions (2, 13, 14). One study showed that vascular lesions, such as

aneurysm, were most commonly missed on head and neck CT angiography, and neck mass, sellar mass, and nasogastric tube malposition were also missed as well (13). In reading cranial CT and magnetic resonance imaging, the most common perceptual errors were extraaxial mass such as meningioma, thrombosis at dural venous sinus, and infarcts at posterior circulation (2). Lesions outside the area of primary examination can be more easily missed (2-6, 9), and careful attention should be paid to these "neglected" areas such as the chest in neck CT examinations. In our study, all original neck CT reports were directly or secondarily confirmed (after preliminary reading by residents) by board-certified radiologists. The missed chest lesions on these neck CT interpretations seem to be caused, not by lack of professionalism or experience, but by radiologists' failure to pay attention.

In the present study, the most common site of the missed chest lesions was the lung. Significantly, 80% of these missed lung lesions were visualized only when lung window settings were used. Therefore it is reasonable to assume that separate reviews of the lungs with lung window settings might eliminate a similar proportion of missed lesions. Not many studies have addressed the importance of systemic review of all organs with appropriate window settings (1, 4, 9).

One recent study demonstrated that lung nodules were reported in 3% of abdominal CT studies, and 19% of lung nodules in patients with underlying malignancy were metastatic (15). Lung metastasis is also common in about 12% of patients with head and neck cancer (16), underscoring the importance of detecting lung nodules not only in abdominal CT scans but also in neck CT scans. In our study, four of the missed chest lesions in patients with head and neck cancer were pulmonary nodules, two of which were metastatic and fortunately clinically known. However, one clinically unknown, indeterminate nodule was

Table 3. Lung Lesions Visualized Only with Lung Window Settings

Lung Lesions	No./Total No. (%)
Nodule	10/13 (77.0)
Emphysema	14/14 (100)
TB	3/4 (75)
Suspicious lung cancer	1/1 (100)
Bronchiectasis	4/4 (100)
Pneumonia	2/2 (100)
Edema	1/1 (100)
Interstitial lung disease	0/1 (0)
Scarring	10/16 (62.5)
Total	45/56 (80.4)

TB = tuberculosis

Table 4. Anatomic Distributions of the Missed Chest Lesions in Patients with and without Head and Neck Cancers

Anatomic Distributions	No. of Missed Lesions		p-Values
	Patients with Head and Neck Cancers	Patients without Head and Neck Cancers	
Lung	14 (60.9%)	42 (64.6%)	0.8465
Lung nodules	4 (17.4%)	9 (13.8%)	0.7038*
Mediastinum & cardiovascular system	6 (26.1%)	18 (27.7%)	0.8992
Pleura	2 (8.7%)	3 (4.6%)	0.4805*
Chest wall	1 (4.3%)	2 (3.1%)	0.7766*
Total	23	65	0.6318

*It is known that chi-square should not be calculated if the expected value in any category is less than 5. In that sense, the chi-analysis of "Lung nodules", "Pleura", and "Chest wall" could be meaningless because of the small number of the frequency.

also missed, which still has the potential for being metastatic. Since our study showed that the incidence of the missed chest lesions, including lung nodules in patients with head and neck cancer, is similar to that in patients without head and neck cancer. Thus it appears that the radiologist's awareness of patients' underlying diseases, such as head and neck cancer, does not influence the miss rate of chest lesions in neck CT interpretations. Another important point is that a small lung nodule can be "burned out" with a mediastinal window setting, so that a lung window setting should be used to avoid missing any pulmonary nodules (4, 17). This problem may also apply to emphysema in that all 14 cases of emphysema were visualized only with a lung window setting in our study.

In the present study, the miss rate of the previously unknown significant chest lesions that would have influenced follow-up or management was 5.7% (6/105). This is comparable to reported interpretation error rates of 2–20% in previous imaging studies (18–20). In a recent, large multifacility study of misinterpretation rates, an approximate 3.7% disagreement rate was detected, including 2.9% difficult cases and 0.8% non-difficult cases (21). That study also found that there were considerable differences in disagreement rates by modalities with CT showing a higher error rate of 7.2%. Similar error rates were observed in neuroradiologic imaging studies: 5.2% significant errors in reading head and neck CT angiography (13), 6% clinically consequential misinterpretation rate in non-contrast cranial CT (22), and 12–15% discordance rate between residents and neuroradiologists in interpretation of transverse and three-dimensional images (23).

The potentially significant and previously unknown missed chest lesions in our study were pulmonary thromboembolism, bullous emphysema, suspicious active TB, suspicious adenocarcinoma of the lung, and diffuse bony sclerosis associated with leukemia. Other studies have reported similar results, with frequently missed lesions on radiologic examinations being pulmonary embolism, venous thrombosis, unexpected gastrointestinal tumors, and bone and soft tissue lesions such as metastasis (2, 3, 9).

The present study has several limitations. First, it was a retrospective study, and our "gold standard" for missed chest lesions was expert consensus for the intrinsic false-negative results. This might have resulted in underestimation of the actual miss

rate. Second, the clinical significance of the missed lesions was determined subjectively by the radiologists, not clinicians. However, it was carefully classified on the basis of all available radiologic and clinical data, combined with experiential knowledge while maintaining objectivity. Third, we did not assess adverse clinical outcomes that might have resulted from missed chest lesions. Lastly, since the imaging reconstruction algorithm for neck CT is slightly different from that of chest CT, and neck CT scans only include the upper third or quarter of the entire lung parenchyma, neck CT scans may provide incomplete interpretation of lung lesions. However, incidental detection of chest lesions on neck CT scans can provide the opportunity for further evaluation, which may include chest CT scans.

In conclusion, chest lesions were commonly identified and missed on the readings of neck CT scans, and a small percentage of them were potentially significant. Lung lesions accounted for the most common missed chest findings, and they were generally visualized only with lung window setting. The present study suggests performing a careful and systematic review of both neck and chest areas in reading neck CT scans, with additional use of lung window settings for optimal visualization of lung lesions.

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경부 전산화단층촬영 판독에서 놓친 흉부 병변들의 특징

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목적: 경부 전산화단층촬영 판독에서 놓친 흉부 병변의 특징을 알아보고자 하였다.

대상과 방법: 총 240명의 경부 전산화단층촬영 검사를 후향적으로 분석하여 흉부 병변이 있는지 확인하였으며, 경부 전산화단층촬영 판독문을 검토하여 흉부 병변을 언급했는지 여부를 확인하였다. 판독문에 언급되지 않은 놓친 흉부 병변들을 기록하고, 임상적 중요성에 따라 중요한, 모호한, 중요치 않은 그룹으로, 그리고 판독 당시 흉부 병변에 대해 임상적으로 이미 알고 있었는지 여부에 따라 인지, 미인지 그룹으로 분류하였다. 흉부 병변들의 영상의학적 특징에 대해 분석하였다.

결과: 240명의 경부 전산화단층촬영 중 87명(36.3%)에서 105개의 흉부 병변들이 있었고, 이 중 88개의 병변은 판독문에서 언급되지 않았다. 임상적으로 이미 인지하고 있거나 중요치 않은 병변을 제외하였을 때, 흉부 병변의 놓친 비율은 35.2%(37/105)였고, 이 중 6개의 병변(5.7%)은 임상적으로 중요한 병변이었다. 놓친 흉부 병변의 가장 흔한 부위는 폐(56/88, 63.6%)였고, 이 중에서 45개(80.4%)가 폐창배경(lung window setting)에서만 보이는 병변이었다.

결론: 경부 전산화단층촬영에서 흉부 병변은 흔하며, 판독에서 자주 놓치기 때문에 판독할 때, 흉부 병변의 가능성에 대해 특별히 주의를 기울여 폐창배경을 사용하여 살펴봐야 한다.

가톨릭대학교 의과대학 서울성모병원 영상의학과