Comparison of Low Dose and Standard Dose MDCT in Detection of Metastatic Pulmonary Nodules

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Objective: *Compare low dose (50 mA) and standard dose (300 mA) MDCT in detection of metastatic pulmonary nodules in extrathoracic malignant patients in Siriraj hospital.*
Material and Method: *Prospectively, 58 patients underwent chest CT examinations by 64-slice MDCT in non-enhanced phase with a reduced tube current of 50 mA (low-dose CT (LDCT)), followed by contrast-enhanced phase with a standard tube current of 300 mA (Standard-dose CT (SDCT)). Other parameter such as tube voltage 120 kVp, spiral pitch 0.984, and section thickness 1.25 mm, were kept constant. Four hundred twenty two nodules found by SDCT and 427 nodules found by LDCT were analyzed.*
Results: *The sensitivity of LDCT was 94.7% for all nodules, 79% for nodules ≤ 2 mm, 94.2% for nodules 2.1-3 mm, 97% for nodules 3.1-4 mm, and 100% for nodules 4.1-5 mm. Three types of nodules were found and classified as calcific nodule, non-calcific nodule, and ground-glass nodule of which sensitivity for detection in LDCT were 100% (p = 1.000), 95.9% (p = 0.337) and 77% (p = 0.581), respectively. Most common causes of discrepancy in SDCT were unseen nodules and in LDCT were end-on vessel nodules. Majority of discrepant nodules and retrospective nodules were ≤ 3 mm. Effective dose ranged from 0.78 mSv.-1.6 mSv in LDCT and 4.22-9.57 mSv in SDCT.*
Conclusion: *There is no statistical difference in detection of metastatic pulmonary nodules by using low-dose and standard-dose CT images. Low-dose CT images can used to follow-up the treatment responsiveness of the known patient, diagnosed to have pulmonary metastasis.*

Keywords: *Low dose CT scan, Pulmonary metastasis*

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Thoracic structures are commonly involved in patients with metastatic neoplasm, and the lungs often are the first site in which metastases are detected[1]. The route of metastasis is mainly from hematogenous spreading and lymphatic spreading[1,2]. Pulmonary nodules are the most common thoracic manifestation of metastasis. Chest radiograph is the primary tool for screening pulmonary metastasis, which sensitivity for detecting nodules in patient suspected metastases is about 40-45%[1]. The lower limit for uncalcified nodules detection on plain chest radiograph is somewhere between 7 and 9 mm[3]. Computed tomography is considerably more sensitive than chest radiograph in detecting pulmonary nodules, although the sensitivity of CT varies with the technique used. Using spiral CT with 5 mm collimation, a sensitivity of about 70% for pulmonary nodule diameter equal or less than 5 mm and the sensitivity of about 95% for pulmonary nodule diameter greater than 5 mm[1]. The study by Ko et al showed sensitivity for detection a small nodule size of ≤ 5 mm and > 5 mm, in diameter approximately about 73.9% and 82.3% respectively[4].

The incidence of pulmonary metastases varies with the primary tumor and the stage of disease, ranging from 30% to 55% in various series[3,5]. Early detection of pulmonary metastases may affect tumor staging and treatment planning[6]. Patients with malignant tumors and pulmonary metastasis frequently undergo chest CT for screening of pulmonary metastases prior to treatment. They are also used for assessing the interval change in nodule size after the institution of

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chemotherapy treatment. Therefore, these patients are exposed to more radiation dose than normal population.

CT examinations are relatively high radiation dose in comparison with other types of diagnostic radiologic procedures. Radiation doses in CT are below the threshold doses for the induction of deterministic effects such as epilation and skin erythema. Therefore, patient risks from chest CT examinations are restricted to the stochastic processes of carcinogenesis and the induction of genetic effects[7].

To compare radiological examinations in terms of radiation risk, it is necessary to estimate effective dose "E". According to International Commission on Radiological Protection, the radiation dose for the normal population is limited to less than 1 mSv/1 year. In general, patients receive a radiation dose of approximately 3.8-10.9 mSv in one CT chest[8,9]. Many studies devise a CT protocol that would minimize patient exposure to ionizing radiation following the principle of ALARA (as low as reasonably achievable) suggested by the International Commission of Radiological Protection[10]. Scanning parameter such as tube current, peak kilovoltage, beam pitch, scan duration, and scan volume can be adjusted to minimize radiation dose to patients while optimizing image quality[11,12].

The authors objective was to compare low-dose to standard-dose MDCT in detection of metastatic pulmonary nodules in extrathoracic malignant patients in Siriraj hospital.

Material and Method

Patient population

Fifty-nine consecutive patients (31 men and 28 women) with primary extrathoracic malignant tumor were studied prospectively for the assessment of pulmonary metastases between December 2007 and June 2008. The age range of the patients was 19-81 years (mean age 57 years). Average weight of the subjects ranged from 37 to 84 kg (mean 59.9 kg). Average thoracic circumference of the subjects ranged from 69 to 103.5 cm (mean length 85 cm). Underlying extrathoracic malignancy is shown in Table 1. Length of CT study ranged from 22.9 cm to 38.4 cm (mean length 29.8 cm $\pm$ 3.6 SD). All patients were informed of the purpose of the study, and consent form was obtained for pre-contrast phase low-dose CT examination after the local ethics committee had approved the study design.

Image acquisition

All chest CT examinations were performed with the same multidetector CT scanner (MDCT) (64-slice MDCT, GE light speed VCT). Patients underwent non-enhanced MDCT of the chest acquired with a reduced tube current of 50 mA (low-dose CT (LDCT)), immediately followed by contrast-enhanced MDCT with a standard tube current of 300 mA (Standard-dose CT (SDCT)). All scans were obtained during suspended full inspiration with the patient in the supine position. The remaining scan parameters were kept constant for both scans, tube voltage 120 kVp, spiral pitch 0.984, section thickness 1.25 mm, reconstruction interval 7.5 mm, scan time 0.5 second/rotation, table feed 40 mm/rotation, and slice collimation 0.625 mm. The field as well as the field of view was defined on the scout view of the individual patient from neck to cover both adrenal glands. Eighty to one hundred milliliters of non-ionic contrast agent with a concentration of 370 mg Iodine/ml (Ultravist, Bayer Korea Ltd, Kyunggi-do, Korea) or 300 mg Iodine/ml (Omnipaque, GE healthcare (Shanghai) co, Ltd, China) were administered with a CT power injector (Stellant TM) into an anticubital vein at a rate of 2.7-3.0 ml/second and 40-seconds delay before the start of the standard-dose MDCT.

Image interpretation

Any focal, rounded, or ovoid lesion that was identified within the lung parenchyma on CT sections viewed at lung window settings was considered as a pulmonary nodule. This led to the inclusion of some areas of nodular pleural thickening that were not distinguishable from parenchymal nodules. Two chest radiologists read all standard-dose and low-dose scans independently and all pulmonary nodules $\leq$ 5 mm in each scan. If the number of pulmonary nodules were

Table 1. Underlying primary malignancy diagnosed at time of CT examination (n = 59)

Disease	No. of patients	%
Colon or rectum cancer	19	32
Breast cancer	14	24
Hepatocellular carcinoma	9	15
Renal cell carcinoma	8	13
Cancer of head and neck	4	7
Cervical cancer	2	3
Thymic tumor	1	2
Chondrosarcoma	1	2
Periampullary carcinoma	1	2

more than 10 in each scan, we chose the scan only at three levels included apical level, carina level, and lung base level. Low-dose and standard-dose images were not interpreted consecutively. Picture archiving and communication system (PACS) were used for review in all images. The window width and window level of lung were adjustable. No coronal reformation was used in the present study.

Number, size, and characters of nodules as non-calcific, calcific, or ground-glass appearance were assessed. To establish the size of the detected foci and nodules, they were assigned to one of four size groups: (a) ≤ 2 mm, (b) 2.1-3 mm, (c) 3.1-4 mm, or (d) 4.1-5 mm in diameter. For comparison purposes, pulmonary nodules were recorded in their segmental location in the right and in the left lung, and each nodule was assigned an identification slice number.

In the second step, for each patient, images obtained both at standard- and low-dose CT. They were compared for the number and size of the nodules (nodule-by-nodule analysis). Nodules seen at both SDCT and LDCT, only at SDCT, or only at LDCT were recorded.

Finally, those nodules seen only at SDCT or LDCT from nodule- by-nodule analysis were re-analyzed by two experienced chest radiologists for the causes of discrepancy.

Statistical analysis

McNemar's test for two related binomial proportion was used to assess differences in the detection of pulmonary nodules demonstrated in the same lung with two different CT protocols[13]. A p-value of less than 0.05 indicated a statistically significant difference. Because true-negative findings could not be recorded for individual nodules in lungs with multiple lesions, specificity and negative predictive value could not be calculated.

Results

Fifty-nine patients were included in the study. Four hundred twenty two nodules were detected at SDCT and 427 nodules were detected at LDCT (Table 2). The number of nodules (size ≤ 5 mm) detected per patient ranged from 0 to 35 (mean 7.15) at SDCT, and from 0 to 35 (mean 7.23) at LDCT. Three hundred ninety eight nodules out of 451 (88.2%) nodules were observed by both techniques, whereas 24 (5.4%) nodules were seen only at SDCT and 29 (6.4%) nodules were detected only at LDCT. There were no statistically significant differences in the number of nodules detected at standard- or low-dose CT ($p > 0.05$). The sensitivity of LDCT was 94.7% (427/451 nodules) for all nodules, 79% for nodules type a ($p = 0.664$), 94.2% for nodules type b ($p = 1.000$), 97% for nodules type c ($p = 0.753$), and 100% for nodules type d ($p = 1.000$) (Table 2).

The types of nodules were classified in calcific nodule, non-calcific nodule, and ground-glass nodule. The sensitivity for detection in LDCT were 100% ($p = 1.000$), 95.9% ($p = 0.337$) and 77% ($p = 0.581$), respectively (Table 3).

The distribution of pulmonary nodules were scattered in all lobes of both lungs as shown in Table 4.

Table 2. Sensitivity of pulmonary nodule detection of LDCT and SDCT category by size

Size			50 mA		Total	p-value
			+	-		
≤ 2 mm	300 mA	+	21	9	30 (71%)	0.664
		-	12	0	12 (29%)	
		Total	33 (79%)	9 (21%)	42	
2.1-3 mm	300 mA	+	169	11	180 (94.7%)	1.000
		-	10	0	10 (5.3%)	
		Total	179 (94.2%)	11 (5.8%)	190	
3.1-4 mm	300 mA	+	123	4	127 (95.5%)	0.753
		-	6	0	6 (4.5%)	
		Total	129 (97.0%)	4 (3.0%)	133	
4-5 mm	300 mA	+	85	0	85 (99%)	1.000
		-	1	0	1 (1%)	
		Total	86 (100%)	0	86	

Table 3. Sensitivity of pulmonary nodule detection of LDCT and SDCT category by characteristic

Characteristic feature			50 mA		Total	p-value
			+	-		
Calcific	300 mA	+	23	0	23 (96%)	1.000
		-	1	0	1 (4%)	
		Total	24 (100%)	0	24	
Non-calcific	300 mA	+	353	16	369 (94.1%)	0.337
		-	23	0	23 (5.9%)	
		Total	376 (95.9%)	16 (4.1%)	392	
Ground-glass appearance	300 mA	+	22	8	30 (86%)	0.581
		-	5	0	5 (14%)	
		Total	27 (77%)	8 (23%)	35	

Table 4. Distribution of pulmonary nodules

Location	Both LDCT and SDCT (398)	Only SDCT (24)	Only LDCT (29)
Right upper lobe	89	5	6
Right middle lobe	89	3	3
Right lower lobe	67	2	4
Left upper lobe	90	9	11
Left lower lobe	63	5	5

Table 5. Characters of discrepant nodules

Size (mm)	Low-dose CT negative					Low-dose CT positive				
	≤ 2	2.1-3	3.1–4	4.1-5	Total	≤ 2	2.1-3	3.1–4	4.1-5	Total
Vessel	1	-	-	-	1	5	3	1	1	10
Fibrotic band	-	-	1	-	1	-	-	-	-	0
Respiratory artifact	-	1	1	-	2	1	1	-	-	2
Adjacent to infiltrate	-	-	-	-	0	-	-	1	-	1
Adjacent to vessel	3	2	-	-	5	2	2	3	-	7
Not seen	1	6	1	-	8	3	1	1	-	5
Apical lung/artifact	2	-	-	-	2	-	-	-	-	0
Adjacent fissure	-	2	1	-	3	1	-	-	-	1
Adjacent pleura	2	-	-	-	2	-	3	-	-	3
Total	9 (37%)	11 (46%)	4 (17%)	0	24	12 (41%)	10 (35%)	6 (21%)	1 (3%)	29

For the nodules detected only in one CT technique, the causes of discrepancy were reported in Table 5. Most common causes of discrepancy in SDCT were unseen nodules and adjacent vessel nodules, and most common causes in LDCT positive were end-on vessel (see Fig.1) and adjacent vessel nodules. Twenty of 24 (83%) nodules seen at SDCT, but not at LDCT, were ≤ 3 mm. Similarly, 22 of 29 (76%) discrepant nodules that were positive at LDCT and negative at SDCT were also < 3 mm. The discrepant nodules were characterized as 1 of 24 calcific nodule (4%), 39 of 392 non-calcific nodules (10%), and 13 of 35 ground-glass nodules (37%).

Forty-seven of 398 (11.8%) nodules that were initially reported to have been negative at LDCT or SDCT were detected retrospectively by

Table 6. Review retrospective nodule

Size	Positive in both LDCT and SDCT (nodule)	Retrospective nodule (nodule)	Percentage
≤ 2 mm	21	9	43.0%
2.1-3 mm	169	27	16.0%
3.1-4 mm	123	8	6.5%
4.1-5 mm	85	3	4.0%
Total	398	47	11.8%

nodule by-nodule analysis (Table 6). Incidence of retrospectively detected nodules declined when the size of nodules increase. The patients were exposed to radiation (effective) dose from 0.78 mSv to 1.6 mSv (mean 1.14 mSv, SD = 0.2 mSv) in LDCT and from 4.22 to 9.57 mSv (mean 6.86 mSv, SD 1.22 mSv) in SDCT. Multiple episode of CT studies, including brain, chest, or abdomen, were obtained, up to 16 studies per person (mean 3.92 ± 3.5 SD), prior to this study for disease evaluation and follow-up treatment. Streak artifacts were obvious in all studies of low-dose CT images. These artifacts consisted of horizontal linear bands that appeared in the lung parenchyma and the chest wall, predominantly in apical and apicoposterior segment of both upper lungs (show in Fig. 2). However, apical steak artifacts affected the interpretation of discrepant nodules seen in upper lobe in two of 12 patients (17%) who had significant discrepant nodules, or two of 59 patients (3%).

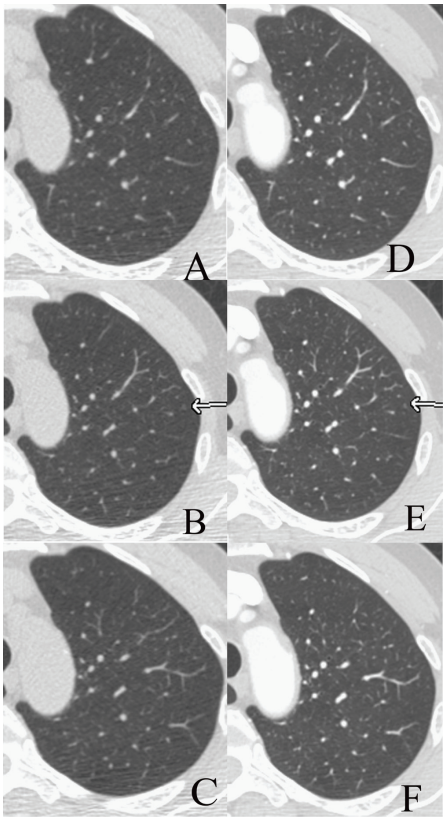

Fig. 1 A 66 year-old man with history hepatocellular carcinoma. A discrepant tiny pulmonary nodule (arrow in B) was detected in LDCT (50 mA) (A, B, C), which was an end on vessel (arrow in E) in SDCT (300 mA) (D, E, F)

Discussion

LDCT was better than digital radiograph in detecting pulmonary metastasis[14]. Concerning the performance of LDCT as compared to those of SDCT in detecting pulmonary nodule, it had been reported that there were no statistical significance in detecting the number of nodules by either SDCT or LDCT with scanning parameters of 43 mA and a pitch of 2. In our study, we used scan parameter 50 mA and a pitch of 0.984. We found no significant difference between LDCT and SDCT for detecting all size of pulmonary nodules (p value >0.05). However we noticed that the sensitivity in detecting nodule of diameter ≤ 2 mm was as low in low-dose CT images (79%) as in standard-dose CT images (71%). It could be from small number of nodules for evaluation or it may be true. Thus, no significant difference was found between these two groups.

The authors characterized nodules in three types as calcific, non-calcific, and ground-glass

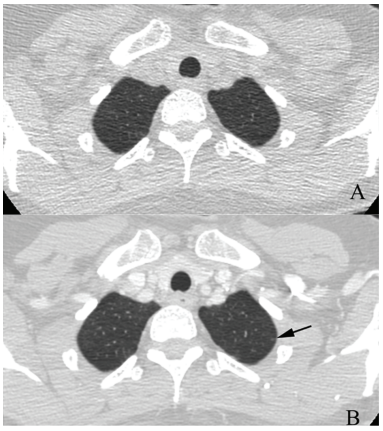

Fig. 2 Streak artifacts in upper lung obscuring a tiny pulmonary nodule in 46 year-old woman with history of colon cancer. (A) LDCT (50 mA) image did not demonstrate pulmonary nodule. (B) SDCT (300 mA) image showed pulmonary nodule (arrow) in apicoposterior segment of LUL

nodules. No significant difference between types of nodules on low-dose and standard-dose CT images was noted. However, we found a difference in the detection rate between LDCT images (77%) and SDCT images (86%) for ground-glass nodules. However, the detection difference may be erroneous due to the small number of nodules evaluated (show in Fig. 3). Further evaluation and collection of LDCT images for ground-glass nodule is required for proper evaluation.

Karabulut N et al[15] demonstrated that the cause of discrepant nodules in LDCT was unseen nodule and in LDCT was end-on vessel or unseen nodule in SDCT. Gartenschlager N et al[16] showed that the cause of discrepant nodules in LDCT was adjacent vessel in the study and in LDCT was alternative scan poor visibility. The present study had also revealed that the cause of discrepant nodules in LDCT was unseen nodule and in LDCT was the end-on vessel in SDCT. This is similar to the study of Karabulut N et al[15]. However, our study result was different from the study of Gartenschlager N et al[16]. This could be due to some difference of discrepant nodule categorization.

In the present study, discrepant nodules were found in 26 patients. The discrepant nodules had affected the interpretation in 12 patients (4 patients had been overestimated with LDCT image, 6 patients had been overestimated with SDCT image and 2 patients had been overestimated with both LDCT and SDCT images). All of these 12 patients had small number of nodules (< 5 nodules) and each nodule had diameter less than 5 mm. The nodules size in the remaining 14 patients did not affect the interpretation. Their number of small nodules ($\varnothing \leq 5$ mm) were greater than 5, the large nodules ($\varnothing > 5$ mm) were more than 2 and they had specific characters to suggest metastatic nodules such as cavitary. We found that LDCT have a slightly higher sensitivity for detection nodules $\varnothing \leq$ 2 mm, 3.1-4 mm, and 4.1-5 mm than SDCT. This could be that LDCT visualize less the distal pulmonary vessels. Therefore, the nodules were less confused with end-on vessels. However, this could be cause of overestimation in LDCT image.

In the studies of Schaner et al[17] and Chang et al[18], the lower limit of detection for CT was 3 mm, compared with 6 mm for conventional linear tomography. In that study, 33 of the 45 (73%) resected nodules that were not detected by means of any study were 3 mm or smaller. Pass et al[19] also found that the median size of lesions missed at CT and/or conventional linear tomography was 3 mm. In the present study, we could found pulmonary nodules that were 3 mm or less ($\varnothing \leq 2$ mm = 42 nodules and 2.1-3 mm = 190 nodules) in SDCT, LDCT or both techniques. However, the majority of our discrepant nodules and retrospective nodules were pulmonary nodule sized $\varnothing \leq 3$ mm.

The reason we used 1.25 mm-scan was because Fischbach F et al[20] revealed that reduced slice thickness to 1.25 mm could improve small nodule detection, confidence levels, and interobserver agreement. Furthermore, it may raise the sensitivity for lung nodule detection and have important positive implication for the treatment and clinical outcome of patients.

Many factors affected interpretation of the pulmonary nodules and caused missed nodules. Those factors were partial volume averaging, particularly near the diaphragm, respiratory motion artifacts (Fig. 4),

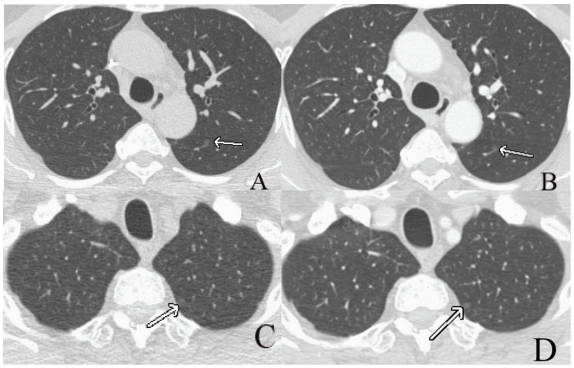

Fig. 3 A 60 year-old man with history of rectal cancer showed pulmonary metastasis. A small ground-glass pulmonary nodule (arrow in A and B) was seen in both (A) LDCT (50 mA) and (B) SDCT (300 mA). Another ground-glass pulmonary nodule (arrow in C and D) was uncertain visualized in (C) LDCT (50 mA), but well identified in (D) SDCT (300 mA)

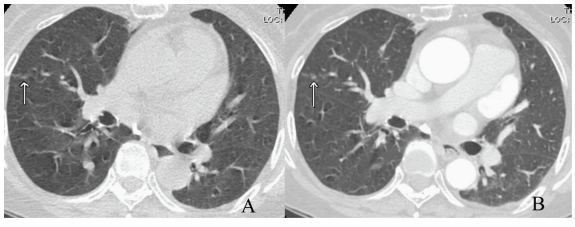

Fig. 4 A 76 year-old woman with left maxillary sinus cancer. Motion artifacts in (A) LDCT (50 mA) and (B) SDCT (300 mA) caused the nodule invisible in LDCT (arrow in A) and partially seen in SDCT (arrow in B)

variation in the degree of inspiration, improper electronic window manipulation, and the differentiation of small nodules from vessels seen on end-on vessels[2,15,16]. Lesions may also have been be over-looked or confused with other entities. Concomitant parenchymal infiltration, atelectasis, postoperative fibrosis, or pleural effusions may obscure nodules[18,21]. In a study by Fischbach F et al[20], a large numbers of axial images lead to reviewers fatigue during interpretation. The present study revealed similar causes as shown in Table 5.

Gruden JF et al[22] suggested that maximal intensity projection (MIP) processing reduce the number of overlooked small nodules. Coakley FV et al[23] also concluded MIP images to improve the detection rate for small high-density pulmonary nodules and to increase reader confidence level. Maximal intensity projection (MIP), which was not used in our study, could improve detection rate, reduce confusion with end-on vessel, and increase reader confidence as mentioned in studies of Gruden JF et al[22] and Coakley FV et al[23].

A potential problem associated with a reduction in tube current was that resolution was limited by quantum mottles and that detectability of low-contrast detail may decrease[24,25]. Zwirewich CV et al[25] reported more prominent linear streak artifacts on images obtained with low-dose high-resolution CT. In the study by Diederich et al[26], who investigated the accuracy of several low-dose CT protocols, no artifact interfering in protocol of tube current 50 mA and pitch 1 or 2, but artifacts interfering with nodule detection were recorded only in the protocol with a tube current of 25 mA and a pitch of 2, particularly in obese patients. They reported that linear streak artifacts arising from the bony structures of shoulder girdle and spine affected to uppermost of lung apex and obscured nodules of predominantly 5 mm or smaller in size. In a study of Rusinek H et al[27], low dose CT of 20 mA showed streak artifacts seen in 40% of images. Those artifacts consisted of horizontal linear bands that appeared in the lung parenchyma and the chest wall, predominantly posterior to the spine. In a study by Jung KJ et al[28], it was demonstrated that the lower signal-to-noise ratio of low-dose CT did not significantly affect subjective image quality. For our 59 patients, we noticed the minimal steak artifacts predominantly in apical and posteroapical segment of upper lungs. However, some artifacts were not significant for interpretation in the majority of our metastatic patients as described previously.

The basic dose descriptor of CT radiation dose is known as multiple scan average dose (MSAD), that can be measured using a special dosimeter made from finely spaced thermoluminescent dosimeter (TLD) chips, but it is not practical to do this in the field on routine basis. The International Electronical Commission showed that CT dose index (CTDI) volume is equivalent to MSAD[12]. We did not directly measure the radiation dose delivered to a patient but calculated effective dose from CT dose index (CTDI) volume as a reference from the study of Payne JT[12]. Many studies reported that they used tube current 20-50 mA, tube voltage 120-140 kVp, pitch 1-2, effective dose from 0.3-2.7 mSv[14-16,26,27]. In the present study, we used LDCT protocol as tube current 50 mA, tube voltage 120 kVp, pitch 0.984, effective dose from 0.8-1.6 mSv. Those showed no significant difference of pulmonary nodule detection.

Limitation of this study was that we did not have gold standard for diagnosis of pulmonary nodules. To our knowledge, no prior study mentions what tube current protocol was the gold standard for evaluation. There was no pathology to prove the pulmonary nodules that we found. Furthermore, there was no reliable follow-up study on the effect of chemotherapy to the pulmonary nodules. The authors decided on a similar agreement as the study of Karabulut N et al[15] where all pulmonary nodules accepted by two experienced radiologists were true nodules.

Conclusion

There is no statistical significant difference in detection of metastatic pulmonary nodules by using low-dose and standard-dose CT images in this study. Low-dose CT images can be used to follow-up treatment responsiveness of the known patients diagnosed to have pulmonary metastasis from multiple nodules seen on CT images or chest radiograph. However, in this study we could not evaluate well the ground-glass nodules or pulmonary nodules that were 2 mm or less in diameter.

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Potential conflicts of interest

None.

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เปรียบเทียบภาพเอกซเรย์คอมพิวเตอร์ปอดเพื่อประเมินการกระจายของมะเร็งมายังปอดโดยใช้ปริมาณรังสีขนาดต่ำและขนาดปกติ

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วัตถุประสงค์: *เพื่อเปรียบเทียบภาพเอกซเรย์คอมพิวเตอร์ปอดที่ใช้ประเมินการกระจายของมะเร็งมาที่ปอดที่ใช้ปริมาณรังสีขนาดต่ำ และปริมาณรังสีขนาดปกติว่ามีความแตกต่างกันหรือไม่*

วัสดุและวิธีการ: *การศึกษาทำในผู้ป่วยมะเร็งในอวัยวะอื่นๆ นอกเหนือจากปอด และถูกส่งมาทำเอกซเรย์คอมพิวเตอร์ปอดเพื่อดูการกระจายมายังปอด โดยผู้ป่วยแต่ละรายจะถูกตรวจด้วยปริมาณรังสี 2 ชนิดคือ รังสีปริมาณต่ำ (50 MA) ในช่วงก่อนฉีดสารทึบรังสี และรังสีปริมาณปกติ (300 MA) ในช่วงหลังฉีดยา โดยวิธีการตรวจทุกอย่างเหมือนกัน ศึกษาผู้ป่วยจำนวน 58 ราย รวมจำนวนก้อนในปอดทั้งสิ้น 427 ก้อน (ในรังสีปริมาณต่ำ) และ 422 ก้อน (ในรังสีปริมาณปกติ)*

ผลการศึกษา: *พบว่าความไวของการตรวจด้วยเอกซเรย์ปริมาณรังสีต่ำ = 94.7% สำหรับก้อนในปอดทุกขนาด = 79% สำหรับก้อนที่มีเส้นผ่านศูนย์กลาง < 2 มม. 94.2% สำหรับก้อนขนาดเส้นผ่านศูนย์กลาง 2.1-3 มม. 97% สำหรับก้อนขนาดเส้นผ่านศูนย์กลาง 3.1–4 มม. และ 100% สำหรับก้อนขนาดเส้นผ่านศูนย์กลาง 4.1–5 มม. นอกจากนี้ในการศึกษานี้ได้แบ่งก้อนในปอดเป็น 3 ชนิด คือ ก้อนที่มีหินปูน, ก้อนที่ไม่มีหินปูน และก้อนที่มีลักษณะคล้ายกระจกฝ้า โดยพบว่าความไวของการตรวจพบก้อนทั้ง 3 ชนิดโดยใช้รังสีปริมาณต่ำ = 100% (p = 1.000), 95.9% (p = 0.337) และ 77% (p = 0.581) ตามลำดับ สาเหตุหลักของการแปลผลภาพเอกซเรย์จากการตรวจด้วยรังสีต่ำและปกติต่างกันนั้นเกิดจากการแปลผลเอาหลอดเลือดเป็นก้อนในปอด โดยความผิดพลาดดังกล่าวมักเกิดในก้อนที่มีเส้นผ่านศูนย์กลาง < 3 มม. ปริมาณรังสีที่ผู้ป่วยได้รับจากการตรวจเอกซเรย์คอมพิวเตอร์แบบปกติ และแบบรังสีต่ำ = 4.22-9.57 มิลลิซิลเวิร์ต และ 0.78-1.6 มิลลิซิลเวิร์ตตามลำดับ*

สรุป: *ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างภาพเอกซเรย์คอมพิวเตอร์ปอด โดยใช้ปริมาณรังสีปกติและปริมาณต่ำดังนั้นการตรวจเอกซเรย์คอมพิวเตอร์โดยใช้ปริมาณรังสีต่ำจึงมีประโยชน์อย่างยิ่ง สำหรับผู้ป่วยมะเร็งที่มีการกระจายมาปอด และต้องการประเมินผลการรักษาเป็นระยะ ๆ*