International Journal of Pharmaceutical and Medical Research
Volume – 4 Issue – 3 June 2016
Website: www.woarjournals.org/IJPMR *ISSN: 2348-0262*

Differential diagnosis of pulmonary masses: enlarging mass size on deep expiration CT

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Abstract: *Purpose: It is supposed that a diameter of a pulmonary mass on deep expiration computed tomography (CT) is greater than that of on deep inspiration CT. The purpose of the study is to evaluate usefulness of changes in mass size between on breath holding expiration and on breath holding inspiration CT for differential diagnosis of pulmonary masses.*
Patients and Methods: CT was performed prospectively both with deep inspiration and with deep expiration in 48 patients, 78 masses with 19 primary pulmonary cancers, 19 metastatic lung cancers, 25 active inflammatory pulmonary lesions and 15 old inactive inflammatory lesions, using 16-detector-row CT unit. Length, width and height of a lesion were measured on both axial and reconstructed coronal images. Expansion rate was defined as [(product of length, width and height of a mass at deep expiration) – (those of at deep inspiration)]/ (those of at deep inspiration).
Results: Mean ± one standard deviation of expansion rate was 13.2 ± 9.9 in primary pulmonary cancers, 13.7 ± 8.8 in metastases, 12.9 ± 13.4 in active inflammatory lesions and -3.5 ± 10.9 in old inactive inflammatory lesions. Expansion rate of old inflammatory inactive lesions was significantly less than that of others ($p < 0.001$). The rate of upper pulmonary lobar lesions, that of middle lobar lesions and lower lobar lesions were 13.1 ± 10.5, 16.9 ± 13.3 and 11.0 ± 10.5, respectively. They are significantly the same.
Conclusion: Expansion rate was useful for differentiation of active inflammatory lesions from inactive lesions.

Keywords: pulmonary mass, inspiration CT, expiration CT

1. Introduction

It is supposed that a diameter of a pulmonary mass on deep expiration computed tomography (CT) is greater than that of on deep inspiration CT (size gap phenomenon). We studied the phenomenon to clarify the relationship between degree of size changes on expiration CT and on inspiration CT and diagnosis of the lesions, to evaluate usefulness of size gap phenomenon for diagnosis of the pulmonary lesions.

2. Materials and Methods

Patient population:
This prosptctive study was approved by the local ethics committee and written informed consent was obtained from each patient.
The subjects consisted of 48 patients, 35 men and 13 women, mean age 63.9 year-old (age range 50~80 years) with peripheral pulmonary masses. There were total 78 masses: 19 primary pulmonary cancers, 19 metastatic lung cancers, 25 active inflammatory lesions and 15 inactive (old) inflammatory conditions.
Patients underwent CT examinations from October 2007 through October 2010. All primary pulmonary cancers and one cryptococcosis were proven pathologically. All metastatic cancers, all active inflammatory masses and all old inactive inflammatory conditions were confirmed the diagnoses by prospective follow up or responsibility of antibiotics / chemotherapy.

CT protocol:
All CT examinations were performed with a 16-detector-row unit (Aquilion, Toshiba Medical systems, Tokyo Japan) in supine position. CT was performed during 15 seconds breath hold, at once deep inspiration and at once deep expiration. Both deep inspiratory and expiratory scans were performed in whole chest under 120kVp, 2.5mm collimation, 11mm helical pitch.

Image review and Measurements:
The CT window width was set at 1600 H.U and the window level at –800 H.U. Coronal images were reconstructed by a computerized tool (Zaio Tokyo Japan) Width, depth and height of a mass were measured manually in both axial, reconstructed coronal images and sagittal images. Expansion rate was defined as [(product of width, depth and height of mass at deep expiration) – (those of at deep inspiration)]/ (those of at inspiration). We classify degree of expansion rate as follows: larger, more than +15%; smaller, less than -15%; no change, between -15 and +15%.

Statistical analysis:

Mean expansion rate was compared between each clinical group, as primary pulmonary cancer, metastatic lung cancer, benign active inflammatory lesion and inactive (old) inflammatory lesion. Statistical analysis was performed using commercial production application software Stat view version 4.51 (Abacus, Berkeley, Calif. USA). Analysis of variance was performed using an F-test. When variance was equal to expansive rate, the comparison was performed using Student's t-test. Meanwhile, when variance was not equal, the comparison was performed using Weltch's t-test. When the distribution is not normal distribution, the comparison was performed using Mann-Whiteney's U-test. A p value of less than 0.05 was considered as a statistically significant difference.

3. Results

Larger expansion rate was presented nine out of 19 in primary pulmonary cancers, 10 of 19 in metastatic lung cancers, 12 of 25 in active inflammatory lesions, one of 15 in old inflammatory lesion (Table, Figure 1, 2). Smaller expansion rate was presented four of 15 in old inflammatory lesions.

Table

Expansion rate	larger	no change	smaller
Primary lung cancer	**9**	**10**	**0**
Metastatic lung cancer	**10**	**9**	**0**
Active inflammation	**12**	**13**	**0**
Inactive inflammation	**1**	**10**	**4**

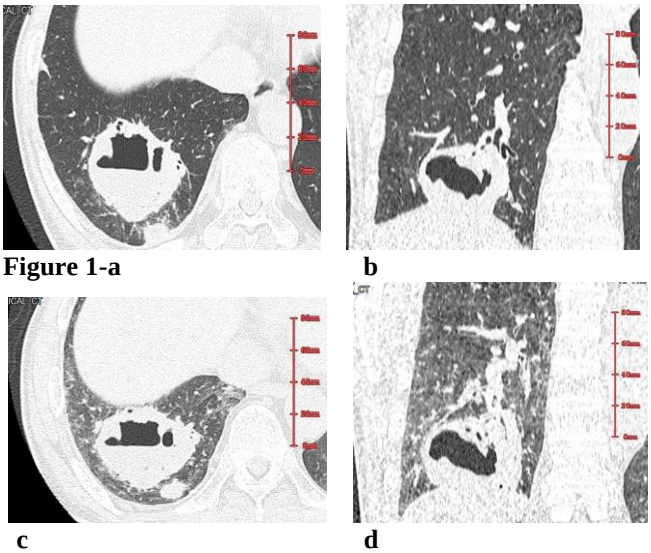

Figure 1-a **b**

c **d**

Figure 1: Pulmonary cancer (squamous cell carcinoma)

Figure 1- a, b: Deep inspiration CT
Tumor size = 59 x 56 x 46 mm (width x depth x height)
Figure 1- c, d: Deep expiration CT
Tumor size = 63 x 55 x 50 mm
Expansion rate = 14.0 %
Expansion rate is positive quantity. The lesion during expiration CT is larger than that of during deep inspiration CT.

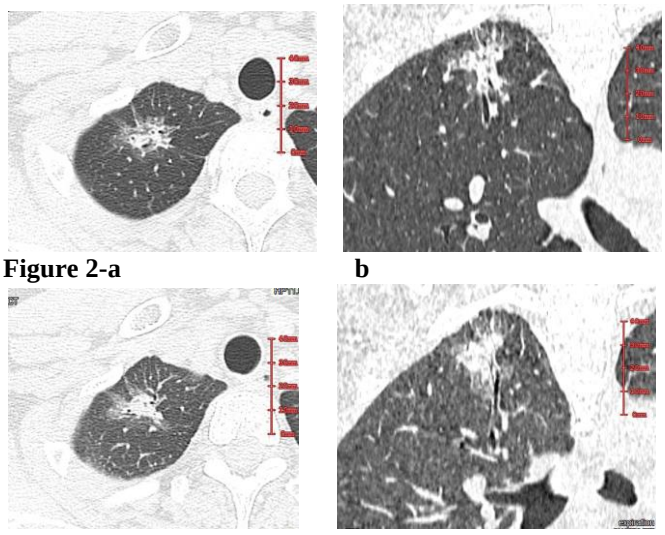

Figure 2-a **b**

c **d**

Figure 2: Old tuberculosis
Figure 2- a, b: Deep inspiration CT
Tumor size = 25 x 12 x 35
Figure 2- c, d: Deep Expiration CT
Tumor size = 25 x 13 x 35
Expansion rate = 8.3 %
The lesion on expiration CT is the same as that on deep inspiration CT.

Mean of expansion rate of primary pulmonary cancers, metastatic lung cancers, active inflammatory lesions and inactive inflammatory lesions were 13.2 ± 9.9 (mean ± one standard deviation), 13.7 ± 8.8, 12.9 ± 13.4 and -3.5 ± 10.9 respectively, respectively (Figure 3). Mean of the rate of malignant lesions (primary and metastatic lung caners, n=38) was 13.5 ± 9.2, and that of benign lesions (active inflammatory and old inflammatory changes, n=40) was 6.4 ± 14.8. Mean of expansion rate of malignant lesions was significantly higher than that of benign lesions (p=0.019).

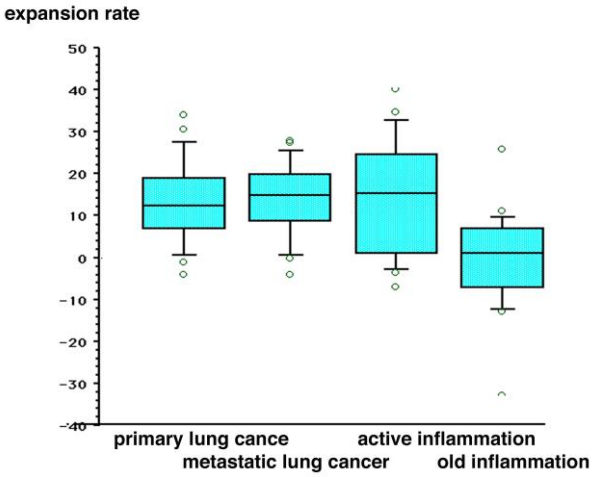

Figure 3: Expansion rate [%]
Primary pulmonary cancer: 13.2 ± 9.9 (mean ± one standard deviation)
Metastatic lung cancer: 13.7 ± 8.8
Active inflammatory lesion: 12.9 ± 13.4
Old inactive inflammatory lesion: -3.5 ± 10.9

Mean of the rate of active lesions (primary pulmonary cancer, metastatic lung cancer and active inflammatory lesion, n = 63) was 13.2 ± 11.0, and that of inactive inflammatory lesion was -3.5 ± 10.9. The rate of active lesions was significantly higher

than that of inactive old inflammatory lesions ($p < 0.001$) (Figure 4).

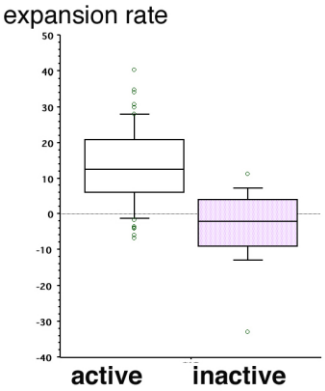

Figure 4: Expansion rate [%]
Active lesion (primary lung cancer, metastatic lung cancer and active inflammatory lesion): 13.2 ± 11.0
Inactive lesion (old inflammatory lesion): -3.5 ± 10.9
The rate of active lesion is significantly higher than that of inactive lesion ($p < 0.001$).

In active lesions, mean of the rate of upper pulmonary lobar lesions (n = 35), middle lobar lesions (n=11) and lower lobar lesions (n =17) were 13.1 ± 10.5, 16.9 ± 13.3 and 11.0 ± 10.5, respectively. It was significantly same between upper and middle lobar lesions ($p = 0.34$), between upper and lower lobar lesions ($p = 0.49$) and between middle and lower lobar lesions ($p = 0.21$) (Figure 5).

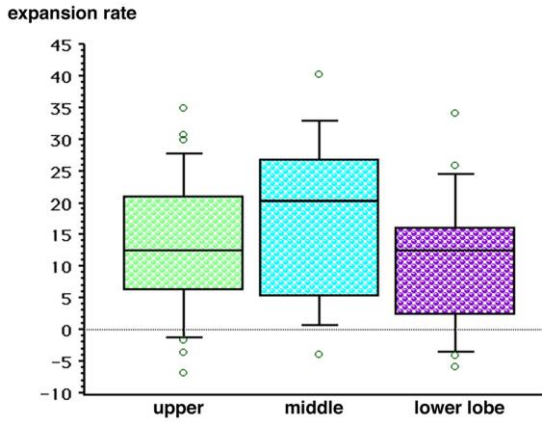

Figure 5: Expansion rate in active lesion [%]
Upper pulmonary lobar lesion: 13.1 ± 10.5
Middle pulmonary lobar lesion: 16.9 ± 13.3
Lower pulmonary lobar lesion: 11.0 ± 10.5
It is significantly the same upper, middle and lower lobar lesions.

4. Discussion

It is tended that diameter of active pulmonary lesions (primary pulmonary cancer, metastatic lung cancer and active inflammatory lesion) on deep expiration CT is greater than that of on deep inspiration CT. We defined expansion rate as [(product of width, depth and height of mass at deep expiration) – (those of at deep inspiration)]/ (those of at inspiration). Expansion rate was useful for differentiation active from inactive pulmonary masses. In active lesions, the diameters at deep expiration were greater than that of at deep inspiration. However, in old inactive lesions, the diameters were almost the same between during deep inspiration and expiration.
We published a study 'parietal pleural invasion of lung masses: evaluation with performed during deep inspiration and expiration' in 1994[1]. We suspected that the size of lung masses during expiration CT was relatively larger than that of during deep inspiration CT.
Possible enlargement of the mass lesions at deep expiration is as follows. At breath holding deep expiration, blood flow of the pulmonary artery is increasing (Figure 6). It makes blood flow of the pulmonary lesion increase. Blood flow of active pulmonary lesions (primary and metastatic lung cancer, active inflammation) is rich by angiogenesis and inflammatory factor. However, blood flow of inactive lesions is poor, and fibrosis of old inflammatory lesions prevents transformation.

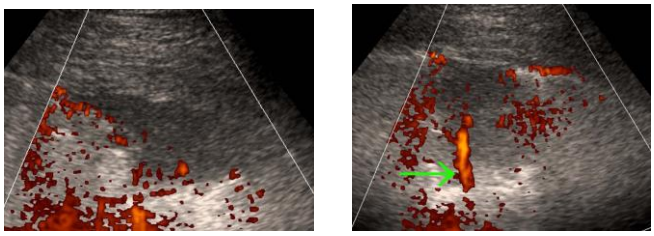

Figure 6: Power Doppler ultrasonography
Figure 6-a: Primary pulmonary cancer during breath holding deep inspiration phase
Primary pulmonary cancer with pleural invasion is shown as hypoechoic mass through the chest wall.
Figure 6-b: Primary pulmonary cancer during breath holding deep expiration phase
Hypervascular feeding artery is shown (arrow).

It is well known that a decrease intrathoracic pressure during inspiration causes an increase venous return and right-side cardiac volume, which also leads to a decrease in left sided volume[2,3]. However, at breath holding deep expiration, hypervascular vessels are presented from central to periphery by ultrasonography. We explain that the alveoli are expanded maximally by deep inspiration breath holding, and the pulmonary capillary vessels are compressed by the massive expanded alveoli.
Tomita etal. [4] noted that cardiac cross-sectional area and transverse cardiac diameter was significantly larger on expiratory CT than on inspiratory CT. They presented it is difficult to explain the larger cardiac cross-sectional area or transverse cardiac diameter on expiration. And they concluded that significant negative correlation was found between the these cardiac measurements and lung volume and vertical lung diameter.
A hypothesis for an explanation of the size gap of the masses between on inspiration CT and on expiration CT that pulmonary alveoli compress the lesions during deep inspiration may be suggested. Physiologically, pulmonary volume differences between at deep inspiration and at expiration is large in the middle and lower lobes. In our study, however, expansion rate of the lesions in the upper, middle and lower lobes was significantly the same. If pulmonary alveoli compress the lesion, the expansion rate should be larger in the middle and lower lobes than in the upper lobe. This explanation may be less likely to be a cause.
We supposed that decreasing surfactant collapses normal pulmonary alveoli at the rim of active pulmonary lesions during expiration. However, there was no hallo at the rim of active lesions on deep expiration CT. Both at deep inspiration and at

expiration, the border between normal pulmonary tissue and an active lesion is clear. On deep expiration CT, the density sharply falls off at the border of an active lesion, same as at deep inspiration (Figure 7). This explanation may also be less likely to be a cause.

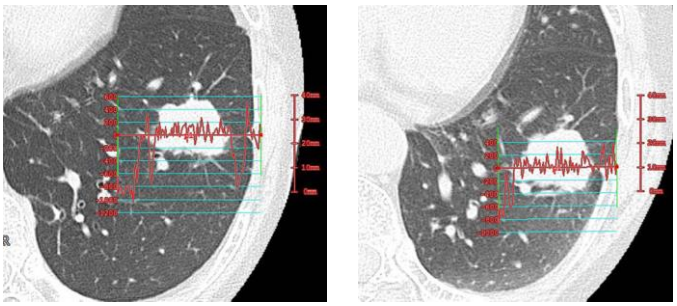

Figure 7: Primary pulmonary cancer (squamous cell carcinoma)
Figure 7-a: Deep inspiration CT
Figure 7-b: Deep expiration CT
The border between normal pulmonary tissue and active lesion is clear. The density curve sharply falls off in the border of a mass, the same as at deep inspiration

5. Conclusion

It is tended that a diameter of a pulmonary lesion on deep expiration CT is greater than that of on deep inspiration CT. Expansion rate (size gap phenomenon) is useful to differentiate active pulmonary lesions from inactive lesions. In follow up chest CT study, it is important that CT should be performed at the same respiratory phase because of size gap phenomenon.

References

[1] Shirakawa T, Fukuda K, Miyamoto Y, Tanabe H, Tada S. Parietal pleural invasion of lung masses: evaluation with CT performed during deep inspiration and expiration. Radiology 1994; 192: 809-811

[2] Andersen K, Vik-Mo H. Effects of spontaneous respiration on left ventricular function assessed by echocardiography. Circulation 1984; 69: 874-879

[3] Jardin F, Farcot JC, Gueret P, Prost JF, Ozier Y. Boundarias JP. Echocardiographic evaluation of ventricles during continuous positive airway pressure breathing. J Appl Physiol. 1984; 56: 619-627

[4] Tomita H, Yamashiro T, Matsushita S, Kurihara Y, Nakajima Y. Changes in cross-sectional area and transverse diameter of the heart on inspiratory and expiratory chest CT: Correlation with changes in lung size and influence on cardiothoracic ratio measurement. PLoS One 2015; 10: e0131902

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