

# Helpful CT Findings for Giving Specific Diagnosis of Anterior Mediastinal Tumors

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**Objective:** To characterize the CT features of common anterior mediastinal tumors and evaluate CT findings that may help in suggesting specific diagnosis among these tumors.

**Material and Method:** Fifty chest CT studies with pathological diagnosis of thymoma (n = 28), mediastinal germ cell tumor (n = 14) and lymphoma (n = 8) were retrospectively reviewed by two radiologists who were blind to the pathological results. The CT findings of fat, cyst and calcification within the lesion, contrast enhancement, associated intrathoracic findings such as mediastinal invasion and lymph node enlargement were evaluated.

**Results:** Fat density within the mass was present in 57.1% with germ cell tumor, which was significantly higher than other anterior mediastinal tumors ( $p < 0.05$ ). The presence of associated mediastinal lymphadenopathy was significantly found in lymphoma (75.0%) compared to other tumors ( $p < 0.05$ ). The other CT findings showed no significant difference among these diseases ( $p > 0.05$ ).

**Conclusion:** The CT findings that help in giving specific diagnosis of anterior mediastinal tumors which are fat attenuation and associated mediastinal lymphadenopathy. The presence of fat attenuation is highly suggestive of germ cell tumor and anterior mediastinal mass associated with mediastinal lymphadenopathy elsewhere is indicative of lymphoma.

**Keywords:** Anterior mediastinal tumor, Computed tomography, Germ cell tumor, Lymphoma, Thymoma

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Primary tumors in the anterior mediastinum are accounting approximately one half of all mediastinal masses<sup>(1)</sup>. The common diagnosis of anterior mediastinal masses is thymoma, germ cell tumor, lymphoma and thyroid mass. Correct diagnosis of these diseases is important because different diseases require different treatment. For instance, Thymoma and germ cell tumor should be resected, if possible, followed by chemotherapy or radiation therapy in some cases<sup>(1)</sup>, while lymphoma should be treated by radiation therapy alone or chemotherapy, then followed by radiation therapy<sup>(2)</sup>.

Computed tomography (CT) is a study of choice for evaluating mediastinal masses. CT can demonstrate the extent and character of the lesion as well as the relationship of masses to adjacent structures<sup>(3)</sup>. Many studies have reported a characteristic CT features of

various anterior mediastinal tumors, however, to give a definite diagnosis of an anterior mediastinal mass based on CT findings alone is still difficult in a clinical practice due to a lack of specificity of these features. To the authors' knowledge, no study has evaluated CT findings that may be helpful in differentiating these tumors.

The aim of the present study was to characterize the CT features of common anterior mediastinal tumors and evaluate that any of these CT features may help in suggesting specific diagnosis among these tumors.

## Material and Method

### Subjects

The present study was approved by the Ethics Committee of Siriraj Hospital (No. Si 057/2008). A total of 301 pathological reports from the pathology department, Siriraj Hospital with the diagnoses of thymoma, mediastinal germ cell tumor and lymphoma between January 2002 and December 2007 were

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collected. Thyroid mass was not included in the present study due to their specific CT appearance which could make the diagnosis with confidence<sup>(4)</sup>. Two hundred and fifty one patients were excluded from the present study due to an absence of pretreatment or post contrast CT study.

The remaining 50 patients were included in the present study, including 28 cases of thymoma (18 benign, 10 malignant; 10 men, 18 women; age range 14-79 years; mean age 49 years), 14 cases of germ cell tumor (4 teratoma, 6 seminoma, 4 nonseminoma; 11 men, 3 women; age range 12-43 years; mean age 24 years) and 8 cases of lymphoma (4 nodular sclerosing type Hodgkin lymphoma, 4 non-Hodgkin lymphoma; all were women; age range 21-65 years; mean age 36 years).

### CT scanning

Twenty seven CT of the chest were performed with GE LightSpeed scanner at 1.25 mm slice thickness (16 patients with thymoma, 6 patients with germ cell tumor and 5 patients with lymphoma) and twenty three CT of the chest were performed with Philips Tomoscan AV scanner at 5 mm slice thickness (12 patients with thymoma, 8 patients of germ cell tumor and 3 patients of lymphoma). The helical CT of the chest was performed from the level of the thyroid gland to the level of the adrenal glands. Evaluation was done in both mediastinal and lung window settings. The exposure parameters for the CT scans were 120 kVp and 250-300 mAs for both scanners. The CT scans were obtained before and after injection of contrast medium with the patients in a supine position.

### Image interpretation

Two radiologists, who had more than eight years experience in a chest CT interpretation retrospectively reviewed the chest CT scans together. Both radiologists were blind to the pathological results. The radiologists evaluated fat, cyst and calcification within the lesion, contrast enhancement in post contrast image, associated intrathoracic findings such as mediastinal invasion and lymph node enlargement. The contrast enhancement was defined as an increase of CT number on post contrast image more than or equal to 15 Hounsfield unit<sup>(5)</sup>. The significantly enlarged mediastinal lymph node was defined as short-axis diameter of lymph node being greater than 10 mm<sup>(6)</sup>. Mediastinal invasion was described as extensive mediastinal fat replacement, mass surrounding or obvious invasion of mediastinal structure<sup>(5)</sup>. Final discussion was reached by a consensus.

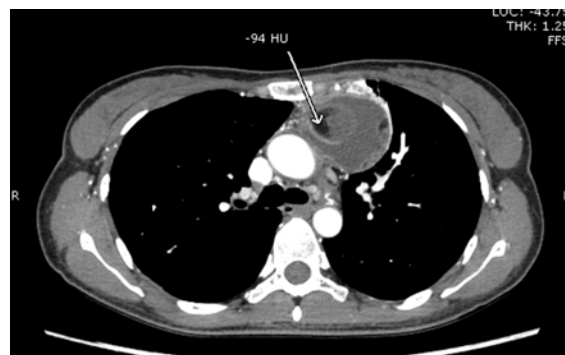
### Statistical analysis

Fisher's exact test was used to test the difference in CT patterns among thymoma, germ cell tumor and lymphoma. A p-value of less than 0.05 was considered statistically significant. The SPSS statistical software (Version 11.5) was used for the statistical evaluation.

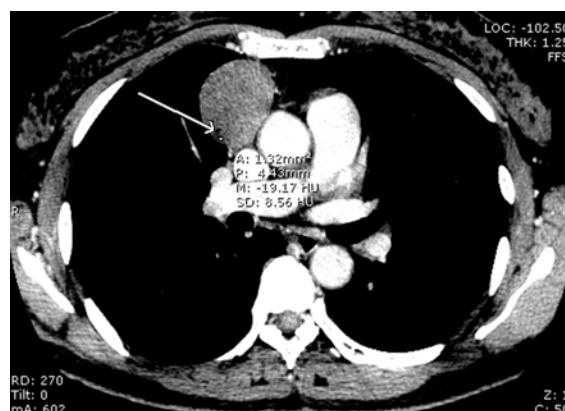
### Results

Fat density within the mass was found in 8 patients (57.1%) with germ cell tumor (3 teratoma, 3 seminoma, 2 non-seminoma) (Fig. 1), in one patient (3.6%) with thymoma (1 malignant) (Fig. 2) and no case (0%) with lymphoma. The presence of fat density within the lesion was significantly higher in germ cell tumors than other anterior mediastinal tumors ( $p < 0.05$ ).

Cystic portion was found in 6 patients (21.4%) with thymoma (3 benign, 3 malignant), 6 patients (42.8%)



**Fig. 1** A 37-year-old female with germ cell tumor (teratoma). Contrast CT scan shows anterior mediastinal mass with fat density (arrow)



**Fig. 2** A 47-year-old female with malignant thymoma. Contrast CT scan show anterior mediastinal mass with small fat density in the mass (arrow)

with germ cell tumor (2 teratoma, 3 seminoma, 1 non-seminoma) and no case (0%) with lymphoma. The presence of cystic portion within the lesion had no significant difference among these tumors ( $p > 0.05$ ).

Calcification was seen in 7 patients (25.0%) with thymoma (3 benign, 4 malignant), 6 patients (42.8%) with germ cell tumor (2 teratoma, 4 seminoma) and 1 patient (12.5%) with lymphoma (non-Hodgkin lymphoma) (Fig. 3).

There was no significant difference in the presence of calcification within the lesion across different kinds of tumor ( $p > 0.05$ ).

The contrast enhancement was seen in 20 patients (71.4%) with thymoma (14 benign, 6 malignant), 4 patients (50.0%) with lymphoma (3 Hodgkin, 1 non-Hodgkin lymphoma) and 7 patients (50.0%) with germ cell tumor (3 teratoma, 2 seminoma, 2 non-seminoma). The mean value incremental Hounsfield unit (HU) after contrast administration was 39 HU in thymoma, 29 HU in lymphoma and 25 HU in germ cell tumor. The presence of contrast enhancement had no significant difference among these tumors ( $p > 0.05$ ).

Associated mediastinal lymphadenopathy was found in 2 patients (7.1%) with thymoma (1 benign, 1 malignant), 6 patients (75.0%) with lymphoma (3 Hodgkin, 3 non-Hodgkin lymphoma) (Fig. 4) and 1 patient (7.1%) with germ cell tumor (teratoma). The presence of associated mediastinal lymphadenopathy was significantly higher in lymphoma compared to other tumors ( $p < 0.05$ ).

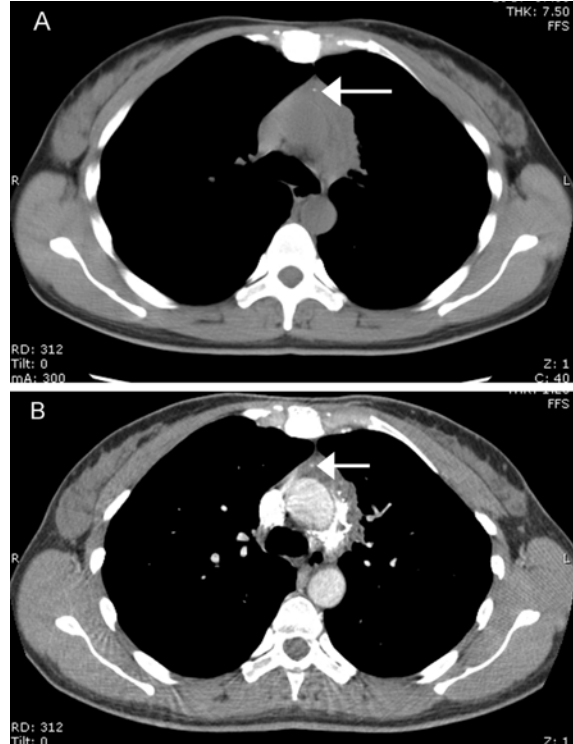
Associated mediastinal invasion was found in 4 patients (14.2%) with thymoma (4 malignant), 2 patients (25.0%) with lymphoma (1 Hodgkin, 1 non-Hodgkin lymphoma) and 4 patients (50.0%) with germ cell tumor (2 seminoma, 2 non-seminoma). There was no significant difference in the presence of associated mediastinal invasion among these tumors ( $p > 0.05$ ).

The tumors with both cystic portion and calcification were found in 2 patients with germ cell tumor (1 teratoma, 1 seminoma) and 2 patients with thymoma (2 malignant) (Fig. 5, 6).

A combination of fat, cyst and calcification within the lesion was found in 2 patients with germ cell tumor (1 teratoma, 1 seminoma) (Fig. 7, 8).

The CT findings of thymoma, lymphoma and germ cell tumor are summarized in Table 1.

The authors calculated the sensitivity, specificity, positive predictive value and negative predictive value of fat and mediastinal lymph node for diagnosis of germ cell tumor and lymphoma, respectively. The detail is shown in Table 2.



**Fig. 3** A 42-year-old female with non-Hodgkin lymphoma. A) Noncontrast CT and B) Contrast CT scans show minimal enhancing mass at anterior mediastinum with tiny calcification (arrow)



**Fig. 4** A 29-year-old female with Hodgkin lymphoma. Contrast CT scan shows inhomogeneous enhancing anterior mediastinal mass (black arrow) and enlarged precarinal lymph node (white arrow)

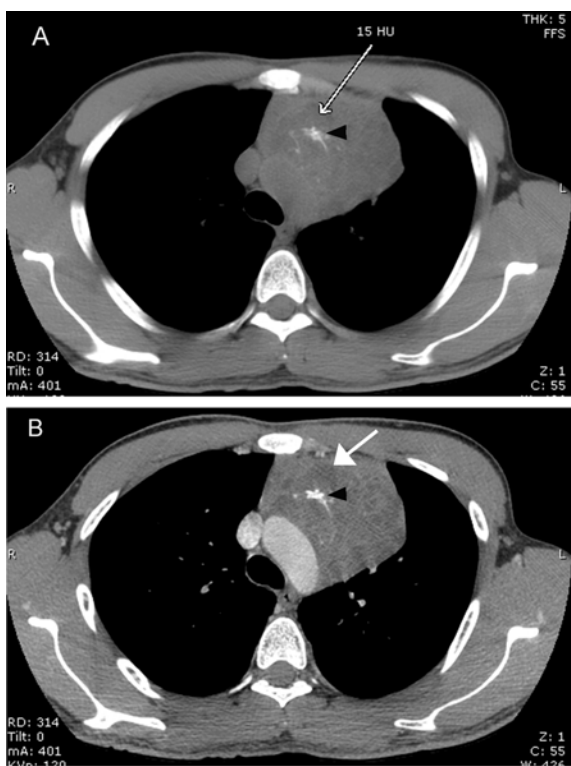
## Discussion

Primary anterior mediastinal masses are a heterogeneous group of neoplasm and non-neoplasm including congenital cyst, intrathoracic goiter and inflammatory disease<sup>(1)</sup>. The anterior mediastinal

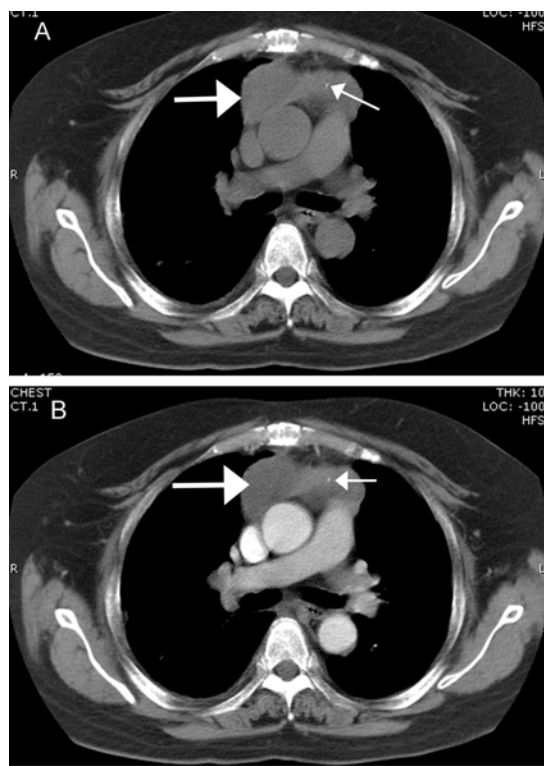
**Table 1.** Summary of the CT findings of thymoma, lymphoma and germ cell tumor

CT findings	Number of patient (%)			p-value
	Thymoma (n = 28)	Lymphoma (n = 8)	Germ cell tumor (n = 14)	
Fat	1 (3.6)	0 (0)	8 (57.1)	0.000
Cyst	6 (21.4)	0 (0)	6 (42.8)	0.056
Calcification	7 (25.0)	1 (12.5)	6 (42.8)	0.286
Contrast enhancement	20 (71.4)	4 (50.0)	7 (50.0)	0.323
Associated intrathoracic findings				
Mediastinal lymph node	2 (7.1)	6 (75.0)	1 (7.1)	0.000
Mediastinal invasion	4 (14.2)	2 (25.0)	4 (50.0)	0.542

Fisher's exact test was used to evaluate the potential correlations for the CT patterns among thymoma, lymphoma and germ cell tumor.  $P < 0.05$  was considered significant



**Fig. 5** A 26-year-old man with germ cell tumor (seminoma). A) Noncontrast CT and B) Contrast CT scans show heterogenous enhancing soft tissue mass at anterior mediastinum with internal cyst (arrow) and calcification (arrowhead)



**Fig. 6** A 51-year-old male with thymoma, A) Noncontrast CT and B) Contrast CT scans show enhancing soft tissue mass at anterior mediastinum with internal cyst (large arrow) and calcification (small arrow)

neoplasm includes thymoma, germ cell tumor, lymphoma and thyroid tumor. Correct diagnosis of these diseases requires both clinical and radiological information. Chest CT has been widely used for evaluating mediastinal lesions. Chest CT can give a

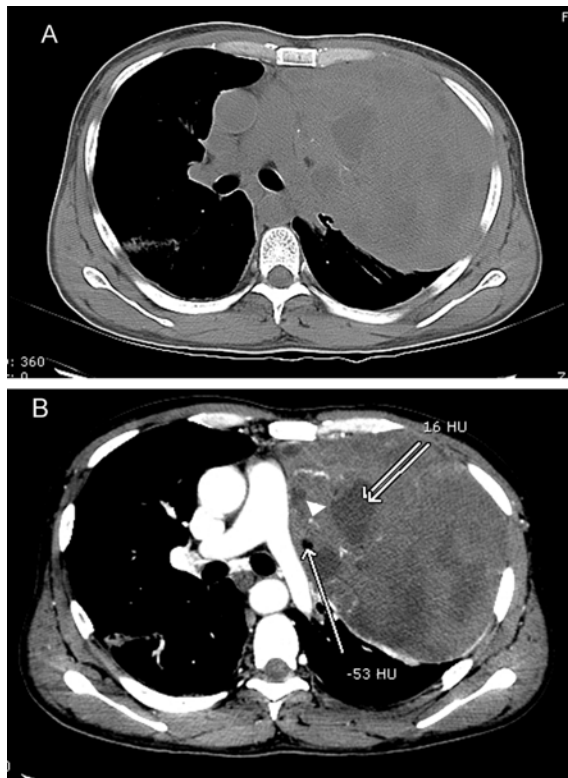
limited differential diagnosis or suggest a specific diagnosis in some cases<sup>(7)</sup>.

Tumor originating from the thyroid gland is the only disease where the authors can give a definite diagnosis from CT findings with a confidence, while

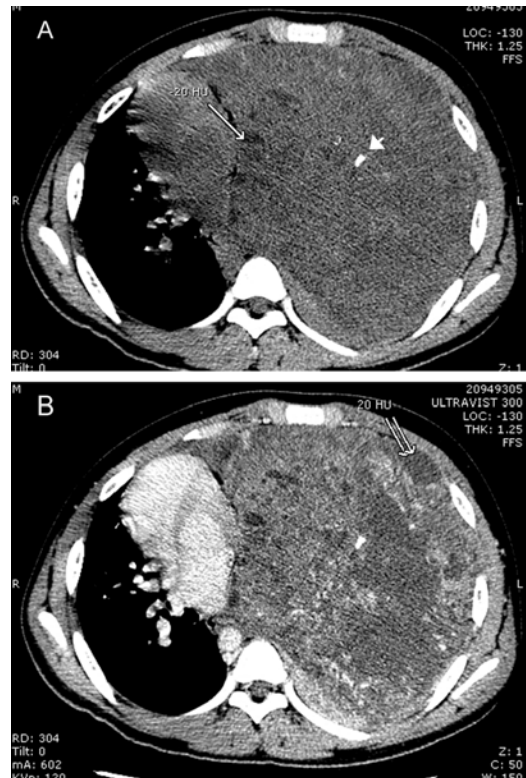
**Table 2.** The sensitivity, specificity, positive predictive value and negative predictive value of fat and mediastinal lymph node for diagnosis germ cell tumor and lymphoma, respectively

CT patterns	Sensitivity (%)	Specificity (%)	PPV	NPV
Fat	57.1 (8/14)	97.2 (35/36)	88.9 (8/9)	85.3 (35/41)
Mediastinal lymph node	75.0 (6/8)	92.8 (39/42)	66.7 (6/9)	95.1 (39/41)

Number in parentheses are values used to calculate the percentage, Sensitivity = true positive/(true positive+ false negative). Specificity = true negative/(true negative + false positive). Positive predictive value (PPV) = true positive/(true positive + false positive). Negative predictive value (NPV) = true negative/(true negative + false negative)



**Fig. 7** A 40-year-old man with germ cell tumor (seminoma). a) Noncontrast CT and b) Contrast CT scans show a huge heterogenous enhancing soft tissue mass at anterior mediastinum with internal cyst (double arrow), calcification (arrowhead) and fat (arrow)



**Fig. 8** A 12-year-old male with teratoma. a) Noncontrast CT and b) Contrast CT scans shows huge anterior mediastinal mass with internal mixed solid, cystic (double arrow), fat (arrow) and calcification (arrowhead)

the remaining anterior mediastinal tumors are still difficult to diagnosis by using CT criteria.

Thymoma is the most common primary anterior mediastinal tumor<sup>(8)</sup>. It usually occurs in patients who are older than 40 years and equally affects both male and female patients<sup>(9-12)</sup>. Pathologically, thymoma is classified into non-invasive (benign) or invasive (malignant) thymoma. About one-third of thymomas are malignant, in which is

defined as invasion of tumor into mediastinal fat and mediastinal structures rather than according to histologic criteria<sup>(13)</sup>. On CT, thymoma is a well defined homogeneous or heterogeneous attenuation depending on the presence of hemorrhage, necrosis or cyst formation<sup>(14)</sup>. In the present study, one patient with malignant thymoma had fat density. To the authors' knowledge, there has been no study reporting this result.

Focal calcification has been reported in 25% of patients<sup>(15)</sup>, similar to the present study.

Calcification was found in both benign and malignant thymoma, which is different from the previous study conducted by Sone S et al<sup>(16)</sup> and Mori K et al<sup>(17)</sup>, who reported that all their patients with thymoma with calcification were malignant. Presence of mediastinal invasion is suggestive of malignant thymoma (all patients with invasion had malignant thymoma) while calcification and cyst can not differentiate between benign and malignant thymoma.

Germ cell tumor accounts for 10-15% of adult anterior mediastinal tumors<sup>(8)</sup>. It usually occurs in young adults in their third decade of life<sup>(18,19)</sup>. Histopathologic types are classified as teratoma, seminoma and non-seminoma (embryonal cell carcinoma, yolk sac tumor, choriocarcinoma and mixed types)<sup>(1,7,20)</sup>. Teratoma is the most common histologic type and is usually benign<sup>(18)</sup>. The CT findings of germ cell tumor vary; depending upon the component of the lesion such as fluid, soft tissue, calcium and fat attenuation.

The combination of cyst, soft tissue, calcium and fat attenuation in an anterior mediastinal mass is a highly specific finding for mature teratoma<sup>(1)</sup>. However, 2 patients with immature teratoma and seminoma in the present study also had this combination. In the present study, germ cell tumor had calcification in 42.8%, fat in 57.1%, cyst in 42.8% and contrast enhancement in 50%. The fat density, cyst and contrast enhancement were observed in all histopathologic types of germ cell tumor. However calcification was not seen in a non-seminoma group. The presence of fat within the lesion is suggestive of germ cell tumor ( $p < 0.05$ ). The sensitivity, specificity, positive predictive value and negative predictive value of fat for diagnosis germ cell tumor are 57%, 97%, 89%, and 85%, respectively. The associated mediastinal lymphadenopathy was found only in 7.1% of germ cell tumors. The mediastinal invasion was observed in 50% of cases with seminoma and non-seminoma, which reflected the fact that mediastinal teratoma is usually benign.

A combination of cyst and calcification in the mass was found in both germ cell tumor and thymoma. So the clinical feature such as patient age is required for differentiation between these two tumors. The mean age is 49 years for patients with thymoma and 24 years for patients with germ cell tumor.

The authors concluded that an anterior mediastinal mass containing cyst and calcification in young adult patients should suggest a diagnosis of

germ cell tumor. If the patients are older than 40 years, the diagnosis of thymoma should be considered.

Lymphoma consists of Hodgkin lymphoma (HL) and non-Hodgkin lymphoma (NHL). Adults with primary mediastinal lymphoma usually have HL, nodular sclerosing type. Childhood mediastinal lymphoma is usually NHL. Nodular sclerosing Hodgkin disease is the most common lymphoma of the anterior mediastinum, occurs more commonly in woman<sup>(21)</sup>. The present study included both HL and NHL equally. All patients of HL were nodular sclerosing types and all were women.

On CT, the enlarged mediastinal nodes in both HL and NHL demonstrate homogeneous attenuation with little or no enhancement. Cystic appearance was seen in 21-50% of cases<sup>(22)</sup>. Calcification was rare prior to therapy but does occur<sup>(23)</sup>. For instance, in the present study, one patient with NHL (12.5%) had calcification. No case of lymphoma shows fat or cystic component. About 50% of lymphoma show contrast enhancement.

HL and NHL most often involve in superior mediastinal lymph nodes (precarina, paratracheal and aortopulmonary nodes) with some different pattern of lymph node involving in these two groups. Involvement of a single node group and posterior mediastinal nodes has been reported to be more common in patients with NHL than HL<sup>(24)</sup>, however this finding was not found in the present study.

In the present study, the associated mediastinal lymphadenopathy was found in 75% of lymphoma, also mediastinal invasion was found in 25% of cases. The distribution of lymph node groups in HL and NHL is similar including prevascular, paratracheal, precarina and hilar nodes. The presence of associated mediastinal lymphadenopathy was significantly found in lymphoma ( $p < 0.05$ ). So an anterior mediastinal mass associated with mediastinal lymphadenopathy elsewhere is strongly indicative of lymphoma. The sensitivity, specificity, positive predictive value and negative predictive value of mediastinal lymph node for diagnosis lymphoma are 75%, 93%, 67%, and 95%, respectively. There are limitations in the present study. First, the number of subjects is small. Second, a variety of CT scanners used and variation in slice thickness on CT were present. Third, it is a retrospective study with a limited possibility of diagnosis (thymoma, germ cell tumor and lymphoma) which may effect imaging interpretation.

In conclusion, CT findings that help in giving a specific diagnosis of anterior mediastinal tumors which are fat attenuation and associated mediastinal

lymphadenopathy. The presence of fat attenuation is highly suggestive of germ cell tumor and anterior mediastinal mass associated with mediastinal lymphadenopathy elsewhere strongly indicates lymphoma.

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## ลักษณะทางเอกซเรย์คอมพิวเตอร์ที่มีประโยชน์ในการวินิจฉัยก้อนเนื้ออกของ mediastinum ส่วนหน้า

กันยารัตน์ โตนะรุ่งโรจน์, ชัชมานันท์ วัชรภรณ์, นิสิตา เมืองแมน

**วัตถุประสงค์:** เพื่อศึกษาลักษณะทางเอกซเรย์คอมพิวเตอร์ของก้อนเนื้ออกที่พบบ่อยใน mediastinum ส่วนหน้า และดูว่าลักษณะทางเอกซเรย์คอมพิวเตอร์ใดที่ช่วยในการวินิจฉัยก้อนเนื้ออกเหล่านี้

**วัสดุและวิธีการ:** รังสีแพทย์ 2 คน ทำการศึกษาลักษณะทางเอกซเรย์คอมพิวเตอร์ทรวงอกของผู้ป่วยที่ได้รับการวินิจฉัยว่าเป็น thymoma, germ cell tumor และ lymphoma จำนวน 28, 14 และ 8 ราย ตามลำดับ ลักษณะทางเอกซเรย์คอมพิวเตอร์ของก้อนเนื้ออกที่ศึกษา ได้แก่ การมีส่วนประกอบของไขมัน, ถุงน้ำ และหินปูน, การเพิ่มขึ้นของค่าความทึบรังสีหลังฉีดสารทึบรังสี, การลุกลามเข้าสู่ mediastinum และ ต่อมน้ำเหลืองที่พบร่วมด้วย

**ผลการศึกษา:** Germ cell tumor พบว่ามีไขมันภายในก้อน ร้อยละ 57.1 ซึ่งสูงกว่าเนื้ออกชนิดอื่นอย่างมีนัยสำคัญทางสถิติ ( $p < 0.05$ ) การพบต่อมน้ำเหลืองใน mediastinum โดยรวมด้วยจะพบใน lymphoma ร้อยละ 75 ซึ่งสูงกว่าเนื้ออกชนิดอื่นอย่างมีนัยสำคัญทางสถิติ ( $p < 0.05$ ) ส่วนลักษณะอื่น ๆ เช่น ถุงน้ำ, หินปูน, การเพิ่มขึ้นของค่าความทึบรังสีหลังฉีดสารทึบรังสี และการลุกลามเข้าสู่ mediastinum ไม่มีความแตกต่างระหว่างก้อนเนื้ออกเหล่านี้ ( $p > 0.05$ )

**สรุป:** ลักษณะทางเอกซเรย์คอมพิวเตอร์ที่ช่วยในการวินิจฉัยก้อนเนื้ออกใน mediastinum ส่วนหน้า ได้แก่ การพบไขมันภายในก้อน และต่อมน้ำเหลืองใน mediastinum โดยรวมด้วยโดยที่ถ้าพบไขมันภายในก้อนจะนึกถึง Germ cell tumor มากที่สุด ส่วนถ้าพบก้อนเนื้ออกใน mediastinum ส่วนหน้าร่วมกับต่อมน้ำเหลืองใน mediastinum โดยจะบ่งชี้ว่าเป็น lymphoma

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