Introduction

Anthracosis is a form of pneumoconiosis, which is not only caused by coal dust, but also other environmental factors such as air pollution, biomass fuels used extensively for cooking (“hut lung”), and cigarette smoking [1–5]. Thus, it is not a disease per se and may occur in many different conditions and diseases. Since anthracosis not only causes alterations of the lung parenchyma, but also of the lymph nodes [6], radiologists should be aware of pathological findings in mediastinal lymph nodes also in this condition. The aim of this comparative study of EBUS-TBNA and chest computed tomography (CT) was to demonstrate the findings in enlarged mediastinal lymph nodes with signs of anthracosis.

Zusammenfassung

Ziel: Darstellung computertomografischer Befunde von mittels endobronchialer ultraschallgesteuerter Nadelbiopsie (EBUS-TBNA) gesicherten Fällen vergrößerter hilärer und mediastinaler Lymphknoten mit Zeichen der Anthrakose.


Ergebnisse: Die durchschnittliche Länge der Kurzachse der erfassten Lymphknoten betrug 13.7 mm. Die anthrakotischen Lymphknoten wiesen am häufigsten eine ovale Form (84 %) auf und waren meistens scharf begrenzt (66 %). 32 % der anthrakotischen Lymphknoten waren allerdings mit umliegenden Lymphknoten verbacken. Anthrakotische Lymphknoten zeigen relativ häufig Verkalkungen (24,5 %), Kontrastmittelanhäufungen (3,8 %) oder zentrale Hypodensitäten als Zeichen der fettigen Degeneration (3,8 %) wurden nur in einzelnen Lymphknoten nachgewiesen. Lymphknotenein- schmelzungen wurden nicht beobachtet.

Schlussfolgerung: Die Lymphknotenanthrakose findet sich am häufigsten in scharf begrenzten ovalen mediastinalen Lymphknoten, kann jedoch relativ häufig auch in konfluierenden und Verkalkungen aufweisenden, vergrößerten mediastinalen Lymphknoten gefunden werden.

Abstract

Purpose: We demonstrate the multislice computed tomography (MSCT) findings of endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA)-proven hilar and mediastinal lymph node enlargement with signs of anthracosis.

Materials and Methods: 53 enlarged lymph nodes in 39 patients (28 male, 11 female) with EBUS-TBNA-confirmed anthracosis were analyzed retrospectively.

Results: The mean short axis diameter of the enlarged lymph nodes with signs of anthracosis was 13.7 mm. Lymph nodes most often showed an oval shape (84 %) and were well defined in 66 % of cases. Lymph node confluence was observed in 32 % of cases. Calcifications were documented in 24.5 % of cases. Contrast enhancement and fatty involution were seen seldom (3.8 %). Lymph node necrosis was not seen.

Conclusion: Lymph node anthracosis may be found most often in enlarged, well defined lymph nodes with an oval shape, frequently associated with confluence and calcifications.
Material and methods

We performed a retrospective study on all patients of our institutions showing enlarged hilar or mediastinal lymph nodes on CT in which EBUS-TBNA confirmed the diagnosis of lymph node anthracosis. The period of patient recruitment was April 2009 to April 2012.

Multidetector CT examinations (MSCT) were carried out using a Siemens Somatom 64 (Siemens Medical Solutions, Forchheim, Germany) or a Toshiba Aquilion 64 (Toshiba Medical Systems, Tokyo, Japan) CT system. Images were obtained at full inspiration using a 64 × 0.75 mm slice collimation with a tube voltage of 120 kV. The tube current (mA) was adjusted in relation to patient attenuation by means of the Care Dose® modus (Siemens Medical Solutions) or the Sure Exposure® modus (Toshiba Medical Systems). The reconstruction slice thickness was 3 – 5 mm. During MDCT 100 – 120 ml of 300 mg or 400 mg/l contrast medium were generally administered intravenously at a rate of 2 – 3 ml/s with a power injector followed by a normal saline “chaser”.

Retrospective evaluation of computed tomographic examinations was performed consensually by two board certified radiologists (JK, RK). Mediastinal and hilar lymph node evaluation comprised measurement of size (short axis and long axis). In this setting, lymph node enlargement was defined as showing a size of more than 7 – 11 mm on the short axis depending on the regional nodal station following Glazer et al. [7]. Enlarged lymph nodes were assessed for density (prevalence of calcification or central low density as a sign of fatty involution), shape (oval, round) and contour (sharp, ill-defined). The presence of lymph node necrosis and noticeable contrast enhancement was documented. Nodal necrosis was considered present when an enlarged lymph node showed ill-defined low-attenuation areas [8]. Noticeable lymph node enhancement was determined as nodal density > 60 HU in CT. The site of the enlarged lymph nodes was documented on a standardized protocol according to the regional lymph node classification of the American Thoracic Society [9]. The evaluation comprised a correlation of CT findings and EBUS reports. In this context, a determination which lymph nodes in CT had been aspirated by TBNB had been performed.

EBUS-TBNA

Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) was performed with the patient under sedation or under general anesthesia as previously described [10]. A linear array 7.5 MHz ultrasonic bronchoscope (CP EBUS, Olympus Medical Systems, Tokyo, Japan) with a 90° angle of view was introduced orally or through an intubation tube. After ultrasound identification of a suspicious lymph node, transbronchial needle aspiration was performed using a 22G needle (model NA 201 SX 402, Olympus Medical Systems, Tokyo, Japan) under real-time ultrasound guidance. The aspirated material was prepared on glass slides, air-dried and stained.

We retrospectively evaluated the patients’ medical reports and computed tomographic examinations with special regard to the underlying illnesses (diagnosis at admission and discharge), the presence of COPD and emphysema, the smoking status or occupational dust exposure as well as definitive pathologic findings. The nicotine dependence degree was estimated by the consumption of cigarettes throughout life (number of pack-years). Patients were classified as non-smokers, having moderate (<20 pack-years) or severe dependence (>20 pack-years).

The thickening of bronchial walls as a sign of chronic bronchitis was classified as moderate or severe compared with the representative HRCT images of airway wall thickness as published by Awadh et al. [11]. Vascular attenuation (thinning of pulmonary vessels and reduction in their number) and distortion (increased branching angle or straightening) were considered as signs of emphysema. The severity of emphysema was classified semi-quantitatively as mild, moderate or severe.

Descriptive data were presented as means with ranges, if appropriate; categorical data were given as counts and percentages. We correlated the different CT findings as lymph node size, shape, contour, etc. with the clinical conditions performing rank correlation by means of a specialized computer algorithm (MedCalc© Software, Mariakerke, Belgium). The local significance level is set to 0.05. An adjustment to multiplicity is not performed. Therefore, an overall significance level is not determined and cannot be calculated. The presented findings may be used to generate new hypotheses.

The study was approved by the ethics committee of our university and was compliant with the “Health Insurance Portability and Accountability Act of 1996” (HIPAA). Patient informed consent was not deemed necessary by the ethics committee.

Results

In 39 retrospectively enrolled patients, cytologically confirmed anthracosis (Fig. 1) was diagnosed in 53 lymph nodes. These patients showed a mean age of 65.1 years (range 19 – 88 years) with a predominance of the male gender (28/39, 71.8 %).

Material and methods

We performed a retrospective study on all patients of our institutions showing enlarged hilar or mediastinal lymph nodes on CT in which EBUS-TBNA confirmed the diagnosis of lymph node anthracosis. The period of patient recruitment was April 2009 to April 2012.

Multidetector CT examinations (MSCT) were carried out using a Siemens Somatom 64 (Siemens Medical Solutions, Forchheim, Germany) or a Toshiba Aquilion 64 (Toshiba Medical Systems, Tokyo, Japan) CT system. Images were obtained at full inspiration using a 64 × 0.75 mm slice collimation with a tube voltage of 120 kV. The tube current (mA) was adjusted in relation to patient attenuation by means of the Care Dose® modus (Siemens Medical Solutions) or the Sure Exposure® modus (Toshiba Medical Systems). The reconstruction slice thickness was 3 – 5 mm. During MDCT 100 – 120 ml of 300 mg or 400 mg/l contrast medium were generally administered intravenously at a rate of 2 – 3 ml/s with a power injector followed by a normal saline “chaser”.

Retrospective evaluation of computed tomographic examinations was performed consensually by two board certified radiologists (JK, RK). Mediastinal and hilar lymph node evaluation comprised measurement of size (short axis and long axis). In this setting, lymph node enlargement was defined as showing a size of more than 7 – 11 mm on the short axis depending on the regional nodal station following Glazer et al. [7]. Enlarged lymph nodes were assessed for density (prevalence of calcification or central low density as a sign of fatty involution), shape (oval, round) and contour (sharp, ill-defined). The presence of lymph node necrosis and noticeable contrast enhancement was documented. Nodal necrosis was considered present when an enlarged lymph node showed ill-defined low-attenuation areas [8]. Noticeable lymph node enhancement was determined as nodal density > 60 HU in CT. The site of the enlarged lymph nodes was documented on a standardized protocol according to the regional lymph node classification of the American Thoracic Society [9]. The evaluation comprised a correlation of CT findings and EBUS reports. In this context, a determination which lymph nodes in CT had been aspirated by TBNB had been performed.

EBUS-TBNA

Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) was performed with the patient under sedation or under general anesthesia as previously described [10]. A linear array 7.5 MHz ultrasonic bronchoscope (CP EBUS, Olympus Medical Systems, Tokyo, Japan) with a 90° angle of view was introduced orally or through an intubation tube. After ultrasound identification of a suspicious lymph node, transbronchial needle aspiration was performed using a 22G needle (model NA 201 SX 402, Olympus Medical Systems, Tokyo, Japan) under real-time ultrasound guidance. The aspirated material was prepared on glass slides, air-dried and stained.

We retrospectively evaluated the patients’ medical reports and computed tomographic examinations with special regard to the underlying illnesses (diagnosis at admission and discharge), the presence of COPD and emphysema, the smoking status or occupational dust exposure as well as definitive pathologic findings. The nicotine dependence degree was estimated by the consumption of cigarettes throughout life (number of pack-years). Patients were classified as non-smokers, having moderate (<20 pack-years) or severe dependence (>20 pack-years).

The thickening of bronchial walls as a sign of chronic bronchitis was classified as moderate or severe compared with the representative HRCT images of airway wall thickness as published by Awadh et al. [11]. Vascular attenuation (thinning of pulmonary vessels and reduction in their number) and distortion (increased branching angle or straightening) were considered as signs of emphysema. The severity of emphysema was classified semi-quantitatively as mild, moderate or severe.

Descriptive data were presented as means with ranges, if appropriate; categorical data were given as counts and percentages. We correlated the different CT findings as lymph node size, shape, contour, etc. with the clinical conditions performing rank correlation by means of a specialized computer algorithm (MedCalc© Software, Mariakerke, Belgium). The local significance level is set to 0.05. An adjustment to multiplicity is not performed. Therefore, an overall significance level is not determined and cannot be calculated. The presented findings may be used to generate new hypotheses.

The study was approved by the ethics committee of our university and was compliant with the “Health Insurance Portability and Accountability Act of 1996” (HIPAA). Patient informed consent was not deemed necessary by the ethics committee.

Results

In 39 retrospectively enrolled patients, cytologically confirmed anthracosis (Fig. 1) was diagnosed in 53 lymph nodes. These patients showed a mean age of 65.1 years (range 19 – 88 years) with a predominance of the male gender (28/39, 71.8 %).
Clinical conditions
The retrospective analysis of the electronic health records of these patients yielded that 7 patients had accompanying malignancy (5 cases of bronchial cancer, 2 cases of NHL). Slightly more than half of our patients were smokers (22/39, 56.4%). Moderate nicotine abuse was documented in 15 (38.5%) patients and severe nicotine abuse in 7 (17.9%) patients. Only one patient had occupational exposure to dust.

The vast majority of our patients (32/39, 82.1%) showed thickening of the bronchial walls as a sign of chronic bronchitis. This finding was classified as moderate in 18 cases (46.2%) and severe in 14 cases (35.9%). Mild emphysema was seen in 16 patients (41.0%), moderate emphysema in 5 (12.8%) and severe emphysema in 2 patients (5.1%).

Distribution of the examined lymph nodes (Table 1)
Comparing the distribution of EBUS-confirmed enlarged lymph nodes in the ATS regions, we found that the most common site of anthracotic lymph nodes was ATS region 7 (in total 22 nodes, i.e. 41.5%). On closer inspection of the other regions, an accumulation of anthracotic lymph nodes was seen on the right side (2R, 4R, 10R, 11R). In these regions 26/53 (49.1%) of all enlarged nodes with signs of anthracosis were found.

CT findings of enlarged lymph nodes (Table 2)
The short axis of the histologically proven enlarged anthracotic lymph nodes ranged from 8mm–23 mm with a mean diameter of 13.7 mm. The long axis ranged from 12mm–31 mm with a mean diameter of 19.3 mm. The majority of these lymph nodes (45/53, i.e. 84.9%) showed an oval shape (Fig. 2). Only five nodes were round-shaped (15.1%), and three nodes (5.7%) showed a polycyclic shape (Fig. 3). Confluence of two or more enlarged lymph nodes (Fig. 4) was seen in 17/53 (32.1%). Calcification-like hyperdensities were documented in 13 of the examined lymph nodes (24.5%). These calcifications were sometimes subtle and spotted, but also diffuse and homogenous (Fig. 5). Contrast enhancement was documented in 2/53 (3.8%). Central hypodensity due to fatty involution was seen in 2/53 (3.8%). Lymph node necrosis was not seen.
Correlation between CT findings and clinical conditions (\(\text{Table 3}\))

We compared clinical characteristics and the most frequent CT findings in enlarged anthracotic lymph nodes. Neither the male gender nor smoking history nor emphysema was correlated with any CT finding of enlarged anthracotic lymph nodes. If at all, only two findings showed correlations with clinical conditions: Calcifications of enlarged anthracotic lymph nodes seemed to be more often present in older patients. Moreover, we found an association between the CT finding of lymph node confluence and a higher degree of chronic bronchitis.

Discussion

Although the CT finding of enlarged mediastinal lymph nodes in cases of lung cancer is commonly interpreted as an indicator for metastatic disease, it is also seen in many benign conditions like sarcoidosis, chronic heart failure, COPD and pneumoconiosis [1, 6, 12–17]. While the occurrence of enlarged calcified mediastinal lymph nodes has been generally accepted as a sign of pneumoconiosis in coal workers [16], to date – perhaps as a result of the decline of the coal mining and steel industries in Western countries – less attention has been paid to the impact of dust on mediastinal lymph node staging in cancer patients. Thus, occupational exposure to dust was documented in only one patient in the present study. On the other hand the majority of patients with EBUS-proven mediastinal lymph node anthracosis showed bronchial wall thickening and emphysema in CT as signs of COPD or reported severe nicotine abuse. A distinct association between degree of COPD, smoking history and CT findings of anthracotic lymph nodes could not be demonstrated – at least not because of the methodological limitations of the present study. Nevertheless, the findings of the present study demonstrate that anthracosis may be found in considerably enlarged mediastinal lymph nodes up to 23 mm in short axis diameter. In these lymph nodes calcification was observed in approximately one third, which is in accordance with the literature [18–20]. While some authors assessed nodal confluence as a reliable indicator of malignancy [21], this finding was observed as well in nearly one third of the anthracotic lymph nodes of our study. Therefore, we think that confluence of enlarged lymph nodes cannot be interpreted as a sign of metastatic disease.

The findings of our study suggest that anthracotic lymph nodes may mimic mediastinal lymph node metastases, due to the considerable sizes and nodal confluence. Although FDG-PET has now become a standard diagnostic procedure, recent studies revealed that the diagnostic accuracy of FDG-PET in patients suffering from pneumoconiosis [22–24] is rather low and similar to that of CT [25–27].

Limitations

There were remarkable limitations to our study. Firstly, the sample size was small, preventing a generalization of our results. Secondly, the study design was retrospective and therefore some critical clinical data are missing as the history of previous pneumonias or other severe airway inflammation. Another method-based limitation seems to be that not all enlarged nodes present on CT could have been evaluated.

In the present study no comparison has been presented with special regard to non-benign causes of lymphadenopathy. Therefore, we can only infer that anthracosis could mimic malignancy
from the fact that some of the anthracotic lymph nodes were enlarged on CT. Therefore, we consider our results preliminary.

**Conclusion**

Enlarged anthracotic mediastinal lymph nodes show most often an oval shape and are well-defined. Nodal confluence and calcifications are frequent.

**Clinical relevance**

- Radiologists should be aware of mediastinal lymph node enlargement due to anthracosis.
- The majority of these lymph nodes show no calcifications.
- Lymph node confluence may be observed in nearly one third of the anthracotic lymph node.

**Affiliations**

1. Department of Interventional and Diagnostic Radiology, Allgemeines Krankenhaus Hagen
2. Department of Medicine, Allgemeines Krankenhaus, Hagen
3. Department of Pathology, Sana Klinikum Duisburg
4. Department of Radiology, University Hospital Duisburg, Heinrich Heine Universität, Duiseldorf
5. Department of Diagnostic and Interventional Radiology and Nuclear-medicine, Marienhospital Herne
6. Department of Radiology, University Hospital Wuerzburg

**References**

27. Yusufuku K, Nakajima T, Motoori K et al. Comparison of endobronchial ultrasound, positron emission tomography, and CT for lymph node staging of lung cancer. Chest 2006; 130: 710 – 718