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Comparison of Mediastinal and Hilar Lymph Node Measurements Between Multidetector Computed Tomography and Endobronchial Ultrasound

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ABSTRACT

Background: Precise assessment of mediastinal and hilar lymph nodes is essential for diagnosing and staging thoracic diseases. MDCT and EBUS are routinely employed. However, the correlation between their nodal measurements remains unclear.

Objective: To compare lymph node size measurements obtained from coronal-plane MDCT and static EBUS images and determine the strength of agreement between these modalities.

Methodology: We performed a cross-sectional study with 210 patients. All underwent MDCT followed by EBUS-TBNA. We recorded short- and long-axis lymph node diameters from both modalities. Histopathology, cytology, and clinical follow-up confirmed diagnoses. Intraclass correlation coefficients (ICC) assessed agreement.

Results: Of 210 lymph nodes evaluated, paratracheal stations were most frequent (44.3%), followed by subcarinal (32.9%) and hilar (22.9%). Mean short- and long-axis diameters measured by CT (14.9 ± 6.4 mm and 18.3 ± 8.2 mm, respectively) were greater than those measured by EBUS (13.2 ± 6.2 mm and 17.1 ± 8.0 mm, respectively). Among malignant nodes, CT and EBUS size measurements showed closer alignment compared to benign nodes. Of nodes <10 mm on axial CT, 68.8% were >10 mm on EBUS or coronal CT, and 22% were found to be malignant. Agreement between CT and EBUS measurements was moderate, with ICC values of 0.46 for short-axis and 0.52 for long-axis measurements.

Conclusion: MDCT tends to overestimate lymph node size compared to EBUS. A substantial portion of subcentimeter nodes harbored malignancy. This underscores the importance of EBUS assessment. Integrating both techniques improves diagnostic accuracy for mediastinal evaluation.

Keywords: Mediastinal Lymph Nodes; EBUS-TBNA; Lymphadenopathy; Lung Cancer Staging

Introduction

Proper assignment of mediastinal and hilar lymph node status is a critical factor in the diagnosis, staging, and treatment of various thoracic diseases, including lung cancer, lymphoma, tuberculosis, and sarcoidosis. Lymph node status, for example, is an important prognostic factor for patients with non-small cell lung carcinoma (NSCLC) and is one of the factors determining treatment decisions (surgery, chemotherapy, radiotherapy).[1] The evaluation of lymph nodes, due to its accessibility, speed, and anatomical detail, continues to be performed primarily by contrast-enhanced computed tomography (CT) scans, even though a node with a short-axis diameter of ≥10 mm is considered enlarged.[2] On the other hand, the disadvantages of CT imaging include its inability to distinguish between benign reactive and malignant nodes, partial-volume effect, relatively low soft-tissue contrast in some stations, as well as axial slices, which may underestimate the maximum dimension of a lymph node.[3]

The introduction of endosonographic methodologies, specifically minimally invasive endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA), has been recognized as an invaluable first-line procedure for sampling mediastinal and hilar nodes.[4] EBUS provides real-time ultrasound visualization of nodes located adjacent to the airway, as well as a guided needle sampling approach to acquire target tissue via cytology/histology. In terms of diagnostic yield for NSCLC staging, EBUS-TBNA has been reported to have a sensitivity of up to 95% and a specificity of 100% in some series.[5] The established anatomical map of lymph node stations devised by the International Association for the Study of Lung Cancer (IASLC) establishes a codified method for nomenclature of nodal stations, and further reinforces the usefulness of accurate nodal imaging and sampling.[6]

Even with these advancements, a pertinent clinical gap remains: the correlation and agreement of the nodal size metric relationship between multidetector CT (especially coronal reconstructions) and static EBUS images have not been established. Some studies have shown a moderate correlation between CT and EBUS diameters, indicating that CT size alone may not accurately describe nodal size and may influence decisions regarding biopsy or staging.[7,8] In a clinical context, it is worth noting that nodes can be larger or differently shaped than seen on CT, which is clinically important because we know that nodes can "non-enlarged" on axial CT (<10 mm) and still be malignant when examined further.[9]

Furthermore, accurate measurements of lymph nodes are important not only for differentiating between benign and malignant nodal processes but also for tracking treatment responses, planning radiotherapy fields, and entering an increasingly monitored era (through immunotherapy and molecular-based regimens), where changes in nodal size may serve as a surrogate marker for disease progression. Some authors have suggested that ultrasound imaging via EBUS may provide a more accurate representation of node morphology than CT, due to its multi-plane imaging capabilities and direct access to adjacent airway structures.[10] The question remains: how well do the measurements from coronal-plane multidetector CT correlate with static EBUS measurements, and how strong is that relationship within an academic cohort?

For this reason, we aimed to compare the numerical measurement of the mediastinal and hilar lymph nodes obtained from multidetector-row CT (MDCT) coronal plane reformats and static EBUS images, and the level of agreement between the two modalities in a cohort of patients being evaluated for nodal disease. The purpose of this study is to add an element of real-world evidence on whether CT and EBUS measurements can be interchanged (or not), for making decisions about when CT measurements may be enough and when management must be changed because measurements are obtained from EBUS in our clinical setting.

Methodology

This was an observational cross-sectional study in the Department of Radiology, Rashid Latif Khan University Lahore. Patients being evaluated for mediastinal and hilar lymphadenopathy from January 2023 to December 2023 were included. A total of 210 patients underwent both multidetector-row computed tomography (MDCT) and endobronchial ultrasound (EBUS). They were recruited using consecutive sampling. Inclusion criteria were age 18 years or older and mediastinal or hilar lymphadenopathy on imaging, with subsequent EBUS-guided evaluation. Exclusion criteria included incomplete imaging templates, prior mediastinal surgery, extensive mediastinal fibrosis, or cases where EBUS could not visualize the mediastinal lymphadenopathy.

All patients had contrast-enhanced multislice computed tomography (MDCT) of the chest. Scanning was performed in the supine position (lying on the back) during full inspiration using a modern multidetector scanner. Axial (horizontal), coronal (frontal), and sagittal (lateral) reformatted images were obtained with slice thicknesses of 1-3 mm. Lymph node evaluations occurred in coronal view, with both short and long axes (diameters) documented in millimeters. Nodes with a short axis diameter (the smaller diameter seen on the image) ≥ 10 mm on CT were considered enlarged. Lymph node stations were coded using the International Association for the Study of Lung Cancer (IASLC) classification system.

Experienced pulmonary doctors performed endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) while patients were under conscious sedation and topical (local) anesthesia. They used a convex-probe endobronchial ultrasound (EBUS) bronchoscope (Olympus, Tokyo, Japan). Real-time ultrasound guided the evaluation of lymph nodes near the trachea and bronchi (tracheobronchial tree). Lymph nodes were measured on static ultrasound images for their long (lengthwise) and short (widthwise) diameters. Nodes were categorized based on ultrasound appearance: echogenicity (brightness), margin (edge definition), shape, and the presence of central necrosis (dead tissue). A 22-gauge aspiration needle was used for TBNA. At least three needle passes per node were made if clinically indicated. Aspirated material was sent for cytological (cellular) evaluation. Rapid on-site evaluation (ROSE) was used when available.

When patients had multiple lymph nodes, the largest or most clinically significant node was selected for analysis. Lymph nodes were classified as benign, malignant, nondiagnostic, or not sampled. Classification was based on pathology, cytology, microbiology, clinical follow-up, and imaging. Malignancy was diagnosed by cytology or histopathology. Benign nodes were confirmed by cytology or clinical follow-up, which showed stability or resolution. Nondiagnostic specimens had insufficient cytological yield.

The primary objective was to compare lymph node sizes obtained from multidetector computed tomography (MDCT; using images from the coronal plane) and static endobronchial ultrasound (EBUS) images. The secondary aim was to determine the level of agreement between these two imaging techniques. All measurements were in millimeters. Data were recorded in Microsoft Excel and analyzed with SPSS (version 26.0; IBM Corp., Armonk, NY, USA). Continuous variables were reported as mean ± standard deviation (SD). Categorical variables were reported as frequencies and percentages. Agreement between CT and EBUS for short- and long-axis diameters was evaluated using the intraclass correlation coefficient (ICC). A p-value <0.05 was considered statistically significant.

Ethical approval was obtained from the Institutional Review Board, Rashid Latif Khan University Lahore. All participants gave written informed consent. Patient confidentiality was maintained, and all procedures followed the Declaration of Helsinki standards.

Results

A total of 210 patients were included in the study. Among study cases, 118 patients (56.2%) were male and the mean age of 63.8 ± 11.7 years (range 28–86 years) (Figure 1).

The majority of participants were aged ≥60 years (61.4%), followed by those aged 40–59 years (28.6%) and <40 years (10.0%). Regarding comorbid history, 146 patients (69.5%) had no prior history of malignancy, while 64 (30.5%) had a previous or current diagnosis of cancer. Chronic lung disease was documented in 29 patients (13.8%), including 24 (11.4%) with chronic obstructive pulmonary disease (COPD) and 5 (2.4%) with asthma (Table 1).

Building on these demographic characteristics, EBUS-

Table 1. Patient Demographics and Clinical Characteristics (n = 210)

Variable	Value
Mean Age (years)	63.8
Age Group (years)	
Lower than 40 40 – 59 ≥60 years	21 (10.0%) 59 (28.0%) 130 (62.0%)
COPD (%)	24 (11.4%)
Asthma (%)	5 (2.4%)
Cancer History (%)	64 (30.5%)

TBNA was used for mediastinal or hilar lymphadenopathy with lung mass in 92 patients (43.8%), without lung mass in 78 (37.1%), and for restaging after therapy in 40 (19.0%). The mean interval between CT and EBUS was 8.7 ± 10.9 days.

In this study, a total of 210 lymph nodes were examined for lymph node evaluation. The most frequently examined stations were paratracheal nodes (44.3%), followed by subcarinal nodes (32.9%) and hilar nodes (22.9%). Of all nodes, 175 (83.3%) underwent EBUS-TBNA sampling, meaning tissue samples were actually collected from these nodes. The remaining 35 nodes (16.7%) were measured but not sampled, based on clinical discretion or procedural considerations (Table 2).

Table 2. Lymph Node Stations and Pathology Distribution

Station	Benign	Malignant
Hilar	31	15
Paratracheal	70	21
Subcarinal	52	21

Adequate diagnostic material was obtained from 162 (92.6%) sampled nodes. Of these, 101 (48.1%) nodes were confirmed benign and 59 (28.1%) were malignant, while 16 (7.6%) samples were nondiagnostic (Table 3).

Benign lymph nodes (n = 101), classified by pathology, had a mean short-axis diameter of 15.3 ± 5.7 mm and a long-axis diameter of 17.3 ± 7.8 mm on CT. EBUS

Table 3. Diagnostic Category Distribution (Benign/Malignant/Nondiagnostic)

Diagnosis	n (%)
Benign	101 (48.1%)
Malignant	59 (28.1%)
Nondiagnostic	16 (7.6%)
Not sampled	35 (16.7%)

measurements were 13.9 ± 5.7 mm (short axis) and 16.2 ± 7.9 mm (long axis). Malignant lymph nodes (n = 59) measured 14.3 ± 7.0 mm (short axis) and 18.9 ± 8.9 mm (long axis) on CT, and 12.7 ± 7.2 mm (short axis) and 18.0 ± 9.2 mm (long axis) on EBUS. Generally, benign nodes appeared larger on CT than on EBUS, while malignant nodes were similarly sized on both modalities. Nonsampled lymph nodes showed greater measurement differences between CT and EBUS, likely due to biopsy selection based on suspected malignancy or node size. Short-axis measurements differed significantly between CT and EBUS ($p < 0.05$) (Table 4).

In all the studied lymph nodes, the average short-axis size was always bigger on CT than on EBUS. The average short-axis diameter on CT was 14.9 ± 6.4 mm, while EBUS showed 13.2 ± 6.2 mm. In the same way, the average long-axis diameter on CT was 18.3 ± 8.2 mm, while EBUS long-axis measurement averaged 17.1 ± 8.0 mm. Benign lymph nodes revealed larger dimensions on CT when compared with EBUS, whereas malignant lymph nodes exhibited tighter congruence between the two imaging techniques (Table 5).

A scatter plot demonstrating the relationship between CT short-axis and EBUS short-axis lymph node diameters among 210 sampled nodes. Points show moderate correlation, with EBUS measurements generally smaller than CT (Figure 2).

In the cohort of lymph nodes initially evaluated as not enlarged on axial computed tomography (CT) (<10 mm; n = 138), 95 nodes (68.8%) exceeded the 10 mm cutoff

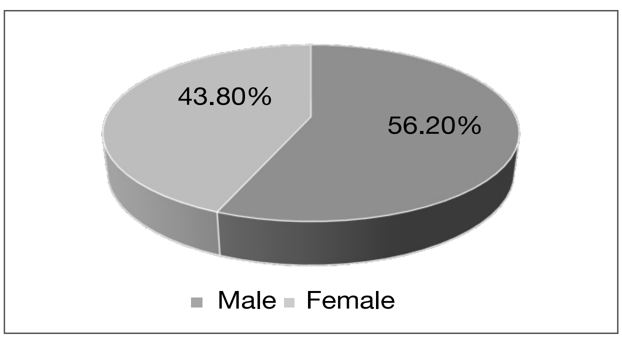

Figure 1. Gender-based distribution of study cases

when evaluated through coronal CT or endobronchial ultrasound (EBUS). The average short-axis diameter in this subgroup was recorded as 11.8 ± 5.3 mm through CT and 10.6 ± 5.0 mm through EBUS. Notably, 22% of these lymph nodes were eventually reported as malignant, highlighting the limited ability of axial CT measurements to accurately detect high-grade lymphadenopathy.

CT and EBUS short- and long-axis measurements showed only moderate agreement, with ICC values of 0.46 for short-axis (95% CI, 0.34–0.57) and 0.52 for long-axis (95% CI, 0.40–0.63). EBUS generally measured lymph nodes as slightly smaller than CT, mainly in non-malignant cases, while measurements for malignant nodes were similar. These results highlight the variability between imaging methods and the potential for underestimation when using CT alone.

Discussion

The research conducted involved comparing the measurements of mediastinal and hilar lymph nodes obtained from coronal multidetector computed tomography (MDCT) and static endobronchial ultrasound (EBUS) images in patients undergoing evaluation for thoracic lymphadenopathy. The outcomes indicate that CT, without exception, produced lymph node sizes that were slightly larger than those obtained by EBUS, and these two methods showed a moderate correlation. The study strengthens the argument for the complementary roles of CT and EBUS in the mediastinal as well as the clinical decision-making process, and also highlights the possible limitations of relying solely on axial CT dimensions for anchoring the latter.

The patients, averaging 64 years in age with a slight male predominance, mirrored global patterns in lung cancer and mediastinal disease.[11] Paratracheal and subcarinal nodes were most frequently affected, consistent with findings from international EBUS cohorts.[12,13] Over 90% of cases produced adequate cytological material, matching the high diagnostic yield for EBUS-TBNA reported by Yasufuku et al. and Gomez et al., with diagnostic accuracy exceeding 90% and sensitivity ranging from 85% to 95%.[14,15]

CT measurements were consistently higher than EBUS measurements across all axes, a finding observed in various trials performed by us. This finding has been previously reported in the literature. For example, Udoji et al. indicated that in their case, the EBUS size was slightly smaller than the CT size.[7] Similarly, Dhooria et al. mentioned a moderate correspondence between the two techniques and the benefits of CT measurement in certain cases.[16] In another study, Gkiozos et al. concluded that the size of lymph nodes measured by CT was larger compared to those measured by endoscopic techniques, probably due to limitations in the technique and the averaging effect of volume in CT imaging.[17] Our moderate ICCs, observed for both axes, align with the afor-

Table 4. Comparison of CT and EBUS Lymph Node Dimensions by Pathology

Status	CT Short-axis (mean ± SD)	CT Long-axis (mean ± SD)	EBUS Short-axis (mean ± SD)	EBUS Long-axis (mean ± SD)
Benign	15.31 ± 5.75	17.32 ± 7.78	13.90 ± 5.72	16.24 ± 7.86
Malignant	14.29 ± 6.96	18.92 ± 8.87	12.68 ± 7.18	17.96 ± 9.23

ementioned findings and reiterate the need for a multimodality approach rather than relying solely on imaging-based decision-making.

Our study showed that the mean differences between CT and EBUS measurements were smaller for malignant than for benign lymph nodes. Chrysikos et al. reached a similar conclusion, attributing this to more uniform malignant lymph node morphology.[17] Sökücü et al. found that malignant nodes on EBUS displayed more consistent echogenic and structural features, resulting in reproducible measurements.[18] Payabvash et al. also found less variability in measurements of malignant nodes compared to reactive or inflammatory lymphadenopathy using various imaging modalities.[19] These results highlight the value of EBUS in complementing CT by revealing nodal architecture and real-time morphology, which is vital when malignancy is suspected.

Notably, 68.8% of nodes classified as non-enlarged on axial CT measured over 10 mm on coronal CT or by EBUS, and 22% of these were malignant. This finding reveals the diagnostic limitations of using axial CT alone, as cited in previous studies. Asano et al. found malignancy in up to 20% of subcentimeter CT-detected nodes.[20] Yasufuku et al. observed cancer in small lymph nodes not identified or underestimated by CT, reinforcing EBUS's role in staging.[21] Iyer et al. also reported malignancy rates of 18-25% in subcentimeter mediastinal nodes.[22] Collectively, these results demonstrate the critical role of combined cross-sectional and endosonographic assessments in accurately staging disease.

The moderate correlation between CT and EBUS in our cohort (ICC = 0.46–0.52) highlights the complementary strengths and weaknesses of each modality. Udoji et al. also reported only modest agreement between CT and EBUS short-axis measurements.[7] In a multicenter staging study, Gomez et al. advocated for combining imaging to enhance diagnostic accuracy and reduce false negatives resulting from size discrepancies.[15] Dietrich et al. stressed that ultrasound's superior border resolution complements CT when nodal morphology is unclear.[23] Our results support these recommendations, endorsing a combined CT-EBUS strategy.

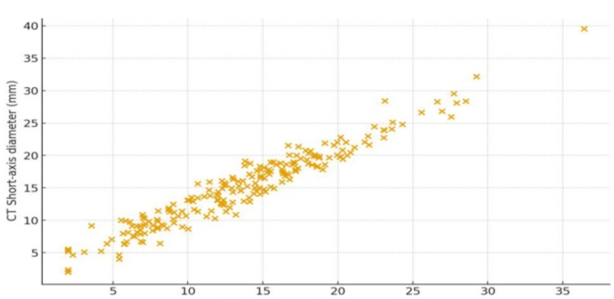

Figure 2. CT vs EBUS short-axis Lymph Node Measurements

Clinical Implications

Our results reveal the limitations of relying solely on axial CT-based size criteria. They advocate for EBUS as a supportive tool for accurate morphological assessment and tissue diagnosis. This is especially important for cases involving both thoracic tumors and granulomatous diseases. The notable incidence of cancer in lymph nodes deemed non-enlarged by axial CT reinforces the need for careful diagnosis and selective EBUS-guided biopsy.

Strengths and Limitations

This study's strengths include a large sample size, real-world clinical data, standardized measurement protocols, and cytopathology correlation when available. Limitations include its single-center nature and the absence of PET-CT data, which could provide additional metabolic detail. Nonetheless, our results provide key regional evidence in support of integrated mediastinal assessment.

Conclusion

This study centered on evaluating mediastinal and hilar lymph nodes using multidetector CT (MDCT) and endobronchial ultrasound (EBUS). CT measurements were consistently greater than those obtained by EBUS, but the modalities showed moderate agreement, highlighting the inadequacy of CT-only size criteria for nodal assessment. Many nodes labeled non-enlarged on axial CT were found enlarged by coronal CT or EBUS, and a substantial portion harbored malignancy.

These findings underscore the importance of EBUS as a routine procedure in mediastinal staging, particularly for patients with sub-centimeter lymph nodes on CT, as

Table 5. Mean Difference Between EBUS and CT Measurements (EBUS – CT)

Status	Short-axis Difference (mean ± SD)	Long-axis Difference (mean ± SD)
Benign	–1.41 ± 1.52	–1.08 ± 1.77
Malignant	–1.61 ± 1.67	–0.96 ± 1.89

significant pathology may otherwise be missed. EBUS enables both visualization of nodal structure and tissue sampling, raising diagnostic accuracy. Combining MDCT and EBUS refines clinical decisions, reduces understaging, and may improve oncologic outcomes by ensuring timely diagnosis and treatment.

Future prospective multicenter studies incorporating PET-CT and long-term outcomes are needed to establish measurement thresholds and refine diagnostic algorithms. In settings that rely mostly on CT, our results suggest that broader EBUS access is essential for accurate and equitable mediastinal staging.

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