Prediction of lymph node metastases in NSCLC

Three dimensional anatomical parameters do not substitute FDG-PET-CT

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Keywords
Lymph node, lung cancer, computed tomography, helical, FDG-PET-CT, tumour volumetry, diagnostic, computer aided

Summary
Purpose: To distinguish between benign and malignant mediastinal lymph nodes in patients with NSCLC by comparing 2D and semi-automated 3D measurements in FDG-PET-CT.

Patients, material, methods: FDG-PET-CT was performed in 46 patients prior to therapy. 299 mediastinal lymph nodes were evaluated independently by two radiologists, both manually and by semi-automatic segmentation software. Longest-axial-diameter (LAD), shortest-axial-diameter (SAD), maximal-3D-diameter, elongation and volume were obtained. FDG-PET-CT and clinical/FDG-PET-CT follow up examinations and/or histology served as the reference standard. Statistical analysis encompassed intra-class-correlation-coefficients and receiver-operator-characteristics-curves (ROC). Results: The standard of reference revealed involvement in 87 (29%) of 299 lymph nodes. Manually and semi-automatically measured 2D parameters (LAD and SAD) showed a good correlation with mean intraclass coefficients of .80 and .72, respectively. Semi-automated prediction revealed the highest areas-under-the-ROC-curve for volume (.75, 95%CI: .69–.81) and SAD (.75, 95%CI: .70–.81). AUC for LAD and maximal-3D-diameter were about .68. Substantially lower accuracies were found for elongation (.57, 95%CI: .50–.64). Conclusion: Optimized semi-automated three dimensional parameters by CT cannot approximate reported data on FDG-PET-CT for lymph node assessment in NSCLC. SAD remains the most accurate and at the same time simple to achieve anatomical criterion for definition of NSCLC target lesions.

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Beurteilung einer Lymphknoten-Metastasierung beim NSCLC – 3D-Parameter ergänzen die PET-CT nicht

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Lung cancer is a common disease with approximately three million new cases per year worldwide and is the leading cause of cancer-related death in many countries. Eighty percent of lung cancers are non-small cell lung cancers (NSCLC) (12), which prognosis and management is strongly related to involvement of hilar and mediastinal lymph nodes (16).

Reliable identification of lymph node metastases is therefore the key to selecting the appropriate treatment and increasing patient survival.

On account of reliable 18FDG-glucose uptake in patients with NSCLC FDG-PET/CT shows highest accuracy of all methods for non invasive evaluation of mediastinal lymph node involvement (17). Several systematic meta-analyses resulted in sensitivities of 74–85% and specificities of 85–92% for the differentiation of an N0/N1 versus N2/3 stage (1, 15, 18). In a FDG-PET/CT setting, simultaneous morphological assessment is recommended to optimize pretest probability of lymph node involvement (10).

The revised RECIST 1.1 criteria proposed anatomical measurement values and rules for categorising lymph nodes as normal or pathologic (25). Herein, anatomical lymph node assessment is mainly based on the

- long axis diameter (LAD),
- short axis diameter (SAD) and
- ratio of these two values (elongation).

The type of measurement to size a lymph node will greatly impact the prediction of malignancy. According to Schwartz et al., lymph node measurement in the short axis (SAD) is the most reproducible and optimal predictor of malignancy in solid tumours, because it is less dependent on the spatial orientation of the lymph node relative to the CT scan (25). However, there has been relatively little uniformity in daily clinical practice and in studies with regard to the manner in which lymph nodes were measured. Furthermore, several studies and meta-analyses adverted to the limited ability of even SAD either to rule in or exclude mediastinal metastases in NSCLC with sensitivities and specificities ranged from the low of 55% to a high of 94% (9, 15, 27). Moreover, manual acquisition of these parameters is not only time-consuming but also bears inherent sources of error as demonstrated by high inter- and intra-observer variability in uniaxial and bi-dimensional measurements in tumour response assessment (2, 11, 26).

These observations lately triggered development of semi-automated lymph node segmentation in oncology (23). Three-dimensional measurements, e.g. maximal 3D diameter and volumetry were recently found to be reproducible and more accurate than manual assessment (3, 21, 34, 35, 36). Manually obtained SAD in lymph nodes of NSCLC patients refers to the axial plane only and hereby is influenced by the orientation of the lymph node within the body. Three dimensional parameters (maximal 3D diameter, volume) have the potential to better reflect asymmetric size alterations of lymph nodes independently of lymph node orientation relative to the CT scan.

The RECIST (International Workshop to Standardise Response Criteria) recently emphasized the need for further data on three-dimensional analysis for adoption of these alternative assessment methods (10). However, the potential role of semi-automatically derived three-dimensional parameters, especially volume, for categorising lymph nodes as normal or pathologic has hitherto remained unclear.

This study aims at the discrimination between benign and malignant lymph nodes identified in patients with non-small-cell lung cancer (NSCLC) by comparing 2D and semi-automated 3D measurements in FDG-PET/CT.

Patients, material, methods

Patients

Forty-six consecutive patients (men/women 37/9) with a histologically confirmed diagnosis of NSCLC were included in this retrospective study (mean age of 64±9 years; 10/2006–07/2008), since this entity can be assessed with FDG-PET highly sensitively (14). Prior to therapy and for staging purposes, the patients underwent diagnostic FDG-PET/CT examination of the chest with contrast-enhanced CT scan. Patients already on carcinoma associated therapy prior to FDG-PET/CT and patients with a non-diagnostic FDG-PET/CT (inappropriate bolus timing, insufficient image fusion, substantial motion artefacts) were excluded.

Written informed consent for FDG-PET/CT was obtained from all patients. The appropriate Institutional Review Board approved this retrospective study design without need for a formal assessment.

FDG-PET/CT

Examinations were performed on a FDG-PET/CT hybrid scanner (Biograph Sensation 16, Siemens Medical Solution, Forchheim, Germany). Patients were examined after fasting for at least 8 h. 18F-FDG (4 MBq/kg body weight) was given intravenously 60 minutes before
FDG-PET/CT scan after ensuring that the blood glucose level was below 120 mg/dl.

Performance of a low-dose CT scan of the whole body for attenuation correction and detection of anatomic landmarks was followed by clinically established contrast-enhanced CT scans of the chest (120 kV and use of CARE dose; 16 × 0.6 mm collimation). Scan acquisition was started after a fixed delay (45 s) with 100 ml contrast agent followed by saline flush (Ultravist 300, Bayer Schering Pharma AG, Leverkusen, Germany). Data sets were reconstructed at a slice thickness of 1.0 mm with a reconstruction index of 0.7 mm using a standard soft tissue kernel (B30).

18F-FDG-PET data were reconstructed iteratively by use of the ordered-subset expectation maximization algorithm and the low-dose CT data sets for attenuation correction.

Lymph node evaluation

Lymph nodes, reference standard

CT and PET data sets were sent to a separate workstation (Syngo MMWP, VE31D, Siemens Medical Solutions, Forchheim, Germany) for lymph node selection and preparation by an unblinded radiologist (4 years experience in FDG-PET/CT and oncologic radiology), who was not involved in lymph node assessment. The reference standard consisted of a combination of 18F-FDG uptake in lymph nodes, findings from histological examinations and/or FDG-PET/CT and clinical follow-up examinations for a minimum of two months (mean 267 days, range 40–1,587 days). We included patients with NSCLC for clinical indications since a reliable 18F-FDG-glucose uptake was reported for this tumour entity (20).

Metastases were assumed for lymph nodes with an uptake two or more times higher than the mean SUV in the liver, and shrinkage or decrease of lymph nodes under therapy in follow-up PET/CT examinations and/or histological confirmation. Lymph nodes with a maximal uptake in the order of the liver or lower, without changes in size during follow-up PET/CT examinations, were regarded as non metastatic. Selected lymph nodes were assigned according to the 1996 AJCC-UICC Regional Lymph Node Classification for Lung Cancer Staging (5).

Manual assessment

Manual assessment was performed by two blinded radiologists (both with more than 6 years of experience in oncological radiology). To assure measurement accuracy of semi-automated analysis, results of corresponding manual and semi-automated evaluations of the same reader (inter-observer variability) were compared. Furthermore, we calculated precision (reproducibility) in terms of inter-observer variability. The tagged lymph nodes were evaluated separately and independently by each radiologist. Manual assessment encompassed caliper measurements of long axis diameter (LAD) and short axis diameter (SAD) on axial CT images.

Fig. 2

Semi-automated evaluation

Manual assessment was followed by semi-automated analysis (Onco, Siemens Medical Solutions, Forchheim, Germany) of lymph nodes performed, independently by two experienced readers. The semi-automated segmentation process was started via point and click on the lymph node. After a few seconds the segmentation result was displayed and could be verified visually using the implemented 3D viewer, which provided multiplanar reconstructions (MPR) and orthogonal views (Fig. 2). Unsatisfactory segmentation results could be modified by entering additional information (e.g., that a lesion was rather round, ovoid or irregular) or by assisting the segmentation manually by drawing a dividing line in axial slices. The number of amendments was documented. Segmentation results which were still insufficient in qualitative terms after the third correction step were evaluated as “inadequate segmentation” and excluded from further analysis. The following parameters were documented: LAD (mm), SAD (mm), WHO area (mm²), max. 3D diameter (mm), HU mean and SD.
maximal 3D diameter (mm), elongation (elongation = maximal longitudinal diameter/maximal perpendicular diameter) and volume (ml).

**Statistics**

Statistical analyses were performed using SAS (version 9.2 for Windows, SAS Institute Inc., Cary, NC, USA), S+ (version 8.1 for Windows, TIBCO Software Inc., Palo Alto, CA, USA) and SPSS Statistics (version 17.0.0 for Windows, SPSS Inc., Chicago, USA).

The diagnostic performance of the semi-automated evaluation of lymph nodes was analyzed as follows: Receiver Operating Characteristics (ROC) curve analyses were performed. The area under the ROC curves was calculated by applying the trapezoidal rule. Associated asymptotic 95% confidence intervals were obtained non-parametrically. The results of the different readers were compared with each other, by analyzing corresponding areas under the ROC curves for possible systematic differences by means of Wald-type significance tests. Inter- and intrareader agreement was assessed by calculating intra-class correlation coefficients. Limits of agreement were calculated. All limits of agreement in this evaluation are 95% limits. Significance was assumed as p < 0.05.

**Results**

**Lymph node characteristics**

In total, 299 lymph nodes were analyzed manually and semi-automatically in 46 patients (mean 6.4 ± 3.1 lymph nodes/patient). The lymph nodes were localized (AJCC-UICC Regional Lymph Node Classification for Lung Cancer Staging) as follows:

- 58 (19.4%) upper paratracheal, highest mediastinal, prevascular and retrotracheal nodes (AJCC-UICC: group 1–3),
- 79 (26.4%) lower paratracheal (group 4),
- 65 (21.7%) subaortic and paraaortic nodes (group 5 and 6),
- 18 (6%) subcarinal nodes (group 7),
- 16 (5.4%) paraoesophageal nodes and nodes of the pulmonary ligament (group 8 and 9) and
- 63 (21%) hilar lymph nodes (group 10).

Based on FDG-PET/CT, FDG-PET/CT follow-up and histology, 87 of 299 (29%) lymph nodes were regarded as metastases, 212 of 299 (71%) as benign.

Lymph node size ranged from 5 to 23 mm in transversal plane (SAD) with a mean size of 9.5 ± 3.2 mm (PET negative lymph nodes: 8 ± 2.7 mm, range 5–23 mm; PET positive lymph nodes: 11.0 ± 3.7 mm, range 5–23 mm).

**Comparison of manual and semi-automated results**

**Inter- and intraobserver variation**

For manual lymph node analysis the mean inter-observer variability was 6% (95% CI: 3.6% to 8.5%) for LAD and 3.8% (95% CI: 1.4% to 6.1%) for SAD over all localizations. Intra-class coefficients in terms of inter-observer variability were .85 for LAD and .84 for SAD (Tab. 1).

In comparison, semi-automated inter-observer variability was found to be lower, at .46% (95% CI: 0% to 2.6%) for LAD and .8% (95% CI: 0% to 1.6%) for SAD over all localizations. Intra-class coefficients in terms of inter-observer variability were .85 for LAD and .84 for SAD (Tab. 1).

In comparison, semi-automated inter-observer variability was found to be lower, at .46% (95% CI: 0% to 2.6%) for LAD and .8% (95% CI: 0% to 1.6%) for SAD over all localizations. These tendencies were supported by semi-automatically intra-class correlation coefficients of .76 for LAD and .81 for SAD. Additionally, in terms of intra-observer variability, manually and semi-automatically obtained lymph node parameters showed good correlation with mean intra-class coefficients of .8 for LAD and .72 for SAD for all localizations.

**Semi-automated evaluation**

**Segmentation quality**

Semi-automated segmentation (Fig. 2) was completed adequately at the first attempt in the majority of cases without the need for further correction (299 of 299, 70%) concordant for both readers. In 6 of 299 (2%) cases segmentation results re-
mained unacceptable after more than three correction steps and were excluded from further evaluation. Hence, 293 of 299 (97.9%) lymph nodes were ultimately taken for further assessment.

Measurement results of semi-automated lymph node analysis for benign and malignant lymph nodes are presented in Figure 3.

**ROC-analysis and predictive value**

The ROC curves of all lymph nodes and separated for the two readers are illustrated in Figure 4. The localization-specific areas under the curves (ROC) for semi-automated measurements are documented in Table 2.

Irrespective of lymph node localization and reader, ROC analysis revealed lower accuracies for LAD (0.688–0.698) and maximal 3D diameter (0.674–0.682) as compared to SAD (0.742–0.753) and lymph node volume (0.73–0.754). The criterion “lymph node elongation” showed significantly smaller areas under the curve, irrespective of lymph node localization (0.528–0.569), as compared to SAD and LAD (p < 0.0001).

Additionally, ROC curve analysis of all criteria revealed lower accuracies for metric and volumetric parameters in the infracarinal and hilar region in comparison to the remainder of the mediastinal nodal regions.

**Discussion**

FDG-PET and FDG-PET/CT for lympho-nodal staging of showed highest accuracies of all available non invasive methods (1, 15, 17, 24, 27, 32). In FDG-PET/CT functional assessment of lymph nodes goes along with anatomical appraisal according to RECIST 1.1 for adequate lymphonodal staging in NSCLC (17). Morphological parameters should also allow for accurate response evaluation in follow up examinations to prevent false diagnosis of progressions and regressions.

In this regard, lymph node assessment in patients with NSCLC so far is mainly based on SAD (9, 15, 27). This axial parameter is supposed to be less dependent on the spatial orientation of the lymph node relatively to the CT scan. However, the arbitrary character of all axial 2D parameters (e.g. SAD and LAD) is evident when we recall that this criterion is strongly influenced by the orientation of the lymph node within the body.

The longest or shortest axial diameter can be determined only if the lymph node is oriented parallel or orthogonal to the z-axis. Other orientations are prone to overestimation of LAD and SAD in the axial plane (4, 34). In fact, previously published studies showed a high range of sensitivities and specificities and generally a limited accuracy when using this 2D axial criterion (25, 27). 3D parameters might have a potential to overcome measurement inaccuracies, inasmuch as they better reflect asymmetric size alterations of lymph nodes and furthermore are independent of lymph node orientation relative to the CT scan. The possibility to achieve such 3D parameters has been raised by the development of semi-automated lymph node segmentation algorithms (13).

In our study, semi-automatic lymph node segmentation was a reliable tool and allowed for true-to-detail lymph node segmentation at the first attempt in the majority of cases (70%). The adequate quality of the semi-automatic segmentation and measurements is supported by high correlation coefficients (.72–.80) between the manually and semi-automatically derived 2D metric parameters. These results are in accordance to Fabel et al., who substantiated feasibility of semi-automated lymph...
Furthermore, we found a substantially lower interobserver variability for semi-automated than for manual lymphnodal measurements. The upper limit of agreement for manual assessment was 8.5% for LAD and 6% for SAD, meaning that a mean increase in LAD/SAD of 8.5%/6% or more is –with 95% confidence – likely to be real growth rather than measurement inaccuracy between readers. Those upper limits were found substantially lower for semi-automated measurements with 2.6%/1.6% for LAD/SAD, respectively.

Numerous studies calculated sensitivities and specificities on the basis of size cut-offs (27). However, variability in the definition of cut offs makes comparison of these studies difficult. The evaluation in this study is strengthened by calculation of ROC curves and AUC values, which are independent from size thresholds. As revealed by ROC analysis, mean accuracies for the two-dimensional parameters were found to be higher for SAD (.753/.742) than for LAD (.688/.698), regardless of localization. This observation confers with recently published revised RECIST 1.1 data, which recommends lymph nodes to be measured in the short axis diameter (25).

We addressed the question whether it may be feasible to move from anatomical unidimensional to three-dimensional volumetric lymph node assessment in order to meet recommendations of the “Revised 1.1 RECIST guideline” (10). We found the maximal 3D diameter (.674/.682) to be less accurate than SAD (.753/.742). Consequently, considerations in daily routine to measure the maximal lymph node diameter in “multiplanar reformations” (e.g. sagittal or coronal) are not helpful to improve accuracy in terms of anticipating malignant lymph node involvement.

Recently, promising volumetric assessment results were published basically for pulmonary nodules and in a lower quantity for liver lesions (6, 7, 19–21, 35, 36). The prognostic capability and the potential supplemental role of volumetric lymph node analysis to FDG-PET has not been studied yet. In this study the area under the curve for the lymph node volume (.75/.73) was similar to established SAD. Thus, the

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lymph nodes may be prone to reactive lymph node changes due to acute or chronically alterations of the lung and airways (e.g. COPD spectrum). Additionally, patients with a central obstructing malignant process often suffer from postobstructive pneumonia (22). Particularly in these patients a separation from metastases therefore might be aggravated as implied by the lower accuracies found in the central and hilar region.

Limitations

This study is limited to the extent that it does not allow histological correlation of all lymph nodes. A pure histopathological ground truth, however, may exhibit selection bias and mapping errors inasmuch as – depending on the surgical regime – only suspicious lymph nodes are extirpated and, methodically, a one-to-one correlation with pre-surgical imaging findings is impaired. We tagged all included lymph nodes with numbers in order to minimize correlation and mapping errors between both readers. In accordance to Strobel et al. (31) and on account of reliable $^{18}$FDG-glucos uptake in patients with NSCLC (8, 14) we used an accepted combined reference standard (FDG-PET/CT baseline, FDG-PET/CT and clinical follow up, histology) when deciding on malignant involvement of the lymph nodes in our patients with NSCLC. Our reference standard is supported by the rate of assumed malignant nodes, which was in the range of histological proved node metastasis in patients with NSCLC (our study: 29%; median in meta-analyses (27): 28%).

Finally the results are based on a single disease and therefore cannot be directly applied to other forms of cancer. The ROC results derived in this study might be transferable to cancers with similar dissemination patterns such as renal or breast carcinoma.

Conclusion

Compared to manual assessment primarily semi-automated analysis of mediastinal lymph nodes in NSCLC is supported by:

- high segmentation quality and
- high reproducibility with
- lower interobserver variability.

We discourage from prediction of lymph node manifestations in NSCLC by obtaining the maximal 3D diameter in “multipla-

Kommentar

Die Arbeit von Johannes Wessler und Mitarbeitern diskutiert die Möglichkeiten der simultanen und vergleichbaren funktionellen Aussage (FDG-PET) und der Morphologie (NSCLC). So wird auch die Wertigkeit der CT allein hinterfragt. Gleichzeitig werden für diese klinische Fragestellung Hinweise gegeben für RECIST (response evaluation criteria in solid tumours) – Kriterien, die auf von Klinikern akzeptierte Surrogat-Parametern beruhen.

- Ist RECIST Goldstandard?
- Ist es der Patient?
- Ist es die die wie auch immer gewonnene Histologie?
- Ist es die Verlaufskontrolle?
- Ist es FDG-PET?

Zumindest ein erstes Statement aus einer aktuellen Arbeit von Schwartz et al. (1): „Since the 1980s CT has emerged as the primary lymph node imaging modality.“ Allein diese ist Grund für eine wissenschaftliche kritische Hinterfragung aus der Sicht der Schriftleitung.

Otmar Schobert
Editor-in-Chief Nuklearmedizin

nar reformations" or elongation. Volumetric analysis offered similar accuracies to established unidimensional SAD and may be an adjunct for follow up of target lesions and partial volume correction of PET data. In a setting with combined functional FDG-PET/CT anatomical assessment of SAD remains the most accurate and at the same time simple to achieve criterion for definition of NSCLC target lesions.

Regarding level of accuracies, neither metric nor volumetric morphological lymph node evaluation can approximate reported data for functional FDG-PET/CT imaging in the definition of lymph node metastases in NSCLC.

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Conflict of interest
The authors declare, that there is no conflict of interest.

References