Three-Dimensional CT Volumetry for Predicting Node-Specific Pathological Response after Neoadjuvant Therapy in Lung Cancer

34th ASM of Hong Kong College of Radiologists 2026 P57

LIN Zhebing[1], ZHANG Hanxiao[2], PEZZELLA Mario[3], FLURY Dominik[4,5], ZHU Yuyao[6], CHENG Xinghua[1]

1 Department of Oncology, Shanghai Chest Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China
2 Institute of Medical Robotics, Shanghai Jiao Tong University, Shanghai, China
3 Thoracic Surgery Unit, Department of Cardiac, Thoracic and Vascular Sciences and Public Health, University of Padua, Padua, Italy
4 Department of Thoracic Surgery, Shanghai Chest Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China
5 Department of Thoracic Surgery, St. Claraspital, University Hospital Basel, University of Basel, Basel, Switzerland
6 Department of Anesthesiology, Shanghai Chest Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China

BACKGROUND / OBJECTIVE

Reliable assessment of nodal response after neoadjuvant therapy is essential in lung cancer. Conventional diameter-based CT measurements incompletely capture the three-dimensional changes of metastatic lymph nodes. We assessed 3D CT volumetric regression of biopsy-proven metastatic lymph nodes for predicting node-specific pathological response (nsPR), compared it with conventional diameter-based measurements, and developed a multivariable model.

MATERIALS AND METHODS

We retrospectively included 144 patients with biopsy-confirmed nodal metastasis treated with neoadjuvant therapy followed by surgery from 2021 to 2023, with one target node per patient. If multiple biopsy-proven nodes were present, the node with the largest CT short-axis was selected. The target node underwent repeat biopsy after treatment. nsPR required concordant absence of residual tumour on repeat biopsy and surgical pathology; discordant cases were classified as non-nsPR.

Pre- and post-treatment contrast-enhanced CT images underwent automated 3D segmentation with manual correction. Changes in nodal volume, 2D/3D diameters,

primary-tumour long-axis diameter, and serum tumour markers were analysed. Logistic regression with variable selection identified independent predictors, followed by 1,000-bootstrap internal validation (Figure 1).

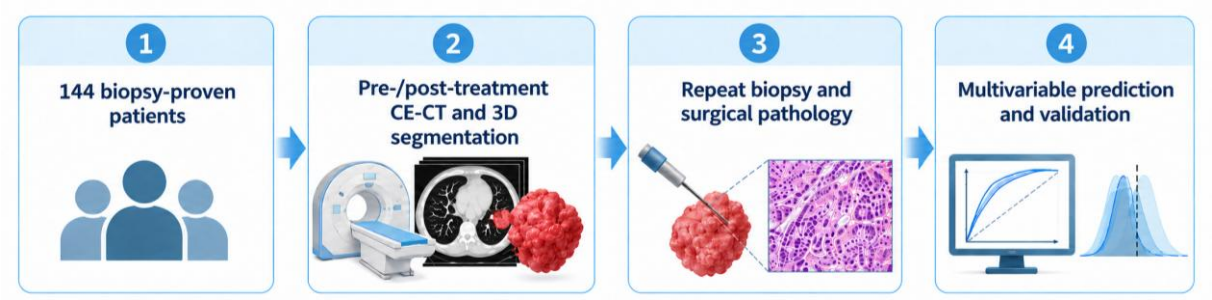


Figure 1. Study workflow. *The study included 144 patients with biopsy-confirmed nodal metastasis and involved 3D CT segmentation, pathological response assessment, multivariable model development, and internal validation.*

REPRESENTATIVE PRE-/POST-TREATMENT SEGMENTATION

Representative cases illustrate pre- and post-treatment CT segmentation of a responding station 4R node and a non-responding station 7 node (Figure 2).

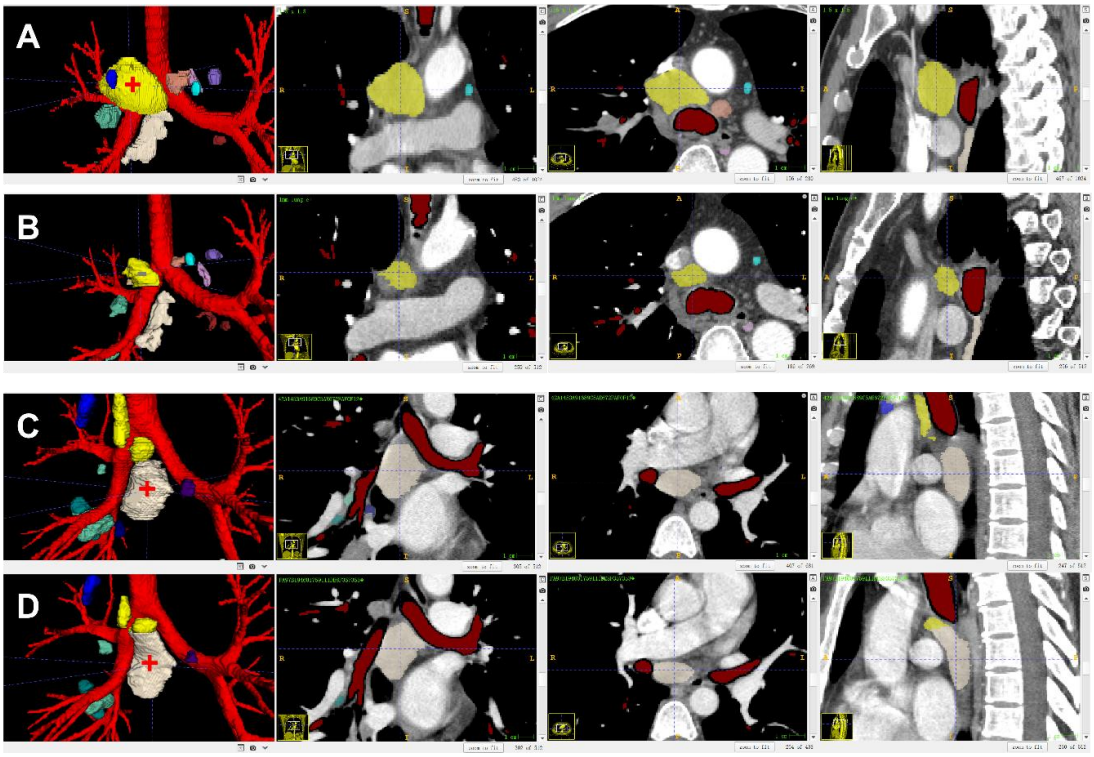


Figure 2. Representative CT-based 3D lymph node reconstructions before and after neoadjuvant therapy. *(A–B) A responding station 4R lymph node before (A) and after (B) treatment. (C–D) A non-responding station 7 lymph node before (C) and after (D) treatment.*

RESULTS: TREATMENT-ASSOCIATED CHANGES

Among 144 target nodes, 89 met nsPR criteria and 55 were non-nsPR. nsPR nodes showed greater reductions in nodal volume (64.06% vs 31.23%), 2D long-axis diameter (37.68% vs 10.89%), 2D short-axis diameter (39.79% vs 13.91%), and primary-tumour long-axis diameter (51.72% vs 24.24%; all p < 0.001; Table 1).

	nsPR (n=89)	non-nsPR (n=55)	*p*
Δ Primary-tumour long-axis diameter%	51.72 [33.66 – 60.25]	24.24 [12.20 – 34.58]	＜0.001
Δ LN volume%	64.06 ± 20.78	31.23 ± 28.74	＜0.001
Δ LN 2D long-axis diameter%	37.68 ± 22.08	10.89 ± 17.50	＜0.001
Δ LN 2D short-axis diameter%	39.79 ± 21.46	13.91 ± 15.41	＜0.001
Δ LN 2D long-to-short axis ratio%	0.48 [-13.22 – 9.06]	-1.98 [-11.04 – 5.26]	0.496
Δ LN height%	34.38 [22.65 – 55.10]	10.00 [-0.81 – 20.85]	＜0.001
Δ LN CT attenuation (HU)	15.59 [-7.03 – 42.15]	-9.08 [-44.63 – 34.82]	0.002
Δ LN 3D long-axis diameter%	33.07 ± 21.27	4.86 ± 18.47	＜0.001
Δ LN 3D short-axis diameter%	37.11 ± 22.22	10.17 ± 14.03	＜0.001
Δ LN 3D long-to-shortW axis ratio%	-9.79 [-20.96 – 9.71]	-3.12 [-17.04 – 6.25]	0.539

Values are presented as mean ± SD or median [IQR], as appropriate. LN, lymph node; 2D, two-dimensional; 3D, three-dimensional.

Table 1. Comparison of CT-derived imaging changes between the nsPR and non-nsPR groups.

RESULTS: INDEPENDENT PREDICTORS

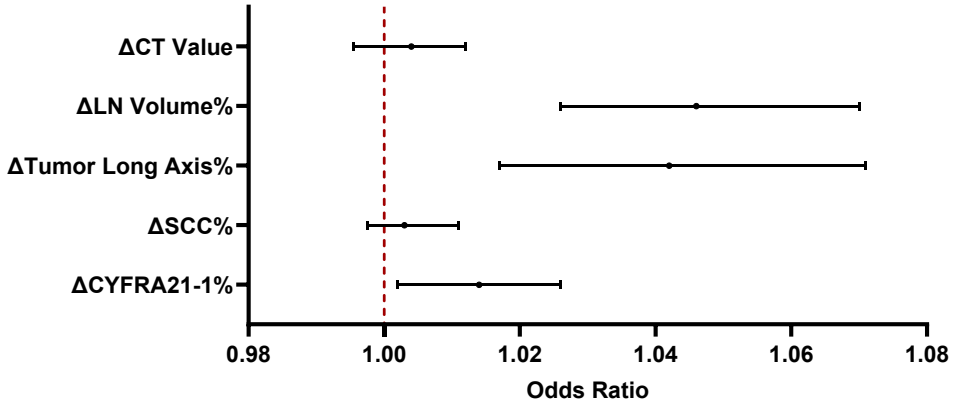


Figure 3. Odds ratios of candidate predictors in the multivariable logistic regression model for nsPR. *Greater reductions in lymph node volume, primary-tumour long-axis diameter, and CYFRA21-1 were associated with a higher likelihood of nsPR. The dashed vertical line indicates an odds ratio of 1.0.*

Although several nodal diameter measures were significant in univariable analysis, they were not retained in the final multivariable model. Nodal volume reduction remained an independent predictor of nsPR (OR 1.046 per percentage-point increase; 95% CI 1.026–1.070; $p < 0.001$), together with primary-tumour long-axis reduction and CYFRA21-1 reduction (Figure 3).

ROC ANALYSIS AND INTERNAL VALIDATION

Nodal volume reduction alone achieved an AUC of 0.8178 (95% CI 0.7479–0.8876). The combined model achieved a higher AUC of 0.8787 (95% CI 0.8191–0.9382), with 86.51% sensitivity and 72.72% specificity. Calibration was satisfactory after 1,000 bootstrap resamples, although external validation is still required (Figure 4).

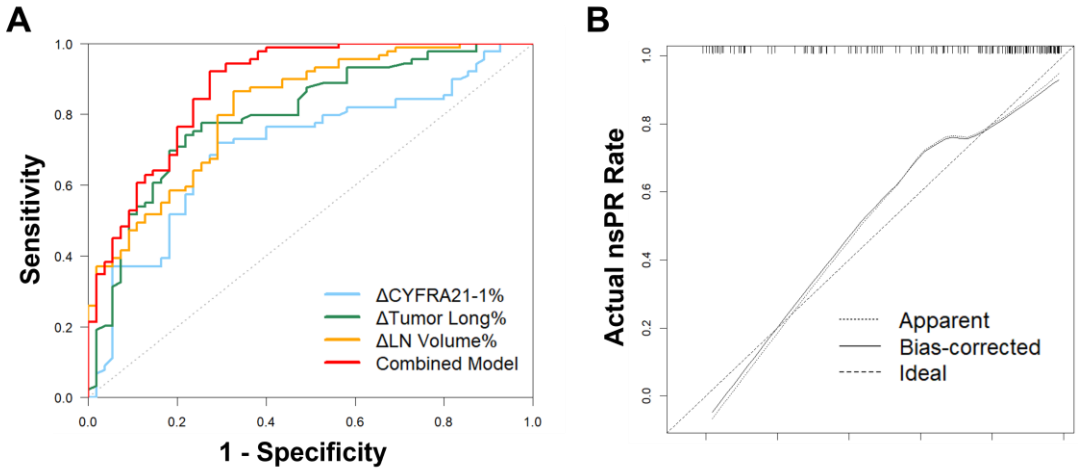


Figure 4. ROC analysis and internal validation of the prediction model. *(A) Receiver operating characteristic (ROC) curves of CYFRA21-1 reduction, primary-tumour long-axis reduction, lymph node volume reduction, and the combined model for predicting node-specific pathological response (nsPR). (B) Calibration curves of the combined model after 1,000 bootstrap resamples, showing the apparent, bias-corrected, and ideal calibration curves.*

CONCLUSION

Three-dimensional CT volumetry may provide a more comprehensive assessment of nodal treatment response than conventional diameter-based measurements. Combining nodal volumetric regression with primary-tumour shrinkage and CYFRA21-1 provides promising, clinically interpretable prediction of nsPR.