Prognostic Value of Clinical and FDG-PET/CT-Derived Parameters for Overall Survival in Oligometastatic Non-Small Cell Lung Cancer Patients

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ABSTRACT

Purpose: Prognostic stratification of patients with oligometastatic (1–5 metastases) non-small cell lung cancer (omNSCLC) remains a challenging yet important task. This study evaluates the prognostic value of clinical and FDG-PET/CT-derived parameters for predicting overall survival (OS), measured from the time of the first oligometastatic disease (OMD) diagnosis.

Methods and Materials: A retrospective cohort of 156 omNSCLC patients was analyzed using clinical and imaging-derived parameters. OS was analyzed using Kaplan–Meier curves, hazard ratios were estimated using univariable Cox proportional hazards regression. A multivariable Cox proportional hazards model was trained and evaluated using the concordance index (C-index), Brier score, and time-dependent AUC.

Results: In the univariable setting, both Kaplan–Meier and Cox regression analyses consistently identified the number of metastases, serum sodium, RDW, and presence of abdominal metastases as significant prognostic factors. Kaplan–Meier analysis additionally identified total lesion glycolysis, albumin, and NT-proBNP, whereas Cox regression further identified erythrocyte count, fibrinogen, calcium (albumin-corrected), hematocrit, and MCHC as significant predictors.

The final multivariable Cox model included the number of metastases (β = 0.333), erythrocyte count (×10¹²/L) (β = −0.440), and mean corpuscular hemoglobin concentration (g/L) (β = −0.018). The model demonstrated moderate predictive performance, with a C-index of 0.69, a Brier score of 0.20, and a time-dependent AUC of 0.76.

Conclusions: Imaging and clinical features enabled meaningful overall survival stratification in patients with oligometastatic NSCLC. A multivariable Cox model comprising the number of metastases, erythrocyte count, and mean corpuscular hemoglobin concentration (MCHC) demonstrated moderate predictive performance.

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INTRODUCTION

Oligometastatic non-small cell lung cancer (**omNSCLC**), defined by the presence of one to five distant metastases, represents an intermediate stage of disease in which selected patients may benefit from curative-intent local therapies. Despite this therapeutic potential, the **clinical course** of **omNSCLC** remains highly **heterogeneous**, and robust prognostic tools are needed to identify patients who may benefit from **curative** treatment.

In this study, we evaluated the **prognostic value** of **clinical** characteristics and quantitative PET/CT-derived **imaging** biomarkers for predicting overall survival (**OS**), measured from the time of the **first** oligometastatic disease (**OMD**) **diagnosis**.

MATERIALS

A retrospective cohort of **156 patients** with **omNSCLC** (**Table 1**) was analyzed using a total of 56 clinical and imaging parameters. The median OS from the first diagnosis of OMD was 38.2 months (**Fig. 1**).

The PET DICOM data were converted to standardized uptake values (SUVs) using the **vendor-aware SUV conversion** strategy [1] implemented in the image-processing software **Z-Rad** [2]. Cancer lesions were segmented using the **GLOW-FDG** model [3], while normal anatomical structures were segmented using the **CADS** model [4].

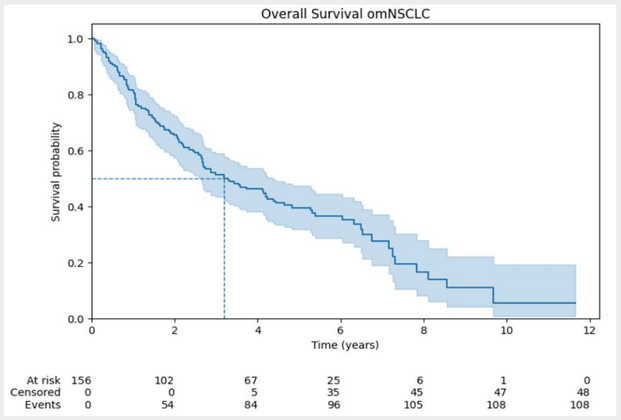

Figure 1. Overall survival of the **156 patients** with **omNSCLC**, measured from the time of the first OMD diagnosis (median overall survival: **38.2 months**).

Table 1. omNSCLC Dataset	Value	Available for N Patients
Sex	M – 59.6% F – 40.4%	N = 156
Age at OMD diagnosis	67.4 y (37.3-90.6)	N = 156
Number of metastases	1 (1-5)	N = 156
Primary – OMD diagnosis time	10.3 mo (0-191.5)	N = 156
PD-L1 (> 1%)	Yes – 60.6% No – 39.4%	N = 132
Histological subtypes	ADC – 73.7% SCC – 23.7% Other – 2.6%	N = 156
Presence of abdominal metastases	Yes – 37.2% No – 62.8%	N = 156

METHODS

Highly correlated features were identified using **Kendall's τ** (|τ| > 0.90) and **Spearman's ρ** (|ρ| > 0.90) and resolved, leaving **47 features** for subsequent univariable and multivariable analyses.

Univariable analysis

Overall survival was evaluated using:

- **Kaplan–Meier** survival **curves** with median or (for blood biomarkers) reference range thresholds and compared with the log-rank test.
- Hazard ratios (**HRs**) were estimated using univariable **Cox** proportional hazards **regression**.

P-values were adjusted using the **Benjamini–Hochberg** procedure. Statistical significance was defined as an adjusted **p < 0.05**.

Multivariable analysis

Prior to multivariable modeling, variables were selected to maximize the number of parameters while retaining complete data, yielding a final dataset of **140 patients** and **18** predictor **variables**.

- Variable selection was performed using **LASSO-penalized Cox** proportional hazards **regression**.
- Variable selection frequency was assessed using **3,000 bootstrap** iterations.
- The optimal number of predictors was determined by minimizing both the Akaike information criterion (**AIC**) and Bayesian information criterion (**BIC**).
- **Cox** model **performance** with selected predictors was **validated** using repeated 10-fold cross-validation and evaluated by the concordance index (**C-index**), inverse probability of censoring weighting (IPCW) **Brier score**, and time-dependent **AUC** over 6–60 months.
- The **final Cox model** was fitted to the dataset of 140 patients using the selected predictors, and the corresponding **regression coefficients** are **reported**.

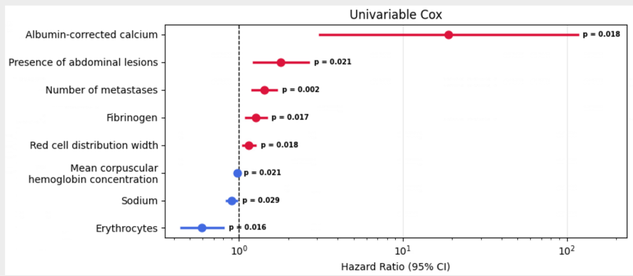

Figure 2. Forest plot of **significant covariates** from the univariable Cox analysis after Benjamini–Hochberg correction.

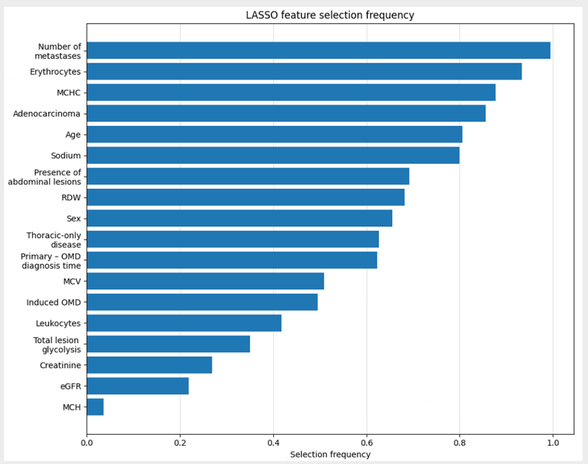

Figure 3. Cox-based bootstrapped LASSO feature selection frequency.

RESULTS

Univariable analysis

- The log-rank test applied to **Kaplan–Meier** survival **curves** identified seven statistically significant features: number of metastases < 2 (**p = 0.002**), sodium level < 134.0 mmol/L (**p = 0.022**), presence of abdominal metastases (**p = 0.022**), total lesion glycolysis < 78.4 (**p = 0.022**), RDW < 14.8% (**p = 0.022**), albumin level < 40.0 g/L (**p = 0.024**), and NT-proBNP concentration < 376.0 ng/L (**p = 0.042**).
- The **Cox** proportional hazards **model** identified eight significant predictors (**Fig. 2**), four of which were also significant based on the Kaplan–Meier analysis.

Multivariable analysis

- Following bootstrapped **LASSO** feature selection (**Fig. 3**), the model minimizing the **BIC** selected a **three-parameter** model, whereas **AIC** favored more complex models.
- The **three-parameter Cox** proportional hazards **model** achieved a **C-index** of 0.69 (95% CI 0.69–0.70), a **Brier score** of 0.20 (95% CI 0.20–0.20), and a time-dependent **AUC** over 6–60 months of 0.76 (95% CI 0.75–0.77) (**Fig. 4**).
- The **final Cox model coefficients**: number of metastases (β = 0.333), erythrocyte count (×10¹²/L) (β = -0.440), and mean corpuscular hemoglobin concentration (g/L) (β = -0.018).

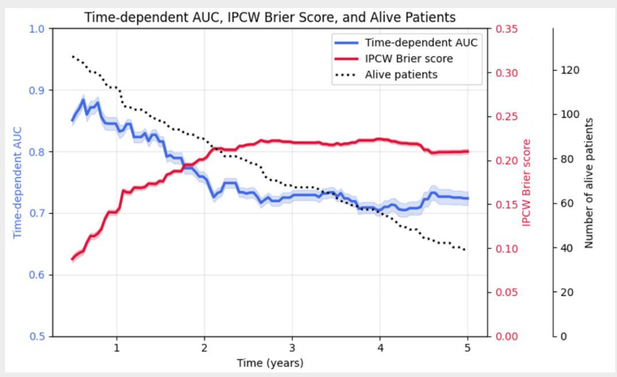

Figure 4. Time-dependent AUC and IPCW Brier score of the three-parameter Cox model. Shaded areas indicate 95% confidence intervals. The dotted black line shows the number of patients remaining at risk.

CONCLUSIONS

Imaging and clinical features enabled meaningful overall survival stratification in patients with oligometastatic NSCLC. A multivariable Cox model comprising the number of metastases, erythrocyte count, and mean corpuscular hemoglobin concentration (MCHC) demonstrated moderate predictive performance.

ACKNOWLEDGMENTS

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REFERENCES

1. Fritsak, M., Gabryś, H. S., Mohan, P., Guckenberger, M., & Tanadini-Lang, S. (2025). *Technical note: Vendor-specific approach for standardized uptake value calculation* (arXiv:2410.13348). arXiv. https://doi.org/10.48550/arXiv.2410.13348
2. https://github.com/medical-physics-usz/z-rad
3. https://github.com/MIC-DKFZ/GLOW-FDG
4. https://github.com/murong-xu/CADS