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A New Horizon in Pneumonia Risk Prediction for ICI-P Patients: The Non-Imaging Based Model

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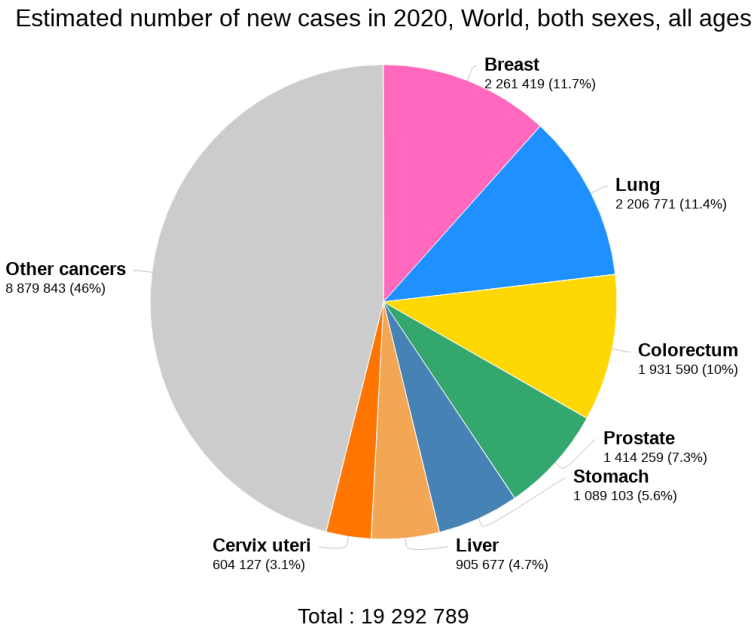
Background

Lung cancer incidence rate

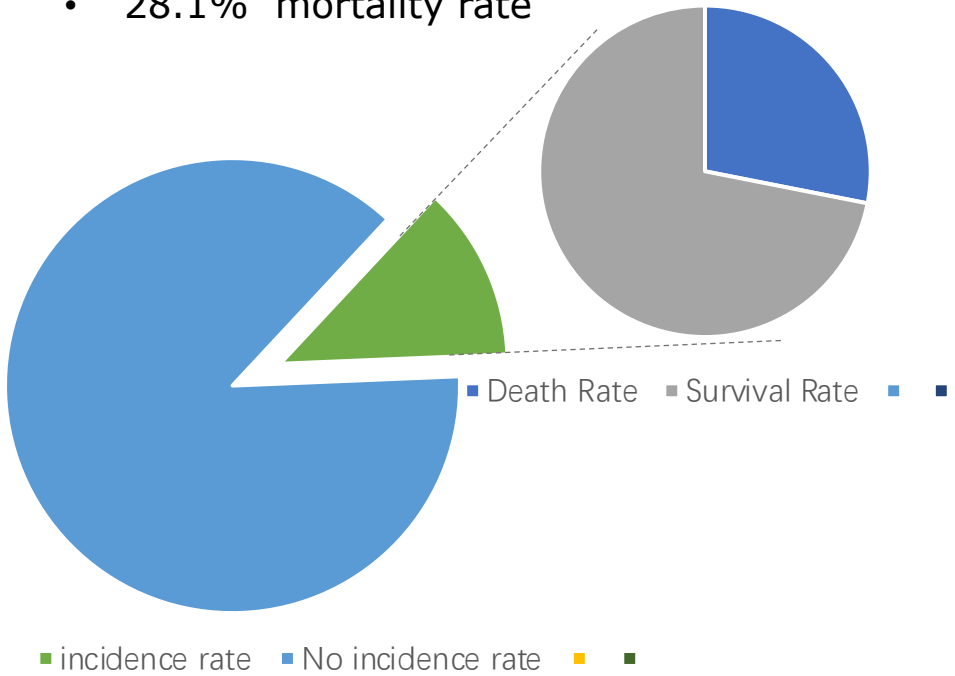
- In 2020, lung cancer accounted for 11.4% of all cancer diagnoses
- Incidence rate is the second highest



ICIs used for the treatment of NSCLC

ICI-P Incidence rate and death rate

- The incidence rate of ICI-P in clinical practice can reach up to 12.4%
- 28.1% mortality rate



The imaging changes associated with ICI-P, characterized by their delay, complexity, and non-specific nature, are easily confused with other respiratory diseases, increasing the difficulty of their diagnose. Therefore, a tool that can predict and detect ICI-P early is crucial.

Previous Work —— CT-based workflow

State-of-the-art **(SOTA)** Positive Risk Prediction Model [1]

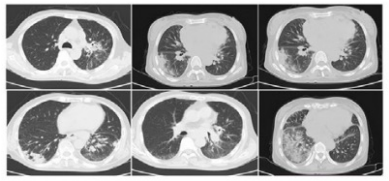
structured data

Clinical data

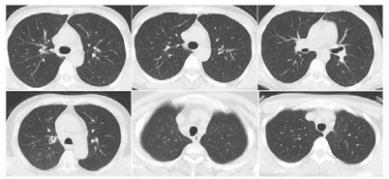
Serum markers

unstructured data

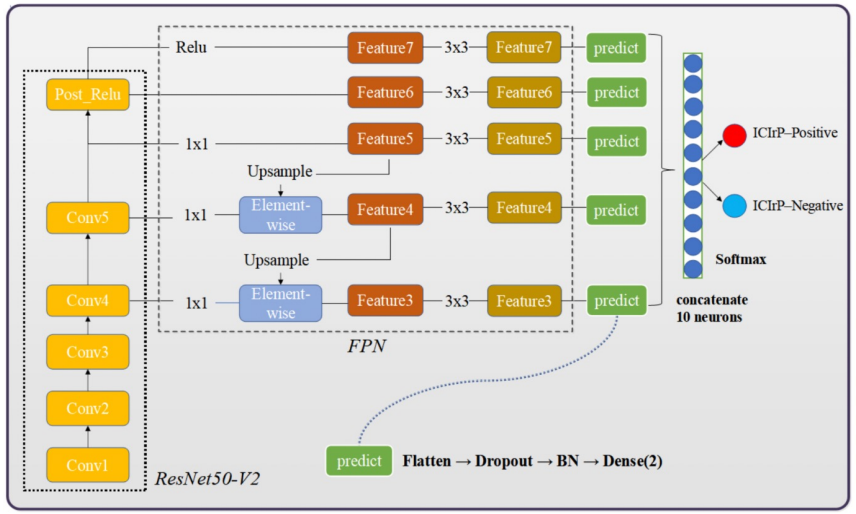
Group 1: ICI-P-positive

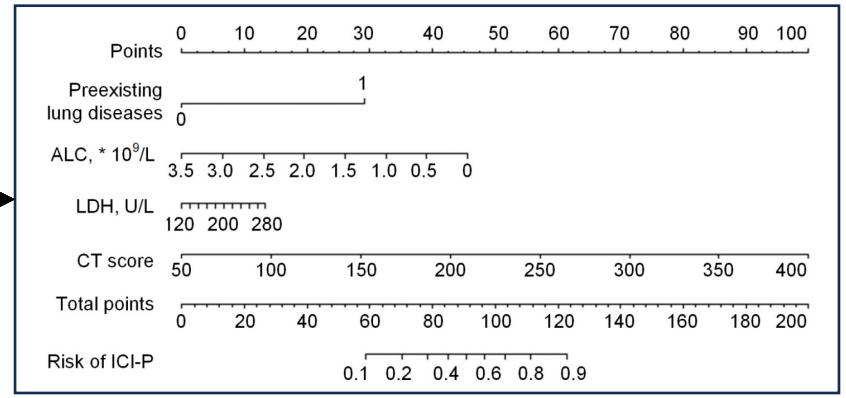


Group 2: ICI-P-negative



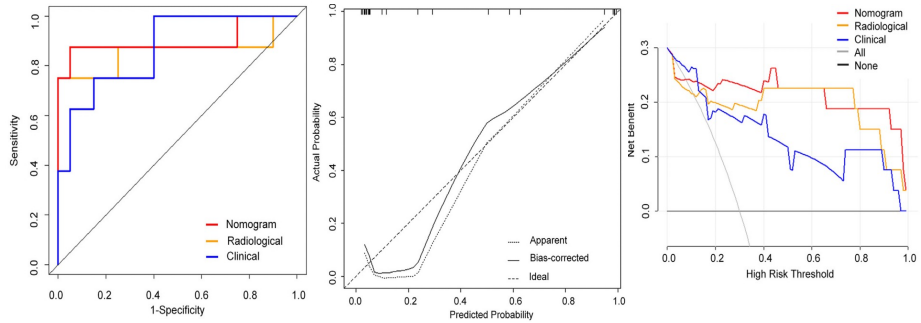
CT scans





AUC = **0.91**

$$\text{CT Score} = \mu \times \sum_{i=1}^{i=n} (i \times p(i))$$



[1] Cheng, M.#, **Lin, R.#, Bai, N.#,** Zhang, Y., Wang, H., Guo, M., ... & Zhao, Y. (2023). Deep learning for predicting the risk of immune checkpoint inhibitor-related pneumonitis in lung cancer. *Clinical Radiology*, *78*(5), e377-e385.

Is CT scan compulsory for early detection?

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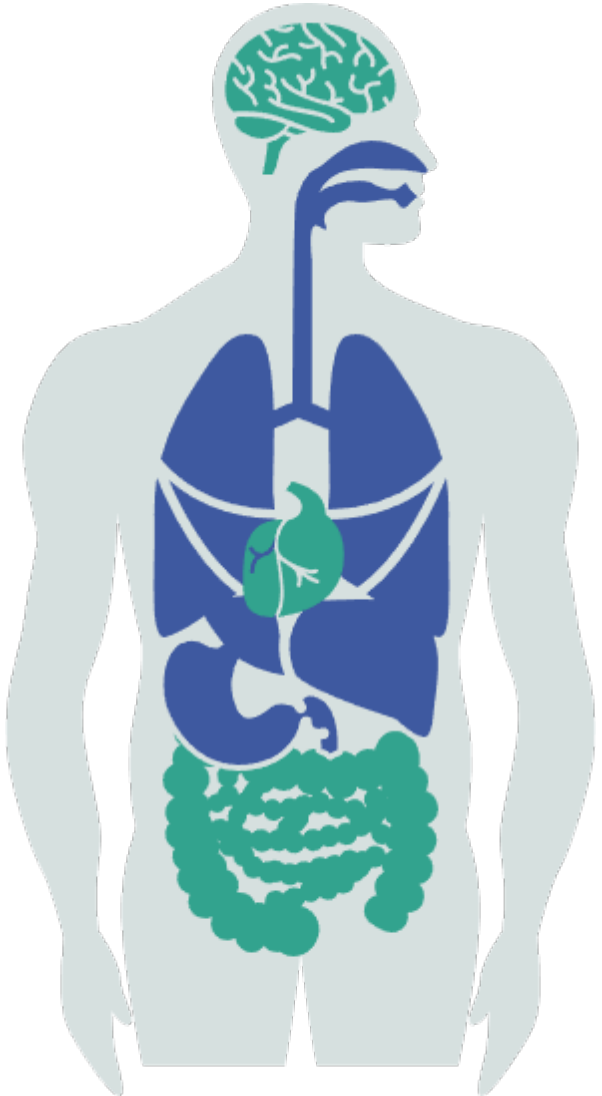
Research Aims

- Develop a risk prediction model for early detection of ICI-P **W/O Medical Imaging** and quantify contributions of risk factors.
- Provides CT-based auxiliary diagnostic methods for ICI-P, including lesion segmentation, quantitative analysis and 3D reconstruction. The calculated lesion volume ratio (LVR) is also used to train the non-imaging prediction models. Draw on the idea of human-in-the-loop and continue to enhance the accuracy and robustness of proposed workflow using data from new intake patients.
- Construct a model for predicting lesion volume ratio (LVR), determining the severity (G1-G5) according to ASCO critieria.



Dataset & Feature Selection

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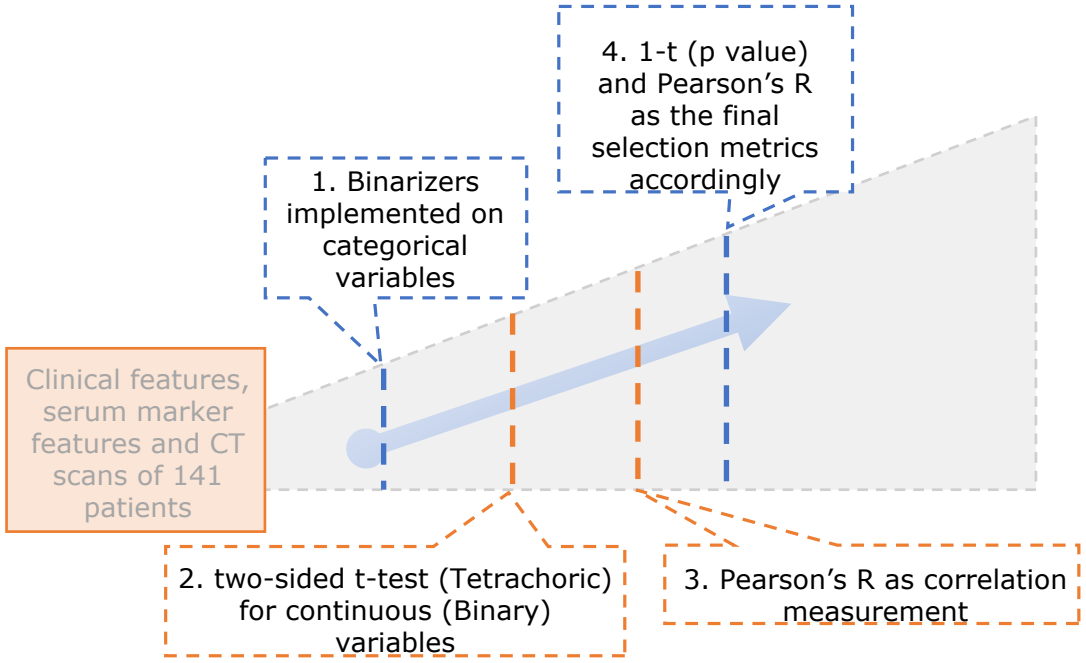
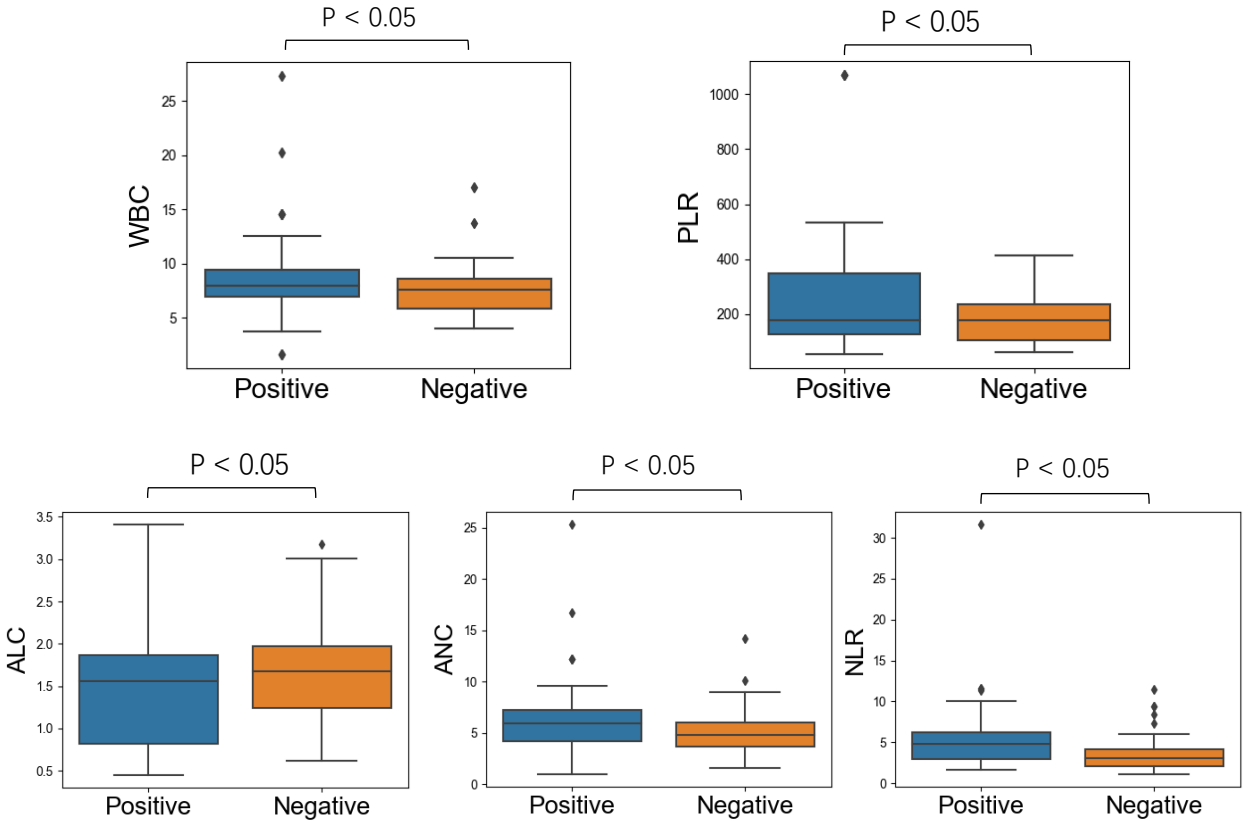
Preprocessing Pipeline

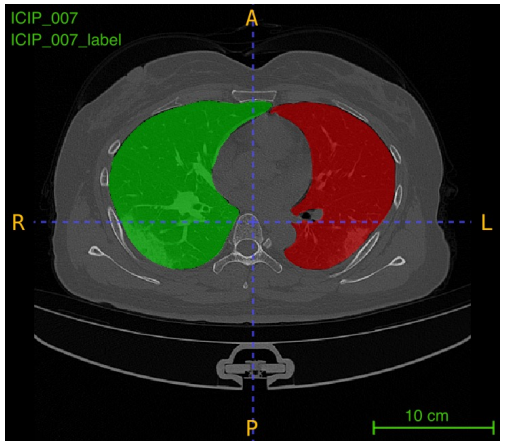


Feature Selection

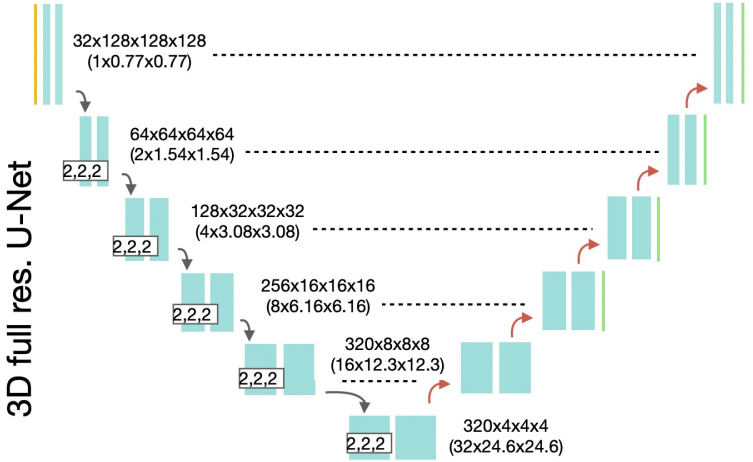


- Example for 5 continuous features

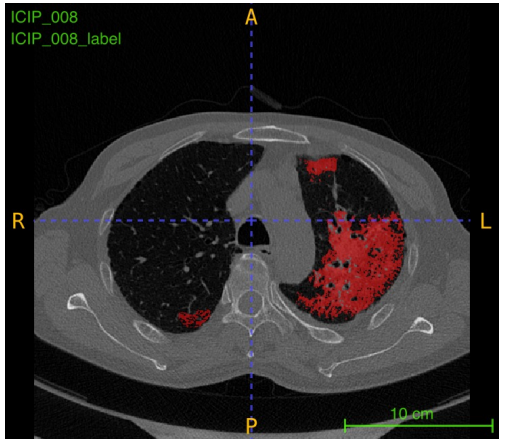
Segmentation & Quantification



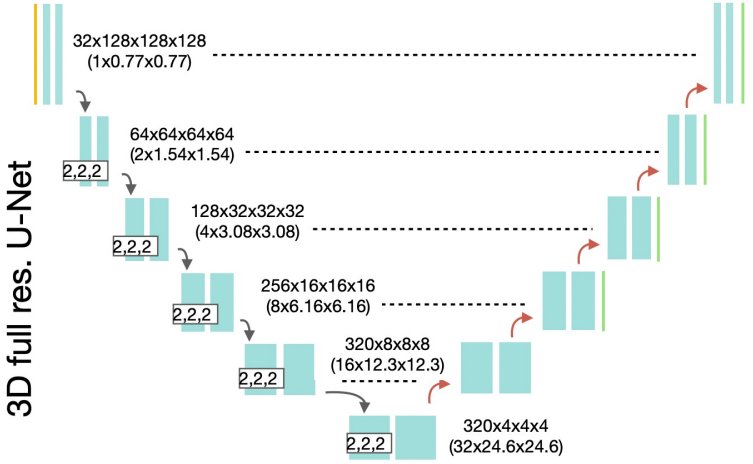
Lung parenchyma annotation



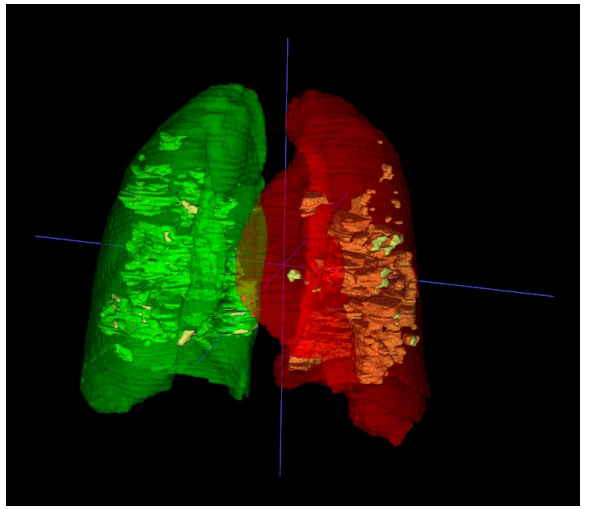
Human-in-the-loop



ICI-P lesion annotation



Region	Dice score
Left Lung	0.95+
Right Lung	0.99+
ICI-P	0.71+



3D reconstruction

$$\text{Lesion Volume Ratio} = \frac{V(ICIP\ Lesion)}{V(Lung\ Parenchyma)}$$

Enhanced Nomogram

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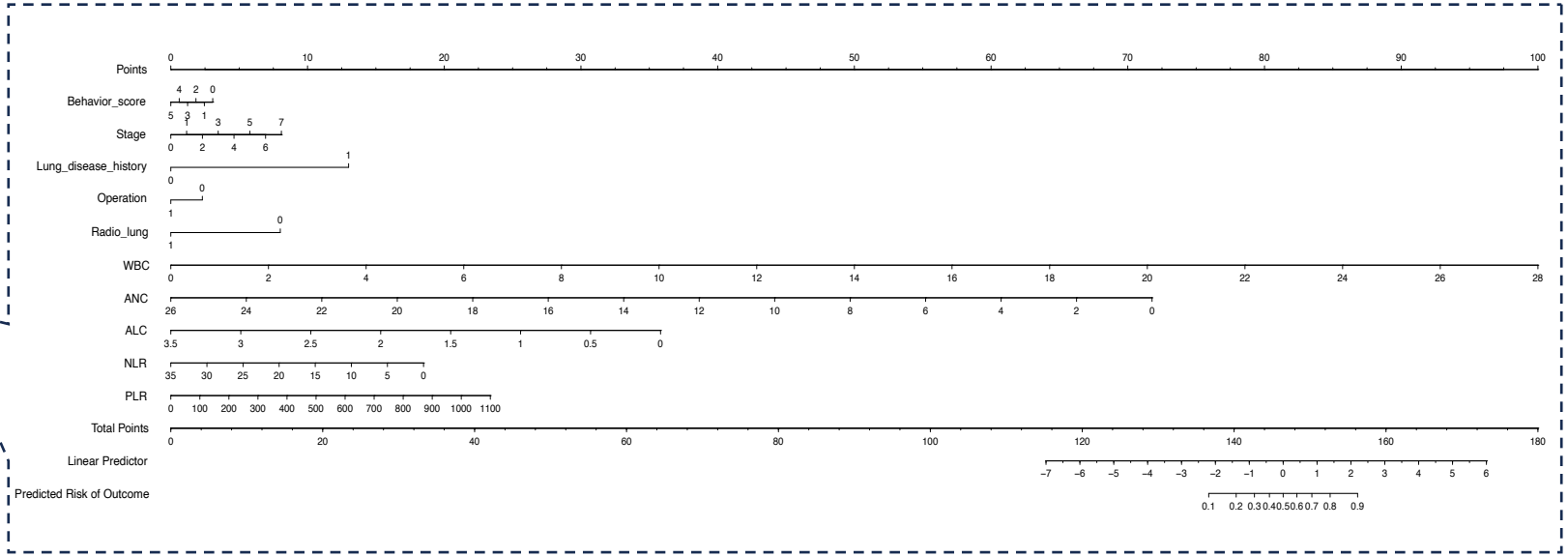
Clinical data
Serum markers

Nomogram Model

Positive Probability

Negative | Positive



Nomogram Model

Lesion Volume Ratio

Training

Lesion Volume Ratio label

$$\textbf{\textit{Nomogram score}} = 1.9839 \times \textit{Lung Disease History} - 1.352 \times \textit{ALC} - 1.146 \times \textit{Radio Lung} + 0.3408 \times \textit{Stage} - 0.2421 \times \textit{Operation} + 0.1208 \times \textit{WBC} + 0.1747 \times \textit{ANC} - 0.1323 \times \textit{NLR} - 0.010667 \times \textit{Behavior Score} + 0.0027 \times \textit{PLR}$$

Our Workflow

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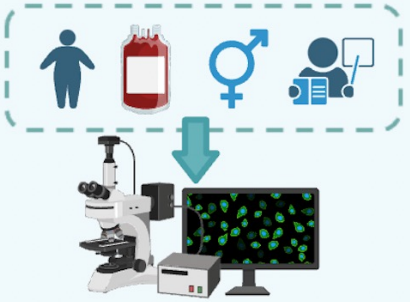
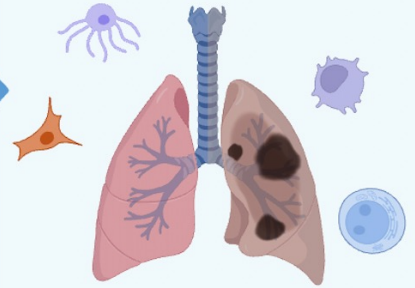
Clinical Data & Serum marker



Database

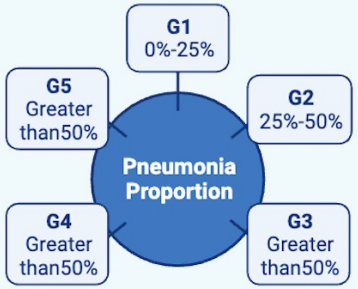
Enhanced Nomogram
Machine Learning Pipeline

Prediction
Risk of Positive(Probability) = 66%



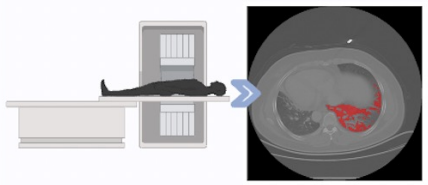
If Positive

ASOC Grading
Classification based on ICI-P severity level

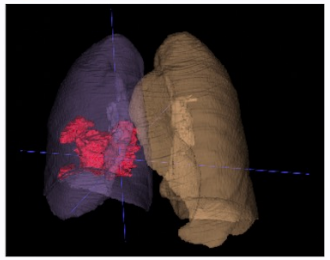


Potential patients are advised to undergo CT examination as soon as possible

Deep Learning Based Segmentation for ICI-P Lesions

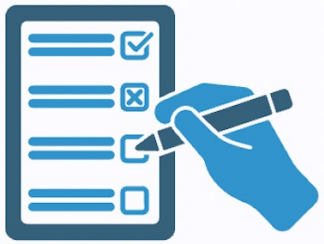


3D Reconstruction & Quantitative Analysis



Lesion volume ratio = 13.37%

Diagnostic Report



Human-in-the-loop

Experimental Results

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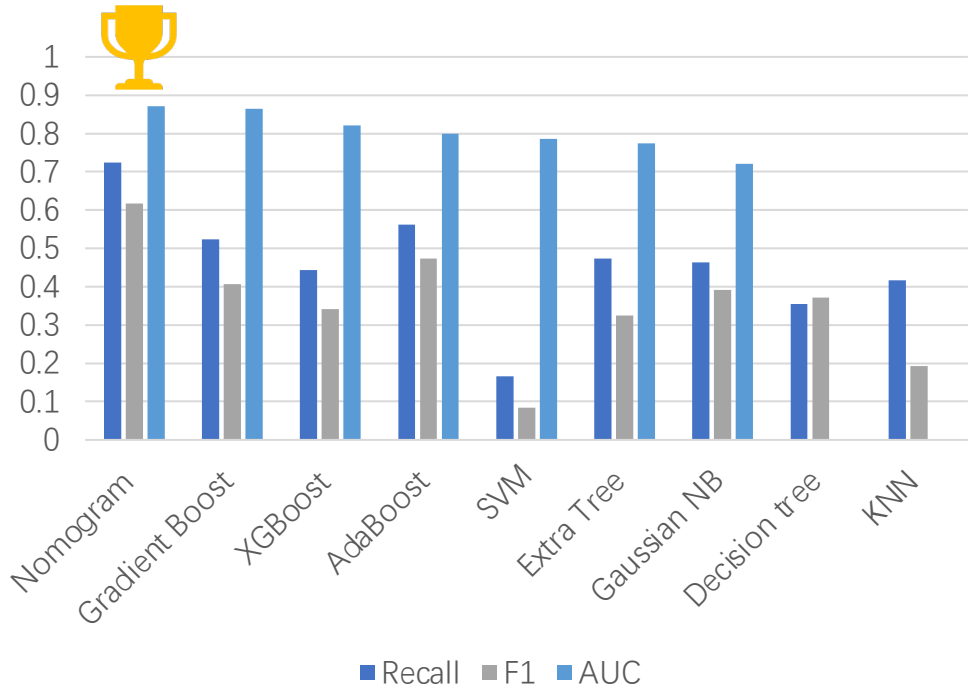
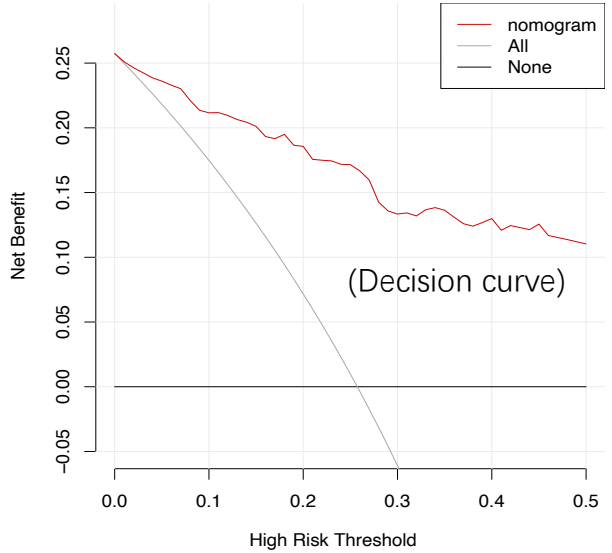
Comparative Experiment

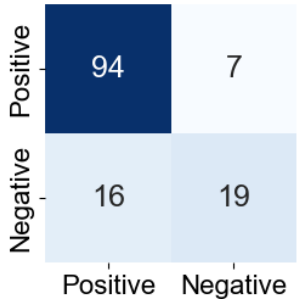


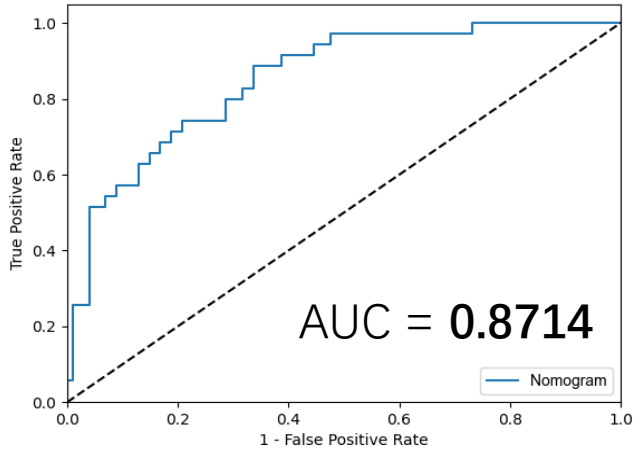
From the table, our workflow shows the best performance in recall, F1 and AUC, indicating its effectiveness.

Model Evaluation

The performance of our model without CT data is nearly equal to previous one with CT scan data







Thanks for attention!

Q&A Contact: rlin@u.nus.edu