Multi-Task Learning for Longitudinal PET Quantification in Pediatric Hodgkin Lymphoma

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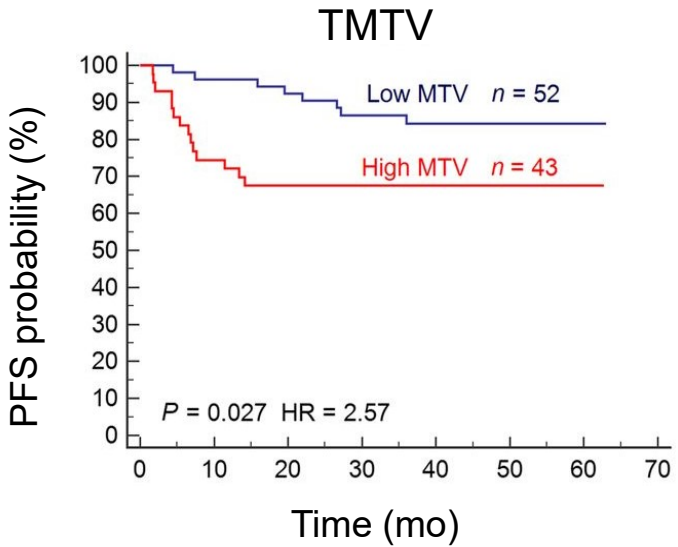
Disclosures

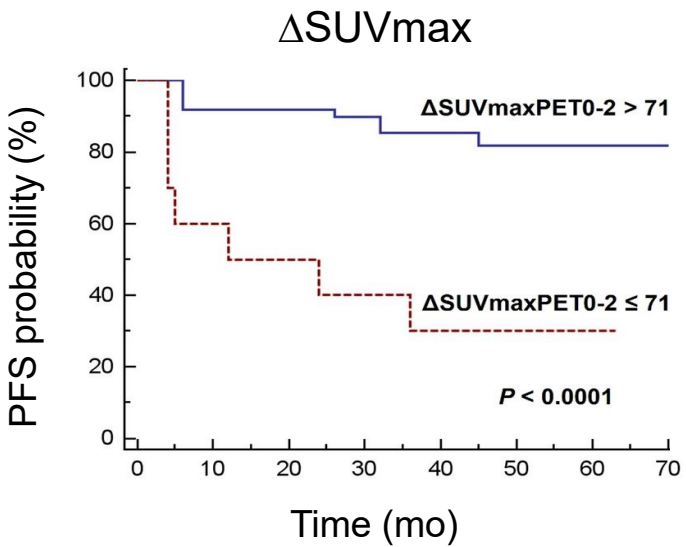
No disclosures

Background

Quantitative PET biomarkers in guiding **lymphoma** treatment strategies

Limited clinical use!

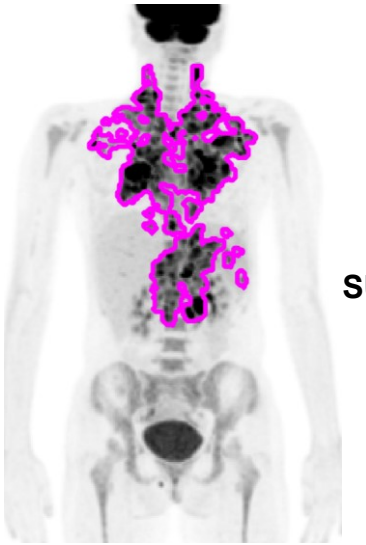




1. Cottereau AS, et al. *J Nucl Med*. 2020; 61(1):40-45.
2. Rossi C, et al. *J Nucl Med*. 2014; 55(4):569-573.

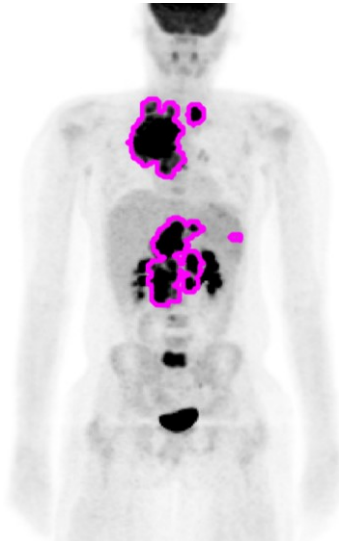
Background

- **Deep learning** (DL) for automatic PET analysis
  - Quantify **baseline** tumor burden



TMTV	878.6 ml
TLG	3664 g
SUVmax	17.8 g/ml
…	…

Baseline PET

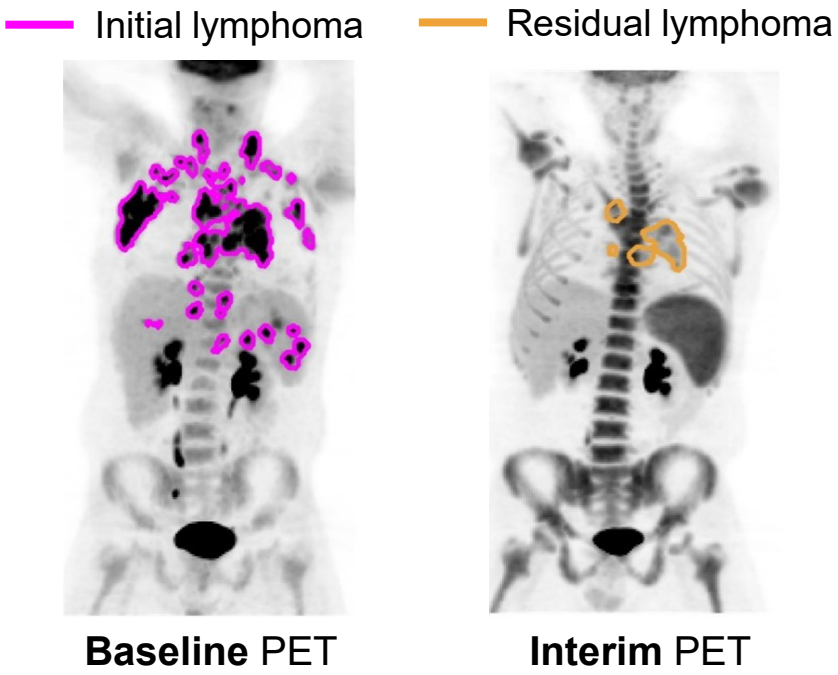


TMTV	499.0 ml
TLG	3061 g
SUVmax	10.8 g/ml
…	…

Baseline PET

Background

- **Interim** PET analysis
  - Response assessments
  - Guide treatment



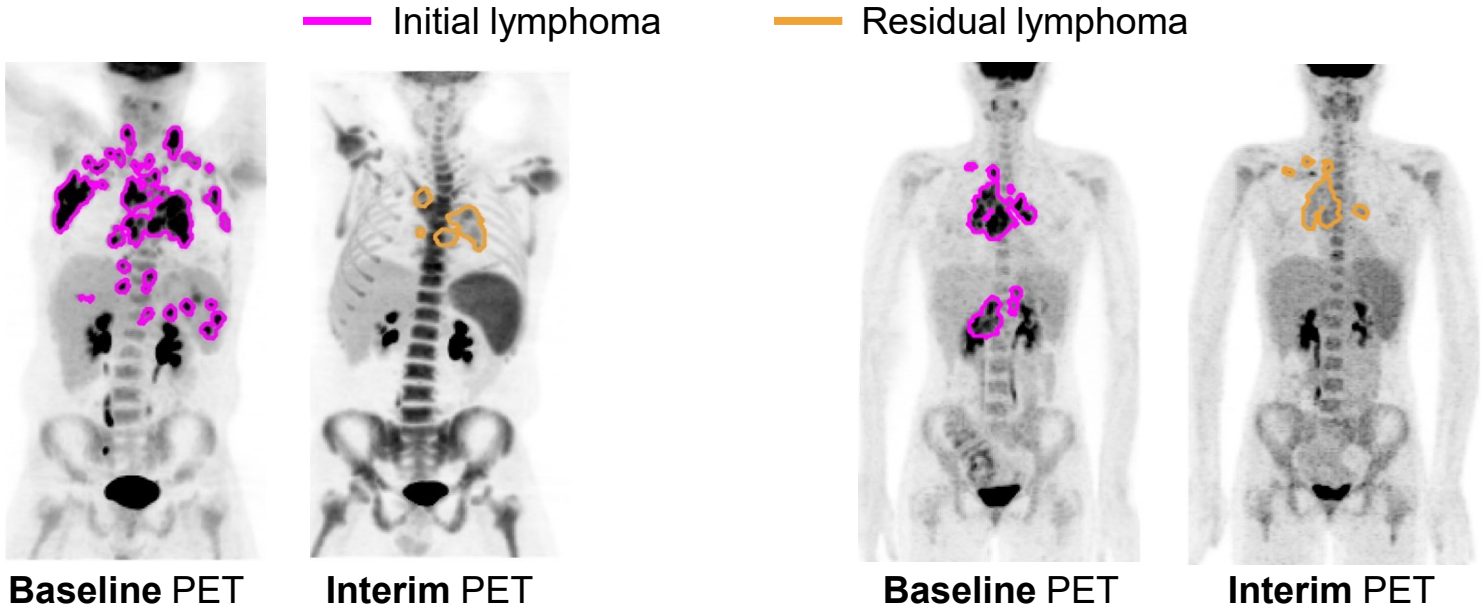
Baseline PET

Interim PET

Background

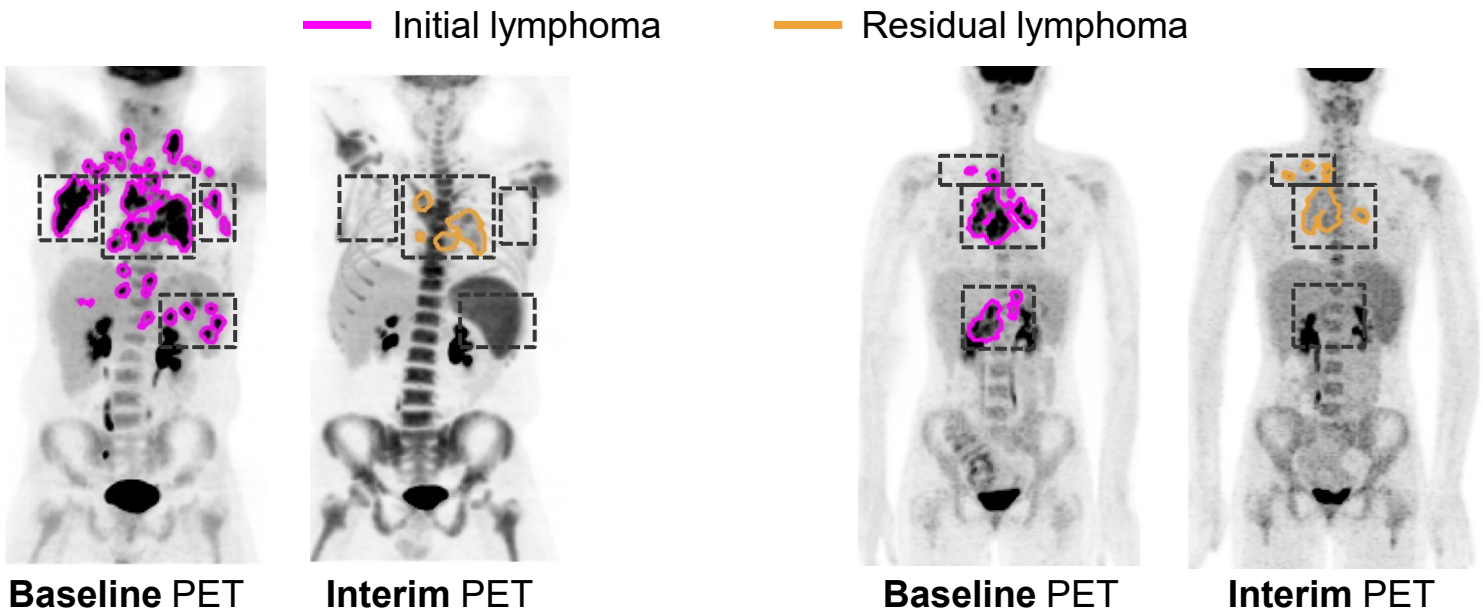
Challenges of Interim PET analysis

- Subtle tumor uptake
- Difficult to differentiate from inflammatory activity



Background

Physicians rely on **cross comparison** with baseline PET



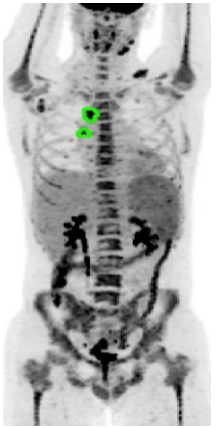
Purpose

To develop a **longitudinally-aware** segmentation network (LAS-Net) that can segment disease on **baseline PET** as well as detect residual lymphoma on **interim PET**

Dataset

- Children's Oncology Group (COG) AHOD1331 clinical trial
  - Phase 3 trial
  - Pediatric patients diagnosed with high-risk Hodgkin lymphoma
  - 200 labeled cases

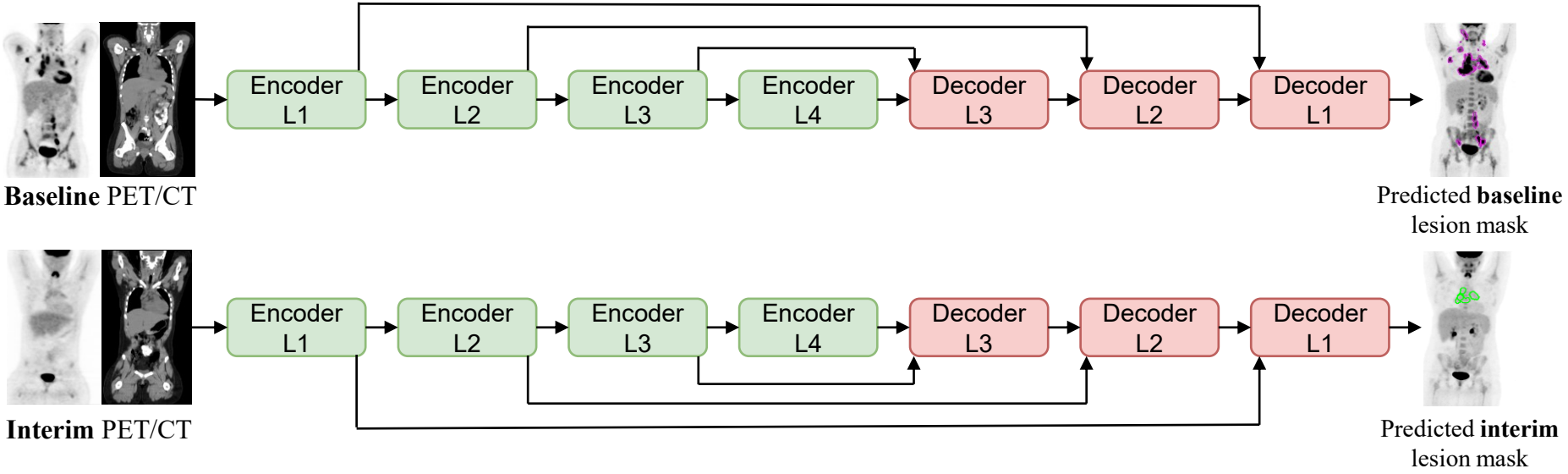
Labeled Baseline PET



Labeled Interim PET

Methods

- Longitudinal-aware segmentation network (LAS-Net)
  - 3D SwinUNETR
  - Dual-branch with longitudinal cross-attention



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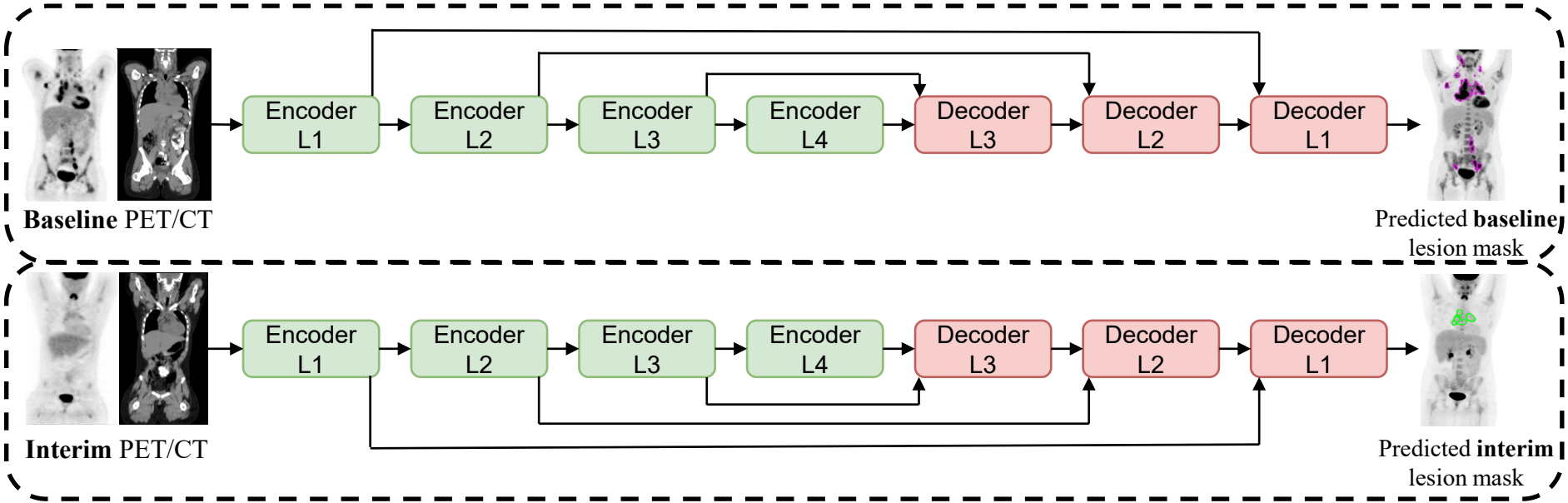

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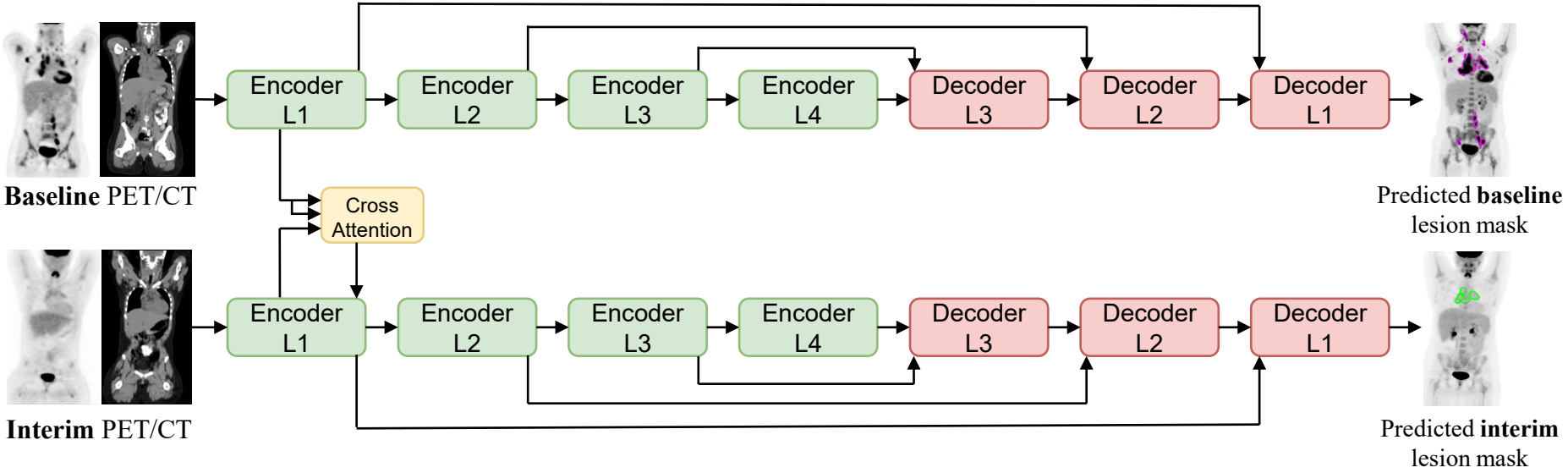

Methods

- Longitudinal-aware segmentation network (LAS-Net)
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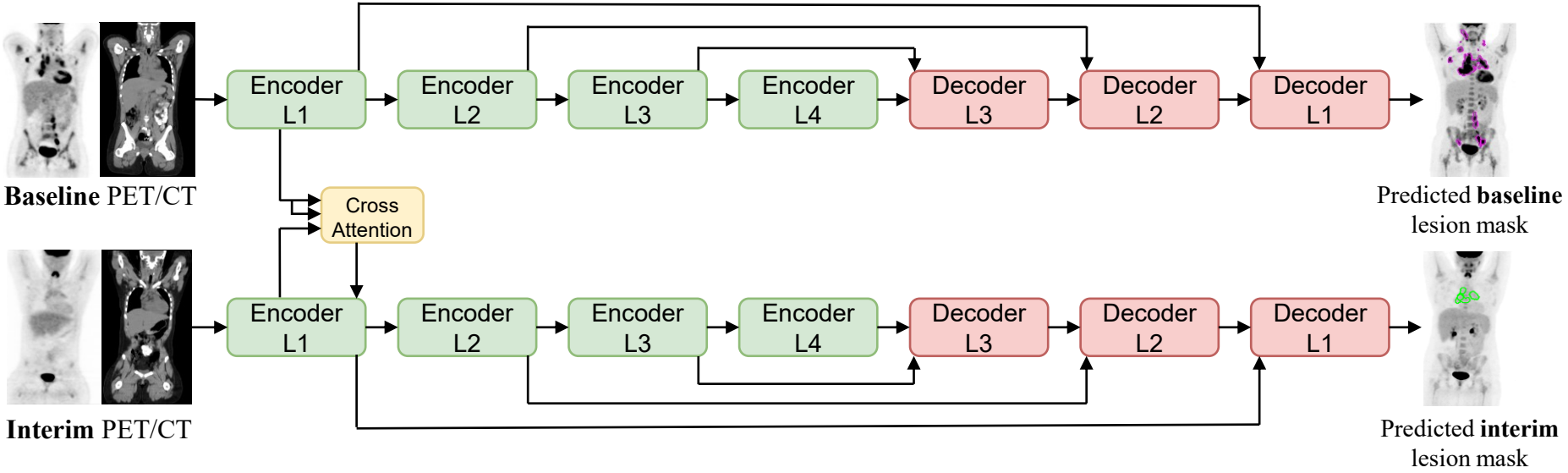
  - Dual-branch with longitudinal cross-attention
  - One-way information flow



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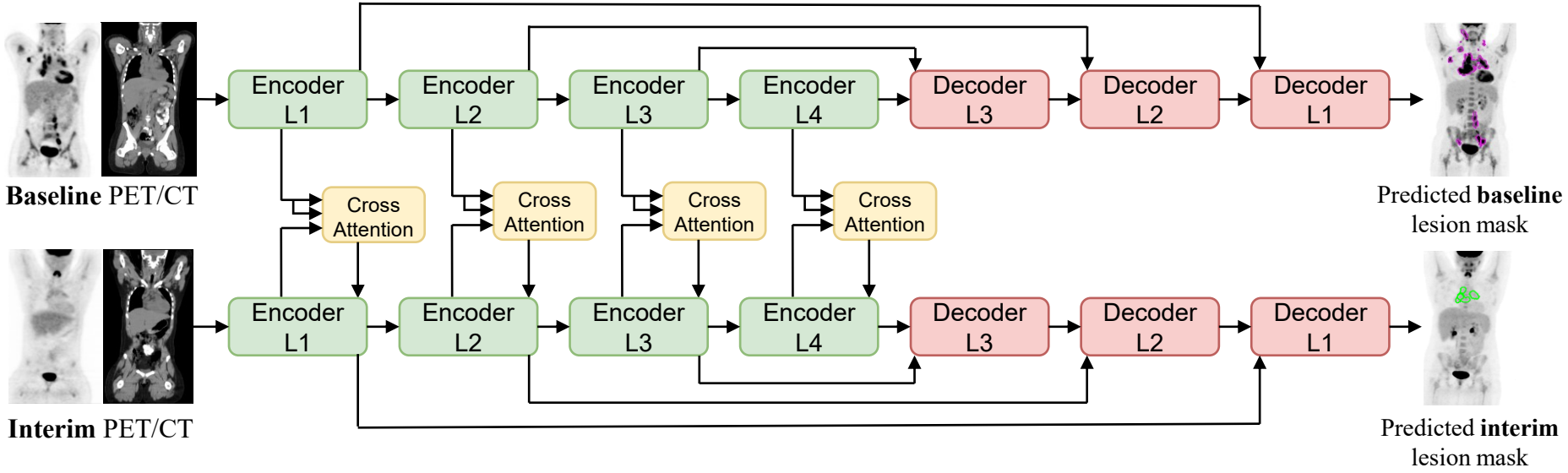

Training and Evaluation

- Multi-Task Learning strategy
  - Joint optimization for baseline and interim PET segmentation

- Evaluation metrics
  - **Dice scores** for baseline PET
  - Detection **F1 scores** for interim PET

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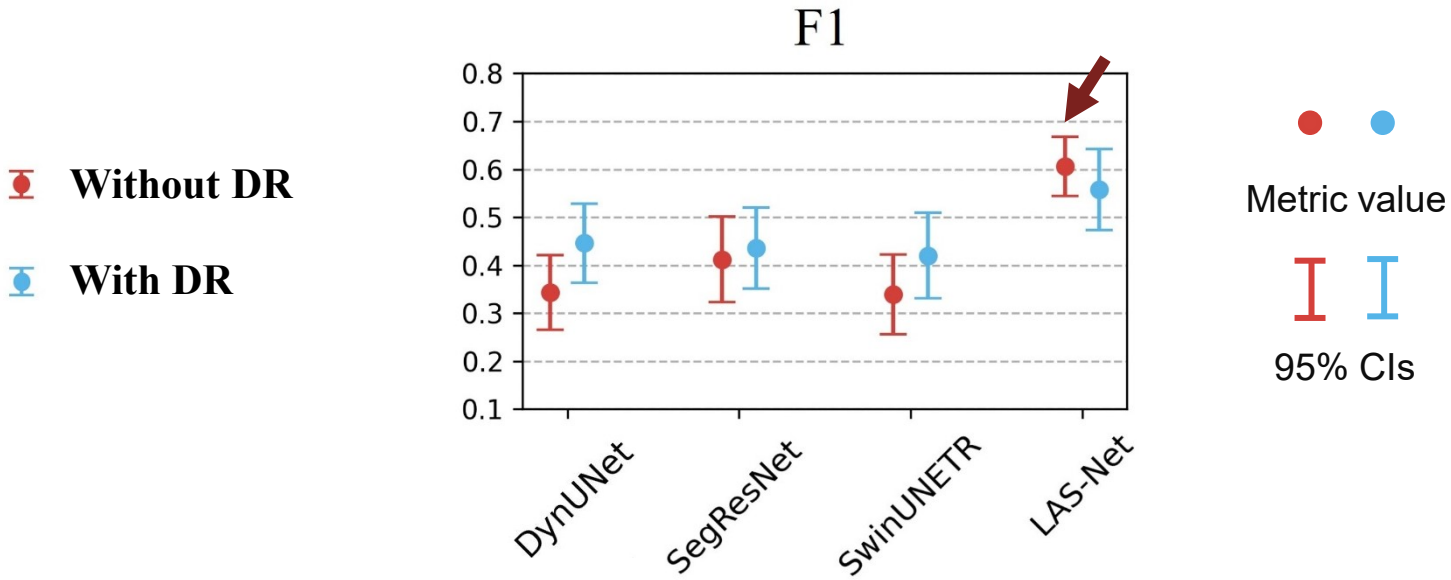
- Multi-Task Learning strategy
  - Joint optimization for baseline and interim PET segmentation
- Evaluation metrics
  - **Dice scores** for baseline PET
  - Detection **F1 scores** for interim PET
  - **PET biomarkers**: TMTV, TLG, ΔSUVmax, qPET
- Method Comparison
  - DynUNet, SegResNet, SwinUNETR
  - Deformable Registration (DR)

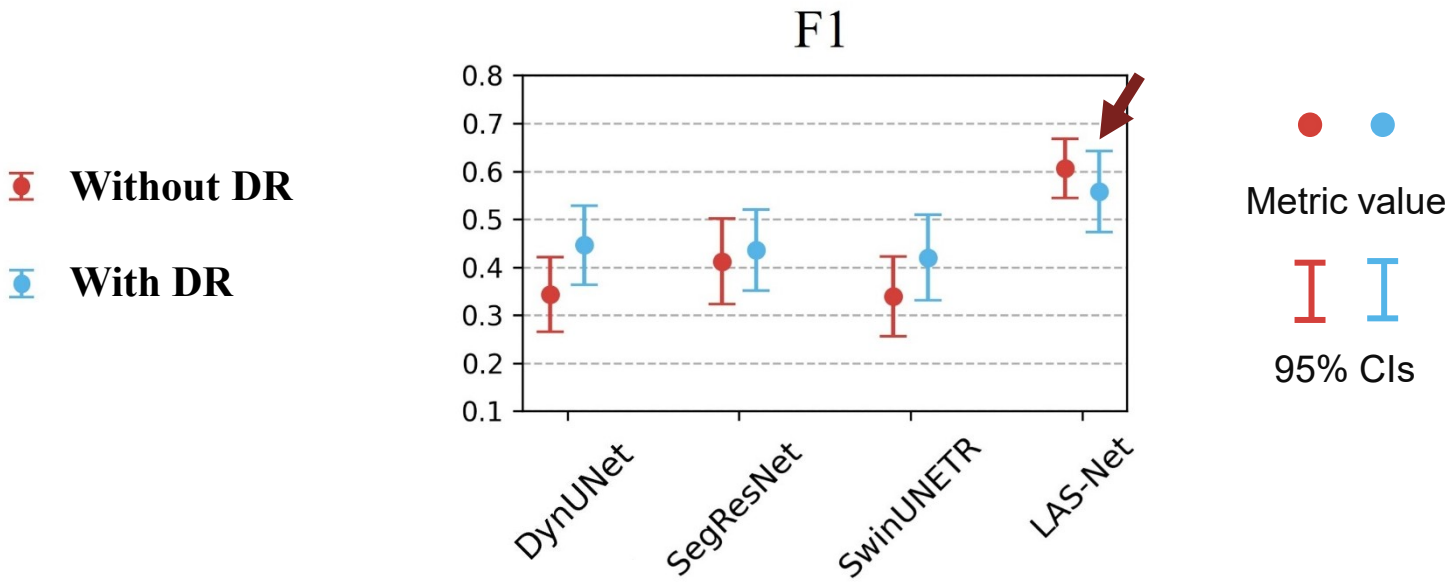
Results – Detection Performance on Interim PET

- Without DR, the detection **F1 score** was **0.61**



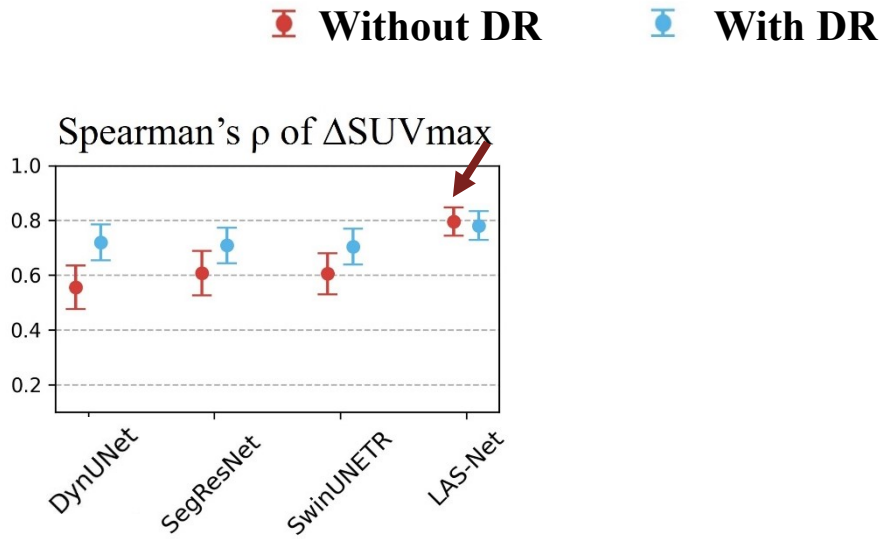
Results – Detection Performance on Interim PET

- Without DR, the detection **F1 score** was **0.61**
- With DR, no increase in the F1 score



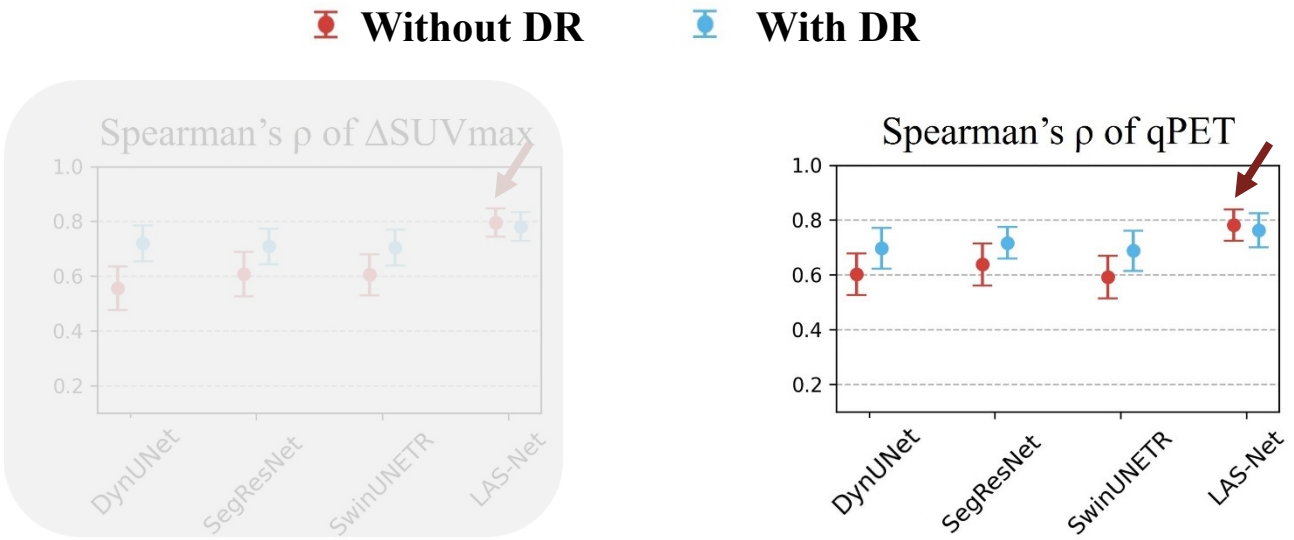
Results – Quantitative Interim Biomarkers

- Agreement with physician measurements
  - **ΔSUVmax**: ρ=0.80



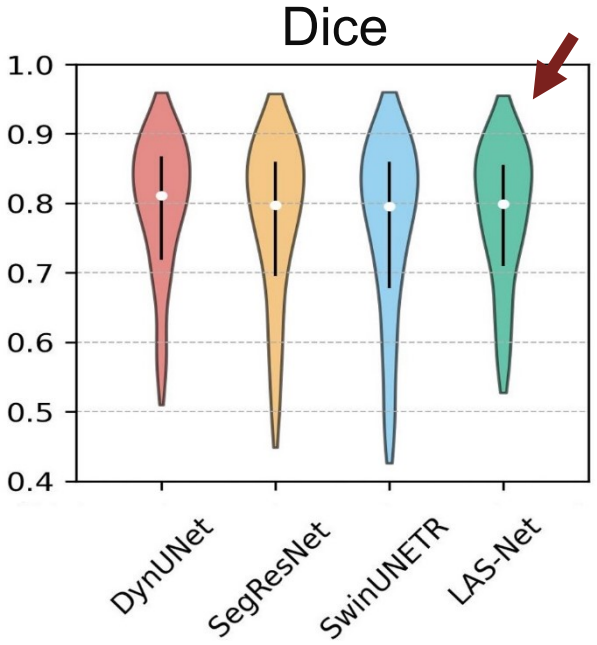
Results – Quantitative Interim Biomarkers

- Agreement with physician measurements
  - ΔSUVmax: ρ=0.80
  - **qPET**: ρ=0.78



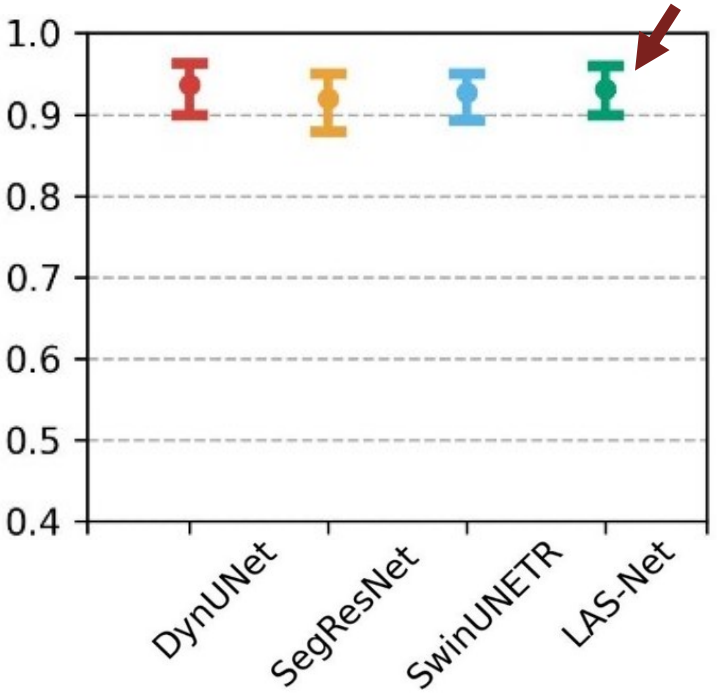
Results – Performance on Baseline PET

- Mean **Dice score** was **0.77**
- Comparable performance to the best method (DynUNet)

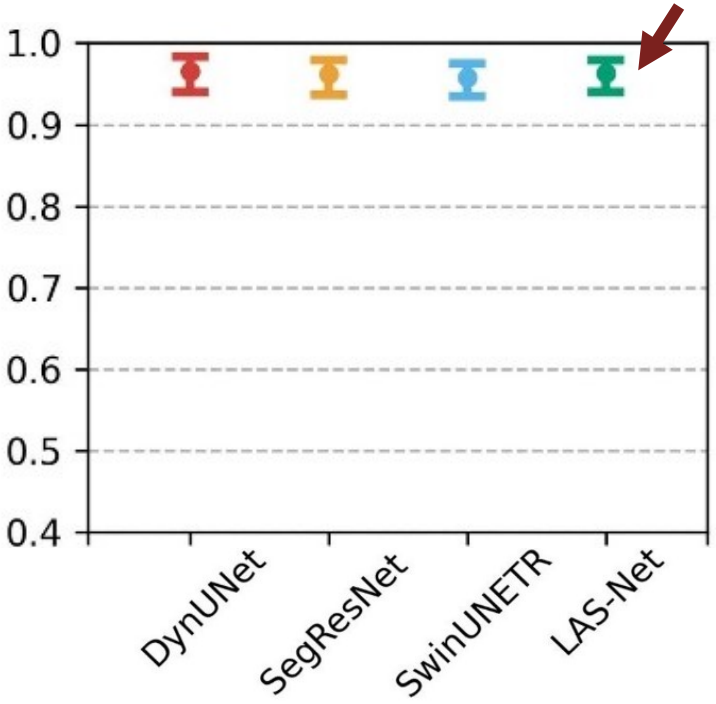


Results – Quantitative Baseline Biomarkers

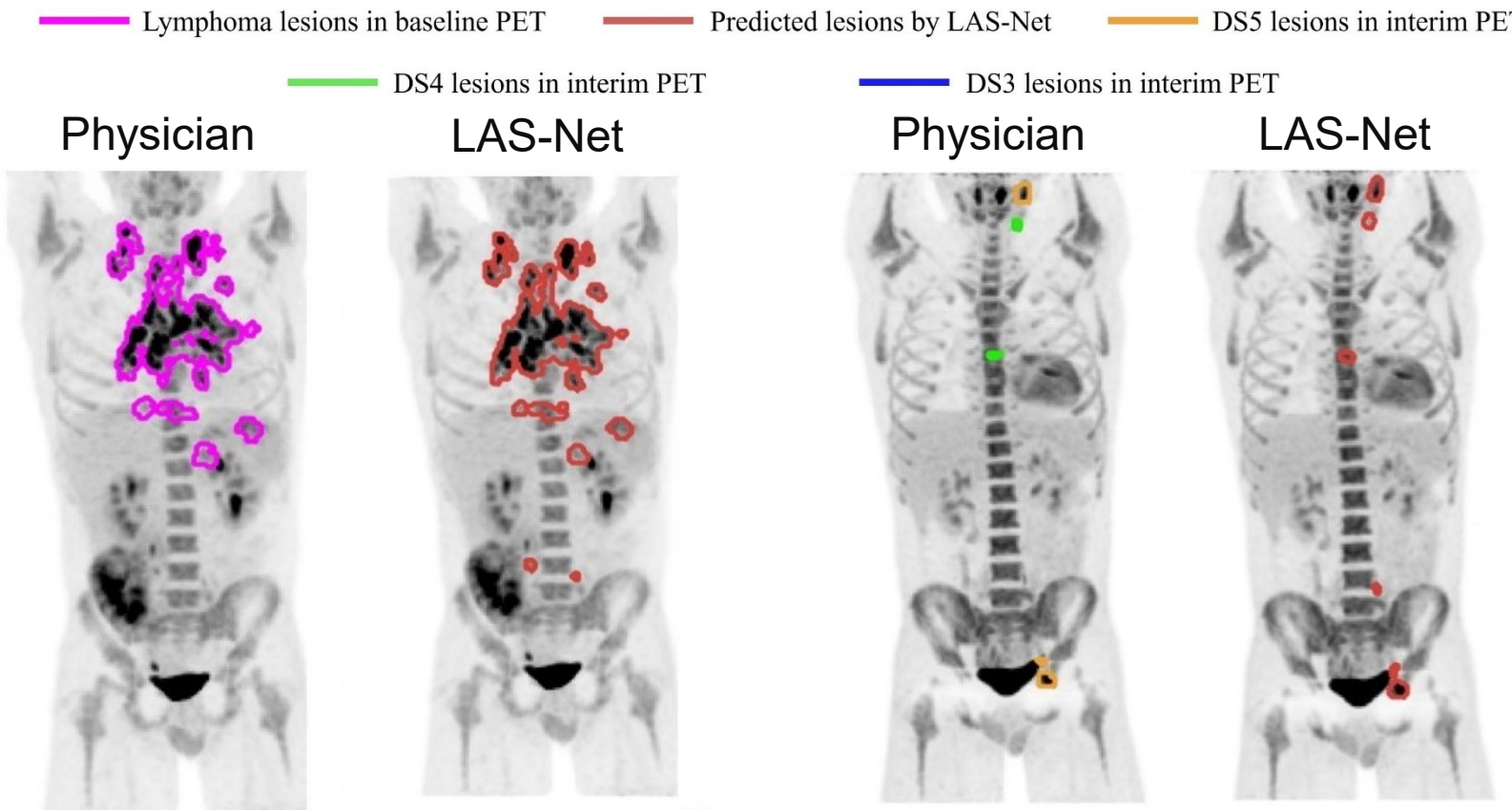
TMTV: Spearman's ρ = 0.93



TLG: Spearman's ρ = 0.96



Results – Sample Case



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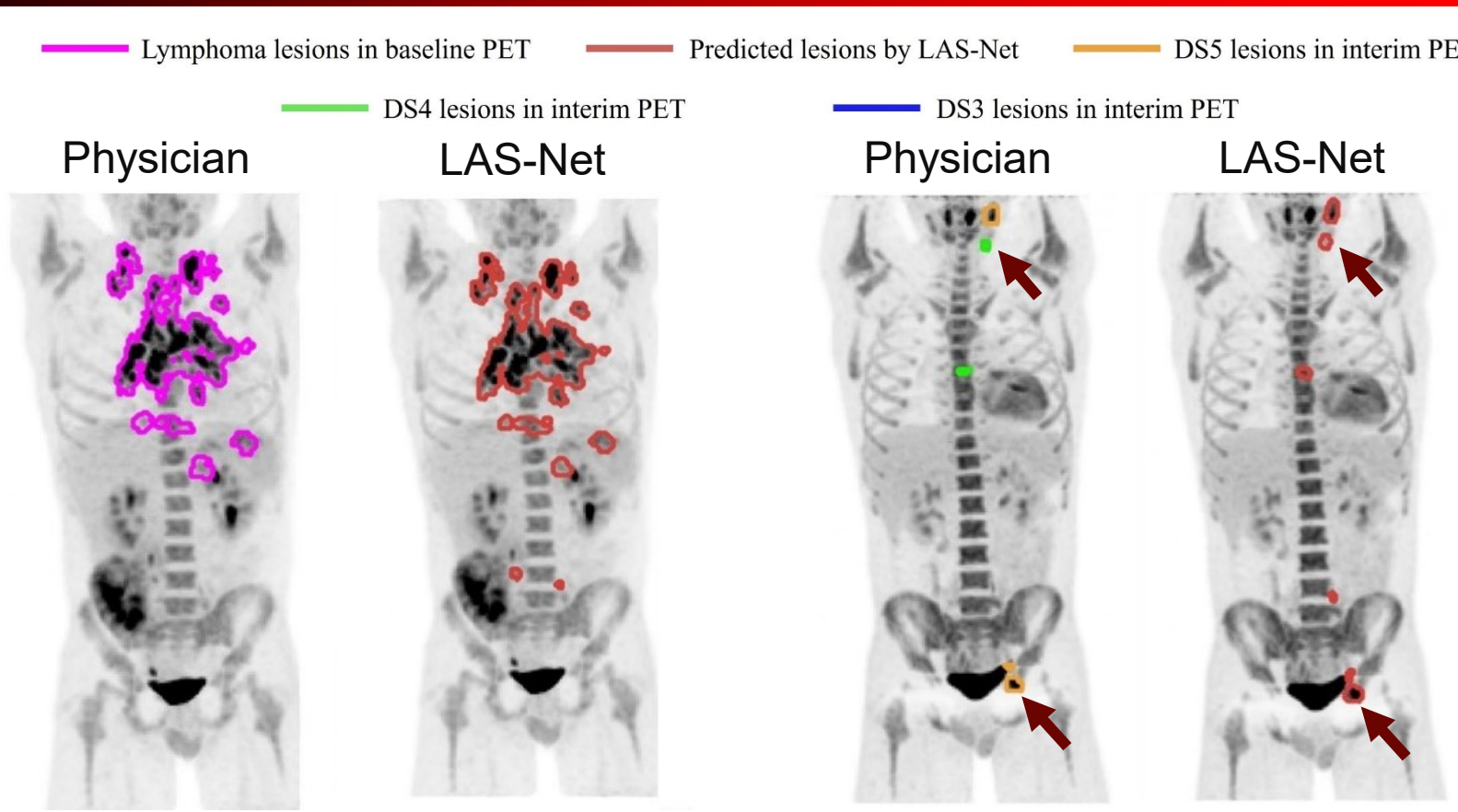

Conclusions

- Our study introduced a novel method that detect residual lesions on **interim PET** without sacrificing the ability to quantify **baseline PET** tumor burden

- **Longitudinal awareness** in analyzing multi-time-point imaging datasets

Thank you

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arXiv

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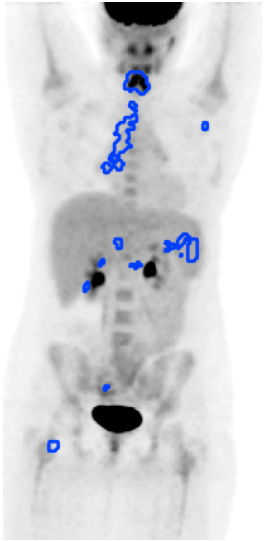
How about Deformable Registration?

Mask Propagation through Deformable Registration (MPDR)

Predicted baseline
lesion mask

Baseline PET

Predicted Interim
lesion mask



Interim PET

1. Weisman AJ, et al. *J Nucl Med (supplement 1)*. 2020; 1434

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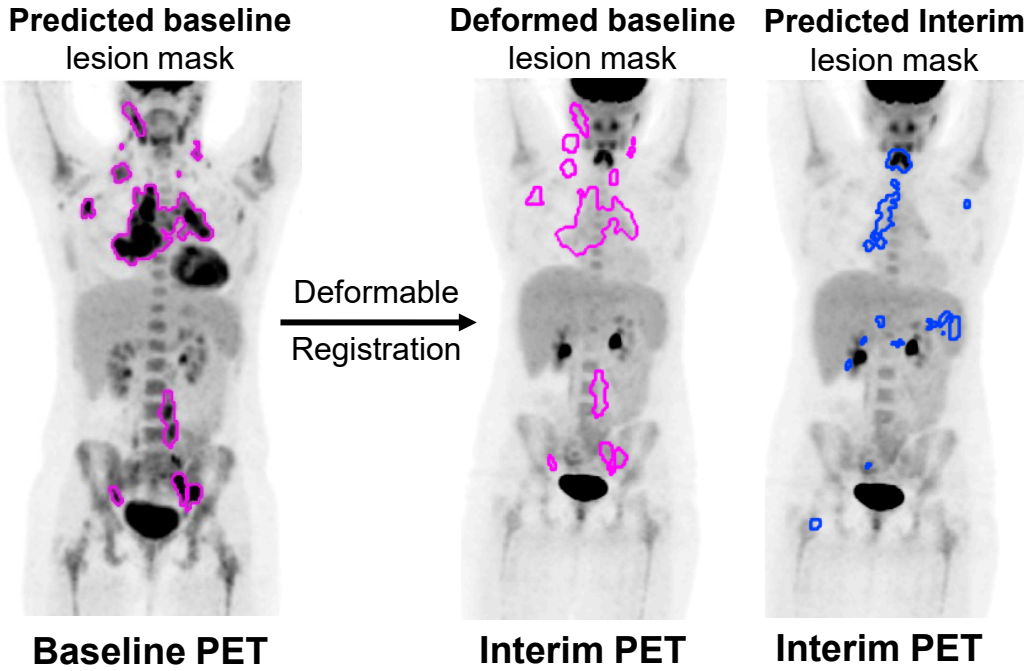

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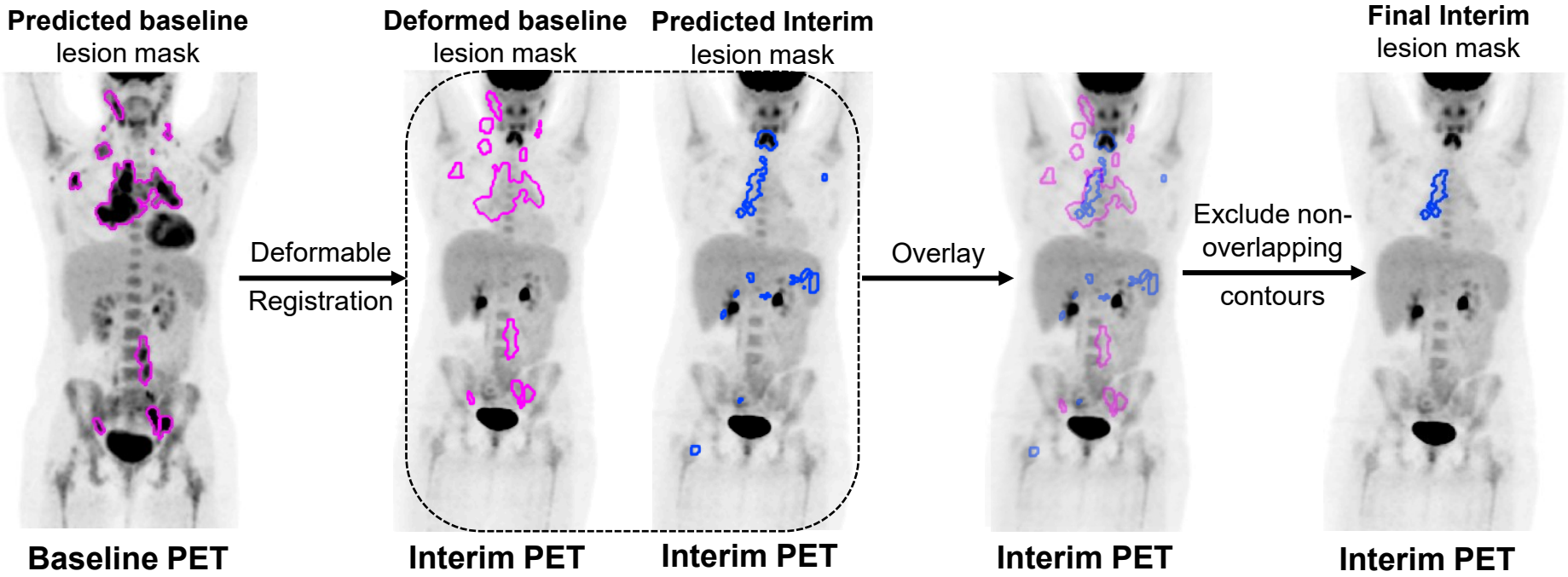

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