Investigating Low Dose CT for Ventilation Imaging

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2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

INTRODUCTION

Regional assessment of lung function has found multiple clinical applications such as earlier detection of airway and parenchymal disease[1] and functional lung avoidance radiation therapy.[2]

Non-contrast **CT Ventilation Imaging (CTVI)** is a recently approved lung function imaging modality with high accessibility. However, additional radiation dose from CT scans limits its widespread clinical adoption, particularly in longitudinal studies and lung screening programs. **This study evaluates the impact of dose reduction on the accuracy of CTVI**.

METHODS

Paired inhale-exhale breath-hold CT images from two lung cancer cohorts (N = 28) were used as inputs to a **validated noise-addition software[3] to generate reduced dose images** at 50%, 25%, 10%, and 5% relative dose.

CT ventilation images were derived from deformable image registration evaluation of volume change ($CTVI_{Jac}$) or change in Hounsfield Unit (HU) value ($CTVI_{HU}$).[4] **Low-dose CT ventilation images were compared against standard-dose** using voxel-wise **Pearson correlation**, and **Dice similarity coefficient** (DSC) of regions of interest defined by upper 85% (functional lung) and upper 15% (highly functioning lung) of ventilation values.

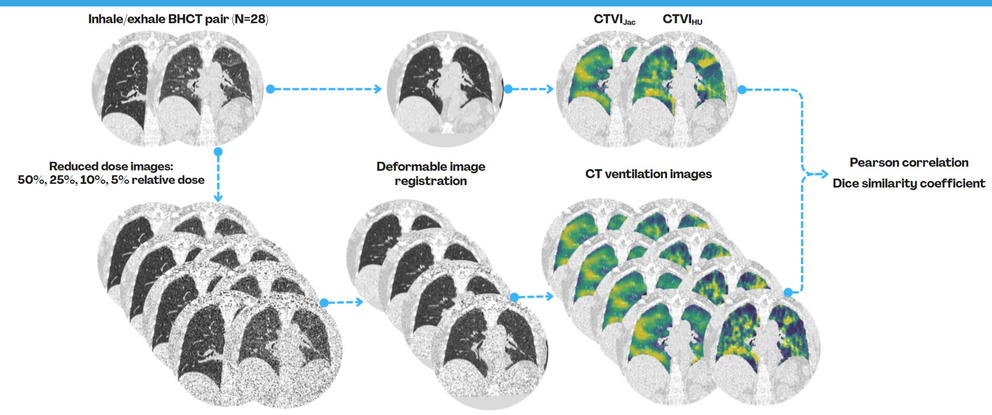

Figure 1: Workflow for generating and evaluating reduced-dose CT ventilation images.

RESULTS

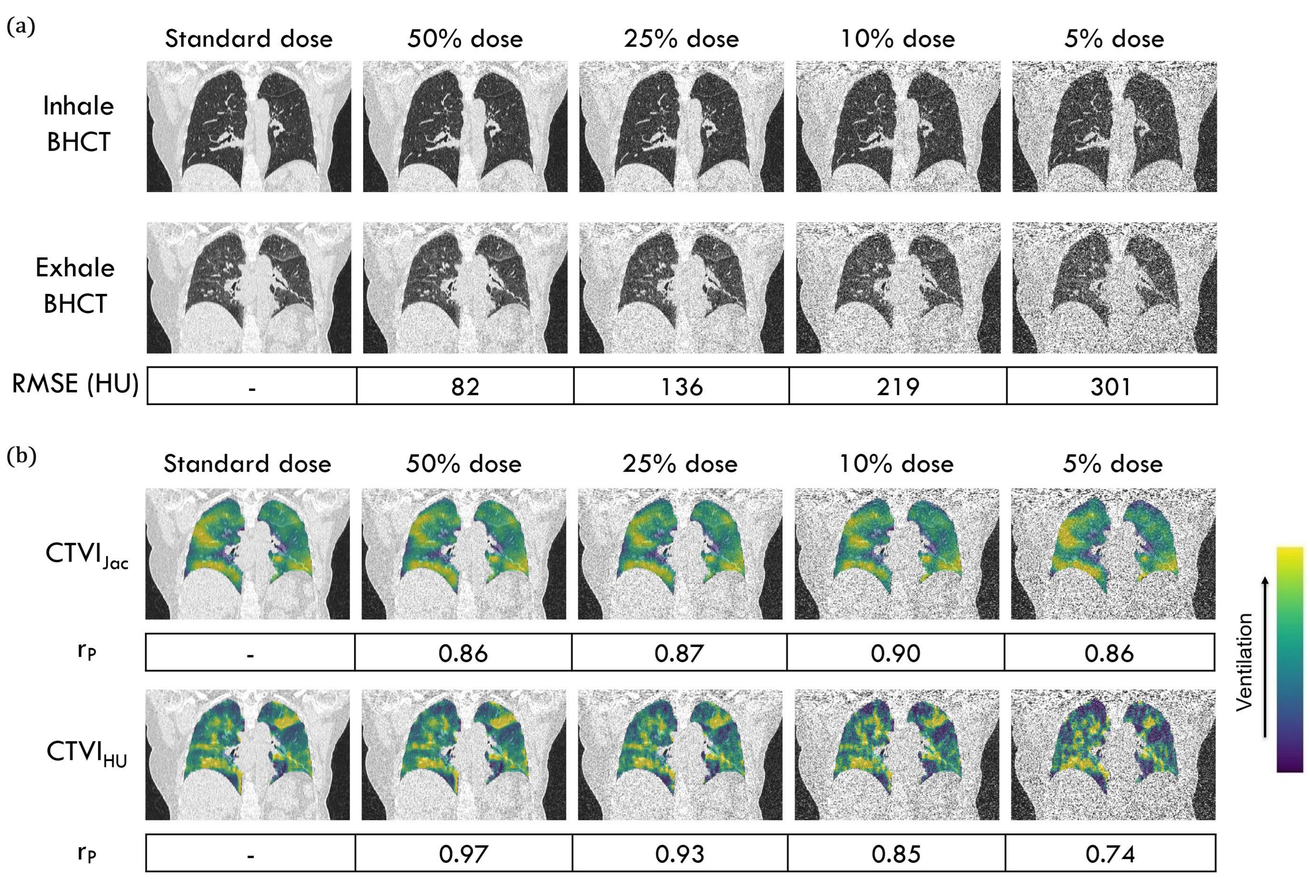

Figure 2: Effect of dose reduction on CT and CTVI image quality on a representative patient. (a) Inhale and exhale BHCT images at standard-dose and low-dose (50%, 25%, 10%, 5% relative dose). Root-mean-square errors (RMSE) within the lung between the standard-dose and low-dose CT images are reported. (b) CT ventilation images derived from the Jacobian-based ($CTVI_{Jac}$) and Hounsfield Unit-based ($CTVI_{HU}$) methods. Pearson correlation coefficients (r_P) between the standard-dose and low-dose CT ventilation images are reported.

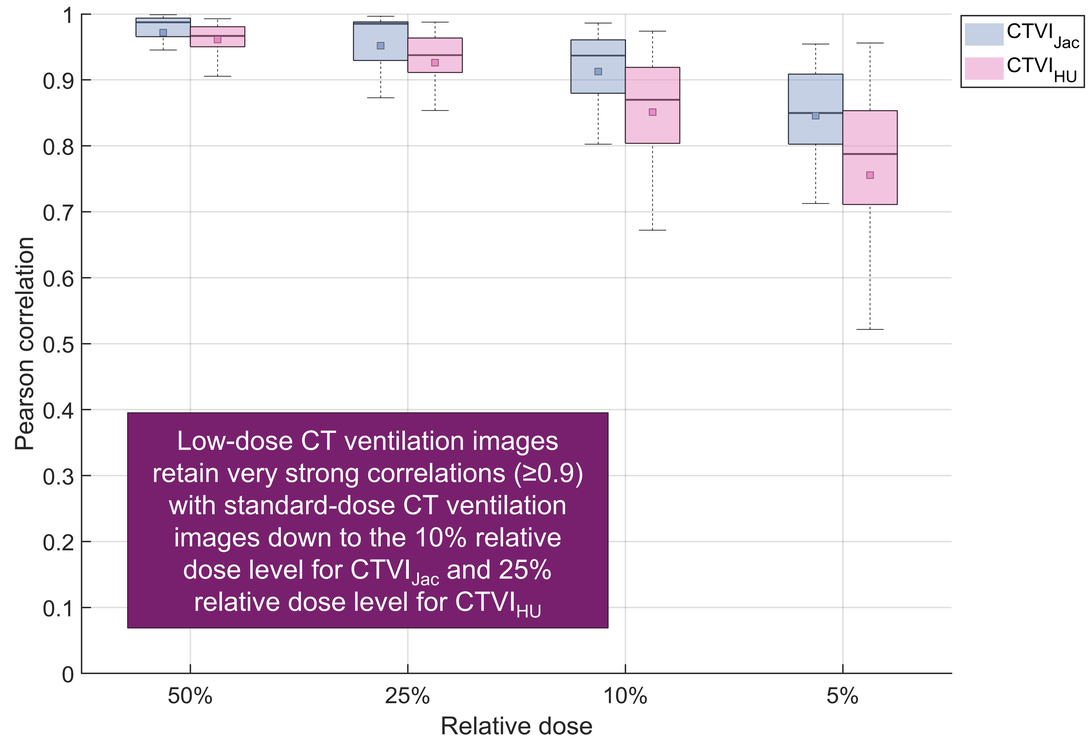

Figure 3: Box plots of Pearson correlations between standard-dose and low-dose CT ventilation images for each CTVI method, with mean correlations indicated with squares.

Table 1: Mean dice similarity coefficients for functional lung (upper 85% of ventilation values) and highly functioning lung (upper 15%) between standard-dose and low-dose CTVIs.

		DSC (standard-dose vs. low-dose CTVI)			
Relative dose		**50%**	**25%**	**10%**	**5%**
Functional lung (upper 85%)	$CTVI_{Jac}$	0.98	0.97	0.96	0.94
	$CTVI_{HU}$	0.96	0.94	0.92	0.90
Highly functioning lung (upper 15%)	$CTVI_{Jac}$	0.91	0.89	0.81	0.69
	$CTVI_{HU}$	0.86	0.82	0.73	0.63

CONCLUSIONS

- **CTVI is robust to dose reduction** and increased image noise, particularly when using volume-based ventilation metrics ($CTVI_{Jac}$).
- These results support the investigation of CTVI for screening and longitudinal studies, and the potential for significant dose optimization in CTVI workflows.

REFERENCES

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