Establishing a Technical Guidance Document for COPD and Lung Cancer Image Acquisition Protocol: Topic Overview

Chuck Hatt
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RSNA QIBA Lung Density Committee

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Quantitative Imaging Biomarkers Alliance

RSNA

QIBA Profile:

Small Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening

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QIBA Profile:

Computed Tomography: Lung Densitometry

*The goal of a QIBA Profile is to help achieve a useful level of performance for a given biomarker.

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ELSEVIER

Clinical Imaging
Volume 77, September 2021, Pages 151-157

QIBA guidance: Computed tomography imaging for COVID-19 quantitative imaging applications

Ricardo S. Avila [a], Sean B. Fain [b], Chuck Hatt [c, p], Samuel G. Armato III [d], James L. Mulshine [e], David Gierada [f], Mario Silva [g], David A. Lynch [h], Eric A. Hoffman [i], Frank N. Ranallo [j], John R. Mayo [k, q], David Yankelevitz [l], Raul San Jose Estepar [m, r], Raja Subramaniam [l], Claudia I. Henschke [l], Alex Guimaraes [n], Daniel C. Sullivan [o]

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PREVIOUS NEXT

Original Research
Thoracic Imaging

Free Access

Well-aerated Lung on Admitting Chest CT to Predict Adverse Outcome in COVID-19 Pneumonia

Davide Colombi, Flavio C. Bodini, Marcello Petrini, Gabriele Maffi, Nicola Morelli, Gianluca Milanese, Mario Silva, Nicola Sverzellati, Emanuele Michieletti

Author Affiliations

Published Online: Apr 17 202 accordion control g/10.1148/radiol.2020201433

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LUNG DENSITY ANALYSIS™
INSPIRATION ASSESSMENT

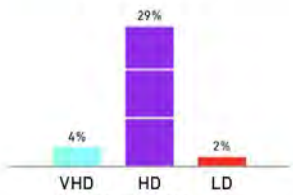
NAME: Unknown	SEX: Unknown	STUDY DATE: March 4, 2021
PATIENT ID: Unknown	DOB: January 1, 1900	REPORT DATE: June 16, 2021
MANUFACTURER: Unknown	MODEL: Unknown	STATION NAME: Unknown
KERNEL: Unknown	SLICE THICKNESS: 0.8	TUBE CURRENT AVG (max/min), KVP: None (None/None) mA, None

Very High Density (VHD)
Indicative of consolidation
Egashira, A., et. al. 2021 Clinical Imaging, 77

High Density (HD)
Indicative of ground glass
Egashira, A., et. al. 2021 Clinical Imaging, 77

Low Density (LD)
Indicative of emphysema
Madani, A., et. al. 2006 Radiology, 239:10

% by lung total



Very High Density: > -200 HU
High Density: -700 to -200 HU
Low Density: < -950 HU

SUMMARY	VOL	VHD	HD	LD
TOTAL LUNG:	2.2 L	4 %	29 %	2 %
Left Lung:	1.0 L	5 %	27 %	2 %
Left Upper		8 %	20 %	3 %
Left Middle		3 %	25 %	2 %
Left Lower		2 %	44 %	2 %
Right Lung:	1.2 L	3 %	31 %	2 %
Right Upper		1 %	17 %	3 %
Right Middle		4 %	34 %	2 %
Right Lower		2 %	47 %	2 %

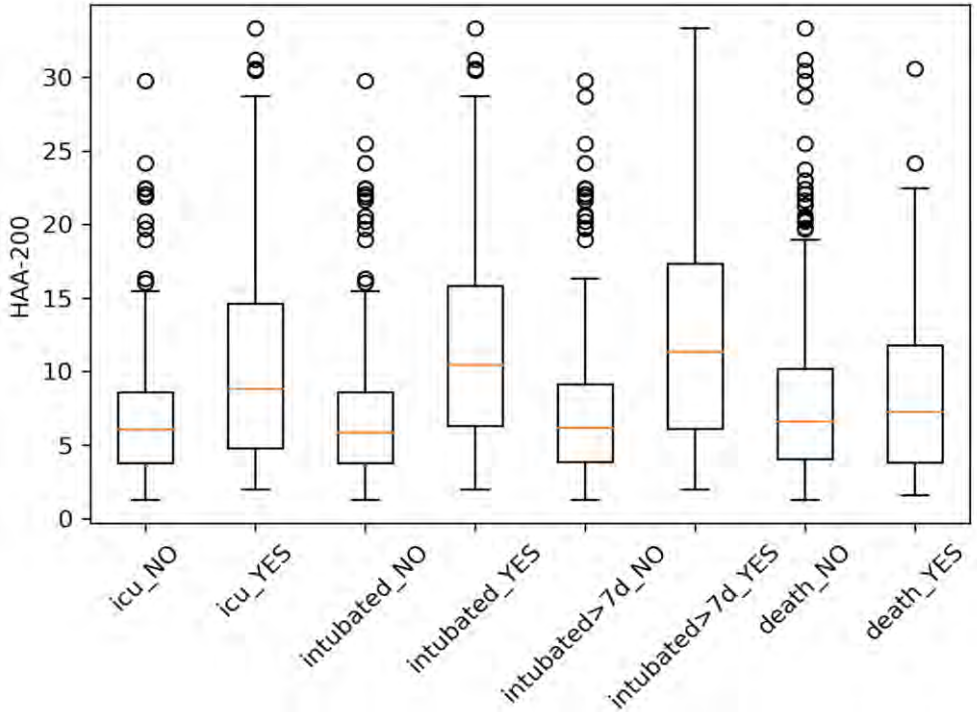


Table 1. Logistic regression results. Odds ratios (ORs) are displayed as 95% confidence intervals. The ORs for %HAA-200 and age are applied to unit increases in percentage and years, respectively.

Predictor	ICU admission	Intubated	Intubated > 7 days	Death
%HAA-200	(1.07, 1.17), p<0.001	(1.09, 1.19), p<0.001	(1.09, 1.19), p<0.001	(1.00, 1.11), p<0.052
Age	(0.99, 1.03), p=0.242	(0.98, 1.02), p=.978	(0.98, 1.02), p=.907	(1.05, 1.12), p<0.001
Sex (male=0, female=1)	(0.56, 1.57), p=0.810	(0.40, 1.27), p=0.247	(0.48, 1.88), p=0.866	(0.36, 1.31), p=0.254

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Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans

Michael Roberts, Derek Driggs, Matthew Thorpe, Julian Gilbey, Michael Yeung, Stephan Ursprung, Angelica I. Aviles-Rivero, Christian Etmann, Cathal McCague, Lucian Beer, Jonathan R. Weir-McCall, Zhongzhao Teng, Effrossyni Gkrania-Klotsas, AIX-COVNET, James H. F. Rudd, Evis Sala & Carola-Bibiane Schönlieb

Nature Machine Intelligence **3**, 199–217 (2021) | Cite this article

Reviews and Commentary
Editorial

Free Access

Artificial Intelligence of COVID-19 Imaging: A Hammer in Search of a Nail

Ronald M. Summers

Author Affiliations

Published Online: Dec 22 2020 | https://doi.org/10.1148/radiol.2020204226

2,212 studies
"With no standardization, AI algorithms for COVID-19 have been developed with a very broad range of applications, data collection procedures and performance assessment metrics. Perhaps as a result, none are currently ready to be deployed clinically Reasons for this include: (1) the bias in small datasets; (2) the variability of large internationally sourced datasets; (3) the poor integration of multistream data, particularly imaging data"

"It is now so much easier to design and conduct a radiology AI experiment. The only prerequisite seems to be possession of a large data set."
"It is time to move beyond studies showing that AI can detect opacities at CT or chest radiography—this is now well established. "

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ELSEVIER

Clinical Imaging
Volume 78, October 2021, Pages 136-141

Cardiothoracic Imaging

The importance of low-dose CT screening to identify emphysema in asymptomatic participants with and without a prior diagnosis of COPD ☆

David Steiger [a], M. Faisal Siddiqi [a], Rowena Yip [b], David F. Yankelevitz [b], Claudia I. Henschke [b, c]
I-ELCAP investigators

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"We found that among the 52,726 asymptomatic participants, emphysema was identified on baseline LDCT in 12,542 (23.8%) participants. Of the 12,542 participants with emphysema, 9595 (76.5%) had no prior COPD diagnosis and 2947 (23.8%) had a prior COPD diagnosis"

Need to establish feasibility of screening for *automated quantitative* COPD/emphysema

Need to establish use cases for *automated quantitative* COPD/emphysema

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HealthPartners

10009Y_Njc_Copd's Report

CT Scan Performed on January 1, 1900

Name: 10009Y_Njc_Copd
Sex: Unknown
Patient ID: 10009Y_NJC_COPD
DOB: Unknown

10009Y_Njc_Copd, Your Lungs Today:

- **36%** NORMAL
  but at risk of damage
  if you don't quit smoking
- **36%** AT HIGH RISK
  of further damage
  if you don't quit smoking
- **28%** DAMAGED

Nonsmoker Lungs

Your lungs look worse than 57% of smokers.

10009Y_Njc_Copd, you have an excellent opportunity to quit smoking now, before things get worse:

Because of your lung health and smoking status you are up to...

3%	2%	4x	2x
more likely to die in the next 6 years [1]	more likely to be diagnosed with lung cancer in 5 years.[1]	more likely to have a heart attack than a nonsmoker.[2]	more likely to have a stroke than a nonsmoker.[2]

10009Y_Njc_Copd, your body starts healing the minute you quit smoking.

20 MINUTES	12 HOURS	2 WEEKS - 3 MONTHS	1 YEAR	5 YEARS	10 YEARS
Your blood pressure and heart rate drop.[3]	Carbon monoxide levels in your blood drops to normal.[3]	Your circulation and lung function improve.[3]	Your risk of coronary heart disease and heart attack drops significantly.[3]	Your risk of stroke can fall to that of a nonsmoker.[3]	Your risk of dying from lung cancer is about half that of a smoker.[3]

HELP

**QUITTING CAN BE VERY DIFFICULT,
BUT PEOPLE WHO KEEP TRYING ARE VERY LIKELY TO SUCCEED.
PLEASE CALL 444-555-8888.**

We want to support you no matter how many times you have tried to quit in the past. It is never too late to improve your health by quitting smoking. At the number above, you will find someone ready to listen to you and connect you with smoking cessation counseling, nicotine replacement products, and prescription non-nicotine medications.

[1] ENTER CITATION HERE
[2] ENTER CITATION HERE
[3] ENTER CITATION HERE

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ELSEVIER

Lung Cancer
Volume 77, Issue 1, July 2012, Pages 58-63

Emphysema detected on computed tomography and risk of lung cancer: A systematic review and meta-analysis

Benjamin M. Smith [a], Lancelot Pinto [a], Nicole Ezer [a], Nicola Sverzellati [b], Shigeo Muro [c], Kevin Schwartzman [a]

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"Systematic literature review shows emphysema detected visually on CT to be independently associated with increased odds of lung cancer. This association **did not hold with automated emphysema detection**."

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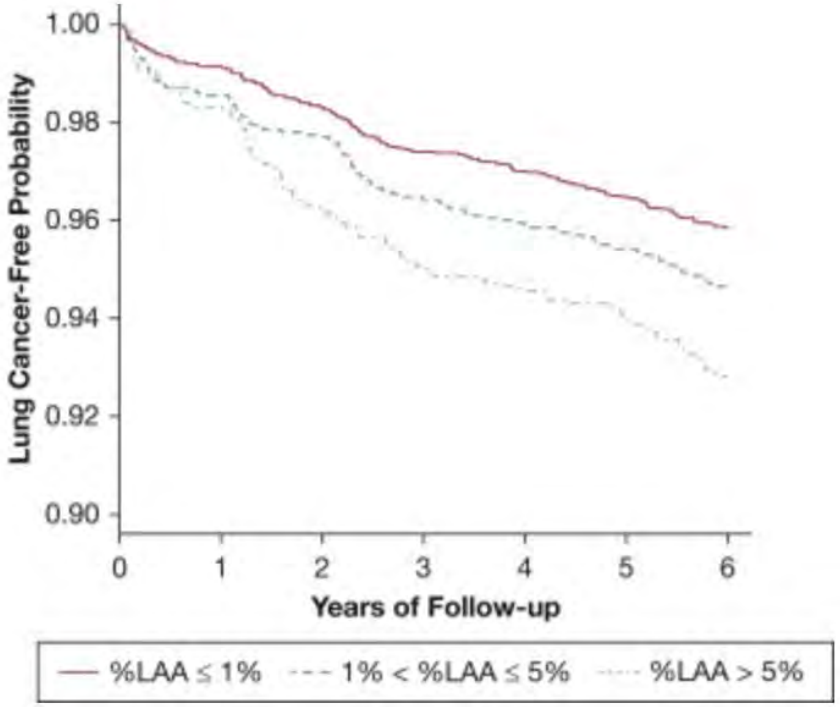
CHEST
Volume 159, Issue 5, May 2021, Pages 1812-1820

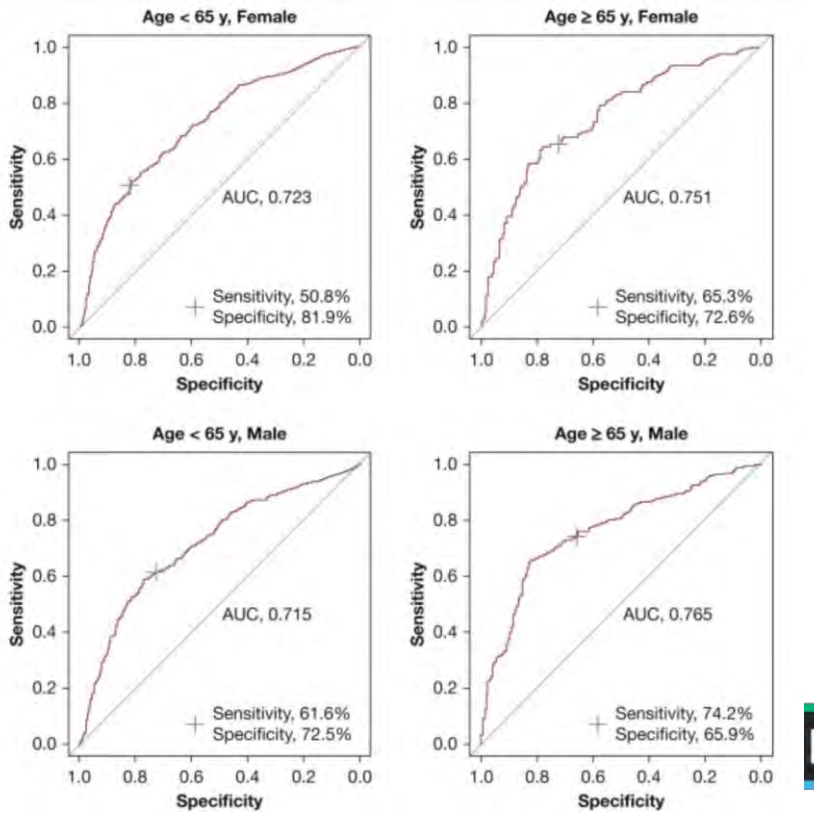
COPD: Original Research

Quantitative Emphysema on Low-Dose CT Imaging of the Chest and Risk of Lung Cancer and Airflow Obstruction: An Analysis of the National Lung Screening Trial

Part of this article has been presented in abstract form at the 2018 American Thoracic Society International Conference, May 18-23, 2018, San Diego, CA.

Wassim W. Labaki MD [a], Meng Xia PhD [b], Susan Murray ScD [b], Charles R. Hatt PhD [d], Abdullah Al-Abcha MD [e], Michael C. Ferrera MD [a], Catherine A. Meldrum PhD, RN [a], Lauren A. Keith PhD [d], Craig J. Galbán PhD [c], Douglas A. Arenberg MD [a], Jeffrey L. Curtis MD [a, f], Fernando J. Martinez MD [a, g], Ella A. Kazerooni MD [c], MeiLan K. Han MD [a]





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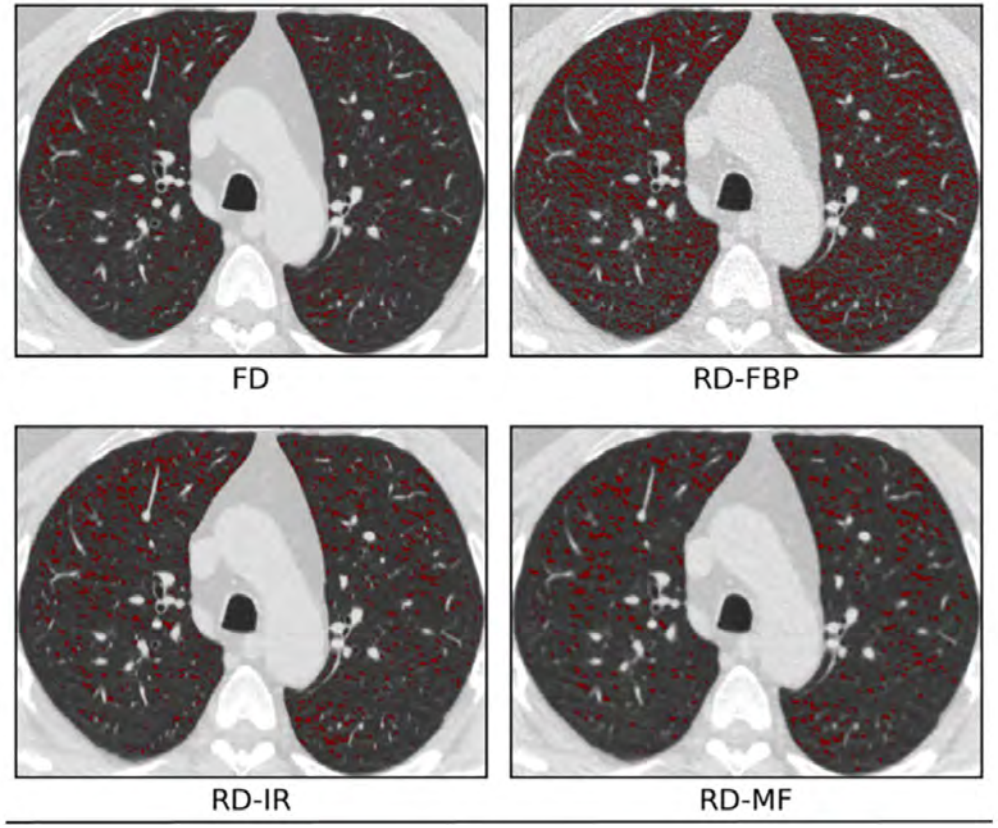
Original Research
Pulmonary Imaging

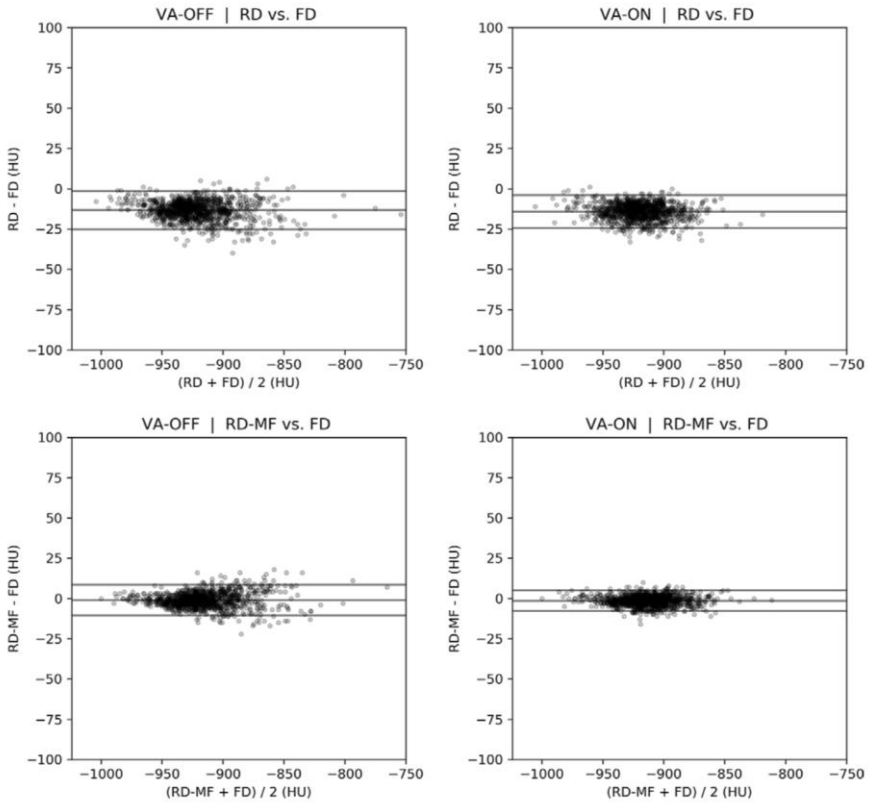
Comparison of CT Lung Density Measurements between Standard Full-Dose and Reduced-Dose Protocols

Charles R. Hatt, Andrea S. Oh, Nancy A. Obuchowski, Jean-Paul Charbonnier, David A. Lynch, Stephen M. Humphries

Author Affiliations



- LDCT lung density measurements can easily be harmonized with standard dose measurements
- Ability of lung density to predict COPD and exacerbations is not diminished with LDCT.



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PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Normalized emphysema scores on low dose CT: Validation as an imaging biomarker for mortality

Leticia Gallardo-Estrella, Esther Pompe, Pim A. de Jong, Colin Jacobs, Eva M. van Rikxoort, Matthias Prokop, Clara I. Sánchez, Bram van Ginneken

Published: December 11, 2017 • https://doi.org/10.1371/journal.pone.0188902

Article | Authors | Metrics | Comments | Media Coverage

Normalizing computed tomography data reconstructed with different filter kernels: effect on emphysema quantification.

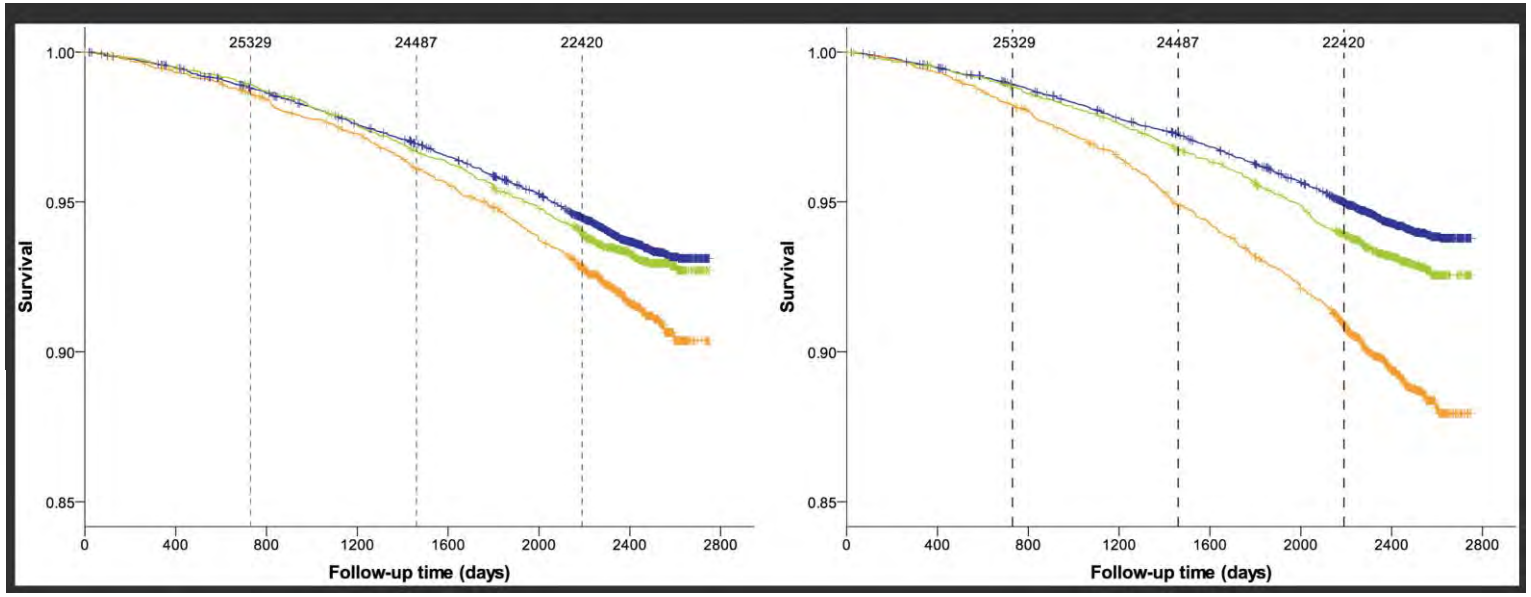
Gallardo-Estrella L[1], Lynch DA[2], Prokop M[1], Stinson D[2], Zach J[2], Judy PF[3], van Ginneken B[1], van Rikxoort EM[1]

Author information

European Radiology, 23 May 2015, 26(2):478-486

DOI: 10.1007/s00330-015-3824-y PMID: 26002132 PMCID: PMC4712239

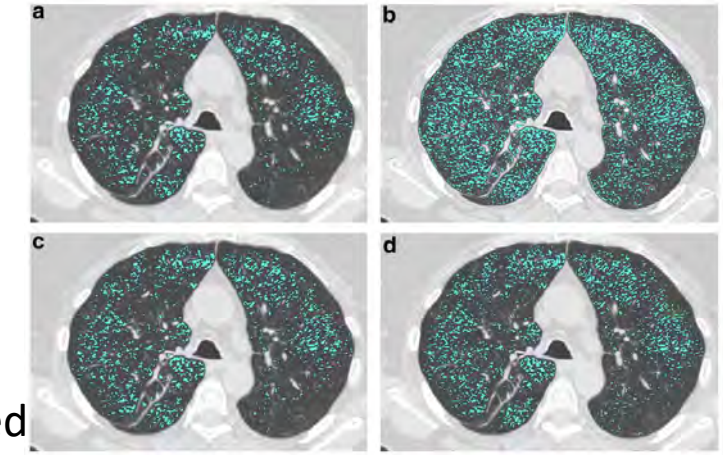
Free to read & use

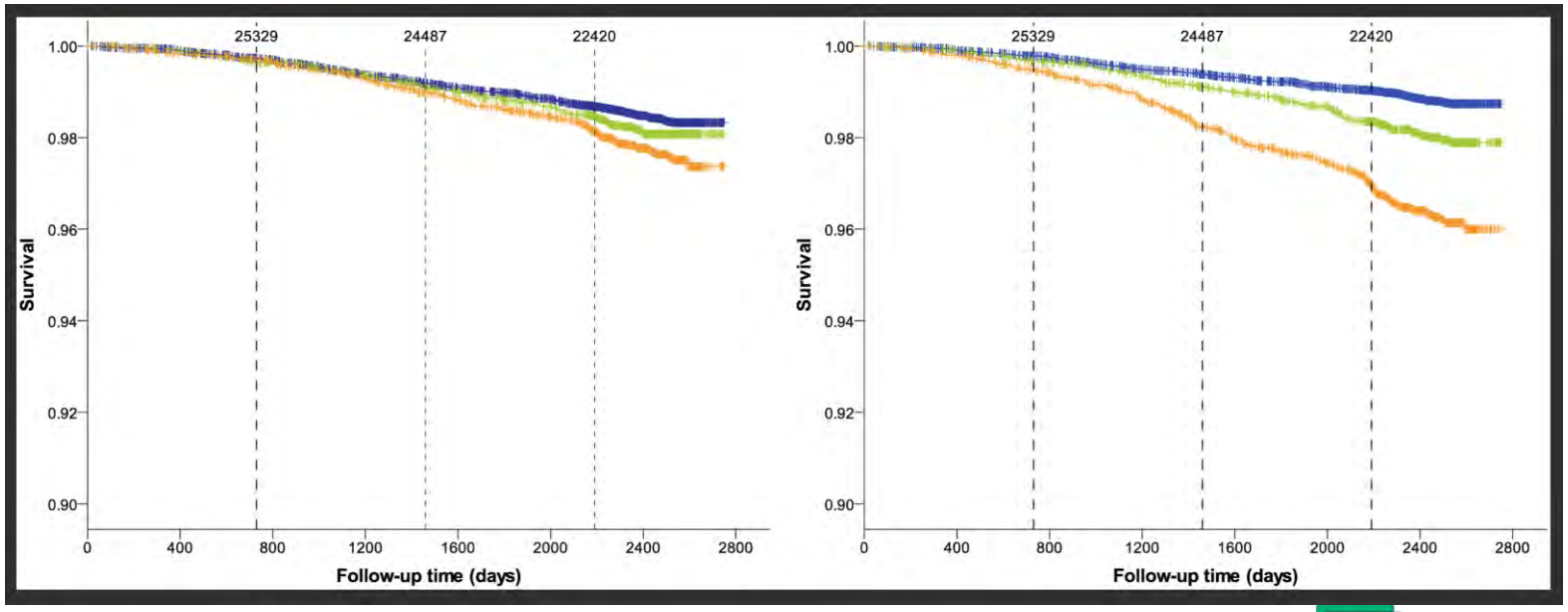


All-cause mortality

Raw

Normalized





Lung cancer mortality

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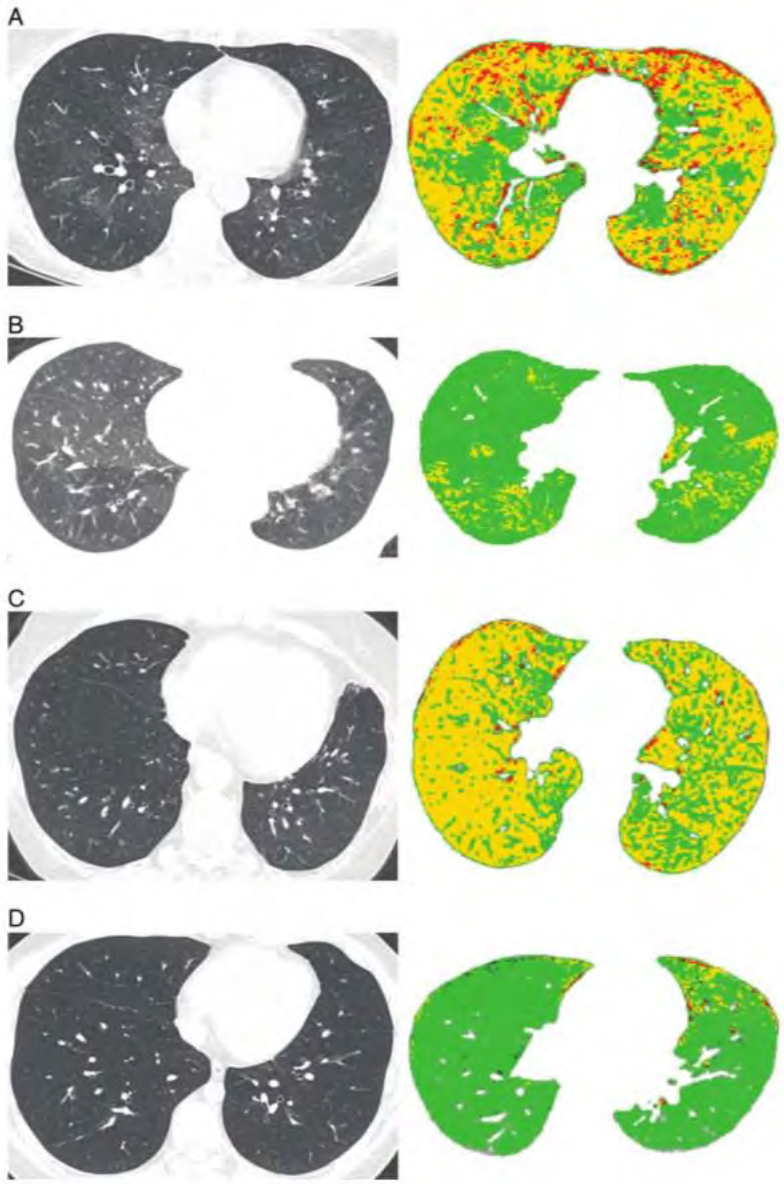

Head-to-head Comparison of Qualitative Radiologist Assessment With Automated Quantitative Computed Tomography Analysis for Bronchiolitis Obliterans Syndrome After Hematopoietic Cell Transplantation

Husham Sharifi, MD, MS, Zachary D. Guenther, MD,† Ann N.C. Leung, MD,† Laura Johnston, MD,‡ Yu K. Lai, MD,* Joe L. Hsu, MD, MPH,* and H. Henry Guo, MD, PhD†*

TABLE 4. Diagnostic Performance for Consensus Radiologist Interpretation for the Diagnosis of BOS*

	Inspiratory Phase	Inspiratory+Expiratory Phase	Inspiratory+Expiratory Phase+PRM	Air Trapping ≥28%
Sensitivity	0.80	0.92	0.92	0.56
Specificity	0.69	0.59	0.73	0.94
PPV	0.56	0.52	0.62	0.82
NPV	0.88	0.94	0.95	0.81
Accuracy	0.72	0.70	0.79	0.82
AUC (95% CI)	0.74 (0.64-0.85)	0.75 (0.67-0.84)	0.83 (0.74-0.91)	0.75 (0.65-0.86)

*N = 76.
CI indicates confidence interval; NPV, negative predictive value; PPV, positive predictive value.

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StratX ™ Lung Report

pulmonX

Patient ID	219	Upload Date	Dec. 28, 2020
Scan ID	73.310	Report Date	Dec. 29, 2020
CT Scan Date	Dec. 18, 2020	Scan Comments	None

SUMMARY

KEY

- ≥ 70% Voxel Density Less Than -910 HU
- ≥ 60 – < 70% Voxel Density Less Than -910 HU
- ≥ 50 – < 60% Voxel Density Less Than -910 HU
- < 50% Voxel Density Less Than -910 HU
- ≥ 95% Fissure Completeness
- ≥ 80 – < 95% Fissure Completeness
- < 80% Fissure Completeness

RESULTS

	RIGHT LUNG				LEFT LUNG	
	RUL	RUL+RML	RML	RLL	LUL	LLL
% Fissure Completeness	67	84	63	84	98	98
% Voxel Density Less Than -910 HU	63	59	48	44	51	65
% Voxel Density Less Than -950 HU	38	34	20	21	24	36
Inspiratory Volume (ml)	1690	2179	489	841	1409	1530

OLYMPUS®

SeleCT REPORT

Report Date: March 4, 2021

PATIENT NAME:	PATIENT ID:	SCAN ID:	STUDY DATE:	ORDER DATE:
JHIIntNAkQjvMhQo	ZSCP8CM	22234237	December 18, 2020	March 4, 2021

EMPHYSEMA SCALE[1]

- >60%
- 40-60%
- <40%

FISSURE COMPLETENESS

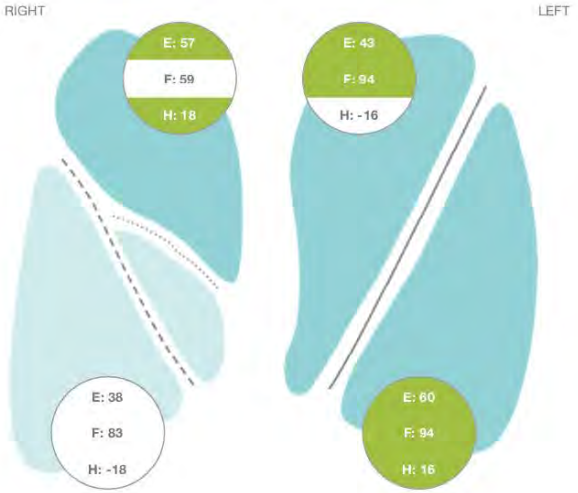
- ≥90%
- 89-80%
- <80%

VALUE KEY

- **E** Emphysema
- **F** Fissure Integrity
- **H** Heterogeneity

EMPROVE INCLUSION CRITERIA[1]

- Meets
- Does Not Meet



	EMPROVE THRESHOLDS[1]	RUL	RML	RLL	LUL	LLL
EMPHYSEMA (%)	≥40%	57	38	38	43	60
FISSURE SCORE (%)	≥90%	59	NA	83	94	94
HETEROGENEITY (%)	≥10%	18	NA	-18	-16	16
VOLUME (cc)	–	1756	405	835	1425	1505

Job Name: 3529926_rerun_reviewed_1

Disclaimer: This report should not be considered a complete radiological analysis.

Analysis by Imbio

[1] Criner GJ et al., 2019 Improving Lung Function in Severe Heterogeneous Emphysema with the Spiration® Valve System (EMPROVE): A multicenter, Open-Label, Randomized, Controlled Trial. Am J Respir Crit Care Med, 2019.

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Questions for panelists

- How can we accommodate Radiologist preference in scanning parameters while maintaining standards for quantitative protocol requirements?
- What are the clinical application targets of a combined CT image acquisition protocol for COPD and Lung Cancer?
- What studies will be necessary to demonstrate effectiveness of a combined protocol?
  - How do we move beyond statistically significant associations between biomarkers and disease, and demonstrate concrete examples how the biomarkers can be used clinically?
- Do we have enough data to support the role and impact of doing expiratory imaging in LCS?
- What is the best way to disseminate and achieve acceptance of such a document?