

^{129}Xe MRI Ventilation Texture Features and Machine Learning to Predict Response to ICS/LAMA/LABA in Moderate Asthma

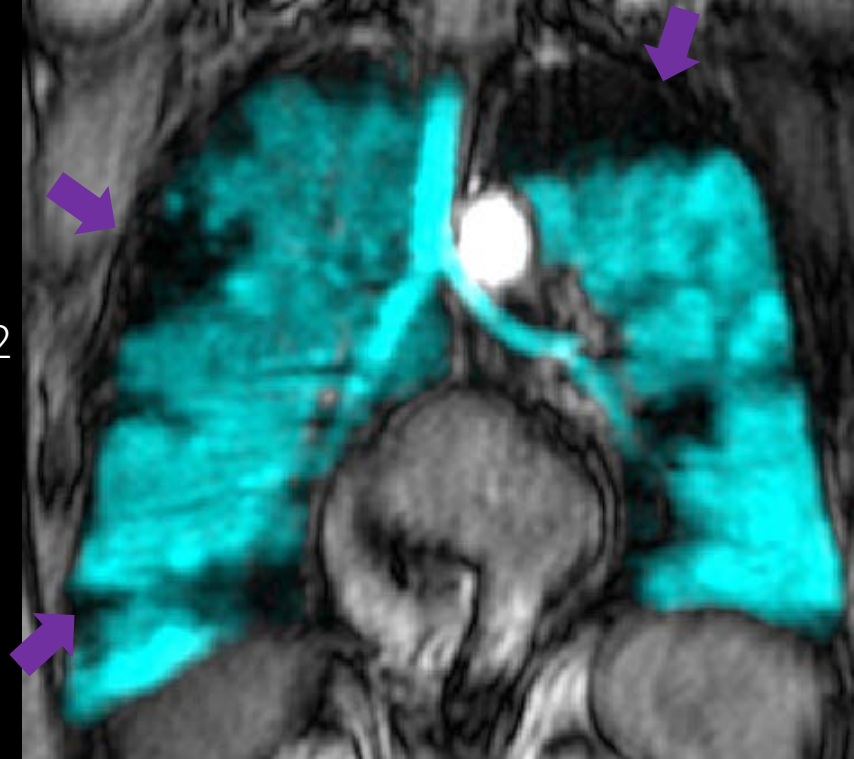
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Hyperpolarized ^{129}Xe MRI Ventilation Abnormalities

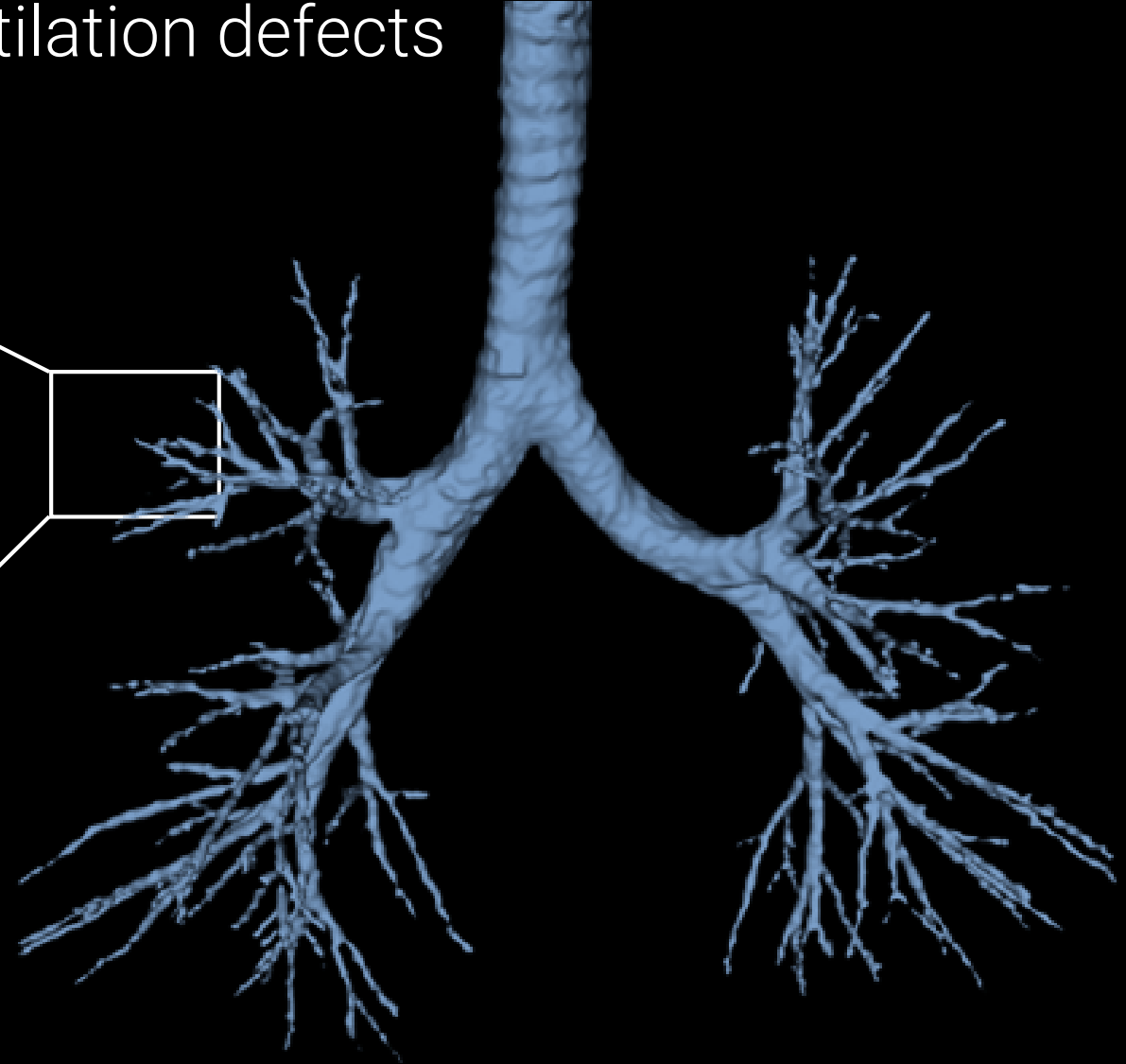
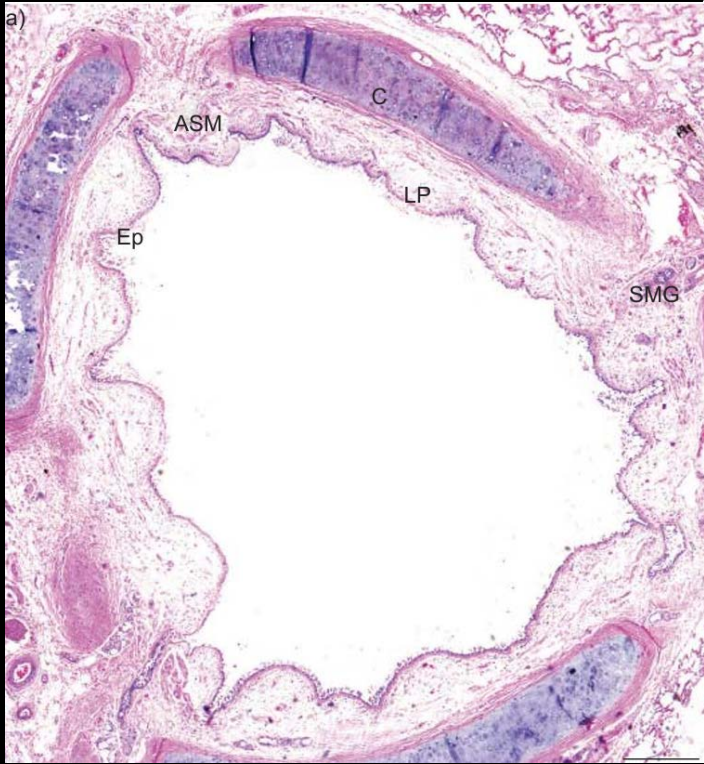
- First identified in 1994 as signal voids¹
- Wedge-shaped ventilation defects reflect segmental and subsegmental airway dysfunction²
- Quantified as Ventilation Defect Percent (VDP)³
- Reproducible⁴ and persistent over months to years⁵
- In asthma, improve with short-acting bronchodilator² corticosteroid and biologic therapy^{6,7}
- Worsen with methacholine and exercise challenge⁸
- Spatially and quantitatively related to airway mucus⁹, narrowed airway lumen and thickened airway walls¹⁰



Airway Remodeling and Dysfunction in Asthma

Smooth muscle dysfunction and chronic airway inflammation lead to airway dysfunction and MRI ventilation defects

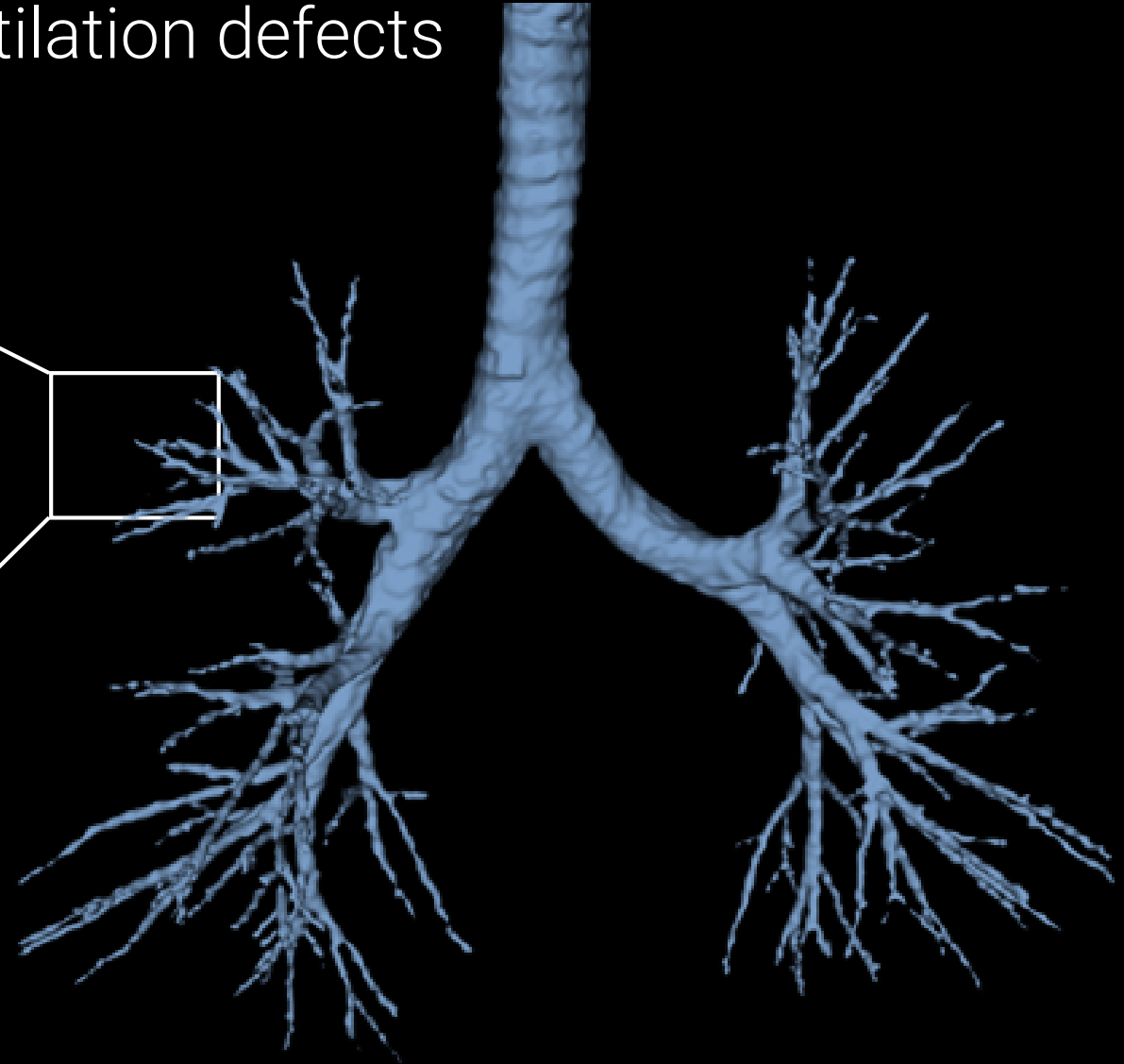
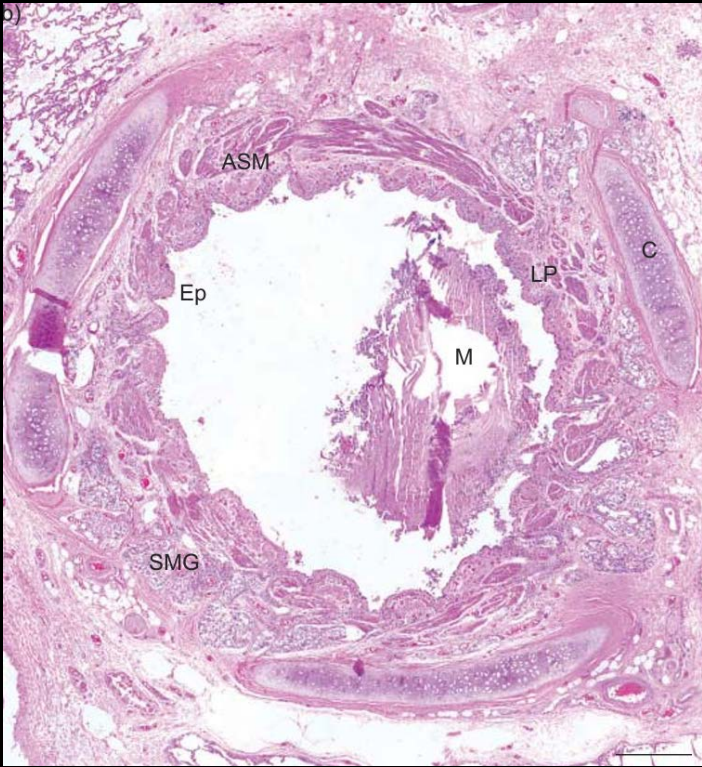
Healthy



Airway Remodeling and Dysfunction in Asthma

Smooth muscle dysfunction and chronic airway inflammation lead to airway dysfunction and MRI ventilation defects

Asthma



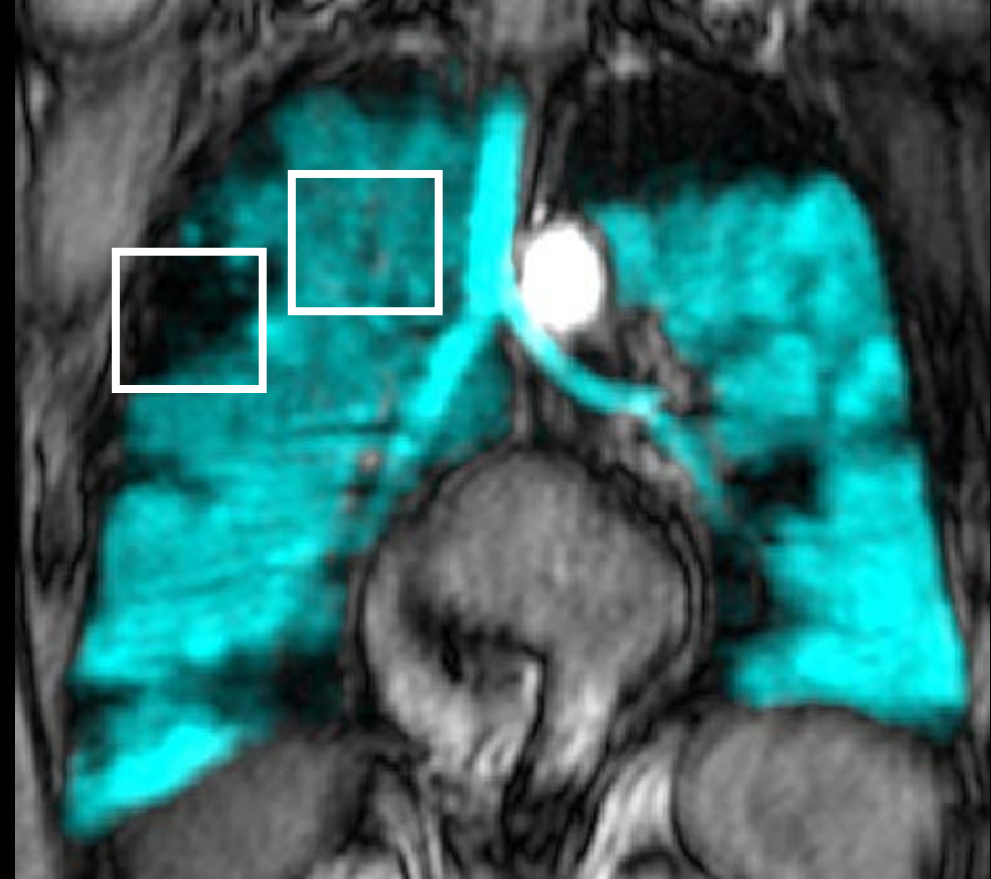
^{129}Xe MRI Ventilation Defects in Asthma

- Progression towards severe asthma results in fine “patchy” ventilation heterogeneity

Subsegmental ventilation defect

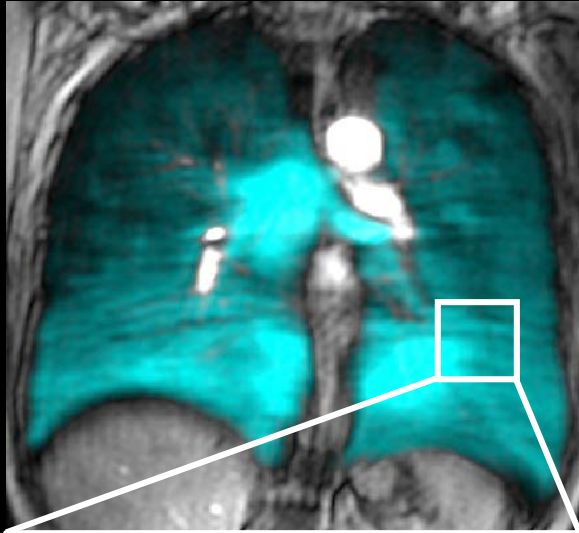


Patchy ventilation abnormalities

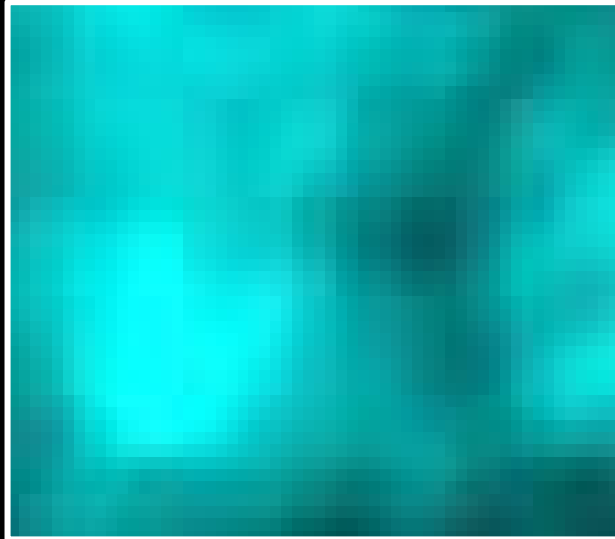
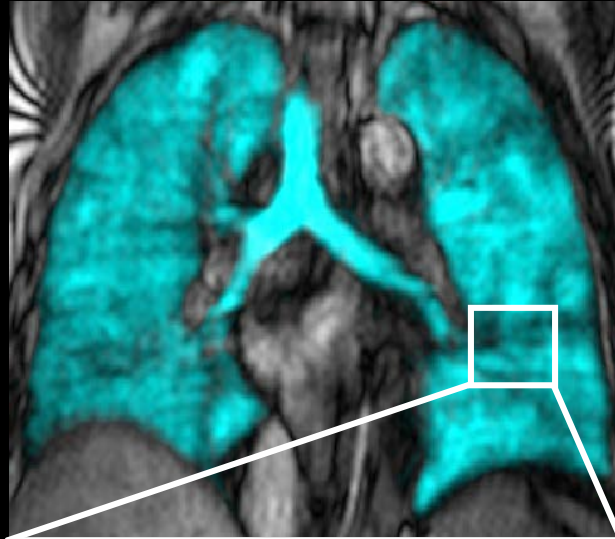


^{129}Xe MRI Ventilation Patterns

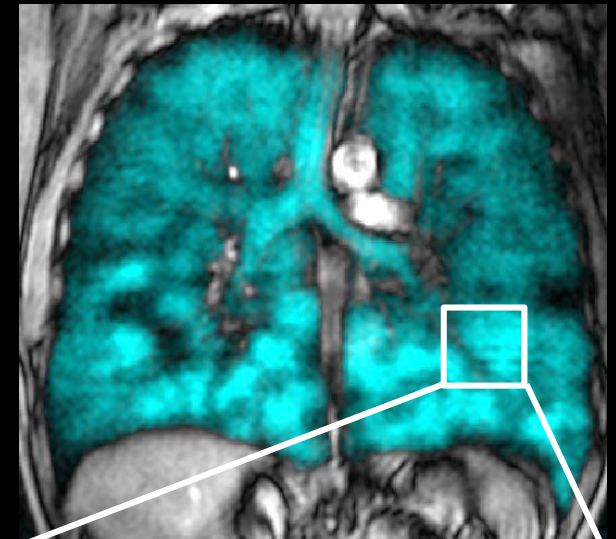
VDP = 4%



VDP = 4%



VDP = 4%



INCREASING VENTILATION HETEROGENEITY but same VDP!

^{129}Xe MRI Ventilation Defects Response to Rx

- 31 moderate-severe asthma patients on guideline-based inhaled corticosteroid/long-acting beta-agonist Rx.
- Monitor ^{129}Xe MRI VDP response to 6 weeks inhaled corticosteroid and long-acting beta-agonist + long-acting muscarinic-antagonist

Parameter Mean (SD)	Visit 1 (n=28)	Visit 2 (n=28)	p
Age years	55 (15)	-	-
BMI kg/m ²	30 (7)	-	-
Female n(%)	21 (75)	-	-
Eos cells/ μL	360 (250)	-	-
Pre-BD FEV ₁ L	2.1 (0.7)	2.3 (0.8)	.04
Pre-BD RV/TLC %	43 (8)	42 (12)	>.99
Pre-BD R ₅₋₁₉ cm H ₂ O sec/L	1.9 (1.0)	1.1 (0.8)	.002
FeNO ppb	36 (40)	29 (17)	.4
ACQ-6	2.0 (1.0)	1.4 (1.3)	.04
AQLQ	4.5 (1.2)	5.4 (1.2)	.02

^{129}Xe MRI Ventilation Defects Response to Rx

- 31 moderate-severe asthma patients on guideline-based inhaled corticosteroid/long-acting beta-agonist Rx.

New Opportunity

Use machine learning to develop novel ventilation textures which capture intensity and spatial information and quantify patchy ventilation and its improvement post-Rx

Female n(%)

21 (75)

-

-

Hypothesis

Machine-learning models trained on ^{129}Xe MRI ventilation texture features will predict clinically-relevant changes of $\text{FEV}_1 \geq 230\text{mL}$ in asthma after 6-weeks novel Rx.

ACQ-6

2.0 (1.0)

1.4 (1.3)

.04

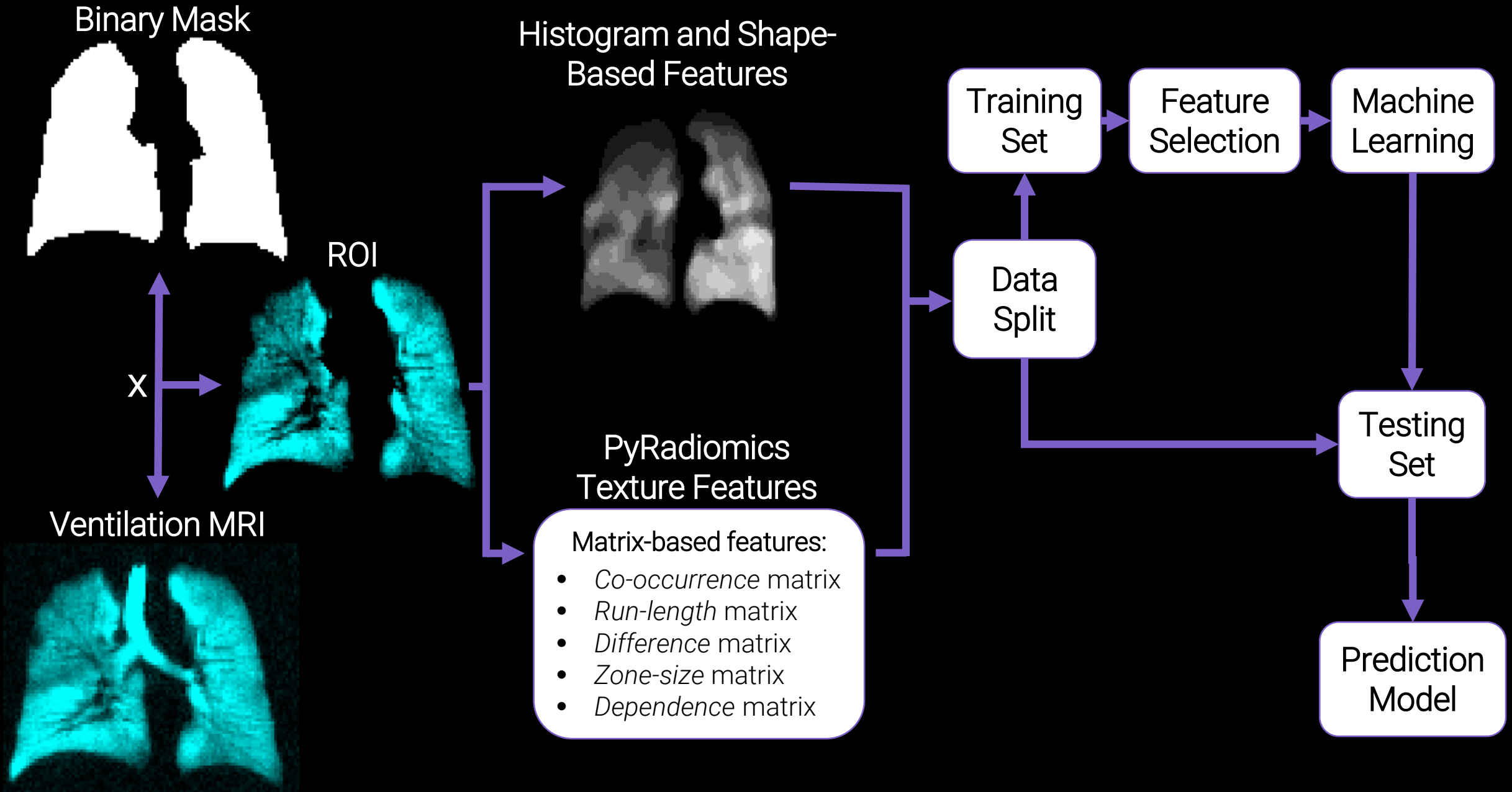
AQLQ

4.5 (1.2)

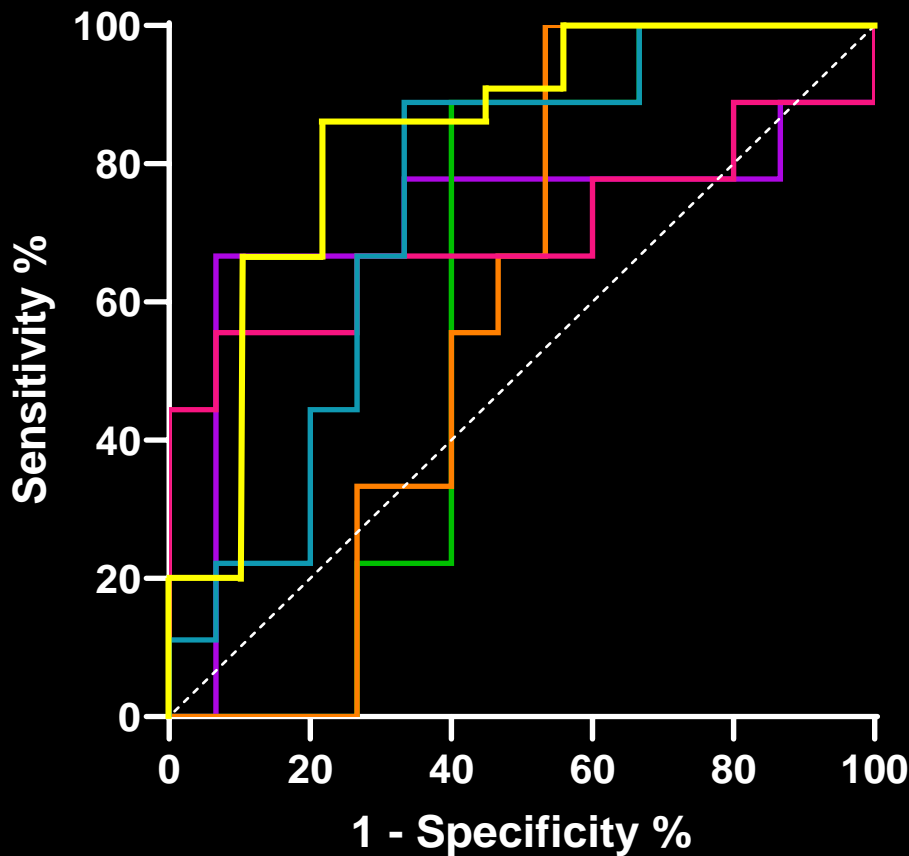
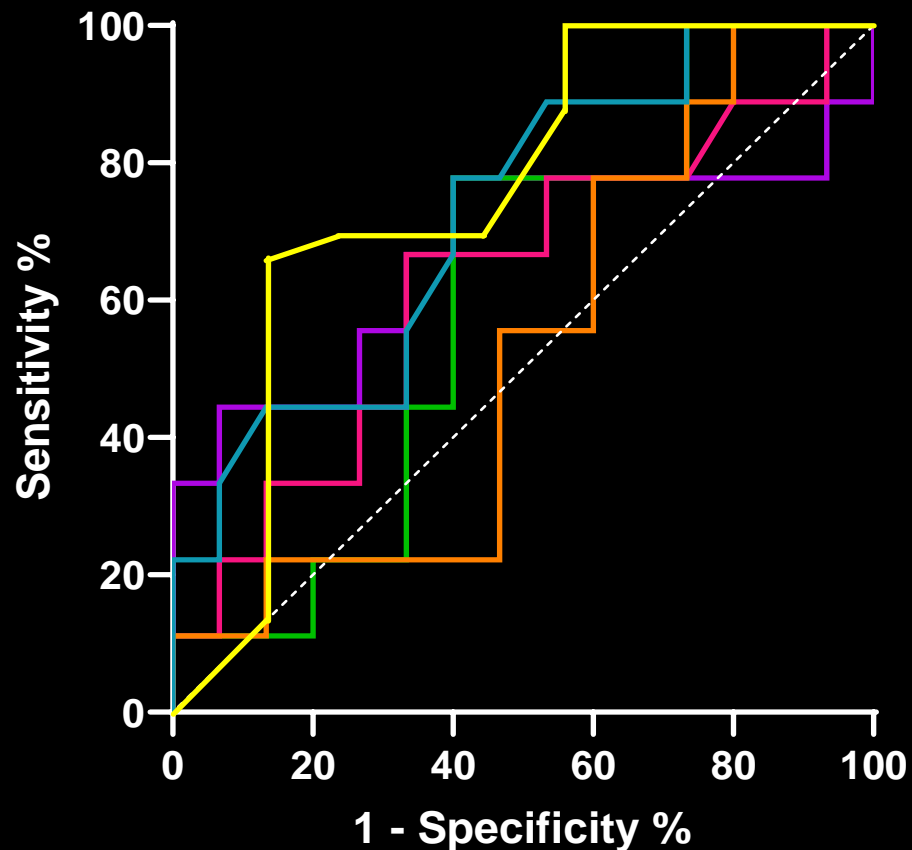
5.4 (1.2)

.02

Texture Analysis Pipeline



Comparison of Clinical and Texture Models



- Ensemble Subspace KNN AUC=0.78
- FeNO (AUC=0.72) Accuracy=70.8%
- BMI (AUC=0.67)
- R₅₋₁₉ (AUC=0.63)
- SGRQ (AUC=.61)
- LCI (AUC=0.53)

- Medium Guassian SVM Model AUC=0.84
- NGTDM Strength (AUC=0.74) Accuracy=77.4%
- NGTDM Coarseness (AUC=0.71)
- OS Maximum 3D Diameter (AUC=0.70)
- FO Median (AUC=0.60)
- FO Kurtosis (AUC=0.59)

Comparison of Clinical and Texture Models

- Top performing texture feature (NGTDM Strength AUC=0.74) outperformed top clinical measurement (FeNO AUC=0.72)
- General trend of texture features outperforming clinical features
 - Texture feature Boruta rankings: 1, 2, 3, 9, 26
 - Clinical feature Boruta rankings: 11, 22, 23, 33, 53

Model	AUC	Accuracy (%)	Sensitivity (%)	Specificity (%)
<i>Texture Based Model</i>				
Medium Gaussian SVM	0.84	77.8	86.7	83.3
<i>Clinical Based Model</i>				
Ensemble Subspace KNN	0.78	70.8	86.7	44.4

Limitations, Conclusions and Future Work

- Individual MRI textures outperformed clinical features
 - Best clinical features ranked 11 and 22 of 169 features

Limitations and Future work:

- Sample size
- External validation and standardization of feature analysis
- Incorporation of quantitative CT features

¹²⁹Xe MRI texture features identified asthma patients who rapidly responded to novel Rx and models with significantly improved sensitivity, specificity and accuracy compared to clinical models and features



Thank You!

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