AI-Automated Detection of Hypertrophic Cardiomyopathy by Echocardiography

Training and External Validation

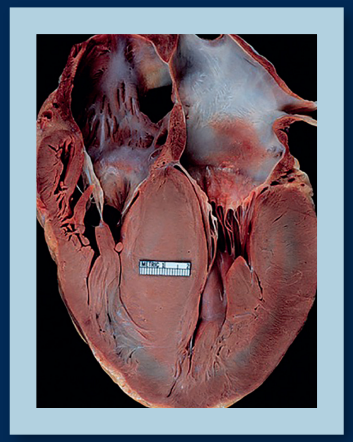
Fawaz Alenezi, MD, MSc, FAHA, FACC, FASE
Associate Professor of Medicine
Duke Heart Center

DukeHealth

HCM- Background

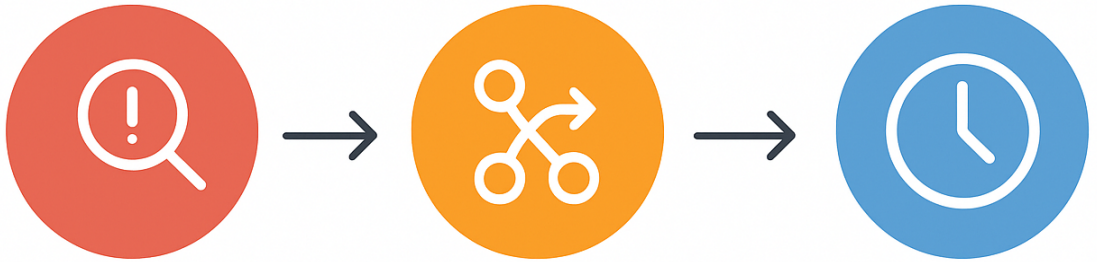
- Unexplained LV hypertrophy (≥15 mm wall thickness in end diastole) in the absence of another disease capable of producing the magnitude of increased wall thickness.
- Affects between 1 in 200 to 1 in 500 people in general population.
- Very heterogeneous phenotypic and diverse natural history.
- Most common cause of SCD in the young.
- Manageable disease, yet largely underdiagnosed.

The Challenge in Hypertrophic Cardiomyopathy



80% of patients with HCM are undiagnosed

Challenges in HCM Diagnosis and Care



Missed Detection

4 misdiagnoses recorded

Poor Care Coordination

5 visits indicating fragmented or repeated care

Delayed Diagnosis

5-year delay from initial presentation to correct diagnosis

Maron B. et al (2022) JACC, Naidu S. et al 2023 Journal of Medical Economics

Methods - HCM Detection Model

HCM Detection Model

- Developed using **1,472 HCM patients and 7,292 matched controls** at Duke University Medical Center.
- Processed with FDA- and CE-marked AI software (Us2.ai, Singapore) for automated view classification and cardiac cycle segmentation; only **A4C and PLAX views** were used.

Internal Testing

- Evaluated in training subset: **818 HCM cases, 3470 controls**
- Evaluated in testing subset: **86 HCM cases, 745 controls**

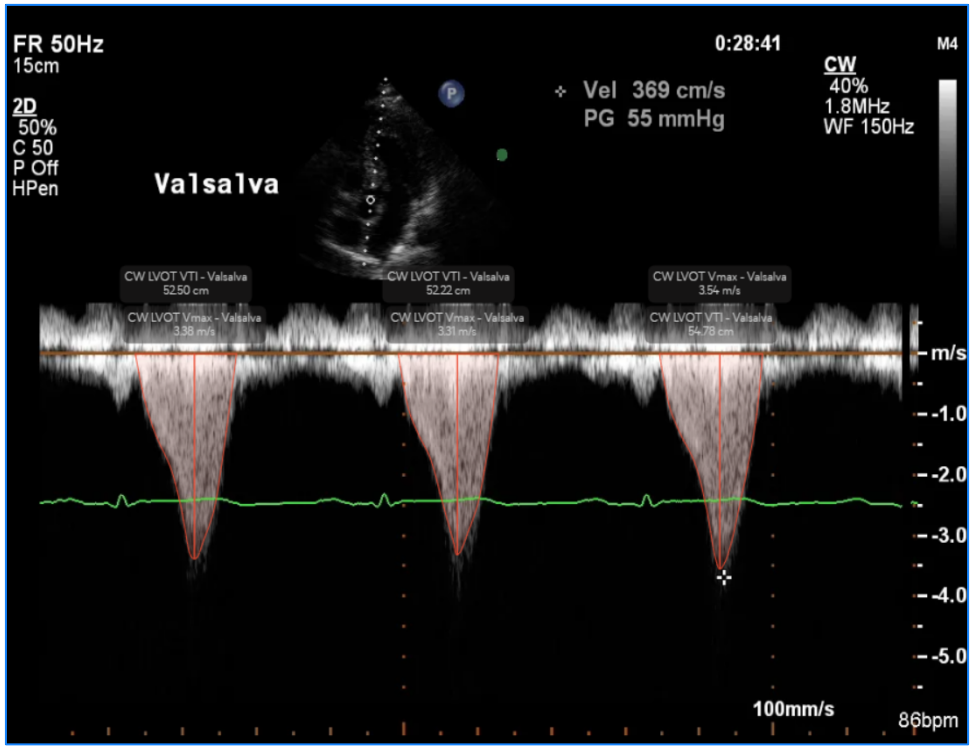
External Validation

- **94 HCM and 351 non-HCM LV hypertrophy controls** from the National Cerebral & Cardiovascular Center, Japan:
- Aortic stenosis: 87; Hypertensive heart disease: 81; Cardiac amyloidosis: 183

Methods - HOCM Gradients Model

HOCM Gradients Model

- Developed using **408 HCM patients** from Brigham CV and Imaging Core Laboratory.
- Processed with Us2.ai for automated Doppler view classification and Valsalva detection.
- Only **CW LVOT, CW Apical, and CW Mid-Ventricular** views were used.
- Generated CW VTI segmentation masks to calculate peak gradients (Pmax).



External Validation

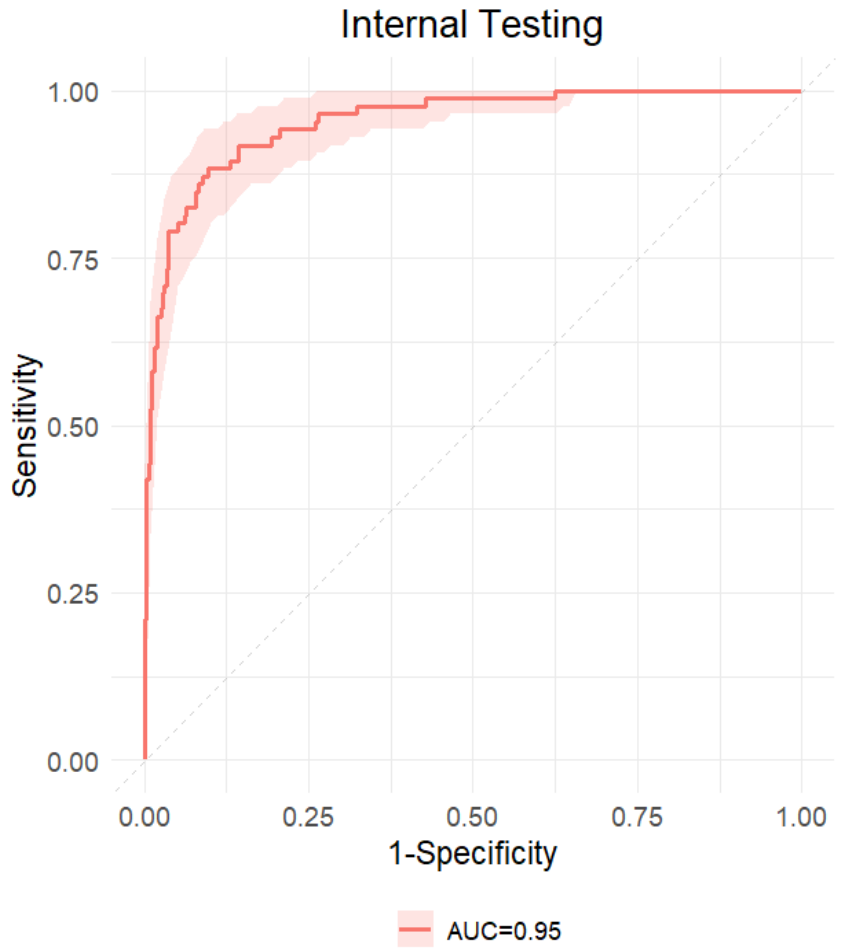
- AI-derived gradients compared with ground-truth rest and provocation values from clinical reports of **712 HCM patients** at Duke University Medical Center.

Results - HCM Detection Model

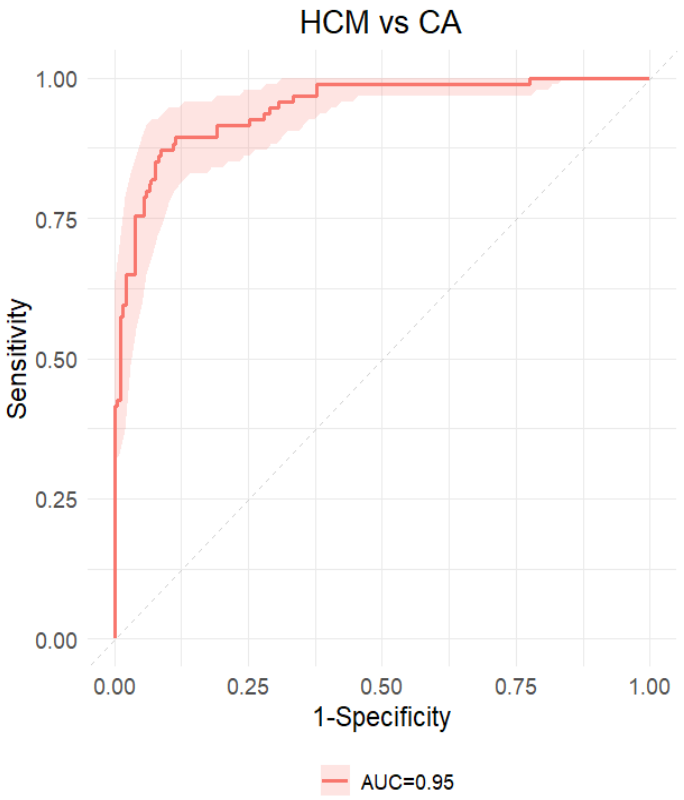
	Training subset (N = 4288)	Internal Testing (N = 831)	External Validation with Phenocopy Controls (N = 445)
Accuracy	99.6%	93.4%	82.5%
Sensitivity (95% CI)	98.9% (98.2, 99.6)	**80.2%** (71.8, 88.7)	79.8% (71.7, 87.9)
Specificity (95% CI)	99.7% (99.6, 99.9)	**94.9%** (93.3, 96.5)	83.2% (79.3, 87.1)
AUC (95% CI)	1.00 (0.996, 1.00)	**0.95** (0.93, 0.98)	0.90 (0.86, 0.93)
PPV at 0.5% prevalence (95% CI)	65.7% (50.3, 77.7)	7.3% (5.4, 10.0)	2.3% (1.8, 3.0)
NPV (95% CI)	100% (100, 100)	99.9% (99.8, 99.9)	99.9% (99.8, 99.9)

Results - HCM Detection Model

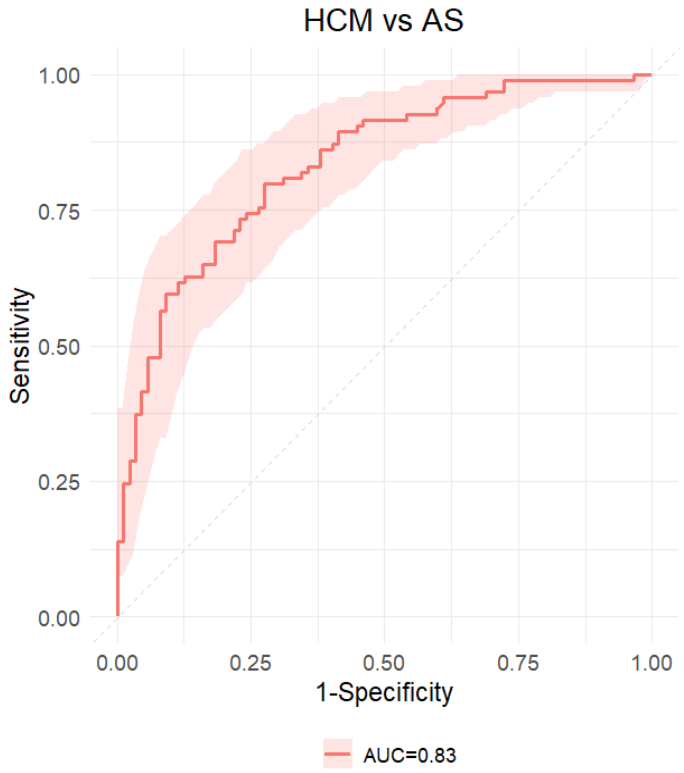
Model achieved AUC=0.95 on the **internal testing set**, indicating excellent discrimination between HCM and non-HCM cases.



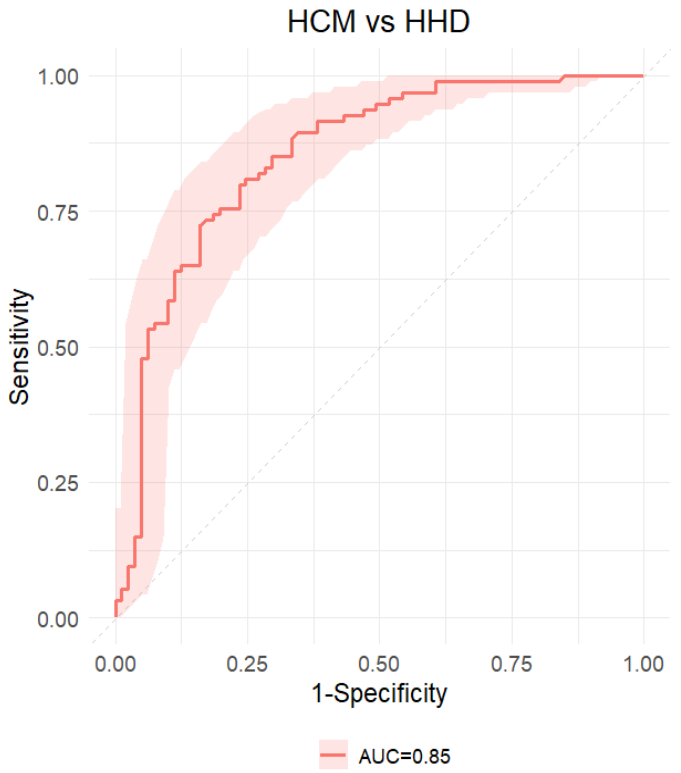
Results - HCM Detection Model



Sensitivity: 80%
Specificity: 93%



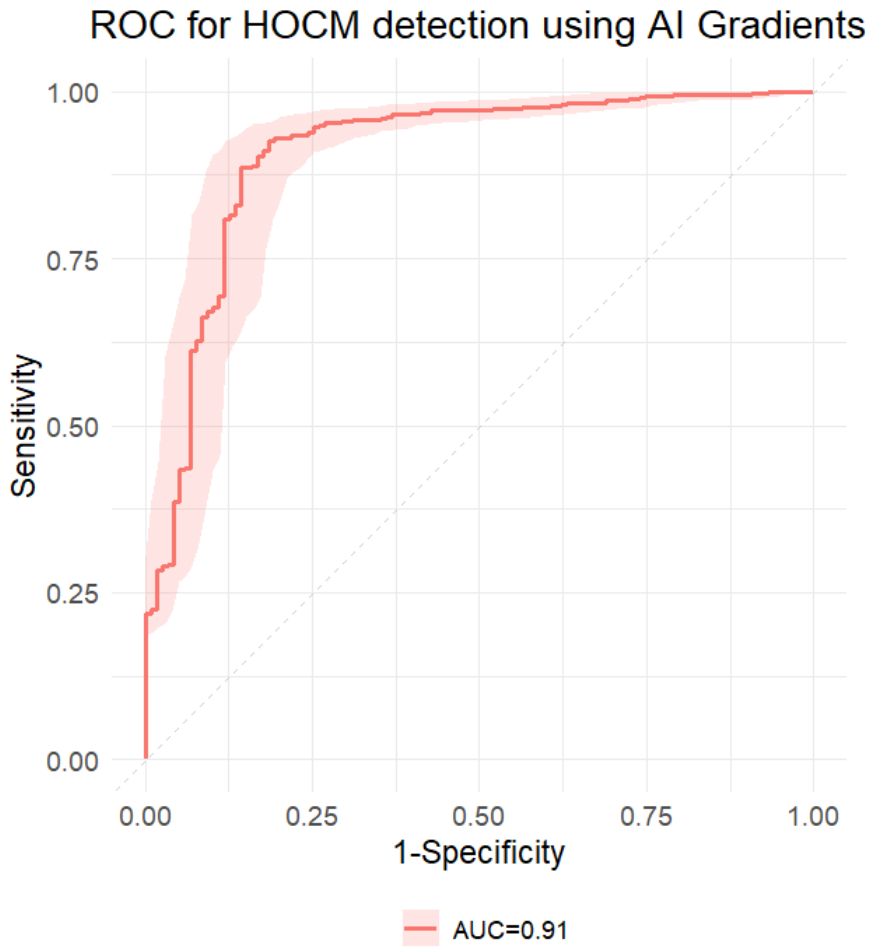
Sensitivity: 80%
Specificity: 69%



Sensitivity: 80%
Specificity: 75%

Results - HOCM Gradients Model

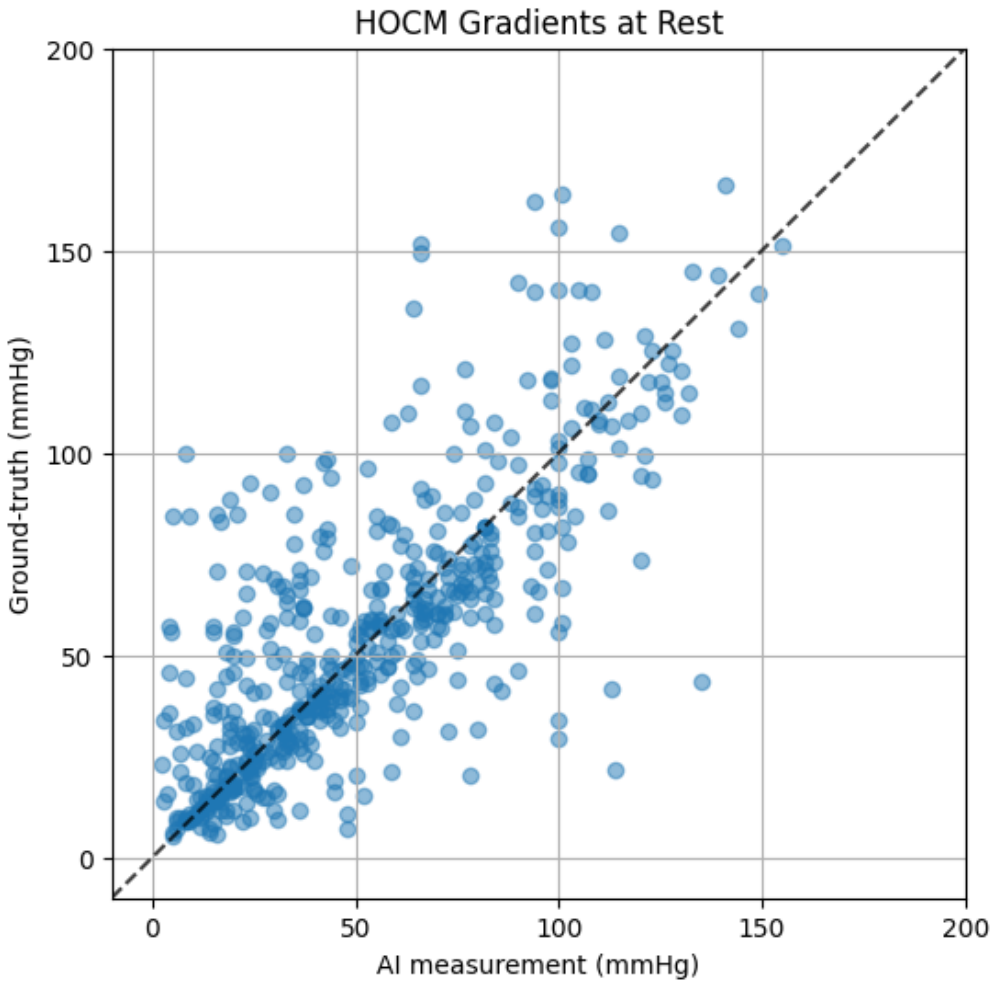
- Results are external validation on Duke dataset
- Obstruction detection was evaluated using automated gradient measurements
- Used ≥30 mmHg cut off as per the 2024 AHA/ ACC HCM Guideline.
- Performance for detecting obstruction in the HCM cohort of external validation dataset:
  - **Sensitivity: 91%**
  - **Specificity: 82%**
  - **AUROC: 0.91**

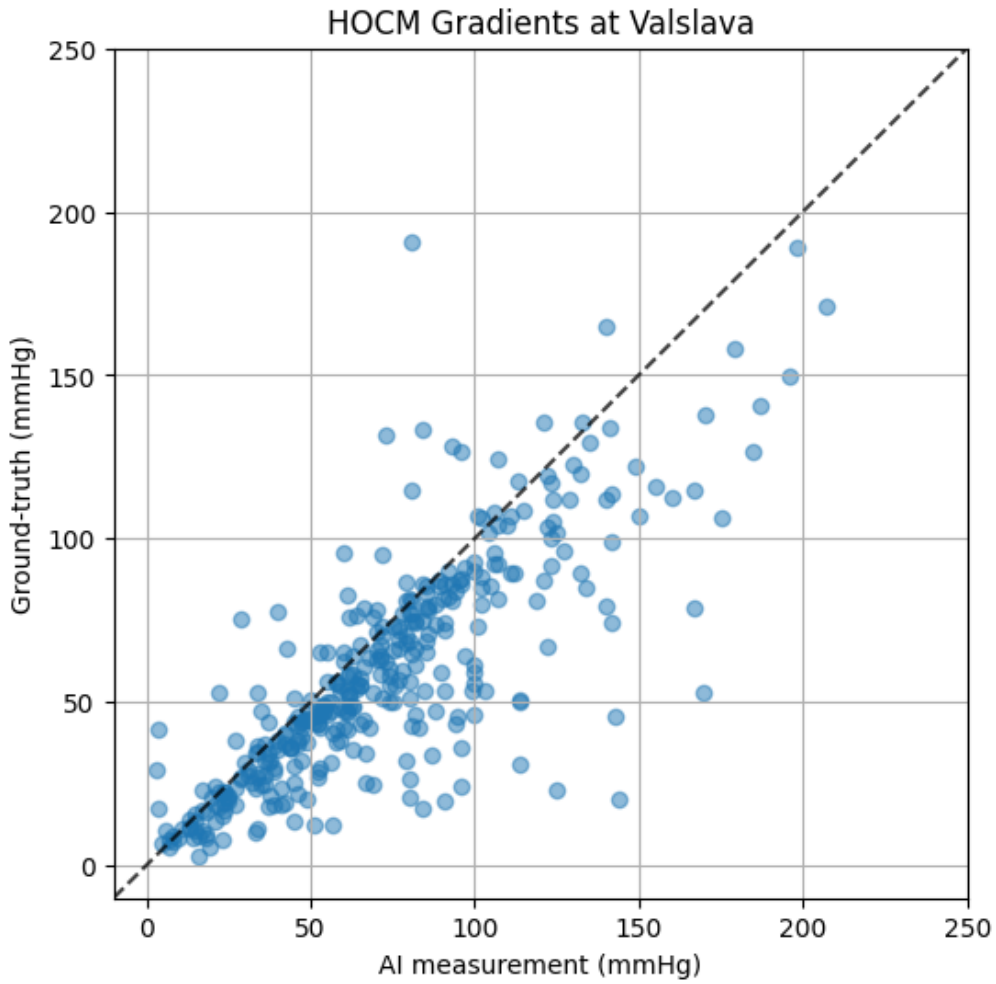


Results - HOCM Gradients Model

	External Validation		
	CW Gradient at Rest (N=643)	CW Gradient at Valsalva (N=453)	All (N=1096)
ICC (95% CI)	0.76 (0.72, 0.80)	0.75 (0.7, 0.79)	0.76 (0.72, 0.79)
Mean Absolute Error (MAE, mmHg)	15.3	17.8	16.3
Correlation	0.77	0.80	0.77
Yield	81.5%	78.8%	80.4%

Results - HOCM Gradients Model





Conclusion

- The AI model accurately detected HCM from routine TTE, with AUCs of 0.95 internally and 0.90 externally.
- Performance was consistent across wall thickness subgroups, including subtle cases.
- The model differentiated HCM from phenocopies (amyloidosis, HTN, AS) with high accuracy.
- Automated gradient analysis enabled obstruction detection with sensitivity 91%, specificity 82%, and AUROC 0.91.

Acknowledgements

Fawaz Alenezi[1], Takeshi Kitai[2], Jonathan W. Cunningham[3], Hicham Skali[3], Wendy Wang[3], Sze Chi Lim[4], Matthew Frost[4], Carolyn S.P. Lam[5], Sreekanth Vemulapalli[1]

(1) Duke University Medical Center, Durham, United States of America (2) National Cerebral and Cardiovascular Center, Department of Heart Failure and Transplantation, Osaka, Japan (3) Brigham and Women's Hospital, Harvard Medical School, Boston, United States of America (4) Us2.ai, Singapore, Singapore (5) Duke-NUS Graduate Medical School Singapore, Singapore, Singapore

Sreekanth Vemulapalli, MD
Associate Professor of Medicine
Medical Director of the Duke Echo Lab and Cardiac Diagnostic Unit
Duke University

sreekanth.vemulapalli@duke.edu
fawaz.enezi@dm.duke.edu

US2.AI

Us2.ai, Singapore, Singapore