CA-AI Echo – Diagnosis of cardiac amyloidosis on echocardiography using artificial intelligence: a multicentre international development and validation study

Dr Adam Ioannou

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Declaration of interest

- Consulting/Royalties/Owner/ Stockholder of a healthcare company : Honoraria: Alexion, AstraZeneca Rare Disease, Advisory boards: Prothena, Bayer

Introduction

- Cardiac amyloidosis (CA) is a progressive and ultimately fatal cardiomyopathy
- The majority of cases are caused by transthyretin amyloidosis (ATTR) and light-chain amyloidosis (AL)
- Despite improvements in cardiac imaging, CA remains an underrecognized and underdiagnosed entity
- Deep learning artificial intelligence-based algorithms have already shown great promise in cardiovascular imaging
- This study sought to develop and validate a deep learning artificial intelligence-based diagnostic algorithm for the detection of CA on echocardiography

Methods

- The data used for training of the Us2.ca model is drawn from the National Amyloidosis Centre (CA = 2241, LVH controls =604) and Taiwan Mackay Memorial Hospital databases (General controls = 1265)
- The training dataset comprised 10028 4Ch images from 4110 patients and was split into 80-10-10 ratio for training, validation and internal testing respectively
- Two separate external cohorts were used for testing:
  - Duke Health System (CA: 326, LVH controls: 823)
  - National Cerebral and Vascular Centre (CA: 183, LVH controls: 223)

Methods

Multiparametric echocardiographic score

- All echocardiograms underwent automated analysis using the Us.2.ai software to generate AI measurements that were used to calculated the multiparametric echocardiographic score
- A cut off of 6 was used to diagnose CA

Parameter	Cut off	Points
RWT	>0.6	3
E/e’	>11	1
TAPSE (mm)	≤19	2
LS (%)	≥-13	1
SAB	>2.9	3

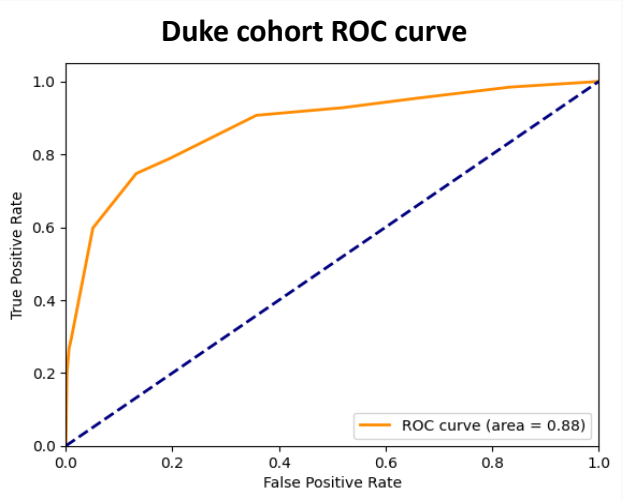
Convolutional neural network

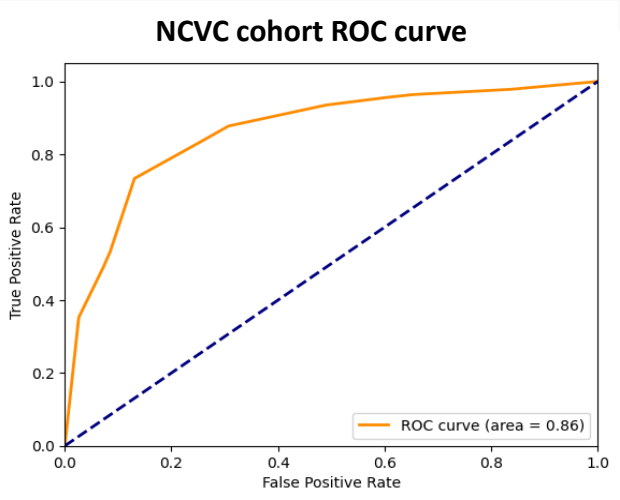
- The Apical 4-Chamber views from CA and LVH control cases were used to develop the Us2.ca model
- A 0.85 probability cut off was used to diagnose CA
- The model was then trialled in the testing dataset

Boldrini M, Cappelli F, Chacko L, Restrepo-Cordoba MA, et al. Multiparametric Echocardiography Scores for the Diagnosis of Cardiac Amyloidosis. JACC Cardiovasc Imaging. 2020;13:909-920.

Results – Multiparametric echocardiographic score

Cohort	No. of patients classified	Accuracy	Sensitivity	Specificity
Duke testing dataset	686 (59.7%)	83.3%	74.7%	86.8%
NCVC testing dataset	292 (71.9%)	78.8%	83.5%	74.5%

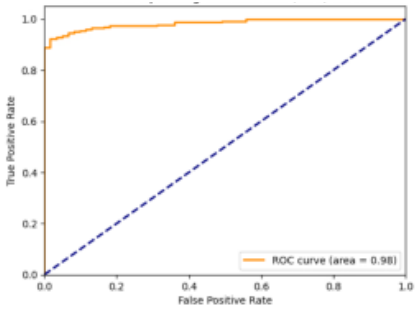




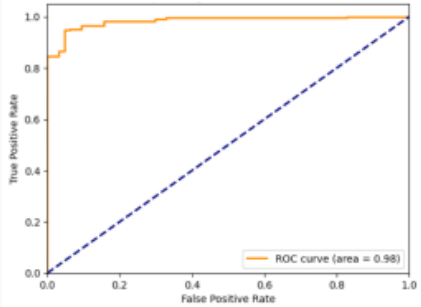
Results – Convolutional Neural Network

Cohort	No. of patients classified	Accuracy	Sensitivity	Specificity
NAC internal validation split	289 (100%)	93.3%	93.3%	93.4%
NAC internal test split	284 (100%)	94.5%	94.7%	93.8%
Duke testing dataset	1149 (100%)	82.1%	83.1%	81.7%
NCVC testing dataset	406 (100%)	85.75	81.4%	89.2%

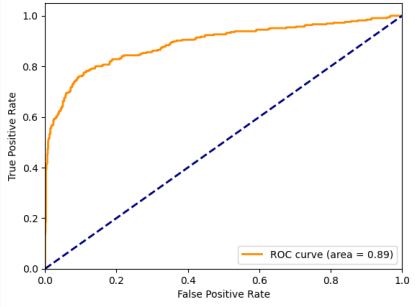
NAC internal validation split cohort ROC curve



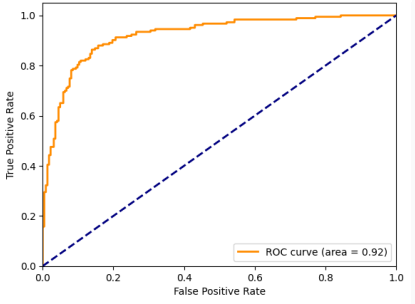
NAC internal test split cohort ROC curve



Duke cohort ROC curve



NCVC cohort ROC curve

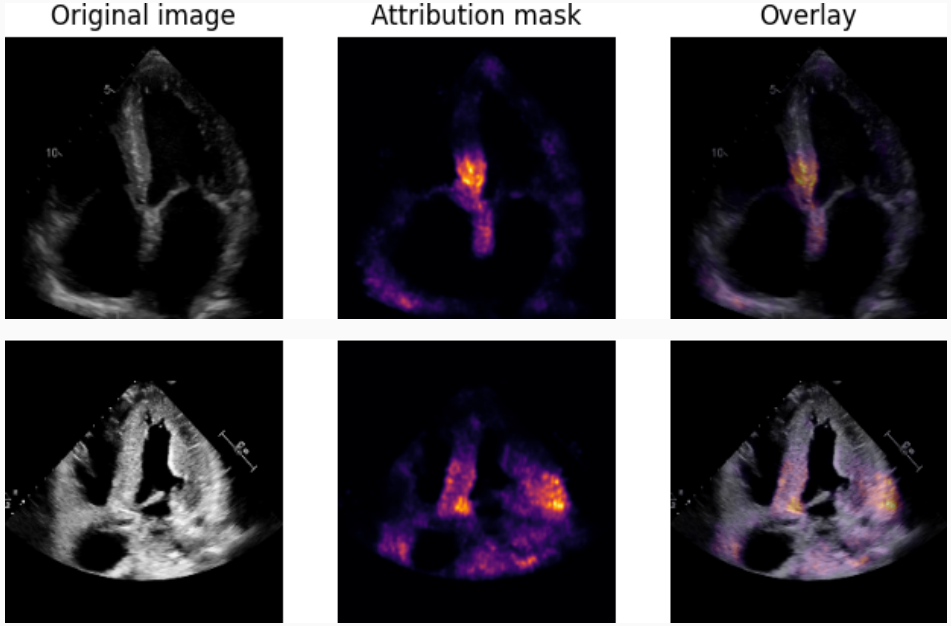


Results – Comparisons

Cohort	Multiparametric AUC	CNN AUC	P value
Duke testing dataset	0.83	0.89	<0.001
NCVC testing dataset	0.85	0.92	<0.001

Results – Saliency maps

- Saliency mapping provides a useful insight as to how the CNN makes decisions and assigns a diagnosis
- Pixels are ranked based on the strength of their effect on the network's decision



Conclusions

- An automated deep learning-based CNN can accurately differentiate between echocardiograms of patients with CA and controls with LVH
- This model utilised a single 4-chamber image to accurately classify patients
- The model performed better than the multiparametric echocardiographic score and was able to classify a greater proportion of patients
- Clinicians could incorporate the information from the model into clinical practice to improve decision making

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(1) University College London, London, United Kingdom of Great Britain & Northern Ireland (2) Duke University Medical Center, Durham, United States of America (3) National Cerebral & Cardiovascular Center, Department of Pediatric Cardiology, Suita, Japan (4) Duke Clinical Research Institute, Durham, United States of America (5) Us2.ai, Singapore, Singapore (6) University of Alberta, Edmonton, Canada (7) Duke-NUS Graduate Medical School Singapore, Singapore, Singapore (8) Brigham and Women's Hospital, Harvard Medical School, Boston, United States of America