

Comparison of clinical algorithms and artificial intelligence applied to an echocardiogram to categorize risk of heart failure with preserved ejection fraction (HFpEF)

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BACKGROUND

Heart failure with preserved ejection fraction (HFpEF) is a clinical syndrome with increasing prevalence, poor 5-year survival rates, high re-admission rates, and substantial morbidity. Echocardiography is critical in the HFpEF diagnostic pathway, but algorithms for echocardiographic interpretation, and the integration into broader clinical decision making are limited by discordant or incomplete data. This leads to variable diagnostic capacity, increasing requirements for further confirmatory testing or incorrect patient management.

METHODS

A three-dimensional convolutional neural network was developed to automatically detect HFpEF using only the apical four-chamber videoclip (EchoGo Heart Failure; Ultrasonics Ltd). Model development utilized retrospective, multi-site, and multi-national cohort data (Mayo Clinic, USA; NHS, UK). Echocardiogram databases and electronic medical records were used to identify patients with preserved ejection fraction ($\geq 50\%$), and echocardiographic evidence of increased intracardiac filling pressure, and a diagnosis of heart failure (ICD-9/10) within one year of the echocardiogram or lack thereof (cases and controls, respectively). In an independent testing dataset comprised of multi-site retrospective data from Mayo Clinic Health System (USA), the AI model was compared to clinically validated algorithms (HFA-PEFF Score¹ and H2FPEF Score²) with respect to classification performance (sensitivity and specificity) and the impact on clinical decision making (decision curve analysis).

RESULTS

Patient demographics for the 2971 cases and 3785 controls utilized for training and validation of the AI model, and 646 cases and 638 controls utilized for independent testing are presented in **Table 1**. The AI model demonstrated excellent discrimination performance in all datasets, with AUROC between 0.91 and 0.97 (**Figure 1**), and very good sensitivity (mean: 87.8% [95% CI: 84.5, 90.9]) and specificity (81.9% [78.2, 85.6]) on 1190/1284 patients in the training dataset (uncertain in 7.3%). The HFA-PEFF and H2FPEF scores also demonstrated very good sensitivity (84.1% [78.1, 91.4] and 98.2% [96.3, 99.8]) and specificity (99.7% [98.8, 100] and 74.0% [66.9, 79.0]), but were indeterminate in 820 (63.9%) and 776 (60.4%) patients, respectively. When indeterminate patients according to the HFA-PEFF score or H2FPEF score were assessed by the AI model, 610 (74.4%) and 571 (73.6%) of patients were correctly reclassified (respectively; **Figure 2**). In the testing dataset, modelling patient management decisions (e.g., prescription of SGLT2i) based on the combined diagnostic capacity of the AI HFpEF model and the HFA-PEFF or H2FPEF score, compared with the clinical score alone, resulted in more true positives being identified per 100 in the target population (**Figure 3**).



A novel AI model to detect HFpEF provided more diagnostic outputs than clinically validated algorithms.

Patients with indeterminate outputs by clinical algorithms were often correctly reclassified by the AI model.

Use of such a model in a screening paradigm or to support uncertain diagnoses could facilitate correct patient management.



For more information, scan the QR code, go to <https://www.ultrasonics.com/products/echo-go-heart-failure>, email Ashley.akerman@ultrasonics.com, or on social media @AshleyAkerman @pattypellikka @ultrasonics



CONCLUSION AND DISCUSSION

A novel AI model demonstrated excellent discrimination between patients with HFpEF compared to patients with common risk factors, but no clinical diagnosis. Comparison of diagnostic capacity between the AI model and current clinical algorithms supports a use-case for the implementation of the AI model in a screening paradigm or to support uncertain diagnoses.

DEMOGRAPHICS

Table 1. Demographics for cases and controls in training, validation, and testing

Patient Characteristics	Controls			Cases		
	Training	Validation	Testing	Training	Validation	Testing
Age, years	55.8 (15.7)	57.5 (15.8)	64.6 (17.4)	73.2 (11.5)	73.7 (11.5)	72.4 (13.3)
Women	1632 (52.2)	344 (52.4)	326 (51.1)	1277 (50.5)	237 (53.7)	337 (52.2)
Obesity	1943 (62.1)	427 (65.1)	451 (70.7)	1924 (76.1)	332 (75.3)	504 (78.0)
Hypertension	1120 (35.8)	272 (41.5)	301 (47.2)	1994 (78.8)	349 (79.1)	559 (86.5)
Diabetes mellitus	364 (11.6)	92 (14.0)	107 (16.8)	1003 (39.6)	171 (38.8)	326 (50.5)
LV mass index, g/m ²	84 (17)	83 (17)	85 (21)	112 (32)	111 (29)	121 (36)
LA volume index, mL/m ²	28.0 (7.5)	27.5 (7.2)	28.8 (8.5)	43.5 (12.0)	43.9 (12.1)	44.8 (15.2)
Ejection fraction, %	63 (6)	63 (5)	63 (6)	62 (6)	62 (6)	61 (6)
E velocity, cm/s	73 (16)	73 (16)	73 (17.0)	97 (23)	99 (24)	102 (26)
E:A, ratio	1.24 (0.46)	1.22 (0.47)	1.08 (0.4)	1.45 (0.84)	1.46 (0.75)	1.52 (0.87)
Average E/e', ratio	7.6 (1.9)	7.8 (2.1)	9.4 (2.7)	17.7 (6.3)	18.0 (6.3)	19.9 (6.8)
TR velocity, m/sec	2.4 (0.3)	2.4 (0.3)	2.4 (0.3)	2.9 (0.5)	2.9 (0.5)	3.0 (0.5)

DISCRIMINATION

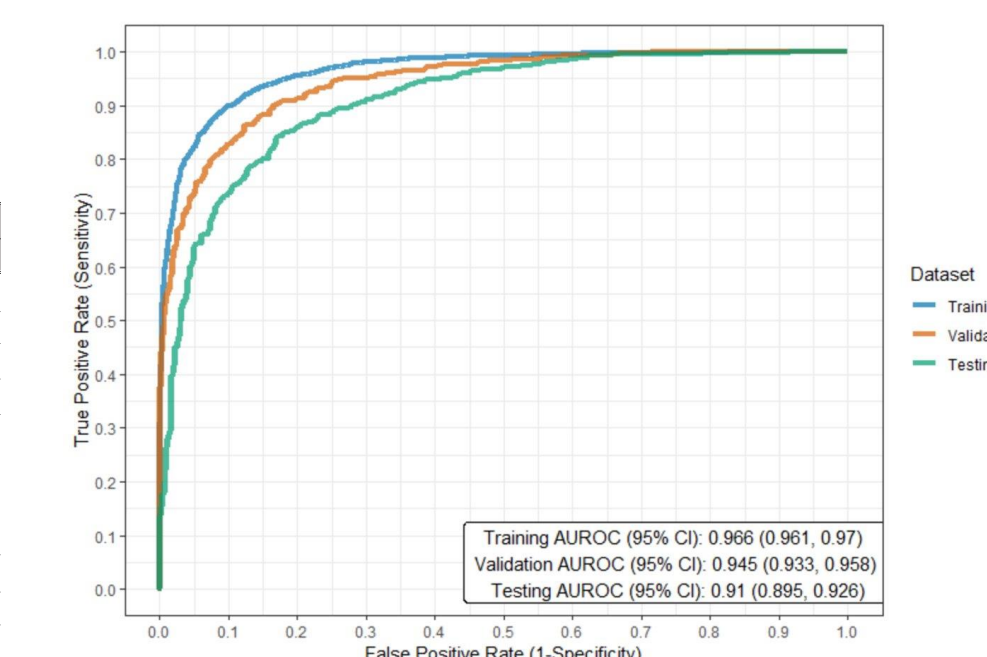


Figure 1. Receiver operating characteristic curves for training, validation, testing datasets

RECLASSIFICATION

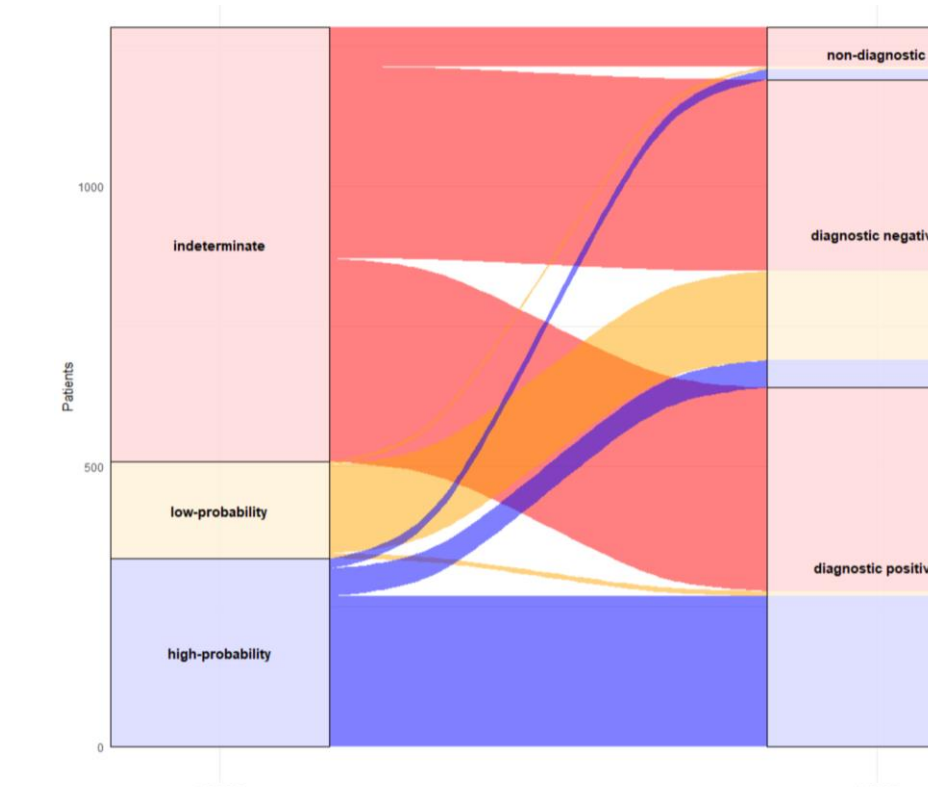
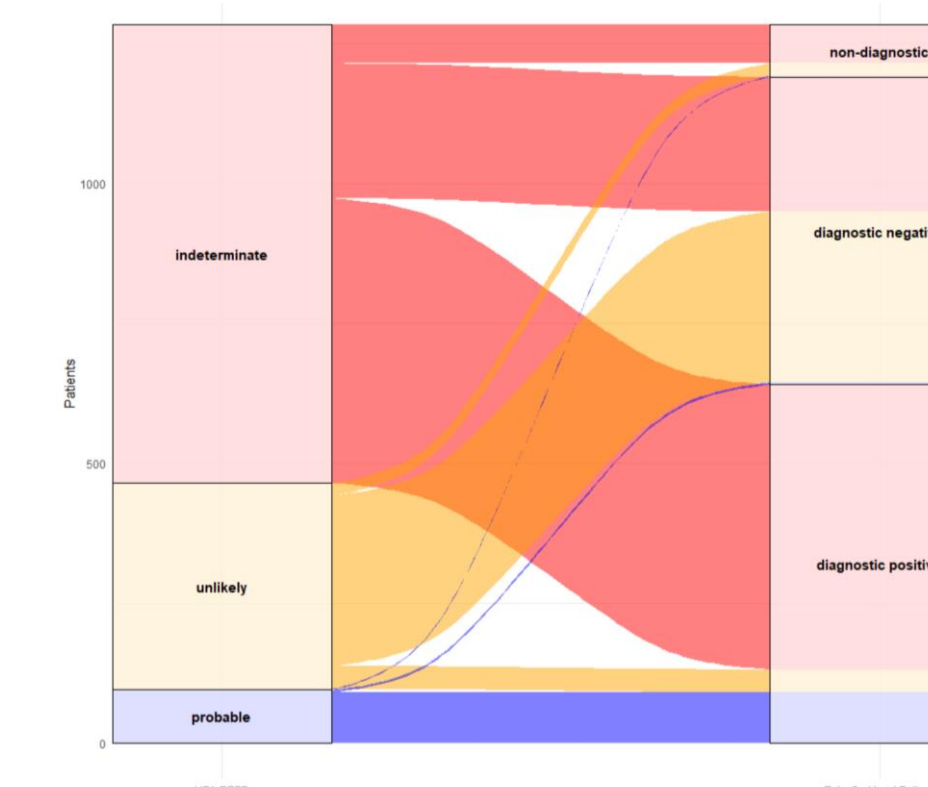


Figure 2. Alluvial plot demonstrating classification of patients according to HFA-PEFF (top panel) and H2FPEF (bottom panel) compared with the AI model

DECISION MAKING

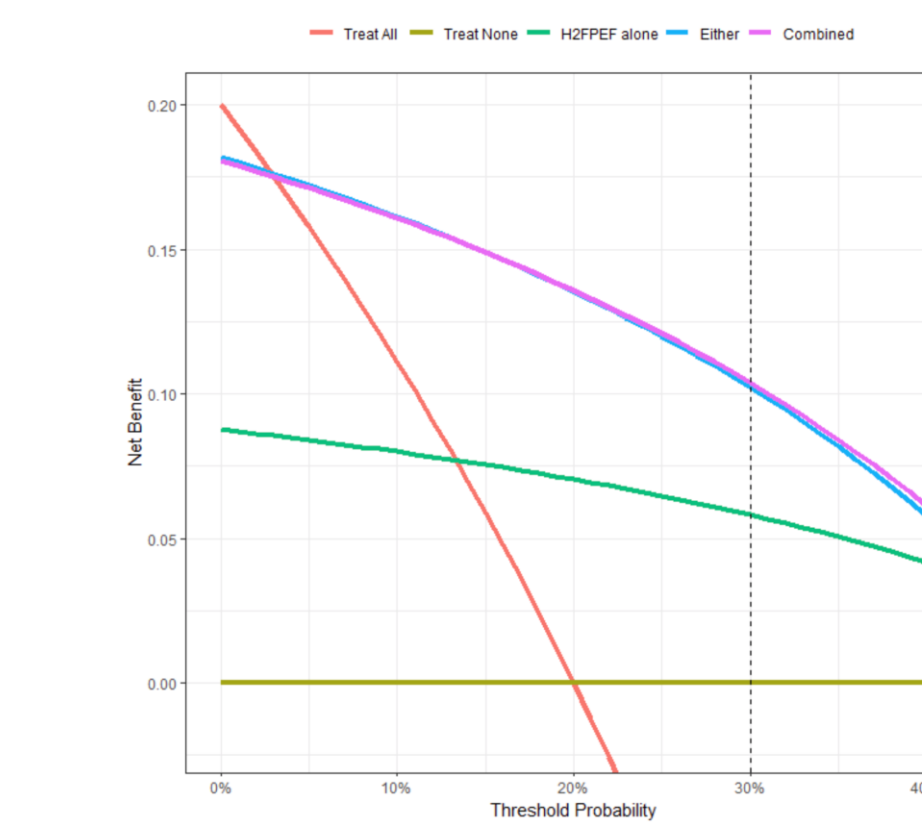
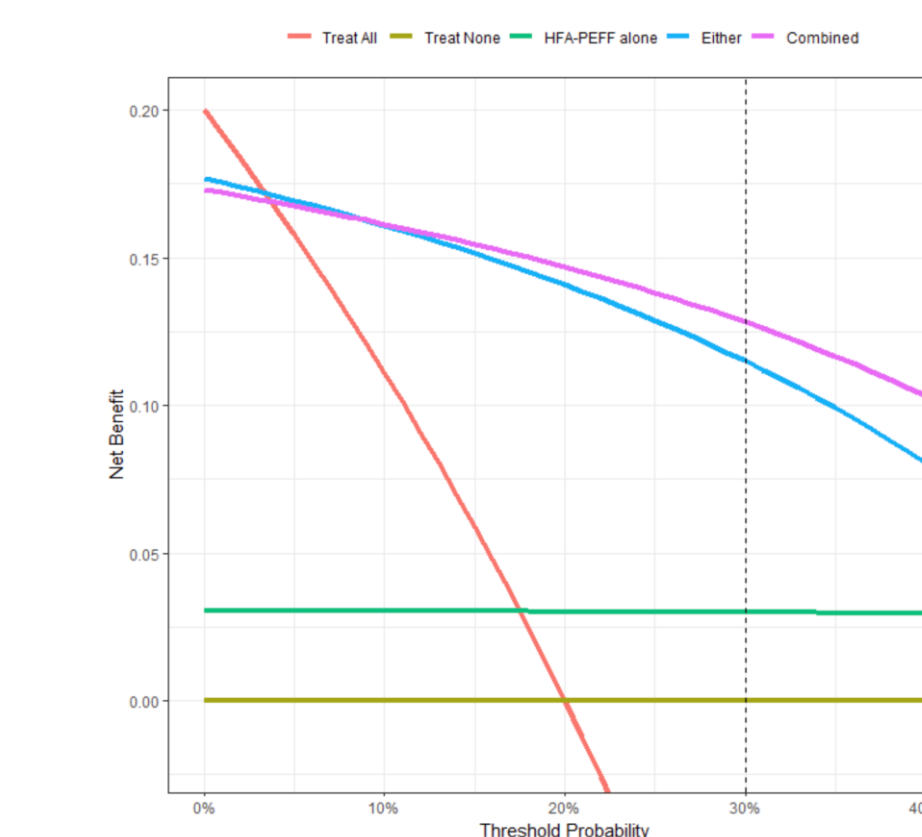


Figure 3. Decision curve analysis of patient management according to the use of HFA-PEFF (top panel), and H2FPEF (bottom panel) compared with the AI model

DISCLOSURE INFORMATION

APA, MP, AB, AC, WH, RS, JOD, PL, RU, and GW are all affiliated with Ultrasonics Ltd. The study was supported by grants from the American Society of Echocardiography (ASE) and Ultrasonics Ltd.

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