A State-Of-The-Art Deep Learning Model For 2D-Echo Interpretation: Synergizing The Curative Potential of Stem Cells With The Transformative Potential of AI in Preclinical And Clinical Settings

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Background: Transthoracic Echocardiography (TTE) remains the mainstay for non-invasive imaging-based assessment of heart function in experimental and clinical settings. Temporal performance of TTE is often affected by image quality and the presence of non-technically diagnostic data, as well as by the clinician's judgment. It becomes more challenging in experimental settings using small-animal models post-stem cell treatment due to the small heart size, rapid heart rate, and small functional changes post-treatment.

Objective: We aim to develop a state-of-the-art hybrid AI-based system to automate real-time TTE data acquisition.

Methods/Approach: Our deep learning (DL) model was trained on a public dataset of 10,000 2D-transthoracic echocardiography (2D-TTE) studies and evaluated on a dataset of 1276 clips. A structured, multistep adjudication process excluded technically non-diagnostic clips, resulting in 1037 clips for final analysis. The model's performance in estimating left ventricular ejection fraction (LVEF) was assessed against the Gold Standard (GS). The evaluation metrics included mean absolute error (MAE), root mean squared error (RMSE), and Pearson correlation coefficient. The agreement between the DL model Vs. GS was further assessed using a Bland–Altman analysis. Our system supports reconstruction of Echo findings into an interactive 3D representation for enhanced visualization.

Results: DL Model achieved an MAE of 2.72 and an RMSE of 3.24 vs. GS. Correlation with the GS was strong (r = 0.958); agreement within ±5 LVEF points was 86.11%, and within ±10 LVEF points it reached 100% with minimal bias (range -6.30 to 6.39). Technically flawed input clips contributed significantly to the overall model error. The system also enabled regeneration of the analyzed Echo data into a 3D interactive model for enhanced visualization and interpretation.

Conclusion: Our DL model shows promise in recognizing, measuring, and analyzing 2D-TTE data from patients and experimental models of heart failure, both pre- and post-stem cell therapy.