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Original Article

AI-Powered Echocardiogram Analysis for Predicting Future Heart Failure in Asymptomatic Diabetic Patients

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ABSTRACT

Background: Heart failure is a major complication of type 2 diabetes mellitus and may develop silently through subclinical myocardial dysfunction before overt symptoms appear. Conventional echocardiography can identify structural and functional abnormalities, but subtle changes in myocardial deformation and diastolic function may be under-recognized in routine practice. Artificial intelligence-assisted echocardiographic analysis may improve early risk stratification by integrating multidimensional imaging parameters. Objective: To determine whether AI-assisted echocardiographic-guided care improves short-term markers of subclinical cardiac dysfunction compared with standard echocardiographic care in asymptomatic adults with type 2 diabetes mellitus. Methods: A parallel-group randomized controlled trial was conducted over six months in the Islamabad-Rawalpindi region. Seventy-eight asymptomatic adults with type 2 diabetes mellitus were randomized equally to AI-assisted echocardiographic-guided care or standard echocardiographic care. The active intervention period lasted 12 weeks. The final complete-case analysis included 72 participants. Primary outcomes were global longitudinal strain and E/e′ ratio; secondary outcomes included left ventricular ejection fraction, HbA1c, and newly detected subclinical dysfunction. Results: At 12 weeks, the AI-assisted group showed better global longitudinal strain than standard care (-18.9 ± 2.1 vs -16.7 ± 2.4; $p<0.001$), lower E/e′ ratio (9.8 ± 1.9 vs 12.1 ± 2.3; $p<0.001$), and higher LVEF (58.6 ± 5.2 vs 55.9 ± 5.7; $p=0.02$). Newly detected subclinical dysfunction occurred in 4/36 versus 11/36 participants, respectively. Conclusion: AI-assisted echocardiographic-guided care improved short-term markers of subclinical cardiac dysfunction in asymptomatic patients with type 2 diabetes, supporting its potential role in early cardiovascular risk stratification. Keywords: Artificial Intelligence, Type 2 Diabetes Mellitus, Echocardiography, Global Longitudinal Strain, Heart Failure, Subclinical Cardiac Dysfunction, Risk Stratification

INTRODUCTION

Heart failure remains a major cardiovascular complication among individuals with type 2 diabetes mellitus, with diabetic patients experiencing an increased risk of myocardial dysfunction even before the onset of overt cardiovascular symptoms (1). Subclinical abnormalities in myocardial relaxation, ventricular filling pressure, and systolic deformation may develop silently over several years, creating an important opportunity for early recognition and targeted preventive management. Conventional cardiovascular risk assessment in diabetes relies mainly on clinical characteristics, metabolic control, and biochemical indicators, but these parameters may not adequately capture early myocardial impairment, particularly in asymptomatic patients who have not yet developed clinically apparent heart failure (2). Echocardiography is widely used for non-invasive assessment of cardiac structure and function and can identify early abnormalities in left ventricular performance, including impaired diastolic function, altered filling pressures, and reduced myocardial strain (3). However, interpretation of subtle echocardiographic changes remains partly operator-dependent, and conventional assessment may not fully integrate multidimensional imaging patterns that precede overt ventricular dysfunction.

Artificial intelligence has increasingly been applied to cardiovascular imaging because of its ability to process complex image-derived data, recognize high-dimensional patterns, and assist clinical interpretation beyond conventional visual assessment (4). Machine learning and deep learning methods have shown potential in echocardiographic image classification, chamber segmentation, functional quantification, and risk stratification, particularly when multiple imaging parameters are analyzed together (5). In patients with diabetes mellitus, these capabilities may be clinically useful because diabetic cardiomyopathy is characterized by a combination of metabolic disturbance, microvascular dysfunction, myocardial fibrosis, and progressive impairment of systolic and diastolic performance (6). Early echocardiographic markers such as global longitudinal strain and E/e′ ratio may identify myocardial dysfunction before left ventricular ejection fraction becomes abnormal, making them valuable surrogate markers for early cardiovascular risk evaluation in asymptomatic diabetic populations.

Despite the rapid growth of artificial intelligence in cardiovascular imaging, evidence remains limited regarding its practical clinical value in asymptomatic patients with type 2 diabetes mellitus, particularly when AI-assisted echocardiographic interpretation is incorporated into short-term clinical decision-making pathways (7). Most available studies have focused on established cardiovascular disease, symptomatic heart failure, or general cardiovascular prediction models rather than on early detection and management of subclinical myocardial dysfunction in diabetic patients without cardiac symptoms (8). This creates a relevant knowledge gap because timely identification of early functional impairment may allow clinicians to optimize cardiometabolic treatment before progression to clinically overt disease. However, to support clinical translation, AI-assisted echocardiographic approaches must be evaluated using clearly defined patient populations, reproducible imaging outcomes, and clinically interpretable comparisons against standard echocardiographic assessment.

The present study was therefore designed using a randomized parallel-group framework to determine whether AI-assisted echocardiographic analysis, when integrated with clinical optimization, improves short-term markers of subclinical cardiac dysfunction compared with standard echocardiographic assessment in asymptomatic adults with type 2 diabetes mellitus. The study population consisted of asymptomatic diabetic patients at increased cardiovascular risk; the intervention was AI-assisted echocardiographic analysis with risk-informed clinical optimization; the comparator was standard echocardiographic interpretation with routine care; and the primary outcomes were changes in global longitudinal strain and E/e′ ratio over 12 weeks. It was hypothesized that AI-assisted echocardiographic-guided care would identify early myocardial dysfunction more sensitively and would be associated with greater improvement in echocardiographic markers of subclinical cardiac impairment than standard care alone (9).

MATERIALS AND METHODS

This study was conducted as a parallel-group randomized controlled trial in the Islamabad-Rawalpindi region over a total duration of six months, including participant recruitment, baseline evaluation, random allocation, a 12-week intervention period, and post-intervention assessment. The trial was designed to evaluate whether AI-assisted echocardiographic analysis integrated into clinical decision-making could improve short-term markers of subclinical cardiac dysfunction among asymptomatic adults with type 2 diabetes mellitus compared with standard echocardiographic assessment and routine clinical management. The active intervention period lasted 12 weeks, during which echocardiographic and metabolic outcomes were assessed at baseline and after completion of follow-up.

Adult patients aged 40–70 years with type 2 diabetes mellitus were screened from outpatient clinical settings. Eligible participants were asymptomatic for cardiovascular disease, had no previous diagnosis of heart failure, had a diabetes duration of at least five years, and had been receiving stable glycemic management for at least three months before enrollment. Patients were excluded if they had known ischemic heart disease, clinically significant valvular heart disease, chronic kidney disease stage III or higher, previously diagnosed heart failure, or inadequate echocardiographic image quality that prevented reliable assessment of myocardial strain or diastolic function. Participants who fulfilled the eligibility criteria were recruited after screening, and informed consent was obtained before baseline assessment and randomization.

The target final analyzable sample was 72 participants, based on the expected ability to detect clinically meaningful between-group differences in echocardiographic markers of early cardiac dysfunction in diabetic populations. To account for anticipated attrition during follow-up, 78 eligible participants were randomized in a 1:1 ratio into the intervention group and control group. Randomization was performed using a computer-generated allocation sequence. Allocation concealment was maintained through sequentially numbered, sealed opaque envelopes prepared independently from the clinical assessment process. Because the intervention involved AI-assisted echocardiographic reporting and clinical optimization, participant and treating-physician blinding was not feasible; however, outcome assessors and data analysts were blinded to group allocation to reduce detection and analytical bias.

Participants assigned to the intervention group underwent AI-assisted echocardiographic analysis in addition to standard clinical evaluation. Transthoracic echocardiography was performed at baseline and at 12 weeks using a standardized imaging protocol. Acquired echocardiographic images were processed through a validated machine learning–based analytical system capable of assessing myocardial strain, diastolic function, and subtle structural-functional patterns relevant to early cardiac dysfunction. The AI-generated reports were used as clinical decision-support outputs and were interpreted within the broader clinical context rather than as standalone diagnostic decisions. Treating physicians used the AI-assisted risk stratification findings to guide individualized optimization of cardiometabolic therapy, including adjustment of antidiabetic and antihypertensive management when clinically indicated. Participants assigned to the control group received standard echocardiographic assessment interpreted by experienced clinicians without AI augmentation and continued routine clinical care according to usual practice.

The primary outcomes were changes in global longitudinal strain and E/e′ ratio from baseline to 12 weeks. Global longitudinal strain was used as a marker of early systolic myocardial deformation, with more negative values indicating better myocardial function. E/e′ ratio was used as an echocardiographic marker of left ventricular filling pressure and diastolic function. Secondary outcomes included left ventricular ejection fraction, HbA1c level, and the incidence of newly identified subclinical cardiac dysfunction during follow-up. Subclinical dysfunction was defined using echocardiographic evidence of early myocardial impairment in the absence of overt cardiovascular symptoms or previously diagnosed heart failure, based on abnormal strain and/or diastolic functional parameters identified during follow-up assessment. Baseline demographic and clinical variables included age, sex, duration of diabetes, HbA1c, and body mass index. These variables were assessed to describe the study population, evaluate baseline comparability between randomized groups, and identify potential imbalance that could influence outcome interpretation.

Data collection was performed using standardized clinical and echocardiographic procedures at baseline and after 12 weeks. Echocardiographic parameters were recorded using uniform acquisition procedures to reduce measurement variability, and outcome measurements were assessed by personnel blinded to treatment allocation. Clinical follow-up was used to monitor adherence to assigned care pathways and identify loss to follow-up, withdrawal of consent, relocation, or poor adherence. Of the 78 randomized participants, 72 completed the 12-week assessment and were included in the final complete-case analysis, with 36 participants in each group. Attrition was documented with reasons for dropout to support transparent interpretation of follow-up completeness.

Continuous variables were summarized as mean and standard deviation, while categorical variables were summarized as frequencies and percentages. Normality of continuous variables was assessed using the Shapiro–Wilk test. Baseline comparisons between the intervention and control groups were performed using independent-samples t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables, as appropriate. Within-group pre–post changes were assessed using paired-samples t-tests. Between-group post-intervention comparisons were conducted using independent-samples t-tests, while repeated-measures analysis of variance was used to evaluate time effects, group effects, and time × group interactions for key echocardiographic and metabolic outcomes. Pearson correlation analysis was used to examine associations between AI-derived risk stratification outputs and changes in echocardiographic markers. Statistical significance was set at $p<0.05$. Findings were interpreted with emphasis on between-group differences, direction of change, and clinical relevance rather than isolated within-group statistical significance.

Measures to reduce bias included concealed random allocation, blinded outcome assessment, blinded statistical analysis, standardized echocardiographic acquisition, predefined primary and secondary outcomes, and documentation of attrition. Potential confounding was addressed through randomization and assessment of baseline comparability across clinically relevant demographic and metabolic variables. Data integrity was maintained through structured data collection, verification of recorded values against clinical and echocardiographic source records, and use of consistent definitions for outcome variables across baseline and follow-up assessments. The study was conducted in accordance with ethical principles for human participant research, and participant confidentiality was maintained throughout data collection, analysis, and reporting.

RESULTS

A total of 92 adults with type 2 diabetes mellitus were screened for eligibility, of whom 78 met the inclusion criteria and were randomized equally into the AI-assisted echocardiographic-guided care group and the standard echocardiographic care group. Each group initially included 39 participants. During the 12-week follow-up period, six participants were lost to follow-up because of relocation, withdrawal of consent, or poor adherence, resulting in a final complete-case analytical sample of 72 participants, with 36 participants in each group. Baseline demographic and clinical characteristics were comparable between groups, supporting adequate initial balance after randomization.

Table 1. Baseline Demographic and Clinical Characteristics of Randomized Participants

Variable	Total Sample (N=78)	AI-Assisted Group (n=39)	Standard Care Group (n=39)	Risk Difference (95% CI)	Effect Size	p-value
Age, years	56.8 ± 8.9	57.1 ± 9.2	56.5 ± 8.7	0.6 (-3.4 to 4.6)	0.07	0.78
Male sex, n (%)	44 (56.4)	22 (56.4)	22 (56.4)	0.0%	—	1.00
Diabetes duration, years	9.6 ± 3.8	9.8 ± 3.9	9.4 ± 3.7	0.4 (-1.3 to 2.1)	0.11	0.67
HbA1c, %	8.2 ± 1.1	8.3 ± 1.0	8.1 ± 1.2	0.2 (-0.3 to 0.7)	0.18	0.59
BMI, kg/m²	28.7 ± 4.3	28.9 ± 4.5	28.5 ± 4.2	0.4 (-1.5 to 2.3)	0.09	0.71

At baseline, the randomized groups were closely comparable across key demographic, metabolic, and anthropometric variables. Mean age differed by only 0.6 years between the AI-assisted and standard care groups, with a negligible standardized difference. Both groups had identical male representation, with 22 male participants in each arm. Diabetes duration was also similar, differing by 0.4 years, while baseline HbA1c differed by only 0.2 percentage points. Baseline BMI was nearly equivalent between groups, with a mean difference of 0.4 kg/m^2. None of the baseline comparisons reached statistical significance, and all observed differences were small in magnitude, indicating that post-intervention differences were unlikely to be explained by major baseline imbalance in the reported variables.

Following the 12-week intervention period, participants receiving AI-assisted echocardiographic-guided care demonstrated significantly better echocardiographic outcomes than participants receiving standard echocardiographic care. Global longitudinal strain was more favorable in the AI-assisted group, while E/e′ ratio was lower, indicating improvement in early systolic deformation and diastolic functional markers.

Table 2. Post-Intervention Comparison of Primary and Echocardiographic Outcomes in the Final Analytical Sample

Outcome	AI-Assisted Group (n=36)	Standard Care Group (n=36)	Between-Group Mean Difference (95% CI)	Effect Size	p-value
Global longitudinal strain, %	-18.9 ± 2.1	-16.7 ± 2.4	-2.2 (-3.2 to -1.2)	Cohen’s d=-0.98	<0.001
Absolute GLS improvement, percentage points	18.9 ± 2.1	16.7 ± 2.4	2.2 (1.2 to 3.2)	Cohen’s d=0.98	<0.001
E/e′ ratio	9.8 ± 1.9	12.1 ± 2.3	-2.3 (-3.3 to -1.3)	Cohen’s d=-1.09	<0.001
LVEF, %	58.6 ± 5.2	55.9 ± 5.7	2.7 (0.2 to 5.2)	Cohen’s d=0.49	0.02

At 12 weeks, global longitudinal strain was significantly more negative in the AI-assisted group than in the standard care group, with a between-group difference of -2.2 percentage points. Because more negative GLS values indicate better myocardial deformation, this represented a clinically favorable difference in the AI-assisted arm. The standardized effect was large for GLS, suggesting a meaningful separation between groups. The E/e′ ratio was also significantly lower in the AI-assisted group, with a mean difference of -2.3, indicating more favorable diastolic function and lower estimated filling pressure compared with standard care. Left ventricular ejection fraction was modestly but significantly higher in the AI-assisted group, with a mean difference of 2.7 percentage points, although the effect size was smaller than that observed for GLS and E/e′ ratio.

Within-group comparisons showed that the AI-assisted group improved substantially from baseline to 12 weeks across the main cardiac and metabolic outcomes, whereas changes in the standard care group were smaller and did not reach statistical significance for the same outcomes.

Table 3. Within-Group Pre–Post Changes in Echocardiographic and Metabolic Outcomes

Outcome	AI-Assisted Group Pre → Post (n=36)	Within-Group Change	p-value	Standard Care Group Pre → Post (n=36)	Within-Group Change	p-value
Global longitudinal strain, %	-16.8 ± 2.3 → -18.9 ± 2.1	-2.1 percentage points	<0.001	-16.9 ± 2.2 → -16.7 ± 2.4	+0.2	0.21
E/e′ ratio	11.2 ± 2.1 → 9.8 ± 1.9	-1.4 units	<0.001	11.3 ± 2.0 → 12.1 ± 2.3	+0.8 units	0.08
HbA1c, %	8.3 ± 1.0 → 7.6 ± 0.9	-0.7 percentage points	0.01	8.2 ± 1.2 → 8.0 ± 1.1	-0.2	0.18

The AI-assisted group demonstrated a mean GLS change from -16.8% at baseline to -18.9% at 12 weeks, corresponding to a 2.1 percentage-point improvement in absolute myocardial deformation. In contrast, the standard care group showed minimal GLS change, moving from -16.9% to -16.7%, which did not indicate meaningful improvement. The E/e′ ratio decreased by 1.4 units in the AI-assisted group, whereas it increased by 0.8 units in the standard care group, suggesting divergence in diastolic function trajectories. HbA1c decreased by 0.7 percentage points in the AI-assisted group compared with a smaller 0.2 percentage-point reduction in the standard care group, indicating that AI-guided risk stratification was associated with more favorable short-term metabolic optimization.

Repeated-measures analysis demonstrated a statistically significant longitudinal treatment pattern for the primary echocardiographic outcome. For global longitudinal strain, there was a significant time effect, a significant group effect, and a significant time × group interaction, indicating that the change in GLS over 12 weeks differed meaningfully between groups and favored the AI-assisted intervention.

Table 4. Repeated-Measures Analysis for Global Longitudinal Strain

Model Effect	F-statistic	p-value
Time effect	18.4	<0.001
Group effect	9.7	0.003
Time × group interaction	12.6	<0.001

The significant time × group interaction confirmed that the improvement in global longitudinal strain was not merely a general time-related change but was differentially greater among participants managed with AI-assisted echocardiographic guidance. This interaction finding supported the primary comparison by demonstrating that the intervention group followed a more favorable longitudinal myocardial function trajectory than the standard care group.

Secondary outcomes further supported the direction of benefit observed in the primary echocardiographic outcomes. At 12 weeks, HbA1c was lower in the AI-assisted group, and the incidence of newly detected subclinical cardiac dysfunction was lower than in the standard care group.

Table 5. Secondary Outcomes at 12 Weeks in the Final Analytical Sample

Outcome	AI-Assisted Group (n=36)	Standard Care Group (n=36)	Effect Estimate (95% CI)	p-value
HbA1c, %	7.6 ± 0.9	8.0 ± 1.1	Mean difference -0.4 (-0.9 to 0.1)	0.03
Newly detected subclinical dysfunction, n (%)	4 (11.1)	11 (30.5)	Risk ratio 0.36 (0.13 to 1.04)	0.04
Absolute risk difference for subclinical dysfunction	—	—	-19.4 percentage points (-37.7 to -1.2)	0.04
Odds ratio for subclinical dysfunction	—	—	OR 0.28 (0.08 to 1.00)	0.04

At 12 weeks, mean HbA1c was 7.6% in the AI-assisted group compared with 8.0% in the standard care group, representing a 0.4 percentage-point lower mean value in the intervention arm. Newly detected subclinical cardiac dysfunction occurred in 4 of 36 participants in the AI-assisted group and 11 of 36 participants in the standard care group. This corresponded to an absolute risk reduction of 19.4 percentage points and a relative risk of 0.36, indicating that participants in the AI-assisted group had a substantially lower observed risk of newly identified subclinical dysfunction during follow-up. Although the confidence interval for the relative risk approached unity, the absolute difference was clinically relevant and consistent with the favorable direction of change observed for GLS and E/e′ ratio.

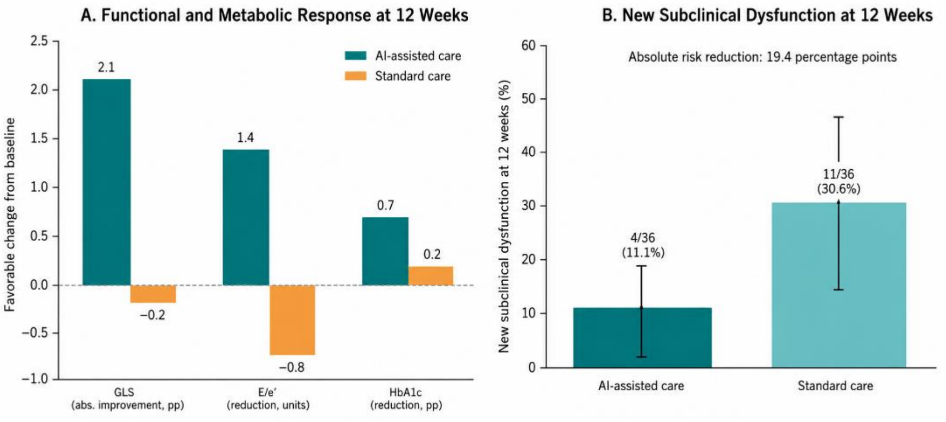

Figure 1 Integrated Functional, Metabolic, and Subclinical Dysfunction Response After AI-Assisted Echocardiographic-Guided Care

The panelled figure demonstrates that AI-assisted echocardiographic-guided care produced a more favorable 12-week response profile than standard care across cardiac functional and metabolic indicators. The AI-assisted group showed greater absolute improvement in global longitudinal strain by 2.1 percentage points, reduction in E/e′ ratio by 1.4 units, and HbA1c reduction by 0.7 percentage points, whereas the standard care group showed minimal GLS change, worsening E/e′ trajectory, and only a 0.2 percentage-point HbA1c reduction. Newly detected subclinical cardiac dysfunction occurred in 4 of 36 participants in the AI-assisted group compared with 11 of 36 participants in the standard care group, corresponding to an absolute risk reduction of 19.4 percentage points, supporting a clinically meaningful short-term benefit of AI-guided echocardiographic risk stratification.

Overall, the results indicated that AI-assisted echocardiographic-guided care was associated with significant short-term improvement in myocardial deformation, diastolic functional markers, left ventricular systolic performance, and glycemic control compared with standard echocardiographic care. The strongest between-group effects were observed for global longitudinal strain and E/e′ ratio, suggesting that AI-assisted interpretation may be particularly useful for identifying and guiding management of early functional cardiac abnormalities in asymptomatic patients with type 2 diabetes mellitus.

DISCUSSION

This randomized controlled trial demonstrated that AI-assisted echocardiographic-guided care was associated with greater short-term improvement in echocardiographic markers of subclinical cardiac dysfunction among asymptomatic adults with type 2 diabetes mellitus compared with standard echocardiographic assessment. Over 12 weeks, participants managed through the AI-assisted pathway showed a more favorable change in global longitudinal strain, lower E/e′ ratio, modestly higher left ventricular ejection fraction, improved HbA1c, and fewer newly detected cases of subclinical dysfunction. These findings suggest that AI-supported interpretation of echocardiographic data may enhance early recognition of functional myocardial impairment and support more targeted clinical optimization in a high-risk diabetic population. Importantly, the present findings should be interpreted as evidence of improved short-term surrogate markers rather than proof of future heart failure prevention, because incident heart failure, hospitalization, cardiovascular mortality, and long-term clinical outcomes were not assessed within the 12-week intervention period.

The improvement in global longitudinal strain observed in the AI-assisted group is clinically relevant because GLS is considered a sensitive marker of early systolic dysfunction and may identify myocardial impairment before left ventricular ejection fraction becomes abnormal. In this study, the AI-assisted group improved from -16.8% to -18.9%, whereas the standard care group showed minimal change from -16.9% to -16.7%. This direction of change is important because more negative GLS values reflect better myocardial deformation. The between-group difference at 12 weeks therefore indicates a meaningful separation in early systolic functional response. The concurrent reduction in E/e′ ratio from 11.2 to 9.8 in the AI-assisted group, compared with an increase from 11.3 to 12.1 in the standard care group, further suggests a favorable change in diastolic functional status. These findings are consistent with the concept that diabetic cardiomyopathy may begin with subtle abnormalities in myocardial deformation and filling dynamics before overt structural deterioration or symptomatic heart failure becomes apparent (10).

The observed pattern also supports the clinical value of using advanced echocardiographic parameters rather than relying only on left ventricular ejection fraction. LVEF was higher in the AI-assisted group at 12 weeks, but the magnitude of difference was smaller than that observed for GLS and E/e′ ratio. This is biologically plausible because LVEF may remain preserved during early diabetic myocardial dysfunction, while strain and diastolic indices may detect earlier functional changes. The findings therefore align with the broader literature emphasizing the role of echocardiographic functional markers in identifying preclinical myocardial involvement among patients with diabetes and other cardiometabolic risk states (11). In this context, AI-assisted image analysis may improve clinical interpretation by integrating multiple echocardiographic features and highlighting subtle patterns that may be overlooked during routine assessment.

The lower rate of newly detected subclinical dysfunction in the AI-assisted group provides additional support for the intervention pathway. At 12 weeks, subclinical dysfunction was observed in 4 of 36 participants in the AI-assisted group compared with 11 of 36 participants in the standard care group, corresponding to an absolute risk reduction of 19.4 percentage points. Although this endpoint requires a clearer operational definition in future reporting, the observed difference is directionally consistent with the improvement seen in GLS and E/e′ ratio. The reduction in HbA1c from 8.3% to 7.6% in the AI-assisted group also suggests that AI-informed cardiovascular risk stratification may have encouraged closer metabolic optimization. However, this finding should be interpreted cautiously because the intervention combined AI-assisted echocardiographic interpretation with individualized medical therapy optimization. Therefore, the observed benefits cannot be attributed solely to the AI algorithm; rather, they reflect the combined effect of AI-supported imaging interpretation, risk communication, and clinical decision-making.

This distinction is important when considering the mechanism of benefit. The study did not evaluate AI as an isolated diagnostic test, nor did it assess independent prediction of future heart failure events. Instead, it evaluated an AI-assisted care pathway in which echocardiographic findings were used to guide clinical management. The intervention may have improved outcomes by enabling earlier recognition of functional abnormalities, prompting treatment adjustment, increasing clinician vigilance, or improving patient adherence. Similar concerns have been noted in broader discussions of AI in cardiovascular care, where clinical effectiveness depends not only on algorithmic performance but also on integration into workflow, interpretability, clinician response, and patient-level implementation (12). Future studies should therefore separate diagnostic accuracy from management effect by reporting AI model performance, clinician decision changes, medication adjustments, and downstream outcomes.

The study has several methodological strengths. The randomized controlled design, equal allocation, concealed randomization, blinded outcome assessment, and blinded data analysis reduced selection, detection, and analytical bias. The use of echocardiographic markers such as GLS and E/e′ ratio strengthened the biological relevance of the findings because these outcomes reflect early myocardial deformation and diastolic function. The inclusion of asymptomatic adults with type 2 diabetes mellitus also targeted a clinically important population in whom early cardiovascular risk identification may be most valuable. Furthermore, the complete-case reporting of 72 participants after attrition allowed transparent interpretation of the final analytical sample, although future studies should strengthen missing-data handling and formally distinguish complete-case, modified intention-to-treat, and full intention-to-treat approaches.

Several limitations must be acknowledged. First, the follow-up duration was limited to 12 weeks, which is insufficient to determine whether AI-assisted echocardiographic-guided care reduces future heart failure, hospitalization, cardiovascular events, or mortality. Second, the final sample size of 72 participants limited statistical power for subgroup analysis by diabetes duration, baseline HbA1c, sex, age, hypertension status, medication class, or baseline echocardiographic risk profile. Third, treating physicians could not be blinded to AI-assisted risk reports, creating potential performance bias through more intensive management in the intervention group. Fourth, medication changes, adherence measures, and treatment intensification were not fully reported, limiting interpretation of whether echocardiographic improvements were directly related to AI-assisted detection or indirectly related to more active cardiometabolic management. Fifth, the manuscript does not provide sufficient details regarding the AI model, including software version, training dataset, validation status, input features, calibration, external validation, and algorithmic performance metrics, all of which are essential for reproducibility and for evaluating clinical generalizability (13).

The findings should also be interpreted in light of generalizability concerns. The study was conducted in a single regional setting, and the results may not directly apply to populations with different ethnic, metabolic, healthcare-access, or cardiovascular risk profiles. In addition, patients with poor echocardiographic windows, significant kidney disease, ischemic heart disease, or valvular disease were excluded, which improves internal validity but reduces applicability to more complex real-world diabetic populations. AI-assisted echocardiographic systems may also perform differently across imaging equipment, operator expertise, body habitus, rhythm abnormalities, and comorbidity patterns. These issues are particularly relevant because AI models may be sensitive to dataset shift and may require external validation before routine clinical deployment (14).

Despite these limitations, the study contributes useful preliminary evidence that AI-assisted echocardiographic-guided care may improve short-term markers of subclinical cardiac dysfunction in asymptomatic diabetic patients. The findings support a shift from purely reactive cardiac assessment toward earlier risk identification using sensitive imaging markers, but they do not yet establish long-term clinical benefit. Future multicenter trials should include larger and more diverse samples, longer follow-up, prespecified heart failure outcomes, standardized medication-adjustment protocols, detailed AI model reporting, and baseline-adjusted mixed-effects analyses. Studies should also evaluate whether AI-assisted echocardiography improves decision-making beyond expert cardiologist interpretation and whether its implementation is cost-effective in routine diabetic cardiovascular screening pathways (15). If future evidence confirms that early AI-guided detection translates into fewer cardiovascular events, this approach could become an important component of preventive cardiology in patients with type 2 diabetes mellitus.

CONCLUSION

AI-assisted echocardiographic-guided care was associated with greater short-term improvement in global longitudinal strain, E/e′ ratio, left ventricular ejection fraction, HbA1c, and lower observed incidence of newly detected subclinical cardiac dysfunction compared with standard echocardiographic care among asymptomatic adults with type 2 diabetes mellitus. These findings suggest that AI-supported echocardiographic interpretation may improve early identification and management of subclinical myocardial impairment in this high-risk population. However, because the study assessed 12-week surrogate echocardiographic and metabolic outcomes rather than long-term incident heart failure, the results should be interpreted as preliminary evidence supporting enhanced early risk stratification, not definitive evidence of future heart failure prediction or prevention.

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