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ORIGINAL INVESTIGATION

The diagnostic value of global longitudinal strain combined with cardiac biomarkers on early detection of anthracycline-related cardiac dysfunction

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Abstract

Background Cardiac dysfunction associated with anthracyclines is a significant side effect of chemotherapy, and early detection is crucial. We aimed to assess the diagnostic value of combining global longitudinal strain (GLS) with biomarkers for the early detection of anthracycline-related cardiac dysfunction.

Methods In a prospective cohort study, 80 consecutive adult patients (mean age 51 ± 11 years; 68.8% females) were screened and underwent 2D echocardiographic assessments and biomarker assessments [high-sensitivity troponin-I (hs-Troponin-I) and NT-pro brain natriuretic peptide (NT-proBNP)] before and after anthracycline-based chemotherapy's initial regimen. The patients were followed up for 12 weeks to monitor for the development of cardiotoxicity.

Results Ten patients (12.5%) developed cardiotoxicity at the end of the 12-week follow-up. Baseline values of hs-Troponin-I and NT-proBNP were significantly higher in patients who developed cardiotoxicity compared to those who did not, with a similar pattern observed at the 3-week follow-up. Receiver operating characteristic (ROC) curve analysis demonstrated that a cutoff value of baseline hs-Troponin-I > 11 ng/L, NT-proBNP > 90.1 pg/mL, 3-week left ventricular ejection fraction (LVEF) ≤ 52%, 3-week GLS ≥ − 14.5%, 3-week hs-Troponin-I > 13.1 ng/L, and 3-week NT-proBNP > 118.1 pg/mL predicted the occurrence of cardiotoxicity with high sensitivity (range 83–94%) and specificity (range 77–92%).

Conclusion Combination of GLS with biomarkers had a high diagnostic value in early identification of anthracycline-related cardiac dysfunction, with an estimated diagnostic accuracy of over 85%. This information could potentially help in the identification of patients at high risk of developing cardiac dysfunction, allowing for earlier management.

Keywords Global longitudinal strain · Biomarkers · Anthracycline-cardiotoxicity

Introduction

Cancer therapy-related cardiac dysfunction (CTRCD) is a common phenomenon in patients with malignant diseases receiving various forms of chemotherapy; however, one of

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the most commonly implicated agents is Anthracyclines which results in dose-dependent cardiac toxicity with higher cumulative doses [1]. Echocardiography is able to detect this toxicity, and some relatively recent echocardiographic modalities such as 2D speckle-tracking have been used for earlier detection of subclinical cardiac injury with good sensitivity and specificity [2]. Additionally, some cardiac biomarkers such as Troponin T, I, and B-Natriuretic Peptide (BNP) have been described as being good prognosticators for the occurrence of CTRCD in some studies [3]. The most recent European Society of Cardiology (ESC) 2022 guidelines on cardio-oncology acknowledged the importance of early detection of asymptomatic CTRCD using a combination of both echocardiography (including GLS) and cardiac biomarkers [4]. Nevertheless, it remains to be determined if a combination of both could have an incremental prognostic value than either alone, with very few studies examining this hypothesis [5]. Therefore, in this study, we aimed to investigate the diagnostic value of GLS and/or cardiac biomarkers for early detection of Anthracycline-related cardiac dysfunction.

Methods

Study design

This was a prospective cohort study done in the period from September 2021 to October 2022 on adult patients scheduled to get the first course of Anthracycline-based chemotherapy at Benha University Hospital, Egypt. Patients were excluded if they had one or more of the following: older than 70 years, prior radiotherapy to the mediastinum, Herceptin therapy for breast cancer that has been used previously or more recently, prior history of cardiovascular disease, prior liver disease (ALT or AST > 50 U/L, serum bilirubin > 1.5 mg/dL), prior chronic kidney disease (Glomerular filtration rate [GFR < 60] mL/min), and baseline left ventricular ejection fraction < 50%. Depending on the type of cancer, adriamycin was given every 2 or 3 weeks for at least six sessions. The intended cumulative dose ranged from 240 to 360 mg/m^2. The total dose of idarubicin administered over the course of three days was 36 mg/m^2. All of the protocols for the current study were approved by the Benha Faculty of Medicine's ethics committee (reference number: RC 6-9-2021), and each patient provided signed written informed consent.

Sample size calculation

With the use of the Medcalc program version 18.2.1, the sample size was determined based on a prior study performed by Mahjoob et al. [5], who reported an AUC of 0.821 for NTproBNP in predicting cardiotoxicity. The estimated overall sample size was 80 (for a possible number of 70 patients without cardiotoxicity and 10 patients with cardiotoxicity). Adjustments to power and alpha were made at 0.05 and 0.8, respectively.

Echocardiographic assessment

All patients underwent a comprehensive 2D echocardiographic assessment prior to the treatment, 3 and 12 weeks following the completion of the first round of chemotherapy. Echocardiographic assessment was done using a commercially available ultrasound system (*Philips EPIQ 7 Ultrasoun System, Andover, MA, USA*) containing a 3.5 MH phased array transducer. Two competent cardiologists who were blinded to the results of the follow-up were responsible for all evaluations. The left ventricular ejection fraction (LVEF) and GLS measures were repeated ten times by these two skilled cardiologists before the study's start in order to ensure repeatability. To estimate inter-observer variability, differences between the two operators' measurements were determined. The 10 measures were repeated by the same operators 4 weeks later, and intra-observer variability was also calculated. The test–retest variability of GLS was 5.0 ± 2.1% (maximum 80.8, minimum − 112.3).

At held end-expiration, the photograph was captured. According to the European Association of Echocardiography and the American Society of Echocardiography recommendations, LVEF was measured using Simpson's biplane method [6]. Sector depth and size were tuned for the 2D speckle tracking echocardiogram imaging technique to obtain flawless visibility of all LV myocardium in the 3 standard apical views (4-, 2-, and long-axis view) at a frame rate between 60 and 100 fps. The closing of the aortic valve in the apical long-axis view was employed to specify end-systole. The endocardial borders were manually drawn in the apical views at end-systole to identify the regions of interest. Each LV apical view had its peak systolic longitudinal myocardial strain automatically calculated across the myocardium, reported circumferentially in a polar plot map, and reported spatially from base to apex using a color-coded parametric representation. The GLS was calculated by averaging the peak systolic segmental strain values from the three standard apical views. Three consecutive cardiac cycles were used to average longitudinal peak strain values (Fig. 1).

Asymptomatic Anthracycline-related cardiac dysfunction was defined according to the ESC 2022 guidelines on cardio-oncology [4] which defined moderate dysfunction as new LVEF reduction by ≥ 10 percentage points to an absolute value of LVEF of 40–49%. After a 12-week period of follow-up, heart dysfunction was definitively diagnosed.

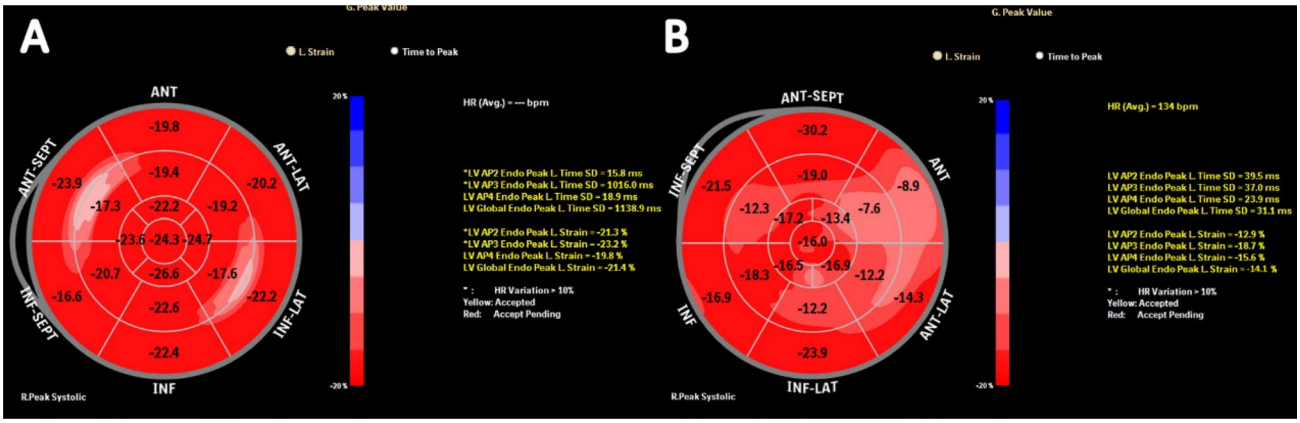

Fig. 1 Baseline (**A**) and 3-weeks (**B**) GLS in case number 10 (50-yr-old female with breast cancer who developed cardiotoxicity). Anthracycline for colon cancer is not a standard regimen in Japan

Biomarkers assessment

Blood sampling

Following an overnight fast and a 20-min interval of rest, patients' blood samples were taken in the morning to reduce possible diurnal, dietary or exercise-induced variations of the biomarkers. Samples were withdrawn from every participant in the study at baseline, and at 3-week follow-up.

Three millilitres of venous blood were collected under complete aseptic precautions into plain test tubes without anticoagulants and were left till coagulation. After centrifugation of 3000 r.p.m for 20 min at room temperature, for further examination, the serum was isolated and kept at – 20 °C.

Measurement of hs-Troponin-I and NT-proBNP

Hs-cTnI and NT-proBNP were measured using the human hs-cTnI ELISA Kit (Catalogue No. 201-12-1243) and human NT-proBNP ELISA Kit (Catalogue No. 201-12-1240) respectively provided by (Shanghai Sunred Biological Technology Co. Ltd, China) on (DAS srl A4 ELISA microplate reader [Serial No. 1912]). These kits utilize a double-antibody sandwich enzyme-linked immunosorbent assays to assess human hs-cTnT with an analytic range of 6–1800 pg/mL and human NT-proBNP with an assay range of 2–36 pg/mL. N-terminal atrial natriuretic peptide, BNP, and atrial natriuretic peptide did not show any sign of detectable cross-reactivity.

Statistical analysis

SPSS version 28 was employed for both data administration and statistical analysis (IBM, Armonk, New York, United States). The Kolmogorov–Smirnov test, the Shapiro–Wilk test, and direct data visualization techniques were employed to establish the normality of quantitative data. Quantitative data were summarized using means, standard deviations, or medians and ranges according to normalcy. Numbers and percentages were employed to display a set of categorical data. Depending on whether the quantitative data were normally or non-normally distributed, the independent *t*-test or Mann–Whitney *U* test was employed to compare the data according to cardiotoxicity. Using the Chi-square or Fisher's exact test, categorical data were compared. To foresee cardiotoxicity, ROC analysis was conducted for several parameters. Calculations were made to determine the optimal cutoff points, diagnostic indices, and areas under the curve with 95% confidence intervals. Cardiotoxicity was predicted using multivariate logistic regression analysis. Calculations were made to determine the odds ratios and their 95% confidence intervals. Each and every statistical test has two sides. *P* values under 0.05 were considered to be significant.

Results

Baseline characteristics

During the study period, we screened 99 patients for inclusion. Eight patients were excluded because of AF ($n=4$), ventricular paced rhythm ($n=1$), and more than mild aortic stenosis ($n=3$). 11 patients were disqualified from the remaining 91 patients because of the image's poor quality. Finally, 80 patients were incorporated (mean age 51 ± 11 years; 68.8% females) of whom 10 patients (12.5%) developed cardiotoxicity at the end of the 12-week follow-up period based on the definition used. No statistically significant differences were found in all baseline characteristics between those patients who experienced cardiotoxicity and those patients who did not. However, the total cumulative

Anthracycline dose was significantly higher in patients who developed cardiotoxicity in contrast to patients who did not (255 ± 5 vs 233 ± 8 mg/m^2, $P < 0.001$) (Table 1).

Echocardiographic data

At baseline, both groups (patients who experienced cardiotoxicity and those who did not) were matched in all echocardiographic parameters including left ventricular end-systolic volume (LVESV) [$P = 0.853$], left ventricular end-diastolic volume (LVEDV) [$P = 0.808$], left ventricular ejection fraction (LVEF) [$P = 0.762$], and global longitudinal strain (GLS) [$P = 0.621$]. At 3-week follow-up timepoint, patients who developed cardiotoxicity showed a significantly higher LVESV and LVEDV, significantly lower LVEF, and significantly worse GLS (− 14 ± 0.4 vs − 17 ± 3.1%, $P < 0.001$). At the final follow-up visit, those patients who developed cardiotoxicity showed a significantly higher LVESV (but not LVEDV), significantly lower LVEF, and significantly worse GLS (− 11.3 ± 0.8 vs − 17.2 ± 2.8%, $P < 0.001$) (Table 2).

Biomarkers data

At baseline, patients who developed cardiotoxicity had significantly higher values for both high sensitivity Troponin-I (hs-Troponin-I) and NT-pro Brain Natriuretic peptide (NT-proBNP) contrasted with patients who did not experience cardiotoxicity. The same pattern was observed at the 3-week follow-up timepoint (Table 2).

Predictors for cardiotoxicity

Receiver operating characteristic (ROC) curve analysis revealed that: [1] a cutoff value of *baseline* hs-Troponin-I of > 11 ng/L predicted the occurrence of cardiotoxicity with a sensitivity and specificity of 90% and 100%, respectively (AUC 0.937, 95% CI 0.819–1.0, $P < 0.001$) (Fig. 2), [2] a cutoff value of *baseline* NT-proBNP > 90.1 pg/mL predicted the occurrence of cardiotoxicity with a sensitivity and specificity of 70% and 91.40%, respectively (AUC 0.880, 95% CI 0.756–1.0, $P < 0.001$) (Fig. 2), [3] a cutoff value of *3-week* LVEF of ≤ 52% predicted the occurrence of cardiotoxicity with a sensitivity and specificity of 80% and 98.6% respectively (AUC 0.871, 95% CI 0.713–1.0, $P < 0.001$) (Fig. 3), [4] a cutoff value of *3-week* GLS of ≥ − 14.5% predicted the occurrence of cardiotoxicity with a sensitivity and specificity of 100% and 81.4%, respectively (AUC 0.877, 95% CI 0.802–0.952, $P < 0.001$) (Fig. 3), [5] a cutoff value of *3-week* hs-Troponin-I of > 13.1 ng/L predicted the occurrence of cardiotoxicity

Table 1 Baseline characteristics of the study population stratified by the status of cardiotoxicity

	Total	Cardiotoxicity		*P*-value
		Yes ($n = 10$)	No (70)	
Age (years)	51 ± 11	48 ± 14	51 ± 10	0.377
Gender				
Males	25 (31.3)	1 (10)	24 (34.3)	0.121
Females	55 (68.8)	9 (90)	46 (65.7)	
BMI (kg/m^2)	28 ± 2	27 ± 2	28 ± 2	0.458
Hypertension	20 (25)	3 (30)	17 (24.3)	0.696
Diabetes mellitus	14 (17.5)	0 (0)	14 (20)	0.119
Smoking	10 (12.5)	0 (0)	10 (14.3)	0.201
Treated dyslipidemia	8 (10)	0 (0)	8 (11.4)	0.260
PH of lung disease	4 (5)	0 (0)	4 (5.7)	1.0
Type of cancer				
Breast	38 (47.5)	5 (50)	33 (47.1)	0.803
Hematological	15 (18.8)	1 (10)	14 (20)	
Colon	11 (13.8)	1 (10)	10 (14.3)	
Others	16 (20)	3 (30)	13 (18.6)	
Type of anthracycline drug				
Doxorubicin or adriamycin	45 (56.3)	5 (50)	40 (57.1)	0.871
Idarubicin	23 (28.7)	3 (30)	20 (28.6)	
Both	12 (15)	2 (20)	10 (14.3)	
Baseline creatinine (mg/dl)	1 ± 0.3	0.9 ± 0.2	1 ± 0.3	0.197
Total cumulative dose (mg/m^2)	236 ± 10	255 ± 5	233 ± 8	**< 0.001**

Data are presented as mean ± SD or number (percentage); Significant *P*-values are marked in bold

BMI body mass index, *PH* past history

Table 2 Echocardiographic and biomarkers data of the study population stratified by the status of cardiotoxicity

	Total	Cardiotoxicity		*P*-value
		Yes ($n=10$)	No (70)	
LVESV (mL)				
Baseline	23.33 ± 8.03	23.78 ± 5.92	23.27 ± 8.32	0.853
3-weeks	31 ± 12.1	53 ± 6.1	27.8 ± 9.1	**< 0.001**
% Change at 3 weeks	32.6 (− 63.4 to 367.9)	130 (59.7–211.2)	19.2 (− 63.4 to 367.9)	**< 0.001**
Final visit	30.5 ± 9.2	40.2 ± 1.4	29.1 ± 9	**< 0.001**
% Change at final visit	34.9 (− 59.9 to 407.1)	83.5 (2.1–117.2)	26.8 (− 59.9 to 407.1)	**0.015**
LVEDV (mL)				
Baseline	57.2 ± 18.7	58.6 ± 17.4	57 ± 18.9	0.808
3-weeks	76.7 ± 23.2	109.1 ± 12	72 ± 20.6	**< 0.001**
% Change at 3 weeks	40.1 (− 50.1 to 203.3)	92.8 (41.7–165.6)	32.3 (− 50.1 to 203.3)	**0.005**
Final visit	74.9 ± 18.9	76.8 ± 2.3	74.6 ± 20.1	0.394
% Change at final visit	39.8 (− 51.1 to 213.2)	38.7 (− 16.1 to 93.8)	39.8 (− 51.1 to 213.2)	0.965
LVEF (%)				
Baseline	61.64 ± 4.85	61.2 ± 5.11	61.7 ± 4.85	0.762
3-weeks	58.1 ± 6.3	53 ± 3.3	58.9 ± 6.3	**0.005**
% Change at 3 weeks	− 7.9 (− 26.2 to 36.5)	− 12 (− 23.6 to − 3)	− 7.1 (− 26.2 to 36.5)	**0.045**
Final visit	57.3 ± 6.9	47.7 ± 1.5	58.7 ± 6.3	**< 0.001**
% Change at final visit	− 7.5 (− 33.5 to 22.4)	− 22.7 (− 33.5 to − 12.1)	− 5.3 (− 26.4 to 22.4)	**< 0.001**
GLS (%)				
Baseline	− 18.2 ± 3.2	− 17.7 ± 3.1	− 18.3 ± 3.2	0.621
3-weeks	− 16.6 ± 3.1	− 14 ± 0.4	− 17 ± 3.1	**< 0.001**
% Change at 3 weeks	− 8.3 (− 47.1 to 39.5)	− 17.5 (− 39.1 to − 7.6)	− 6.3 (− 47.1 to 39.5)	**0.025**
Final visit	− 16.4 ± 3.3	− 11.3 ± 0.8	− 17.2 ± 2.8	**< 0.001**
% Change at final visit	− 8.4 (− 53.2 to 52.8)	− 33.1 (− 53.2 to − 23.6)	− 6.3 (− 43 to 52.8)	**< 0.001**
Hs-Troponin-I (ng/L)				
Baseline	9.4 ± 2.7	14.4 ± 2.1	8.7 ± 1.9	**< 0.001**
At 3-weeks	13.7 ± 5.9	26.7 ± 8.8	11.8 ± 1.3	**< 0.001**
% Change	29.7 (− 3.6 to 146.1)	93.3 (11.2–146.1)	27.1 (− 3.6 to 122)	**0.007**
NT-proBNP (pg/mL)				
Baseline	75.6 ± 20.2	109 ± 24.3	70.8 ± 14.3	**< 0.001**
At 3-weeks	124.4 ± 40	218.4 ± 44.1	111 ± 10.6	**< 0.001**
% Change	61.4 (1.2–265.6)	79.5 (11.9–265.6)	61 (1.2–155.8)	**0.029**

Data are presented as mean ± SD or median (min–max); Significant *P*-values are marked in bold

LVESV left ventricular end-systolic volume, *LVEDV* left ventricular end-diastolic volume, *LVEF* left ventricular ejection fraction, *Hs-Troponin-I* high sensitivity troponin-I, *NT-proBNP* NT-pro brain natriuretic peptide

with a sensitivity and specificity of 90% and 100%, respectively (AUC 0.910, 95% CI 0.742–1, $P < 0.001$) (Fig. 3), and [6] a cutoff value of *3-week* NT-proBNP of > 118.1 pg/mL predicted the occurrence of cardiotoxicity with a sensitivity and specificity of 90% and 100%, respectively (AUC 0.909, 95% CI 0.738–1.0, $P < 0.001$) (Fig. 3).

Moreover, an examination of multivariate adjusted logistic regression utilizing the occurrence of cardiotoxicity as the dependent variable revealed that percent change of LVEF, GLS, hs-Troponin-I, and NT-proBNP (from baseline to the 3-week timepoint of follow-up) to be significant independent predictors for the incidence of cardiotoxicity (Table 3).

Discussion

The current study was a prospective cohort study performed at Benha University Hospital in Egypt from September 2021 to October 2022 to determine the diagnostic value of GLS combined with cardiac biomarkers on early identification of Anthracycline-related cardiac dysfunction. Eighty patients

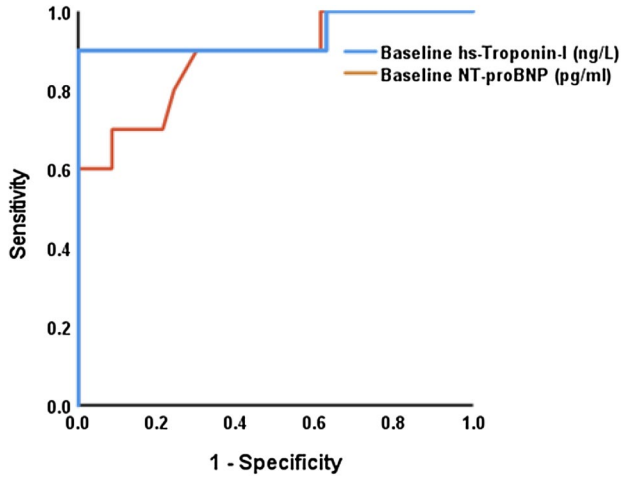

Fig. 2 Baseline hs-Troponin-I and NT-proBNP as predictors for Anthracycline-induced cardiotoxicity. Anthracycline for colon cancer is not a standard regimen in Japan

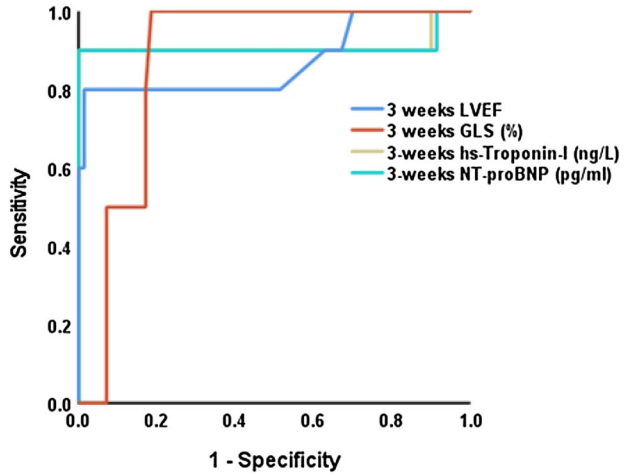

Fig. 3 Three weeks hs-Troponin-I, NT-proBNP. LVEF, and GLS as predictors for Anthracycline-induced cardiotoxicity. Anthracycline for colon cancer is not a standard regimen in Japan

Table 3 Multivariate logistic regression for prediction of cardiotoxicity

% Change at 3-weeks	OR (95% CI)[a]	*P*-value
LVEF (%)	1.091 (1.001–1.189)	**0.047**
GLS (%)	1.045 (1.001–1.091)	**0.048**
Hs-troponin-1 (ng/L)	1.025 (1.007–1.044)	**0.008**
NT-proBNP (pg/mL)	1.017 (1.002–1.031)	**0.022**

GLS global longitudinal strain, *LVEF* left ventricular ejection fraction, *Hs-Troponin-I* high sensitivity troponin-I, *NT-proBNP* NT-pro brain natriuretic peptide

[a]Adjusted for age and gender; OR: Odds ratio; 95% CI: 95% confidence interval; Significant P-values are marked in bold

were incorporated into the study, of which 12.5% developed cardiotoxicity after the 12-week follow-up period. The study found that patients who developed cardiotoxicity had higher values of hs-Troponin-I and NT-proBNP at baseline and 3 weeks after chemotherapy. The study also found that the percent change of LVEF, GLS, hs-Troponin-I, and NT-proBNP were significant predictors for the occurrence of cardiotoxicity.

Anthracycline-induced cardiotoxicity is a well-known adverse effect of chemotherapy treatment with anthracyclines, which are a class of drugs commonly used in the treatment of various cancers. Studies have shown that the prevalence of anthracycline-induced cardiotoxicity can range from 6% to as high as 27%, depending on various factors such as the dose and duration of treatment, age, and preexisting cardiovascular conditions [7]. These findings highlight the need for ongoing monitoring and management of cardiac function in patients undergoing treatment with anthracyclines.

GLS has been demonstrated to be more capable of identifying early alterations in cardiac function linked to anthracycline-induced cardiotoxicity than LVEF. According to several studies [8], GLS is a more sensitive marker of early myocardial dysfunction compared to LVEF, which is a commonly used measure of cardiac function. GLS has been demonstrated to be more sensitive than circumferential or radial strains in spotting early alterations in cardiac function associated with anthracycline-induced cardiotoxicity. This is because the longitudinal axis of the heart is more affected by anthracycline-induced cardiotoxicity compared to the circumferential or radial axis. Studies have reported that GLS is a more sensitive marker of early myocardial dysfunction associated with anthracycline-induced cardiotoxicity compared to circumferential or radial strains. As such, GLS may be a more reliable tool for the early identification of anthracycline-induced cardiotoxicity [9]. Studies have shown that measuring hs-Troponin-I and NT-proBNP levels in patients receiving anthracycline treatment can help foresee the emergence of cardiotoxicity and monitor the progression of the disease. In addition, these biomarkers have been used to monitor the effectiveness of preventive and therapeutic strategies in reducing the risk of cardiotoxicity associated with anthracycline treatment [10].

Combining cardiac biomarkers such as NT-proBNP and hs-Troponin I with GLS has the potential to enhance the prediction of anthracycline-induced cardiotoxicity. The use of multiple biomarkers enables a more thorough evaluation of the risk of cardiotoxicity and can help to increase the accuracy of the prediction. Few studies have shown that combining NT-proBNP and hs-Troponin I with GLS can improve the sensitivity and specificity of the prediction compared to using each biomarker alone. This is because each biomarker provides different information about the heart,

and the combination of these markers provides a more comprehensive picture of the heart's function and the risk of cardiotoxicity [5, 11]. While studies have shown promising results in using a combination of cardiac biomarkers such as NT-proBNP and hs-Troponin I with GLS for the prediction of anthracycline-induced cardiotoxicity, there are some limitations that to these studies, including a limited number of these studies, small sample sizes, and differences in methods used for measuring the biomarkers which make it difficult to draw general conclusions.

This study's strengths include the utilization of a prospective cohort design, which allows for the assessment of cause-and-effect relationships between exposure (in this case, the first course of anthracycline-based chemotherapy) and outcome (cardiotoxicity and biomarker levels). Additionally, the use of a consecutive sample of patients helps to reduce the risk of selection bias. The *combined* use of speckle-tracking echocardiography and biomarker assessment at multiple time points (baseline and 3 weeks after completion of chemotherapy) allows for a thorough evaluation of the impact of chemotherapy on cardiac function and biomarker levels. However, there are also some limitations to consider. The sample size of this study is relatively small, which can limit the generalizability of the results to larger populations. Additionally, the study was performed at a single centre and focused on a single type of chemotherapeutic agent, so the results may not be representative of other populations or healthcare settings. Furthermore, the study only assessed cardiac function and biomarker levels for a limited time period (12-weeks of follow-up), so the long-term impact of chemotherapy on cardiac function and biomarker levels is uncertain. Even though the prediction models were adjusted, the study also did not control for all potential confounders such as comorbidities and other medications, which may have influenced the results. We believe that the timing of serial echocardiographic follow-ups during cancer chemotherapy should be individualized based on each patient's characteristics, however, we aimed to unify these follow-ups at fixed time points/intervals for purposes related to our research methodology. Finally, and statistically speaking, we were not able to include the incremental prognostic value of adding cardiac biomarkers to echocardiographic measurements due to an extremely high level of multi-collinearity between NT-proBNP and hs-Troponin-I which will confound the model.

Conclusion

Combining global longitudinal strain with cardiac biomarkers, such as high-sensitivity Troponin-I and NT-proBNP, was a valuable tool in detecting Anthracycline-related cardiac dysfunction in early stages and that a multivariate-adjusted logistic regression analysis showed a significant relationship between percent change in LVEF, GLS, hs-Troponin-I, and NT-proBNP and the occurrence of cardiotoxicity. These findings suggest that combined monitoring of hs-Troponin-I, NT-proBNP, LVEF, and GLS can assist in identifying patients at risk for cardiotoxicity and allow for timely intervention to prevent or mitigate the damage. Additional research is essential to validate these results in larger and more diverse patient populations.

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Author contributions MK and AB conceived and designed the consensus and critically revised the manuscript. AB was the major contributor to the initial draft and writing. HA, MB, AO and HA helped in drafting the manuscript. All authors have read and approved the final manuscript.

Data availability All data are available upon request from the corresponding author(s).

Declarations

Conflict of interest The authors declare no conflict of interest.

Consent for publication Not applicable.

Ethics approval and consent to participate The study protocol was approved by the research ethics committee of Benha Faulty of Medicine at Benha University (REC-FOMBU)–reference number: RC-6-9-2021. An informed written consent to participate in the study was provided by all participants. We excluded patients under 16 years old from the study.

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