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Using Speckle Tracking Analysis, Does Age Affect RV Longitudinal Strain?

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Abstract: Introduction: The right ventricle (RV) is increasingly crucial in clinical settings, but traditional echocardiography is challenging to evaluate its function. Advanced techniques like speckle tracking improve RV functional assessment. According to previous studies, RV free wall longitudinal strain measurements vary with age necessitating further research. Aim: This study aimed to evaluate the effects of age on RV longitudinal strain using speckle tracking (ST) analysis. Methods: 103 healthy adult volunteers, mean age 37.1±11.9 years (range: 20-66), underwent comprehensive speckle tracking analysis, to determine age-related changes in RV dimensions and function. Results: showed a significant decrease in global and segmental (basal, mid, and apical) FWLS with age (p < .001). Conclusion: These significant differences in free wall longitudinal strains among age groups by 2D-ST analysis indicate the need for age-adjusted measures in RV function evaluation. Conventional techniques may ignore minor changes, leading to underestimated RV function assessment. The findings also suggest that advanced techniques allow early identification of RV dysfunction by detecting subclinical dysfunction before anomalies revealed by traditional echocardiography occur.

Keywords: Right Ventricle, Speckle Tracking, Age.

1. INTRODUCTION

The RV has been largely overlooked in cardiac research, but recent studies have shown that accurate measurement and performance can significantly impact clinical therapy and prognosis, especially in patients with right-sided heart failure and congenital heart disorders. Traditional echocardiographic methods are more challenging due to the RV's complex 3-dimensional cavity architecture, myocardial fiber architecture, and complex contraction

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mechanism. However, the development of novel echocardiography techniques, such as strain imaging, has altered the incorrect understanding of RV role in general cardiovascular function and made it possible to precisely examine RV structure and function. [1] [2]
Advanced assessment of RV function using speckle tracking (ST) is a non-invasive imaging technique that allows for the assessment of myocardial strain by tracking speckles within the myocardium. The development of this novel technique, has altered the incorrect understanding of the RV's role in general cardiovascular function and made it possible to precisely examine RV structure and function, overcoming some of the drawbacks of traditional echocardiographic measures [3]. Meanwhile, there is a paucity of information on how these new modalities differ depending on age and gender [4]. Over its lifespan, the RV is anticipated to adapt in a variety of ways, but differences between young and old RV are not well understood [2].This study contributes to the body of evidence encouraging the incorporation of these strategies into standard clinical practice, potentially improving healthcare and patient management by early detection and monitoring of age-related changes in RV function. The aim of this study was to evaluate the effects of age on RV longitudinal strain using ST analysis.

2. RELATED WORK

Myocardial contractility can be evaluated in the focused apical four-chamber view through strain and strain rate, which refer to the percentage change in length and the rate of deformation over time. A six-segment model can be generated by dividing each of the interventricular septum and RV free wall into three segments. The global longitudinal strain of the RV is determined by averaging the six segmental values, while the longitudinal strain of the RV free wall is determined by averaging the three segmental values of the free wall. [5-7]
Longitudinal strain, expressed as a negative percentage, measures the percentage shortening of a myocardial region of interest (ROI) relative to its original length. RV free wall strain values are generally higher than global RV longitudinal strain and have prognostic value by detecting early deterioration of RV function that can be applied in various diseases such as pulmonary hypertension and congenital heart diseases. [8]
2D-STE is advantageous in that it is angle-independent and relatively load-independent compared to TDI-derived parameters and can detect subtle myocardial abnormalities that conventional parameters may miss. RV strain has been found to be a predictor of cardiovascular mortality, outperforming other conventional parameters such as TAPSE and FAC, as well as CMR derived RV strain and EF. [9]
Studies have shown that aging is associated with decreasing RV systolic function, which is similar to the findings in the LV. The thickness of the RV wall also increases over aging. These modifications imply that, like in the LV, RV stiffness rises throughout aging. These studies are supported by Addetia *et al*.'s observation of variations in echocardiography parameters, which imply that the RV becomes stiffer with aging. It has been demonstrated that pulmonary arterial modification and elevated pulmonary vascular resistance are consequences of aging. There's an evident positive relationship between PA systolic pressures and aging identified through echocardiographic investigations on RV function. This could therefore result in modified contraction dynamics, lower global and regional RV systolic strain, and enhanced RV afterload and remodeling. [10, 11]

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in a study by Qu *et al*. (2020) which comprised 150 healthy volunteers divided into three age groups (20–40, 41–60, and 61–80) with a mean age of (49.8±17.3) years. RVFW global and regional longitudinal strain (basal, mid, and apical) were measured using CMR with the aim to look at changes in RVFW-LS related to age and gender. According to their findings, the apical LS was substantially smaller than the basal and mid LS. Nonetheless, there was no relationship or obvious age-related difference in RVFW-GL. [12]

3. SUBJECTS AND METHODS

This cross-sectional study involved 102 healthy male participants from November 2022 to October 2023 who were referred to the echocardiography unit at Al-Forat Teaching Hospital in Al-Najaf Governorate. They were screened for cardiovascular disease, including medical history, medication use, risk factors, and lifestyle choices. A physical examination was performed to rule out cardiovascular and metabolic co-morbid disorders. The participants were divided into four groups based on age: Group A (aged 20-29), Group B (aged 30-39), Group C (aged 40-49), and Group D (aged 50-60). The study excluded participants with a history of coronary artery disease, diabetes mellitus, systemic arterial hypertension, smoking, bicuspid aortic valve, congenital heart disease, heart failure, cardiomyopathy, sinus rhythm disturbances, or respiratory disorders, treatments affecting the heart, poor quality echocardiogram images, and athletes.

Echocardiographic Analysis

The study involved a single examiner conducting echocardiography examinations using Vivid E9 equipment. Participants were informed about the study's purpose and given the option to accept or reject participation. Methods included recording height and weight, determining BMI, and computing body surface area. The study assessed RV function through ST echocardiography exam, with participants in the left lateral decubitus posture. (table 1)

Table: 1. Anthropometric data of study:

Data (M±SD)	**Group A (20_29 yrs) No. 33**	**Group B (30_39 yrs) No. 25**	**Group C (40_49 yrs) No. 25**	**Group D (50>60 yrs) No. 20**	**Total No. 103**
Age	24.9±2.8	32.7±2.99	43.7±3.0	55.7±5.4	37.1±11.9
Weight (kg)	73.5±15	78.3±12.0	81.4±11	81.1±14	78±13.6
Height (cm)	171.7±6.5	172.2±4.5	172±4.9	171.7±6.1	171.9±5.5
BMI (kg/m^2)	24.6±4.4	26.2±3.2	27.3±2.90	27.2±3.9	26.1±3.8

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BSA (m2)	1.8±0.1	1.8±1.9	1.8±0.1	1.8±0.1	1.8±0.1

The study used 2D-ST strain analysis to measure the global longitudinal RV systolic function. The RV-focused apical 4-chamber view was acquired from the apex at end-expiratory apnea, allowing for a more precise characterization of the RV free wall. This approach offers more reliable results and allows for a proper image of the entire RV. To ensure proper orientation, the LV apex was positioned at the center of the scanning sector, and the largest RV dimensions were displayed throughout the cardiac cycle. The aortic valve and coronary sinus were not visible in the RV-focused apical four-chamber image. An automatically generated region of interest (ROI) was created, centered on the end-systolic RV endocardial border. The region's width and position were manually adjusted to encompass the entire myocardial wall and avoid the intensely reflective and inextensible pericardium. The RV free wall was automatically divided into three segments by the software: basal, mid, and apical. Subjects whose tracking was consistently unsatisfactory were excluded from the study. An echocardiographer analyzed the echocardiographic results. [13-15]

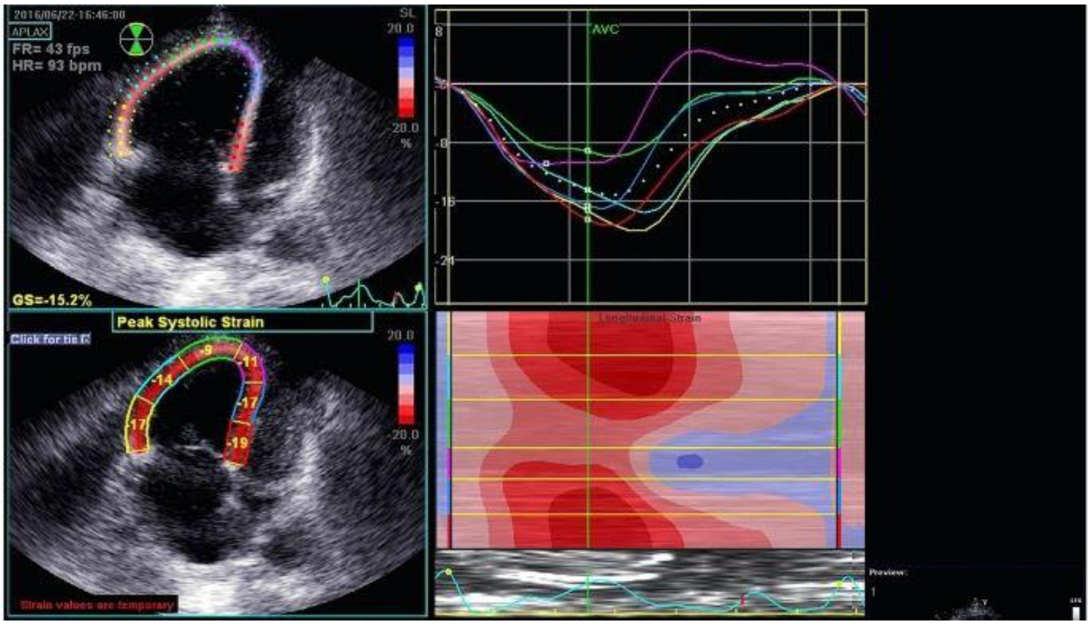

Fig 1: 2D ST for measuring RVFWLS, which was calculated as the arithmetic average of the free wall segments (basal, mid, and apical) and traced in the apical 4 chamber view.

Statistical Analysis

The data were analyzed per age categories [group A (20-29 year), group B (30-39 year), group C (40-49 year) and group D (50-60 year or more)]. We calculated the mean and standard deviations. To compare the study groups, SPSS version 28 was used along with analysis of variance (ANOVA) and correlation regression testing. An analysis of the relationship between

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the different variables and age was conducted using the correlation coefficient (r). Probability value P less than 0.05 was considered statistically significant (α=0.05).

4. RESULT AND DISCUSSION

Result

The mean values by age for the GLS, basal, mid and apical FWLS which are measured by STE are shown in Tables 2.

RV GLS, basal, mid and apical FWLS demonstrated a significant decrement with age ($p < 0.01$). RV GLS, basal, mid and apical FWLS measurements were significantly different between group A and group D. These measurements also were statistically significant among groups B-D and C-D, except apical FWLS was not significantly different in these groups.

Table 2: The values of RV GLS, Basal, Mid, Apical FWLS according to age groups.

Data (M±SD)	Group A (20_29 y) No. 33	Group B (30_39 y) No. 25	Group C (40_49 y) No. 25	Group D (50>60yr) No. 20	Total No. 103	P. value
GLS (%)	28.6±4.5	27.7±6.03	25.3±5.3	21.2±5.7	26.2±5.9	Highly Sig.
Basal FWLS (%)	30.0±5.2	30.0±6.9	26.9±6.4	20.1±7.2	27.4±7.3	Highly Sig.
Mid FWLS (%)	30.3±4.5	29.5±6.5	26.9±5.7	22.2±6.2	27.8±6.3	Highly Sig.
Apical FWLS (%)	26.8±6.0	24.6±7.2	23.0±6.4	22.0±6.9	24.4±6.7	Sig.

Values presented as means ± SD. GLS: global longitudinal strain, Apical FWLS: apical free wall longitudinal strain, Mid FWLS: mid free wall longitudinal strain, Basal FWLS: basal free wall longitudinal strain.

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Correlation of RV GLS, Basal, Mid, and Apical FWLS Derived by STE with age:
There was significant medium negative relationship between age and each of the GLS (r= -.397, p < .001), basal (r= -.423, p < .001) and mid FWLS (r= -.392, p < .001). Apical FWLS show a significant small negative relationship with age (r= -.24, p = .015). (Figure: 2,3,4,5)

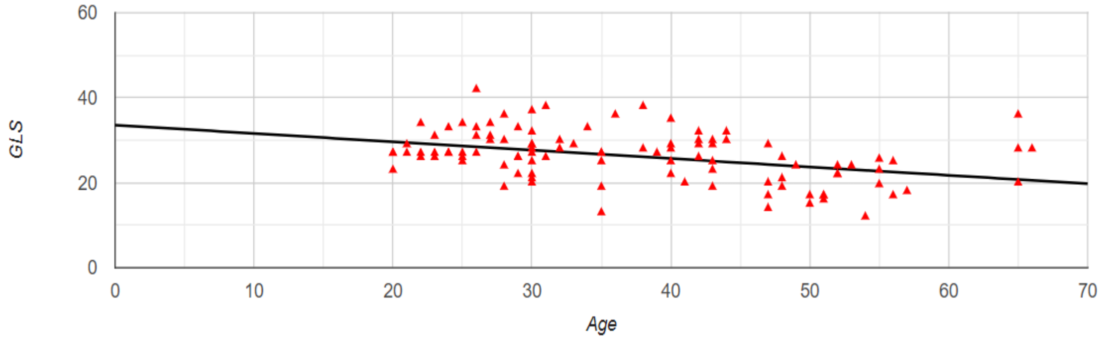

Figure 2: linear regression plot demonstrating the relationships between GLS and age in years.

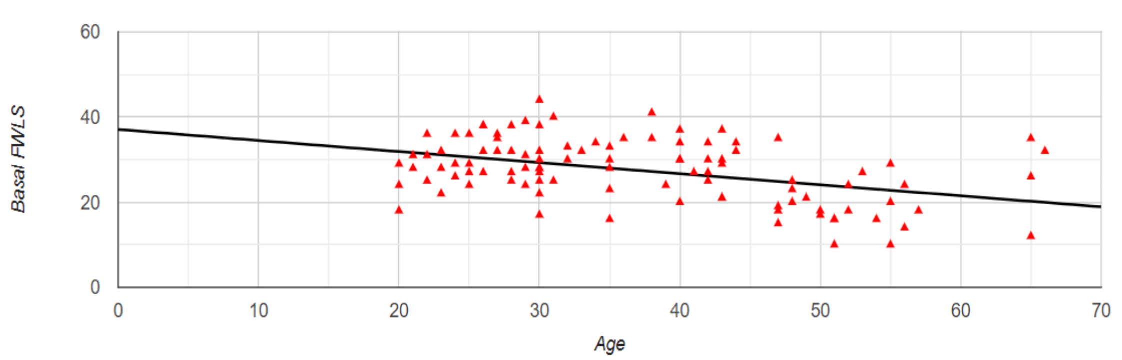

Figure 3: linear regression plot demonstrating the relationships between basal FWLS and age in years.

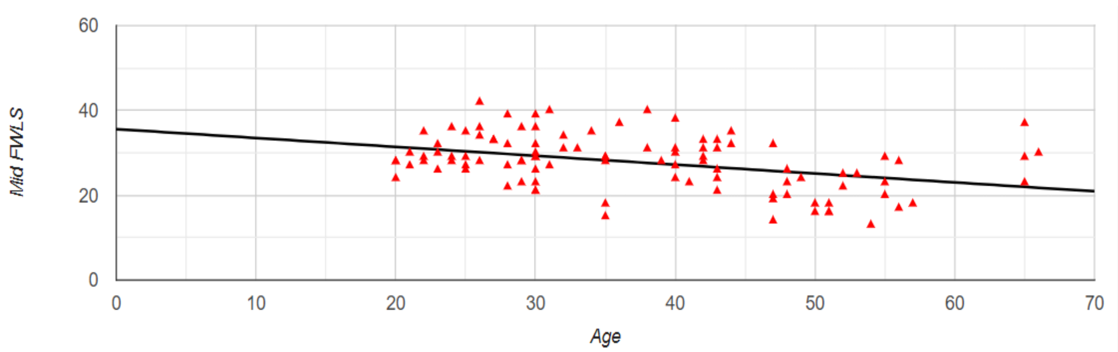

Figure 4: linear regression plot demonstrating the relationships between mid FWLS and age in years.

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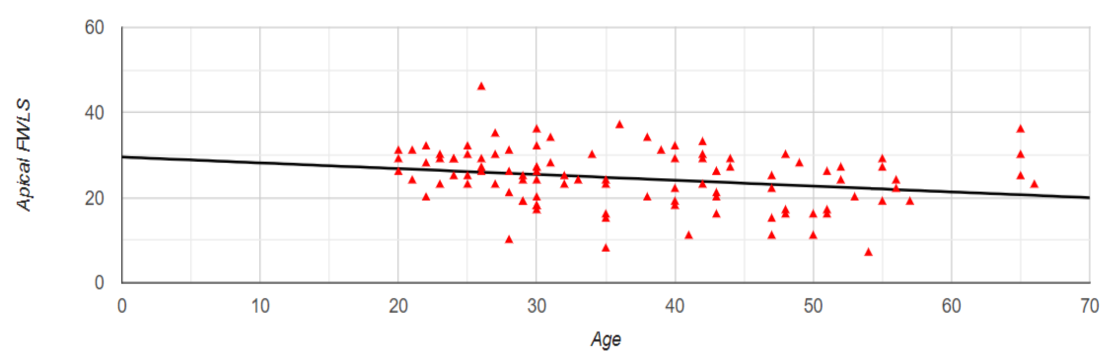

Figure 5: linear regression plot demonstrating the relationships between apical FWLS and age in years.

Discussion

The study reveals that age significantly impacts RV strain, with strain measurements from STE decreasing with advancing age. This has implications for clinical and research settings, as age normalized values must be considered when interpreting RV parameters to establish normality or abnormalities. RV functional capability is crucial for predicting outcomes in various disorders, making age normalized values essential.

RV contraction is mostly caused by longitudinal shortening. The architecture of the cardiac muscle fibers in the LV and RV varies depending on the myocardial level. While circumferential fibers predominant in the lateral wall of LV, longitudinally arranged fibers predominate in the RV free wall. Early detection of RV dysfunction may be possible with longitudinal strain assessment since it can detect subclinical dysfunction before anomalies revealed by FAC occur.

The septal segments of RV are not included in the global strain analysis of the majority of studies [16]. Given that the interventricular septum primarily composes the LV and just represents 20% of the overall systolic performance of the RV, RVFW analysis seems to be more accurate for evaluating RV contraction. To rule out the impact of the LV, we conducted the study without including the septal segments.

We observed a significant decrease in RV GLS along with different age-related changes in segmental strain. The apical region of RV is slightly immobile and extensively trabeculated [17]. This study found that there is a significant small negative correlation between apical FWLS and aging, but a highly significant difference between basal as well mid FWLS and increasing age. This suggests that there is variation in RV involvement with aging, owing to the basal and mid segments being impacted more compared to the apex. Furthermore, older individuals showed a rise in the apical segment contribution to overall strain, which could be a compensatory process for compensating with the reductions in basal and mid segmental functionality. Similarly, Chia *et al*. found that the RV apical function was relatively spared with age in a study involving 142 healthy participants using 2D STE [18]. They found that whereas apical strain did not decrease to a statistically significant level, basal and mid strain significantly decreased with age. In addition, GLS in their study showed a significant decrease with aging, which is consistent with findings of current study. Analysis of the regional RVFWLS readings showed that the apical LS was smaller than the basal and mid LS.

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This finding are consistent with those of [12], who used CMR to measure the global and regional longitudinal strain (basal, mid, and apical) of RVFW. On the other hand, they reported that RVFW-GLS did not exhibit any significant age-related differences. However, in current study, perhaps as a result of using of 2D-ST analysis, we found significant age-related decreases in GLS as well as regional strains (basal, mid, and apical). Dalen *et al*. observed a similar decrease in LV strain with increasing age; but, the RV was not evaluated in their research [19]. In accordance with findings of this study, age showed a negative association with RVLS in the biggest ST analysis conducted by Muraru *et al*. involving 276 healthy individuals [20]. While Park *et al*. reported that total and free wall RVGLS in females changed significantly with age groups, but there were no statistically significant differences in the male group [21]. According to Addetia *et al*. study, regional and global longitudinal free wall strain did not change or only slightly decreased with age. [22]
The age-related increases in PVR and pulmonary artery pressure may be the cause of these strain changes. Reduced strain may also be the consequence of poor calcium uptake by cardiomyocytes, myocyte loss owing to collagen deposition, and subsequent replacement by fibrosis with aging [23]. This emphasizes the necessity of using appropriate age-matched controls once comparing RV function when evaluated via strain.

5. CONCLUSIONS

Global and regional RVFWLS were significantly decline with age, therefore age-adjusted measures are required in the evaluation of RV function. These findings also indicate that advanced techniques allow early identification of RV dysfunction since they can detect subclinical dysfunction before anomalies revealed by traditional echocardiography occur.

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