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The Effect of Age on Right Ventricular Systolic Function Using Traditional Echocardiographic Measures

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ABSTRACT

Background: *In a wide range of clinical settings, comprehensive evaluation of the right ventricle has become increasingly essential. Measures of right ventricle systolic function, including fractional area change, tissue Doppler, S velocity, tricuspid annular plane systolic excursion, show a significant variation in previous studies and different data known regarding how these measurements change with age.* ***Aim of the study:*** *The aim of this study is to evaluate the effects of age on right ventricle systolic function by using conventional 2D echocardiographic assessment.*

Patients and methods: *Comprehensive transthoracic echocardiography examinations were performed on 103 healthy adult volunteers, mean age 37.1±11.9 years (range: 20-66), to determine age related changes in right ventricle dimensions and function.* ***Results:*** *2DE assessment of right ventricle function demonstrates slightly significant differences in tricuspid annular plane systolic excursion (r= -.197, p = .047), and FAC (r= -.241, p = .015), among age groups, with a non-significant very small negative relationship between age and tissue Dopplers (r= -.0925, p = .355).*

Conclusions: *This study has demonstrated that age-adjusted measures are required for the evaluation of right ventricle function. Further, the conventional techniques may ignore mild or slight changes leading to underestimated assessment which regarded as a fundamental challenge for their use; so, the use of advanced techniques which allow early identification of right ventricle dysfunction are recommended since they can detect subclinical dysfunction before anomalies revealed by traditional echocardiography occur.*

Keywords: Age, Right Ventricle, Systolic Function, Traditional Echocardiography.

Abbreviation: (RV) Right Ventricle, (TAPSE): Tricuspid Annular Plane Systolic Excursion, (Tds): Tissue Doppler Derived Tricuspid Lateral Annular Systolic Velocity, (FAC): Fractional Area Change, (TDI): Tissue Doppler Imaging.

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INTRUDUCTION

The right ventricle (RV) has been traditionally considered an irrelevant cardiac chamber, with little attention given to its specific physiologic and pathophysiologic characteristics. However, recent research has highlighted the need for a deeper understanding of RV characteristics. Accurate assessment of RV performance can significantly impact prognosis, especially in patients with right-sided heart failure and congenital heart disorders[1-7].

Echocardiography is the primary method for RV assessment due to its simplicity and diagnostic data. However, challenges like complex cavity, myocardial fiber architecture, and nonconcentric contraction mechanism make RV function assessment one of the most technically challenging tasks in echocardiography[1, 8-12]. The RV has a unique myocardial fiber arrangement, with most fibers oriented longitudinally. This structure explains RV contraction primarily based on longitudinal shortening. To accurately assess

RV systolic function, a multi-parametric method with global and regional measurements are recommended. Global measurements include fractional area change (FAC), while regional measurements focus on specific RV function aspects like tricuspid annular plane systolic excursion (TAPSE) and tricuspid annular longitudinal velocity. Conventional 2DE parameters assess both radial and longitudinal RV contraction elements, but there is a lack of information on how these new modalities differ depending on age and gender [9, 13-15][16-20]. The tricuspid annular peak systolic velocity (S') is a reliable technique for evaluating the systolic function of the RV. It correlates positively with RVEF determined by CMR and has better prognostic value than other parameters like FAC and TAPSE. TAPSE is a reliable index for primary RV function evaluation and monitoring, but has limitations such as being angle-dependent and not fully representative of RV global function. FAC measures the change in RV area from end-diastole to end-systole, but may overlook outflow tract contraction, which is crucial for congenital heart disease cases. Studies show that RV FAC is a significant predictor of cardiovascular and overall mortality [18, 21-23].

The aim of this study is to evaluate the effects of age on RV systolic function by using conventional 2D echocardiographic assessment, which are important for distinguishing between pathological conditions and normal physiological changes. It improves a diagnostic precision by identifying initial RV impairment signs and understanding mechanisms of age-related modifications in the RV.

PATIENTS AND METHODS

This cross-sectional study investigated 102 healthy male participants from November 2022 to October 2023 who were referred to the echocardiography unit at al-Foratul-Ausat Teaching Hospital in Najaf-Iraq. 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.

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 (Tab. 1). The study assessed RV function through 2DE echocardiography exam, with a 3.5-MHz phased array transducer, while participants in the left lateral decubitus posture

Table 1: Anthropometric data of the 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
BSA (m2)	1.8±0.1	1.8±1.9	1.8±0.1	1.8±0.1	1.8±0.1

By passing an M-mode cursor through the tricuspid annulus in the typical apical four-chamber window and calculating the difference between the end-diastolic and end-systolic measured longitudinal movement of the annulus, in mm, taken at the onset of an electrocardiogram QRS complex, TAPSE was calculated as an indicator of the RV longitudinal systolic function (24, 25).

RV FAC (%) = 100 × (EDA − ESA)/EDA is the formula employed to calculate fractional area change, after the end-diastolic and end-systolic RV areas derived from planimetry of the endocardial boundary in the apical four-chamber view. It represents the radial and longitudinal elements of RV contraction (18).

By pulsed-wave DTI, peak systolic tricuspid annular motion velocity (S) in conjunction with simultaneous electrocardiography were measured at the lateral corner of the tricuspid annulus from the apical four-chamber view (18, 26-28).

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)]. The mean and standard deviations were calculated. 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 the different variables and age was conducted by using the correlation coefficient (r). Probability value P less than 0.05 was considered statistically significant (α=0.05).

RESULTS

The mean values by age for the RV systolic indices (TAPSE, FAC, TDs) derived by 2DE and TDI:there was a statistically significant decrease in FAC with age. In contrast, TAPSE and the tissue Doppler S wave doesn't show a significant variation with age. (Tab. 2).

FAC also was statistically different among group A-C and A-D. TAPSE and S wave were not significantly different in these four groups. The Correlation of RV systolic indices (TAPSE, FAC, TDs) derived by 2DE and TDI with age: According to the person correlation results, there was a significant small negative relationship between age and TAPSE (r= -.197, p = .047), as well as age and FAC (r= -.241, p = .015). There was a non-significant very small negative relationship between age and TDs (r= -.0925, p = .355). (fig: 1, 2, 3).

Table 2: The values of TAPSE, TDs, FAC according to age groups.

Data (M±SD)	Group A (20_29yrs) No. 33	Group B (30_39yrs) No. 25	Group C (40_49yrs) No. 25	Group D (50>60yr) No. 20	Total No. 103	P value
TAPSE (mm)	22.8±2.893	23.3±2.408	21.6±3.202	22.1±2.685	22.5±2.85	Non-Sig.
TDs (m/s)	0.13±0.021	0.14±0.029	0.12±0.028	0.13±0.031	0.13±0.02	Non-Sig.
FAC (%)	51.1±7.639	47.2±7.059	43.3±10.94	45.9±8.676	47.2±9.01	Sig.
	P value< 0.05: significant. P value< 0.01: highly significant.					

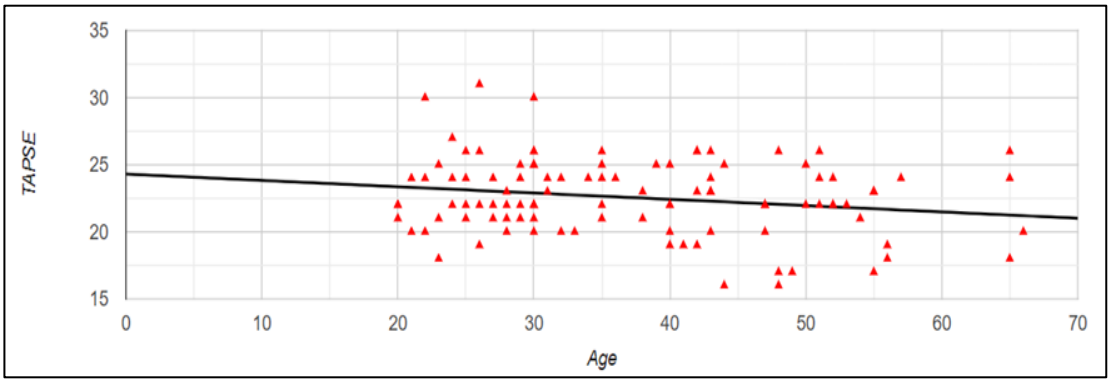

Figure 1: linear regression plot demonstrating the relationships between TAPSE and age in years.

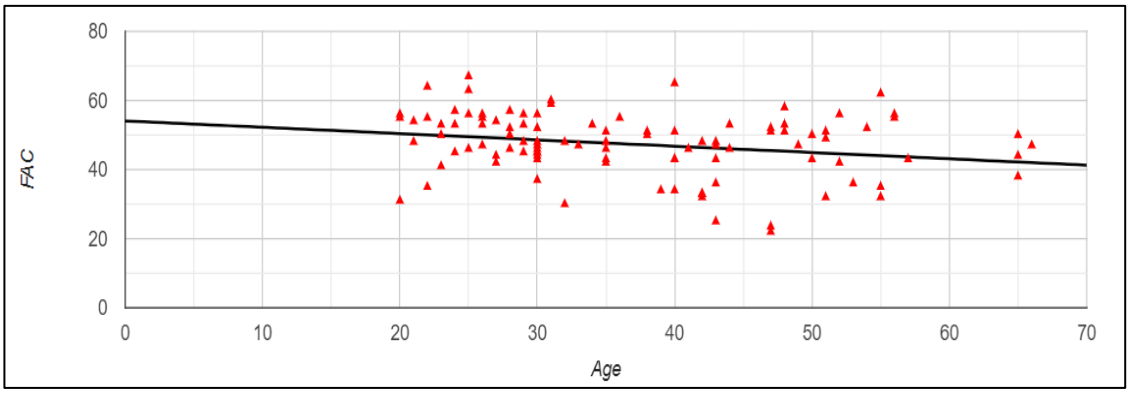

Figure 2: linear regression plot demonstrating the relationships between FAC and age in years.

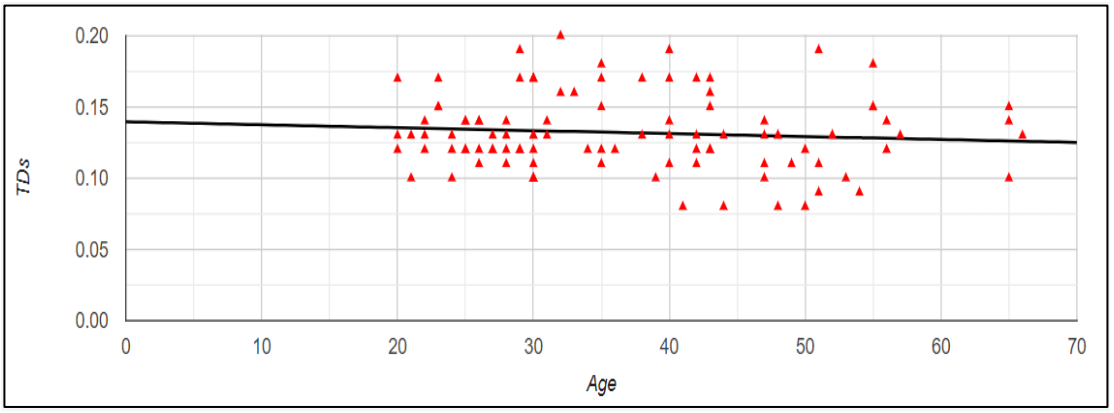

Figure 3: linear regression plot demonstrating the relationships between TDs and age in years.

DISCUSSION

This study has demonstrated that age has a significant effect on certain clinical parameters of RV systolic function. Age-related reductions were observed in longitudinal systolic function, as expressed by TAPSE, and RV contractility, estimated by FAC. There was a slight but non-significant negative correlation between age and the tissue Doppler S wave. The finding highlights the importance of routine cardiac assessment in elderly people to identify early aging-related changes. These results have significant implications for both present and future clinical and research settings. Specifically, they indicate that age normalized values have to be considered when interpreting RV parameters in clinical scenarios, to establish normality or the degree of abnormalities. This is particularly noteworthy as the RV functional capability serves as an important indicator of outcome in a variety of disorders.

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. Most previously proposed assessments of RV function(11) have relied on the imaging of peak systolic motion and TAPSE which provides easy indication of RV longitudinal shortening and FAC which is a primary indicator of RV contractility.

Like the study conducted by (29), the current study has observed a small but significant negative correlation between TAPSE and age. However, the slight negative relationship found here between age and S velocity was not statistically significant. It means that these parameters are possibly less vulnerable to the subtle changes in RV performance brought on by aging. Other research (11, 30-32), with the exception of the study of McGhie et al., which reported a non-significant correlation between TAPSE and age, found a decline in basal RV longitudinal function exhibited by TAPSE and s velocity. However, no significant change in RV systolic velocities with age was observed in other studies employing pulsed wave tissue Doppler (33-38). Perhaps as a result of the somewhat younger participants in current study.

The current study observed reduction in FAC which indicates an aging-related decline in right ventricular contractility and pumping capacity. The structural and functional alterations in the myocardium may be responsible for this age-related decrease in FAC. Lower RVFAC may result from impaired RV contraction caused by myocardial stiffness and fibrotic remodeling from collagen fiber deposition with age.

According to three earlier investigations (31, 37, 39), there was no significant change in FAC with aging. Further research is required to offer a more comprehensive knowledge of the correlation between RVFAC and age, as the current body of research is very restricted.

CONCLUSIONS

2DE derived FAC and TAPSE were shown to decrease significantly with age. RV longitudinal systolic function as measured by tissue Doppler s wave showed a small negative correlation **WITH** age, which demonstrate that conventional techniques may ignore mild or slight changes leading to underestimated assessment regarded as a fundamental challenge for their use. So, the use of advanced techniques which allow early identification of RV dysfunction are recommended since they can detect subclinical dysfunction before anomalies revealed by traditional echocardiography occur.

RECOMMENDATIONS

1. A long-term follow-up of the participants would support the findings of this cross-sectional analysis.
2. It is recommended that a greater number of participants including female gender be examined.

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