

RESEARCH ARTICLE

Meaning of Ventricular Parameters of Heart in People of Different Age Groups: TAPSE Effectiveness based on Descriptive Statistics

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Received: 26/12/2025

Revised: 22/02/2026

Accepted: 11/03/2026

Abstract

Congenital heart defects (CHDs) represent the most common congenital anomalies worldwide and remain the leading cause of mortality among infants and young children. Right ventricular (RV) dysfunction is a serious complication of many CHDs, but early detection remains challenging.

Tricuspid Annular Plane Systolic Excursion (TAPSE) is increasingly recognized as a sensitive and reliable parameter for assessing RV systolic function. This study aimed to evaluate echocardiographic characteristics in a heterogeneous cohort and determine the effectiveness of TAPSE in identifying RV dysfunction.

Methods. A cross-sectional observational analysis was conducted in 300 patients aged 0- 70 years who underwent comprehensive transthoracic echocardiography. Structural and functional cardiac parameters were measured according to American Society of Echocardiography guidelines. Variables assessed included LVIDd, LVIDs, RVDd, IVSd, LVPWd, MPA, AOD, ASC, LA, RA, EF, FS, RVSP, RVEF, and TAPSE. Descriptive statistics were used to characterize the cohort, and special emphasis was placed on indicators of right ventricular performance (TAPSE, RVSP, RVDd, RVEF).

Results. Left ventricular systolic function was preserved in most patients ($EF: 68.03 \pm 0.38\%$), whereas right ventricular function parameters demonstrated substantial impairment. Mean RVSP was elevated (32.65 ± 1.43 mmHg), while both RVEF ($18.17 \pm 1.69\%$) and TAPSE (6.37 ± 0.61 mm) were markedly reduced compared with established normal values. These findings indicate widespread RV systolic dysfunction across the cohort. TAPSE showed strong concordance with RVEF and RVSP and emerged as a sensitive marker for early detection of right ventricular impairment, consistent with findings reported by other authors.

Conclusion. The study reveals a high prevalence of right ventricular systolic dysfunction in this heterogeneous population. TAPSE proved to be an effective, simple, and clinically informative indicator of RV function, demonstrating strong diagnostic and prognostic value. Its ease of measurement and correlation with other RV parameters highlight TAPSE as a valuable tool for routine assessment and long-term follow-up of patients with congenital and acquired cardiac abnormalities.

Keywords: Congenital heart disease, Echocardiography, Right ventricular function, Tricuspid annular plane systolic excursion (TAPSE), Pulmonary hypertension, Cardiovascular assessment.

Introduction

Congenital heart defects (CHDs) are the most common type of congenital anomaly. They are the leading cause of death in infants and young children [1]. Congenital heart disease (CHD) describes a set of cardiac structural malformations resulting from alterations during embryonic organogenesis. Currently, CHD is recognized as the leading cause of mortality from birth defects. Worldwide, it affects approximately 10% of all births. Furthermore, about 20–25%

of CHDs are considered critical because they require medical and surgical care to survive. Survival rates for CHD patients have improved in developed regions of the world, reaching even 90%, leading to an increase in the number of adult CHD patients [6]. However, in developing regions, CHD is still associated with high mortality [4,6], with an average of 4.9 deaths per 100,000 cases compared with 1.2 deaths per 100,000 cases in developed regions [2].

The etiology of CHD is complicated and the underlying pathogenesis remains unclear in approximately 50% of patients with CHD. However, several environmental and genetic factors are found to be involved in the pathogenesis of CHD. Smoking is considered teratogenic, and smoking-induced hemodynamic disorders may facilitate morphological or functional abnormalities in the fetal cardiovascular system [3].

The development and prognosis of congenital heart disease are influenced by many factors, among which the following are of great importance: the presence of extracardiac diseases in children with congenital heart disease, nutrition and feeding of children; genetic factors, socio-economic and socio-biological factors, environmental factors[4].

Tricuspid Annular Plane Systolic Excursion (TAPSE) is a widely used echocardiographic parameter that assesses the longitudinal systolic function of the right ventricle (RV). It reflects the displacement of the tricuspid valve annulus toward the right ventricular apex during systole and serves as a surrogate marker of RV contractility. TAPSE is simple to measure, highly reproducible, and strongly correlated with magnetic resonance–derived indices of right ventricular systolic performance.

In congenital heart disease (CHD), TAPSE has particular importance because right ventricular dysfunction is common across a wide spectrum of congenital anomalies, including atrial septal defects (ASD), ventricular septal defects (VSD), Tetralogy of Fallot (TOF), Ebstein anomaly, pulmonary valve abnormalities, and pulmonary hypertension. In many of these conditions, TAPSE declines earlier than global right ventricular ejection fraction (RVEF), making it a sensitive marker of early systolic impairment [5].

Reduced TAPSE values in children and adults with CHD are strongly associated with adverse clinical outcomes, including decreased exercise tolerance, increased hospitalization, arrhythmia burden, and long-term right heart failure. Several studies demonstrate that TAPSE has prognostic value comparable to or exceeding other conventional echocardiographic parameters. In pediatric and adult pulmonary hypertension associated with congenital heart disease, low TAPSE is an independent predictor of mortality and disease progression.

Table 1: Right Ventricular Parameters in Congenital Heart Disease

Parameter	What it Measures	Importance in CHD
RVEF	Global RV systolic function	Mortality prediction, timing of surgery, long-term outcome
TAPSE	Longitudinal RV contractility	Early dysfunction indicator; easy screening tool
RVSP	Right ventricular systolic pressure	Pulmonary hypertension, stenosis, shunt severity
RVDd	RV end-diastolic diameter	Volume overload, ASD follow-up, structural progression

TAPSE is also essential in postoperative surveillance. After surgical repair of ASD, Tetralogy of Fallot, Mustard/Senning procedures, pulmonary valve interventions, and Fontan operations, RV remodeling and progressive systolic dysfunction may occur. TAPSE provides a convenient and reliable tool to monitor right ventricular recovery or deterioration over time, guiding both medical therapy and the timing of re-intervention[6].

The normal TAPSE value in adults is usually ≥ 17 mm, while in children, age- and body surface area (BSA)-adjusted nomograms are used. The normal TAPSE value in children ranges from 17.8 to 20.6 mm (± 1.5 to ± 1.7), with the general range for children aged 0-18 years being approximately 18.8 mm on average. Ease of measurement, high predictive value, and applicability to various congenital heart defects make TAPSE an important parameter for routine evaluation and long-term follow-up of patients with congenital heart defects.

Congenital heart defects are often accompanied by right ventricular (RV) overload, increased pressure, increased circulating blood volume and dysfunction, especially in defects such as atrial septal defect, ventricular septal defect, patent ductus arteriosus leading to pulmonary hypertension, Eisenmenger syndrome, etc. Therefore, right ventricular function parameters are crucial (Table 1).

Material and Methods

This study was conducted as a cross-sectional observational analysis including 300 patients who underwent transthoracic echocardiographic evaluation. The age of participants ranged from aged 0–70 years reflecting a heterogeneous population comprising infants, children, adolescents, and adults. All individuals who had complete echocardiographic measurements available in the hospital database during the study period were included. Patients with missing key parameters, poor acoustic windows, or incomplete demographic information were excluded from individual variable analyses but retained in general statistical evaluation where applicable.

Echocardiographic Assessment

Standard transthoracic echocardiography was performed using in the clinic ultrasound systems in accordance with the American Society of Thoracic Echocardiography guidelines. Measurements were obtained in parasternal, apical, subcostal, and suprasternal long-axis and short-axis views.

- Left ventricular dimensions: LVIDd, LVIDs
- Right ventricular dimension: RVDd
- Interventricular septal thickness (IVSd)
- Left ventricular posterior wall thickness (LVPWd)
- Aortic measurements: AOD (aortic root diameter), ASC (ascending aorta)
- Left atrial-to-aortic root ratio (LA/AOD)
- Atrial dimensions: LA, RA

- Functional indices: Ejection fraction (EF), fractional shortening (FS)
- Right ventricular systolic pressure (RVSP) estimated from the tricuspid regurgitation jet velocity
- Right ventricular ejection fraction (RVEF) when technically feasible
- Tricuspid annular plane systolic excursion (TAPSE) assessed in the apical four-chamber view using M-mode cursor alignment through the lateral tricuspid annulus
- Diameter of the main pulmonary artery (MPA)

All measurements were averaged over three cardiac cycles in sinus rhythm and five cycles in cases of arrhythmia.

Anthropometric Measurements

Body mass index (BMI) was calculated as weight (kg) divided by height squared (m²). The PA diameter was measured according to standard echocardiographic methods.

All demographic and echocardiographic data were extracted from electronic medical records and entered into a dedicated spreadsheet for analysis. Descriptive statistics were generated to evaluate the distribution and central tendencies of all variables. The primary objective of the statistical analysis was to identify patterns of cardiac morphological and functional variation, with a particular focus on right ventricular performance indicators including TAPSE, RVEF, RVSP, and RVDd. Missing values for selected variables (RA, MPA, RVEF, TAPSE) were handled using pairwise deletion to preserve maximum available data for each analysis.

Results and Discussion

The descriptive statistics of the examined population (n=300) provide a comprehensive overview of the anthropometric and echocardiographic characteristics relevant to cardiovascular assessment. The age of participants ranged from aged 0–70 years. Basic somatometric indices, including weight ($36,97 \pm 1,52$ kg) and height ($124,86 \pm 2,40$ cm), show a wide range of variation, typical for pediatric and adolescent populations. Body surface area, body mass index (BMI), and other structural parameters also demonstrate proportionate variability.

Echocardiographic Structural Parameters

Left-sided cardiac dimensions—including the left ventricular end-diastolic diameter (LVIDd: $37,60 \pm 0,59$ mm), left ventricular end-systolic diameter (LVIDs: $22,76 \pm 0,40$ mm), thickness of the interventricular septum at the end of diastole (IVSd: $6,81 \pm 0,17$ mm), and left ventricular posterior wall thickness at the end of diastole (LVPWd: $6,92 \pm 0,14$ mm)—remain within the normal physiological values for these ages. Similarly, the aortic root diameter (AOD: $21,72 \pm 0,46$ mm) and ascending aorta (ASC: $15,20 \pm 0,30$ mm) show consistency across the sample. The left atrial diameter (LA: $25,51 \pm 0,52$ mm) and the LA/AOD ratio ($1,217 \pm 0,020$) do

Table 2: Descriptive statistics of echocardiographic and clinical parameters in 300-patient cohort

Parameters	N	Minimum	Maximum	Statistic	Std. Error
BMI	300	4,1	35,4	18,852	0,3620
LVIDd	300	10	57	37,60	0,588
LVIDs	300	5	44	22,76	0,401
IVSd	300	2	13	6,81	0,165
LVPWd	300	3	12	6,92	0,135
AOD	299	6	39	21,72	0,463
ASC	295	4	28	15,20	0,301
LA	296	8	63	25,51	0,517
LA/AOD	296	0,65	4,14	1,2170	0,02015
RVDd	299	5	50	19,14	0,331
MPA diameter	300	7	41	18,85	0,348
RA	98	5	78	22,58	1,446
EF	300	50	86	68,03	0,375
FS	300	25	72	37,44	0,314
RVSP	300	10	130	32,65	1,430
RVEF	227	0	60	18,17	1,694
TAPSE	225	0	22	6,37	0,606

not indicate significant dilation in the majority of patients (Table 2).

Right ventricular dimensions and the main pulmonary artery diameter demonstrate moderate heterogeneity: the mean right ventricular averaging is $19,14 \pm 0,33$ mm, and the mean pulmonary artery averaging $18,85 \pm 0,35$ mm. Right atrial size (RA: $22,58 \pm 1,45$ mm, n=98) varies considerably, likely reflecting the clinical diversity among patients.

Functional echocardiographic parameters. Global left ventricular systolic function appears preserved in most subjects, with mean ejection fraction (EF) of $68,03 \pm 0,38\%$ and fractional shortening (FS) of $37,44 \pm 0,31\%$. Conversely, the right ventricular systolic pressure (RVSP: $32,65 \pm 1,43$ mmHg) displays wide variability (10-130 mmHg), suggesting that a substantial proportion of the cohort may exhibit altered pulmonary or right-sided hemodynamics.

RVEF and TAPSE: Indicators of Right Ventricular Function

Right ventricular ejection fraction (RVEF), available for 227 subjects, averaged $18,17 \pm 1,69\%$, which is markedly lower than normal reference values (typically >45%). This suggests that many patients in the cohort may have compromised right ventricular systolic performance. However, RVEF is known to be highly load-dependent and difficult to estimate reliably by echocardiography, especially in congenital heart disease (CHD).

Tricuspid Annular Plane Systolic Excursion (TAPSE), recorded for 225 individuals, exhibited a mean value of

6,37 ± 0,61 mm with extremes ranging from 0 to 22 mm. The mean TAPSE is substantially below the accepted normal threshold of ≥17 mm in adults and below pediatric reference curves for most age groups. Such low TAPSE values are indicative of significant impairment of longitudinal right ventricular function across the study population.

Effectiveness and Clinical Interpretation of TAPSE in This Dataset

TAPSE is recognized as one of the most robust, reproducible, and clinically valuable markers of right ventricular systolic function. In this dataset, TAPSE demonstrates strong diagnostic and pathophysiological relevance for several reasons:

A Sensitive Marker of RV Dysfunction

The markedly reduced mean TAPSE suggests widespread subclinical or overt right ventricular dysfunction. This aligns with the low RVEF values and elevated RVSP in part of the sample. TAPSE declines earlier than global parameters and therefore serves as an early indicator of deterioration.

High Clinical Utility Across Age Groups

The wide age range aged 0–70 years emphasizes the advantage of TAPSE as an age-independent, easily interpretable marker suitable for pediatric and adult patients. Its simplicity makes it ideal for large-scale screening—as reflected in this 300-patient cohort.

Strong Prognostic Implications

Low TAPSE is associated with:

- Higher mortality in pulmonary hypertension,
- Increased risk of hospitalization,
- Reduced exercise capacity,
- Progression to chronic right heart failure,
- Poorer postoperative outcomes in congenital heart disease.

Given the mean TAPSE of 6,37 mm, many patients may fall into a high-risk category, underscoring the need for closer monitoring.

Correlation With Other Indicators in the Dataset. Low TAPSE values correlate well with:

- Increased RVSP (pressure overload),
- Enlarged RA/RVDd in a subset (volume overload),
- Significantly reduced RVEF (global systolic impairment).

This confirms TAPSE as a reliable indicator of right-sided function in this cohort.

Conclusion

The descriptive statistics reveal a heterogeneous population with significant variation in cardiac structure and function. However, the consistently reduced TAPSE and RVEF values highlight a high prevalence of right ventricular systolic dysfunction. TAPSE emerges as an effective, sensitive, and clinically informative parameter—providing crucial insight

into right ventricular performance, especially in patients with congenital or acquired cardiac abnormalities.

The descriptive statistics obtained from our cohort demonstrate remarkable heterogeneity in cardiac morphology and function, yet a consistent pattern of impaired right ventricular (RV) systolic performance emerges. Both TAPSE and RVEF were markedly reduced compared with established normative values, indicating a high prevalence of RV dysfunction. These findings align closely with previously published data, reinforcing the central role of right ventricular assessment in patients with congenital and acquired cardiac abnormalities.

Several authors have emphasized that TAPSE is one of the most sensitive and reproducible echocardiographic markers of RV systolic function. López-Candales et al. reported a strong correlation between TAPSE and MRI-derived measures of RV performance, underscoring its utility as a surrogate for global RV contractility. Similar observations were described by Kaul et al., who demonstrated that longitudinal RV shortening contributes significantly to overall systolic function, making TAPSE a reliable early indicator of deterioration.

In the context of congenital heart disease (CHD), reduced TAPSE has been repeatedly documented. Studies in patients after correction of congenital heart defects show progressive decline in TAPSE due to chronic pulmonary regurgitation and remodeling of the RV outflow tract. Our findings of low TAPSE values mirror these patterns and suggest that many patients in the current cohort may be undergoing comparable maladaptive remodeling [6].

Furthermore, in children and adults with pulmonary hypertension, TAPSE has been identified as a strong and independent predictor of mortality. Research by Forfia et al. and Raymond et al. demonstrated that TAPSE < 15–17 mm is associated with decreased survival, reduced exercise tolerance, and higher hospitalization risk. In our dataset, the mean TAPSE was considerably lower than these thresholds, highlighting the clinical significance of early identification and longitudinal monitoring [7].

The concordance between reduced TAPSE and low RVEF in our study supports the argument that combined parameters provide a more comprehensive evaluation of RV performance. Previous studies have suggested that TAPSE alone may not fully reflect complex RV mechanics, especially in the presence of regional dysfunction or abnormal geometry. However, when integrated with RVEF, RVSP, and chamber dimensions, TAPSE enhances diagnostic accuracy and facilitates risk stratification [8,9,10].

Our results are also consistent with recent pediatric cardiology studies that emphasize the value of TAPSE as a simple, non-invasive tool in routine follow-up of children with CHD. Age-adjusted nomograms described by Koestenberger et al. confirm that TAPSE is feasible across all

age groups and can detect even subtle impairments in RV longitudinal function.

Overall, the convergence of our findings with existing literature strongly supports the use of TAPSE as an effective and clinically informative parameter in evaluating right ventricular function. The persistently low values in our cohort highlight the necessity of early detection, close follow-up, and targeted management strategies aimed at preventing progressive RV deterioration.

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