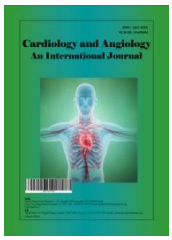

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Effect of Intra Cardiac Shunts on Left Ventricular Systolic Function: A Speckle Tracking Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: The left ventricular (LV) chamber size and its systolic function is the most common and quickest assessment made by echocardiography, either in the intra operative or intensive care setting, being the pressure generator for the blood supply to the body .Congenital cardiac defects come in two main types: atrial and ventricular septal defects (ASD/VSD). Regression or spontaneous closure may be the natural course of minor septal defects.
Aim and Objectives: The aim of the study was to assess the feasibility of speckle tracking echocardiography in estimation of left ventricular systolic function in congenital shunt lesions (ASD, VSD and PDA).
Subjects and Methods: This study was done in Tanta University Hospital including 270 patients. The patients were divided into four groups: ASD patients, VSD patients, PDA patients and control subjects.
Results: It showed statistically significant difference between ASD, PDA and control group. The difference between the PDA group and the control group was statistically significant. There was a statistically significant difference between the ASD group and the control group in terms of EF percent, FS percent, and ESV ROC curve for Validity of GLS to predict LV systolic dysfunction in PDA Group. Sensitivity was 68 and sensitivity was 80.
Conclusion: It was determined that Speckle-tracking echocardiography offers an additional non-invasive method for evaluating patients' left ventricular function. With congenital shunt lesions.

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Keywords: Intra cardiac shunts; left ventricular; systolic function; a speckle tracking study.

1. INTRODUCTION

The left ventricular (LV) chamber size and its systolic function is the most common and quickest assessment made by echocardiography, either in the intra operative or intensive care setting, being the pressure generator for the blood supply to the body [1].

Congenital cardiac defects come in two main types: atrial and ventricular septal defects (ASD/VSD). Regression or spontaneous closure may be the natural course of minor septal defects [2].

While more serious flaws require surgical correction or catheter closure. The location, size, hemodynamic effects, concomitant defects, and patient symptomatology all play a role in how an ASD or VSD should be managed. When there is a significant left-to-right shunt, the therapeutic strategy is often to repair an isolated ASD or VSD [3].

A persistent contact between the descending aorta and the left subclavian artery immediately distal to the proximal left PA is known as a patent ductus arteriosus (PDA). Although it can be connected to a number of CHD lesions, in adults it is typically an isolated finding. Patients with signs of LV volume excess but no PAH should consider PDA closure. Regardless of symptoms, PDA closure is advised [4]. L-R shunt and volume overload in the LV and LA are the initial effects of PDA. PAP is increased in mild and severe PDA. When patients with moderate PDA reach adulthood, either LV volume excess or PAH may predominate. Eisenmenger physiology has generally established in adult patients with extensive PDAs [5].

The dynamic size of the defect and the ratio of pulmonary-to-systemic vascular resistance are the main determinants of the hemodynamic changes in patients with an isolated ventricular septal defect or a patent ductus arteriosus [6]. These two factors control the degree of left-to-right shunt and pulmonary blood flow [6] as well as the resistance to left ventricular ejection via the defect. Recent developments in echocardiographic imaging, such as speckle tracking echocardiography (STE), which is based on myocardial strain analysis, have enhanced the evaluation of left ventricular (LV) function in people [7].

2. PATIENTS AND METHODS

270 participants participated in this study that was conducted at Tanta University Hospital. ASD patients, VSD patients, PDA patients, and control participants made comprised the four groups of patients. The IBM SPSS software programme, version 20.0, was used to enter data into the computer and analyse it. (IBM Corp., New York, Armonk) The terms used to describe qualitative data were number and percentage. The Kolmogorov-Smirnov test was used to determine whether the distribution was normal. Quantitative data were described using the range (minimum and maximum), mean, standard deviation, and median. At the level of 5%, the results' significance was evaluated.

2.1 The Used Tests Were: F-test (ANOVA)

Using normally distributed quantitative variables, apply the Post Hoc test (Tukey) for pairwise comparisons when comparing between more than two groups. For comparisons involving more than two examined groups and quantitative variables with an atypical distribution, use the Kruskal-Wallis test. For pairwise comparisons, utilise Dunn's multiple comparisons test (Post Hoc). The Chi-square (X2) test's significance level was used to compare the proportions between two qualitative factors. To determine the parameter's overall predictability and the appropriate cut-off value with the detection of sensitivity and specificity at this cut-off value, receiver operating characteristic (ROC curve) analysis was employed.

3. RESULTS

According to Table 1's patient age data, the average age of the ASD patient group was 15.64 9.57 years old (range: 2–40), the average age of the VSD patient group was 16.18 4.65 years old (range: 1.5–20), and the average age of the PDA patient group was 12.72 3.91 years old (range: 1.5–16). The control group's average age was 19.78 11.05. (Interquartile range: 1.5 to 40). Among the study groups, there was an age difference that was statistically significant.

As regards the patient's gender, Table 1 illustrated that the group of ASD patients included 31 male (40.3 %) and 46 females (59.7 %) and the group of VSD patients included 37

male (43.5%) and 48 females (56.5%) and the group of PDA patients included 26 male (44.8%) and 32 females (55.2 %). whereas the normal echo group included 23 male (46%) and 27 females (54%). There was no significant difference between the studied groups.

Regarding Body mass index (BMI), Table 1 revealed that the mean BMI of the group of ASD patients was 26.14 ± 2.58 (range 21.3 – 32.3) kg/m2., whereas, VSD patients' mean BMI was 26.37 2.74 (range 22.5 - 33.9) kg/m2, while PDA patients' mean BMI was 26.54 1.86 (range 21.8 - 29.5) kg/m2. While the normal echo group's mean BMI was 27.40 2.46 kg/m2 (with a range of 22.8 - 31.5). The groups under study did not differ significantly from one another.

Table 2 showed the echocardiographic parameters of our studied groups. Regarding EDD, ESD, EF, EDV, and ESV, The difference between the PDA group and the control group was statistically significant. There was a statistically significant difference between the ASD group and the control group in terms of EF percent, FS percent, and ESV.

Table 3 showed Comparison between different groups regarding Mitral Annular Plane Systolic Excursion (MAPSE). It showed statistically significant difference between ASD, PDA and control group.

Table 4 regarding MPI and S wave, it showed no statistically significant difference between the studied groups regarding MPI and S wave.

Table 5 showed comparison between studied groups regarding Regional LV Longitudinal Strain Velocities of 2D Speckle tracking echocardiography (Apical 2 Chamber view). There was statistically significant difference between our studied groups at Apical anterior, Apical inferior, Mid inferior and Basal inferior segments.

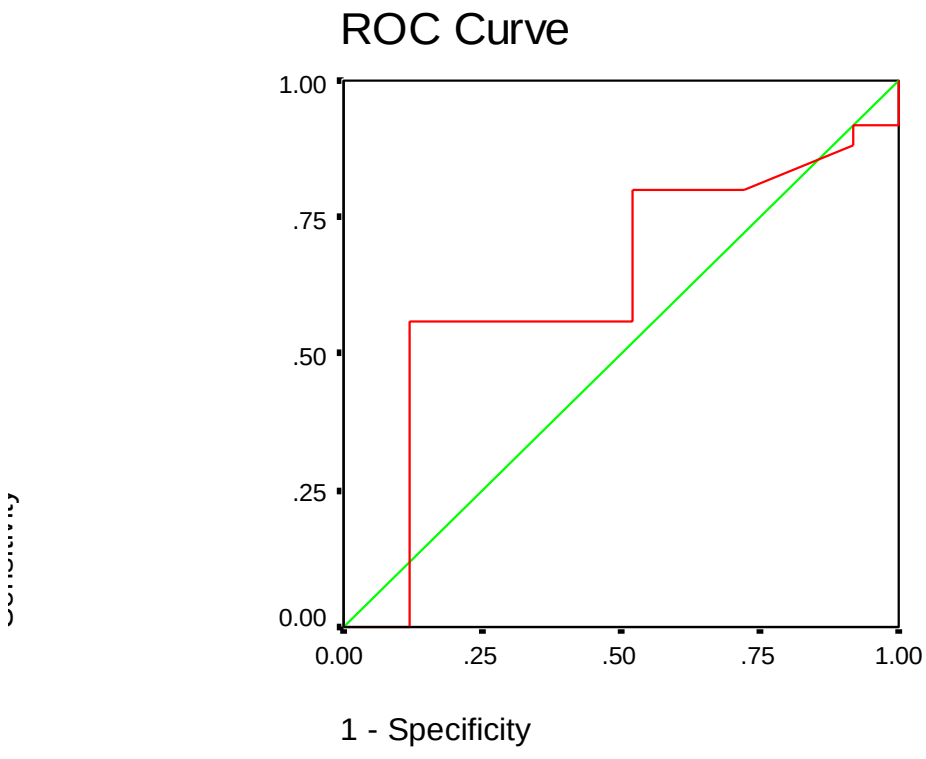

Fig. 1. ROC Curve of validity of GLS in ASD

Table 1. Comparison of the several investigated groups based on demographic information

		ASD	VSD	PDA	Control	Test	P value
Age	**Range**	2 – 40	1.5 – 20	1 – 16	1.5 – 40	F: 4.565	0.005*
	Mean ±SD	15.64 **±** 9.57	13.45 **±** 5.02	12.04 **±**3.32	19.78 **±** 11.05		
	Median	20	24	25	21		
BMI	**Range**	21.3 – 32.3	22.5 – 33.9	21.8 – 29.5	22.8 – 31.5	F: 1.285	0.284
	Mean ±SD	26.14 **±** 2.58	26.37 **±** 2.74	26.54 **±** 1.86	27.40 **±** 2.46		
	Median	25	25.9	26.5	27.3		
Sex	**Male (%)**	31 (40.3%)	37 (43.5%)	26 (44.8%)	23 (46%)	X^2: 0.502	0.920
	Female (%)	46 (59.7%)	48 (56.5%)	32 (55.2%)	27 (54%)		

Table 2. Echo parameters of Left ventricle in studied groups

		Range			Mean	±	S. D	F. test	p. value		
EDD	ASD	3.5	-	4.9	4.11	±	0.46	2.929	0.038*	P1	0.290
(cm)	VSD	2.7	–	5.2	4.04	±	0.99			P2	0.472
	PDA	3.6	–	7.8	4.48	±	0.88			P3	0.005*
	Control	3.5	–	4.9	3.89	±	0.40				
ESD	ASD	2	–	2.9	2.56	±	0.32	2.180	0.045*	P1	0.223
(cm)	VSD	1.5	–	3.1	2.40	±	0.60			P2	0.907
	PDA	2.1	–	5	2.69	±	0.63			P3	0.029*
	Control	2	–	2.9	2.39	±	0.28				
EF%	ASD	58	–	78	70.56	±	6.94	38.568	0.001*	P1	0.002*
	VSD	54	–	66	58.88	±	3.59			P2	0.382
	PDA	57	–	67	61.80	±	3.51			P3	0.003*
	Control	54	–	66	57.72	±	3.75				
FS%	ASD	31	–	45	40.12	±	5.61	4.620	0.005*	P1	0.001*
	VSD	27	–	44	36.00	±	4.62			P2	0.594
	PDA	29	–	48	37.64	±	5.13			P3	0.094
	Control	32	–	44	35.24	±	4.68				
EDV	ASD	15	–	70	56.60	±	27.35	14.245	0.001*	P1	0.235
(ml)	VSD	44	–	74	63.20	±	8.63			P2	0.816
	PDA	41	–	76	97.44	±	38.42			P3	0.001*
	Control	44	–	74	64.80	±	7.29				
ESV	ASD	6	–	36	24.68	±	12.20	21.149	0.001*	P1	0.033*
(ml)	VSD	21	–	36	30.28	±	5.18			P2	0.918
	PDA	21	–	89	45.36	±	13.44			P3	0.001*
	Control	21	–	36	30.56	±	3.74				

Table 3. Comparison between studied groups regarding Mitral Annular Plane Systolic Excursion (MAPSE)

		Range			Mean	±	S. D	F. test	p. value		
MAPSE	ASD	1.1	–	4.3	2.09	±	0.81	2.572	0.047*	P1	0.026*
	VSD	1.3	–	2.8	1.60	±	0.44			P2	0.692
	PDA	1.2	–	9	2.02	±	1.58			P3	0.048*
	Control	1.0	–	2	1.50	±	0.28				

Table 4. Comparison between studied groups regarding Myocardial Performance Index and S wave

		Range			Mean	±	S. D	F. test	p. value		
MPI	ASD	0.26	–	0.67	0.43	±	0.12	1.483	0.224	P1	0.612
	VSD	0.32	–	0.56	0.42	±	0.09			P2	0.924
	PDA	0.26	–	0.46	0.38	±	0.05			P3	0.147
	Control	0.33	–	0.56	0.41	±	0.08				
S	ASD	6	–	13	10.08	±	2.33	0.684	0.564	P1	0.999
	VSD	8	–	17	10.72	±	2.91			P2	0.339
	PDA	6	–	13	9.80	±	1.73			P3	0.675
	Control	6	–	15	10.08	±	2.31				

Table 5. Comparison between studied groups regarding regional LV longitudinal strain velocities of 2D speckle tracking echocardiography (Apical 2 Chamber view)

		Range			Mean	±	S. D	F. test	p. value		
Apical anterior	ASD	-29	–	-18	-25.20	±	4.19	2.296	0.043*	P1	0.036*
	VSD	-30	–	-18	-25.20	±	3.82			P2	0.036*
	PDA	-37	–	-17	-23.60	±	4.16			P3	0.511
	Control	-27	–	-19	-22.88	±	3.17				
Mid anterior	ASD	-27	–	-20	-24.16	±	2.43	6.882	0.001*	P1	0.001*
	VSD	-28	–	-16	-21.44	±	4.55			P2	0.057
	PDA	-26	–	-12	-20.48	±	4.39			P3	0.287
	Control	-26	–	-14	-19.28	±	4.11				
Basal anterior	ASD	-24	–	-12	-19.56	±	4.22	1.689	0.175	P1	0.072
	VSD	-27	–	-11	-19.28	±	6.48			P2	0.051
	PDA	-31	–	-11	-20.96	±	5.65			P3	0.352
	Control	-37	–	-13	-22.44	±	5.77				
Apical inferior	ASD	-29	–	-20	-26.08	±	3.26	10.443	0.001*	P1	0.001*
	VSD	-30	–	-17	-23.96	±	4.15			P2	0.001*
	PDA	-35	–	-17	-21.56	±	5.03			P3	0.101
	Control	-27	–	-9	-19.48	±	5.05				
Mid inferior	ASD	-27	–	-19	-25.36	±	2.36	10.403	0.001*	P1	0.001*
	VSD	-28	–	-17	-21.72	±	4.13			P2	0.015*
	PDA	-26	–	-13	-20.92	±	3.46			P3	0.072
	Control	-26	–	-6	-18.72	±	6.22				
Basal inferior	ASD	-25	–	-17	-22.76	±	2.57	7.208	0.001*	P1	0.002*
	VSD	-28	–	-11	-21.24	±	4.94			P2	0.049*
	PDA	-27	–	-13	-17.68	±	4.21			P3	0.340
	Control	-27	–	-14	-18.84	±	4.94				

Table 6 showed statistically significant difference between ASD and control group at apical lateral segment. Also, showed statistically significant difference between VSD and control group at mid anteroseptal segment.

Table 7 showed statistically significant difference between our studied groups at Apical lateral and basal anterolateral segment. Also, showed statistically significant difference between ASD and control group at mid anterolateral and inferoseptal segment.

ROC curve for Validity of GLS to predict LV systolic dysfunction in ASD Group Sensitivity was 68 and sensitivity was 88 Table 8.

Table 6. Comparison between studied groups regarding regional LV longitudinal strain velocities of 2D Speckle tracking echocardiography (Apical 3 Chamber View)

		Range			Mean	±	S. D	F. test	p. value		
Apical septum	ASD	-27	–	-13	-21.56	±	5.54	0.823	0.484	P1	0.594
	VSD	-37	–	-16	-23.76	±	6.00			P2	0.314
	PDA	-36	–	-16	-22.54	±	4.80			P3	0.875
	Control	-27	–	-15	-22.32	±	3.39				
Mid anteroseptal	ASD	-25	–	-9	-21.36	±	3.95	3.343	0.022*	P1	0.444
	VSD	-30	–	-16	-23.32	±	4.09			P2	0.018*
	PDA	-27	–	-11	-19.76	±	4.60			P3	0.571
	Control	-27	–	-11	-20.44	±	4.24				
Basal anteroseptal	ASD	-26	–	6	-20.40	±	6.89	1.000	0.396	P1	0.399
	VSD	-28	–	-16	-21.04	±	3.90			P2	0.646
	PDA	-23.1	–	18.7	-19.04	±	8.33			P3	0.098
	Control	-28	–	-18	-21.80	±	2.08				
Apical lateral	ASD	-28	–	-14	-24.16	±	5.06	5.291	0.002*	P1	0.020*
	VSD	-36	–	-16	-24.80	±	5.26			P2	0.005*
	PDA	-37	–	-16	-26.14	±	5.43			P3	0.001*
	Control	-24	–	-14	-20.96	±	2.92				
Mid inferolateral	ASD	-27	–	-21	-23.76	±	1.33	2.000	0.119	P1	0.507
	VSD	-27	–	-16	-21.50	±	3.93			P2	0.317
	PDA	-28	–	-12	-20.74	±	4.48			P3	0.120
	Control	-37	–	-14	-22.86	±	7.36				
Basal inferolateral	ASD	-25	–	-14	-20.32	±	4.29	0.804	0.495	P1	0.613
	VSD	-27	–	-12	-20.52	±	5.17			P2	0.523
	PDA	-36	–	-12	-19.56	±	7.19			P3	0.131
	Control	-27	–	-14	-21.84	±	3.88				

Table 7. Comparison between studied groups regarding regional LV longitudinal strain velocities of 2D speckle tracking echocardiography (Apical 4 chamber view)

		Range			Mean	±	S. D	F. test	p. value		
Apical lateral	ASD	-28	–	-14	-24.16	±	5.06	5.291	0.002*	P1	0.020*
	VSD	-36	–	-16	-24.80	±	5.26			P2	0.005*
	PDA	-37	–	-16	-26.14	±	5.43			P3	0.001*
	Control	-24	–	-14	-20.96	±	2.92				
Mid anterolateral	ASD	-31	–	-21	-23.88	±	2.93	4.010	0.010*	P1	0.001*
	VSD	-26	–	-19	-21.88	±	1.90			P2	0.220
	PDA	-28	–	-13	-21.64	±	4.12			P3	0.330
	Control	-27	–	-14	-20.72	±	3.87				
Basal anterolateral	ASD	-31	–	-14	-21.40	±	4.89	9.381	0.001*	P1	0.010*
	VSD	-27	–	-11	-17.80	±	4.13			P2	0.001*
	PDA	-36	–	-11	-19.84	±	7.08			P3	0.001*
	Control	-29	–	-15	-25.16	±	3.48				
Apical septum	ASD	-27	–	-13	-21.56	±	5.54	0.823	0.484	P1	0.594
	VSD	-37	–	-16	-23.76	±	6.00			P2	0.314
	PDA	-36	–	-16	-22.54	±	4.80			P3	0.875
	Control	-27	–	-15	-22.32	±	3.39				
Mid inferoseptal	ASD	-25	–	-13	-20.20	±	3.15	1.645	0.184	P1	0.072
	VSD	-27	–	-16	-22.72	±	3.41			P2	0.848
	PDA	-27	–	-15	-21.76	±	4.25			P3	0.567
	Control	-37	–	-14	-22.48	±	6.23				
Basal inferoseptal	ASD	-23	–	-9	-17.80	±	3.63	6.738	0.001*	P1	0.001*
	VSD	-36	–	-15	-21.44	±	4.13			P2	0.336
	PDA	-37	–	-13	-24.54	±	7.92			P3	0.317
	Control	-28	–	-11	-22.96	±	5.51				

Table 8. ROC Curve of validity of GLS in ASD

	Cutoff	AUC	Sensitivity	Specificity	PPV	NPV	Accuracy
ASD	- 22	0.626	68	88	85	73	78

Table 9. ROC Curve of validity of GLS in VSD

	Cutoff	AUC	Sensitivity	Specificity	PPV	NPV	Accuracy
VSD	- 20	0.518	56	60	58	57	58

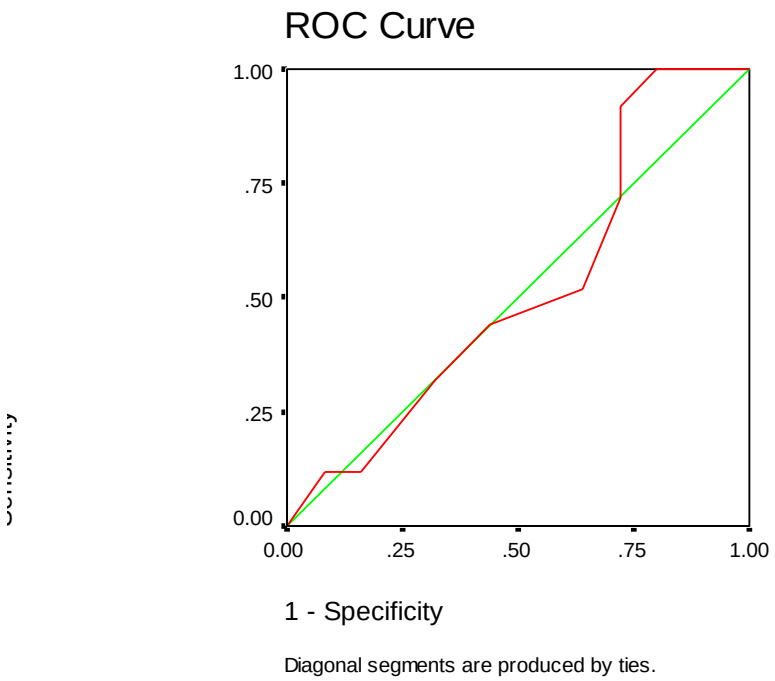

Fig. 2. ROC Curve of validity of GLS in VSD

Table 10. ROC Curve of validity of GLS in PDA

	Cutoff	AUC	Sensitivity	Specificity	PPV	NPV	Accuracy
PDA	- 19	0.516	68	80	77	71	74

ROC curve for Validity of GLS to predict LV systolic dysfunction in VSD Group Sensitivity was 56 and sensitivity was 60 Table 9.

ROC curve for Validity of GLS to predict LV systolic dysfunction in PDA Group Sensitivity was 68 and sensitivity was 80 Table 10.

4. DISCUSSION

The left side of the heart's chambers experience greater pressure than the right side's chambers in healthy individuals. Blood shunts from the left atrium to the right atrium in the event of ASD, which may cause a clinically notable left-to-right shunt. The right atrium and right ventricle may become volume-overloaded as a result of the left atrial's excess blood. If left untreated, this illness may expand the right side of the heart, eventually leading to cardiac failure [8].

Echocardiography is usually regarded as the first-line modality for cardiovascular imaging in CHD due to its vast range of procedures (transthoracic, transoesophageal, 3D, contrast, and stress).(congenital heart disease). It significantly improves clinical treatment and provides a full examination of anatomy and physiology many years following surgery or catheter interventional procedures. For follow-up

studies, it is advised to develop imaging protocols unique to the lesion. , to make sure that the imaging study contains the crucial data for clinical decision-making, and for longitudinal data comparison [9].

The main aim of this study was to assess the feasibility of speckle tracking echocardiography in estimation of left ventricular systolic function in congenital shunt lesions (ASD, VSD and PDA).

This was a case–control study included 270 patients undergoing echocardiography in the Outpatient Clinic of Tanta University Hospital. The study was starting from 1st of October 2018 to 28th of November 2020. Patients were divided into four groups as follows: The first group consisted of 77 patients diagnosed with isolated (ASD) echocardiography and totally asymptomatic. The second group consisted of 85 patients diagnosed with isolated (VSD). The Third group consisted of 58 patients diagnosed as isolated (PDA). The Fourth group consisted of 50 healthy subjects with normal echocardiography and totally asymptomatic.

The mean age of the group of ASD patients was 15.64 ± 9.57 years old, The average age of the VSD patient group was 16.18 4.65 years old, whereas the average age of the PDA patient group was 12.72 3.91 years old. The normal echo group's median age was 19.78 11.05 years old. Regarding age, There was a statistically significant difference. For either sex or BMI, there was no statistically significant difference between the tested groups. However, in the study of Mosbah et al. [10], These findings agreed with those of Frank et al. [11], who's demographic research found no statistically significant difference between patients with congenital cardiac conditions related with Control group and pulmonary arterial hypertension. There were no statistically significant variations in age or gender between cases and controls ($p>0.05$). In contrast to this study, Muntean et al, research's [12] showed no statistically significant variation in BMI between the patient and control groups. , Sanli et al. [13] found that there was no significant difference among groups as regard body mass index which support our study.This could be explained by wide range of age that was included in our study.

The current study showed that as regard the echocardiographic parameters of our studied groups. Regarding EDD, ESD, EF, EDV, and ESV, there was a statistically significant difference between the PDA group and the control group. In terms of EF, FS, and ESV, there was a statistically significant difference between the ASD group and the control group. There were statistically significant differences for Mitral Annular Plane Systolic Excursion between the ASD, PDA, and control groups (MAPSE). There was no statistically significant difference between the studied groups for MPI or S wave. However, the study by Schroh et al. [14] found no appreciable variations in EF or left ventricular FS between the ASD group and control group. In terms of pulsed tissue Doppler velocities, the systolic lateral tricuspid annular velocity (ST wave) was noticeably greater in the ASD group (P=.0216) even though the systolic lateral mitral annular velocity at the lateral level (SM wave) was the same in both groups (P=.4584). Preload, stroke area, area ejection percent, and fractional shortening of the D1 following ASD repair but not after VSD repair (Measurements of septal-freewall) all increased (p 0.05), according to Hart et al. in their study [15]. Following the closure of the ASD, end-diastolic symmetry improved; after the closure of the VSD, it worsened (p 0.05). After ASD repair, increases in stroke area and ejection fraction predominantly reflected enhanced shortening of D1. Percentage change in end-diastolic area (EDA) and percentage change in area ejection fraction were found to be positively correlated overall (p 0.0001).

In this study, as regard comparison between studied groups regarding Regional LV Longitudinal Strain Velocities of 2D Speckle tracking echocardiography (Apical 2 Chamber view). In addition to our study groups, There was a statistically significant difference. Between the ASD and control groups, there was a statistically significant difference in the apical septum segment. There was a statistically significant difference between the ASD and control groups at the mid-antero-lateral segment. There was a statistically significant difference between the ASD, VSD, PDA, and control group in the basal anterolateral region. There was a statistically significant difference between the ASD and control groups at the basal inferoseptal segment. ASD and LD did not differ statistically significantly from each other., VSD, PDA and control group regarding to GLS.this was in agreement with Hou et al. [16], while there was disagreement with Mosbah et al. [12], because there shunt groups were associated pulmonary hypertension. Schroh et al. [14], found that while the left ventricular end-diastolic diameter was smaller in the ASD group than in the control

group, the right ventricular end-diastolic diameter adjusted for body surface area was considerably bigger in the patients with ASD group. The left ventricular diastolic function was assessed by looking at the mitral spectral Doppler (E wave and A wave; E/A ratio and E wave deceleration time). Except for the isovolumic relaxation period, which was much longer in the ASD group than in the control group, there were no other obvious differences between the 2 groups. The PDA group and the control group experienced comparable results., with a statistically significant difference in (EDV and ESV). Elsheikh et al. and Galal et al. found that significant left-to-right shunt is frequently associated with PDA and that, in order to overcome this significant shunt and maintain systemic circulation, The Frank-Starling response, which involves stretching LV muscle fibres and increasing contractility and systolic function, appears to be required to enhance cardiac output. Consequently, because a large left-to-right shunt through PDA causes the LV remodelling, [17].

Mosbah et al. [12], demonstrated that assessment of left ventricular systolic and diastolic functions in their study by echocardiographic conventional methods showed a statistically non-significant differences between cases and controls This came in agreement with Güvenc et al. [18].

The present study showed that as regard ROC curve for Validity of GLS to predict LV systolic dysfunction in ASD Group. Sensitivity was 68 and Specificity was 88. As regard ROC curve for Validity of GLS to predict LV systolic dysfunction in VSD Group. Sensitivity was 56 and Specificity was 60. As regard ROC curve for Validity of GLS to predict LV systolic dysfunction in PDA Group. Sensitivity was 68 and Specificity was 80.To my knowledge; there is no other studies used Roc curve for Validity of GLS to predict LV systolic dysfunction in ASD, VSD and PDA groups.

5. CONCLSUION

Based on our findings, it was concluded that a complementary non-invasive method for evaluating left ventricular function in patients with congenital shunt defects is speckle-tracking echocardiography.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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