VALUE OF SPECKLE TRACKING ECHOCARDIOGRAPHY IN ASSESSMENT OF LEFT VENTRICULAR FUNCTION IN B-THALASSEMIC PATIENTS

By

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ABSTRACT

Introduction: *Beta-thalassemia is a genetic disease with different clinical aspects, over the last years; growing interest has been reported for biomarkers that may help in the diagnosis, staging and prognosis of heart disease at an early stage, in patients with beta thalassemia* ***(Maria et al., 2020)****. Speckle tracking echocardiography has recently emerged as a quantitative ultrasound technique for accurately evaluating myocardial function by analyzing the motion of speckles identified on routine two dimensional sonograms. It provides non Doppler, angle independent and objective quantification of myocardial deformation and LV systolic and diastolic dynamics. By tracking the displacement of the speckles during the cardiac cycle, strain and the strain rate (SR) can be rapidly measured offline after adequate image acquisition* ***(Ahmed et al., 2020)****.*

Aim of the work: *Assessment of left ventricular function in B- Thalassemia patients using different echocardiographic modalities and determine the value of Speckle Tracking Echocardiography (STE) in early detection of myocardial affection. Methodology: a cross-sectional study that included 62 patients aged from 7 to 18 years (31 known Beta thalassemia Major child from hematology outpatient clinic & 31 control apparently healthy child) from pediatric Cardiology and Hematology units , Al Hussein University Hospital, Faculty of Medicine, Al Azhar University from September 2018 to October 2020 using different echocardiographic modalities.*

Results: *the mean age was 10.32± 3.13 (range 7.0 to 16.0 ys), mean body surface area (BSA) 1.15 ± 0.26 m2 (range 0.70 to1.68 m2) with females representing 22.6% and males 77.4%. There was no affection in EF as the EF of the beta thalassemia group and control group were within normal ranges with mean EF in patients 65.32 ± 7.74% and mean EF 70.05 ± 5.8% in controls. There was a highly significant difference in Mitral E/A ratio with p value 0.003 between beta thalassemia group and control group also there was a highly significant difference between two groups regarding Myocardial performance index (Tei Index) with p value 0.013 using tissue Doppler imaging technique (TDI) denoting diastolic affection in beta thalassemia group. By*

performing 2D speckle tracking technique the global longitudinal strain (GLS) mean of the beta thalassemia was -17.72 ± 4.14 and the controls was -20.80 ± 2.69 with a highly significant difference between them with a p value 0.001 and the global circumferential strain (GCS) mean for the beta thalassemia group was -19.96 ± 6.20 and the mean of the control group was -23.42±6.15 with a highly significant difference between them with a p value 0.032 denoting early myocardial systolic and diastolic affection detection despite of the normal EF values.

There was no significant correlation between serum ferritin level and EF, on the other hand there was highly significant correlation between serum ferritin with GLS with a p value 0.013and a highly significant correlation between serum ferritin and GCS with a p value 0.01, but there was no significant difference between patients that had serum ferritin <1500ng/ml and patients that had serum ferritin >1500ng/ml with GLS and GCS values indicating that all patient groups has GLS affection with different serum ferritin values making GLS calculation in all patient group is very important to be estimated for early detection of LV affection regardless the serum ferritin value.

Keywords: *Beta Thalassemia, Tissue Doppler Imaging, Myocardial Performance Index, 2D speckle tracking technique, GLS.*

INTRODUCTION

Beta-thalassemia is considered as one of the most common inherited hemoglobin disorder caused by the declined synthesis of β-globin chains, resulting in ineffective erythropoiesis, subsequent chronic hemolytic anemia and iron overload **(Mozhgan et al., 2017)**. Cardiac complications are the main cause of mortality and one of the most significant causes of morbidity in patients with beta thalassemia. These patients may develop cardiomyopathy, arrhythmias and heart failure (HF) **(Maria et al., 2020)**. Speckle tracking echocardiography is a new noninvasive imaging technique that allows for an objective and quantitative evaluation of global and regional myocardial function independently from the angle of insonation and from cardiac translational movements **(Ahmed et al., 2020)**.

Ethical considerations:

1. Ethical committees of Al-Azhar faculty of medicine & pediatric department approved the study.
2. Informed consent was obtained from parents of all included children.
3. The research protocol did not interfere with any medical recommendations or prescriptions.
4. The aim of the study & all investigations as well as the risks & benefits of study have

been explained to parents of the patients.

5. The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.
6. All data of patients & results of study are confidential & patients have the right to keep it.

PATIENTS AND METHODS

This was a cross-sectional study included 62 patients aged from 7 to 18 years (31 known Beta Thalassemia Major selected from hematology outpatient clinic & 31 apparently healthy child as a control) from pediatric Cardiology and Hematology units, Al Hussein University Hospital, Faculty of Medicine, Al Azhar University.

All the studied cases were subjected to the following:

1. Demographic data through medical history taking.
2. Through clinical examinations.
3. Laboratory investigations including: CBC, S. Ferritin, S.Iron, TIBC, Transferrin Saturation.
4. Different Echocardiographic modalities:

a. Conventional 2D.

b. Color Flow Doppler.

c. Tissue doppler imaging (TDI).

d. 2D speckle tracking technique using Philips EPIC 7 & data analysis by Q-LAB software analysis& Using Philips EPIQ 7 C ultrasound system with X5-1, S8-3, or X7-2 broadband phased-array transducers, in assessment of LV systolic and diastolic function in Beta Thalassemia Major patients.

Statistical analysis:

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

RESULTS

Our results were demonstrated in the following tables:

Table (1): Descriptive analysis between the two studied groups according to demographic data

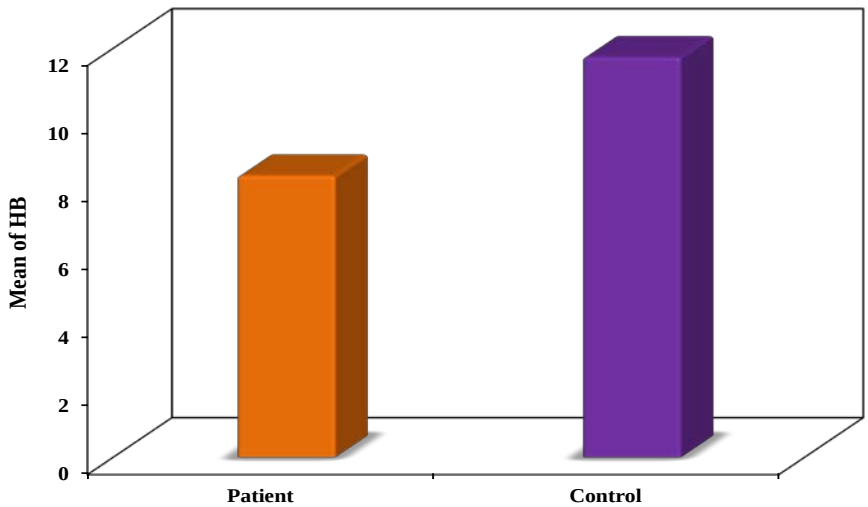
Demographic data	Patient (n=31)		Control (n=31)		Test of sig.	p
	No.	%	No.	%		
Sex						
Male	24	77.4	20	64.5	χ^2= 1.253	0.263
Female	7	22.6	11	35.5		
Age (years)						
Range	7.0 – 16.0		7.0 – 15.0		t=1.488	0.142
Mean ± SD.	10.32 ± 3.13		9.27 ± 2.36			
Median (IQR)	10.0(7.50 – 13.50)		9.0(7.0 – 11.0)			
Weight (kg)						
Range	16.0 – 58.0		20.0 – 48.0		t=0.847	0.401
Mean ± SD.	35.68 ± 12.33		33.32 ± 9.36			
Median (IQR)	34.0 (26.0–46.0)		29.0 (25.0–42.50)			
Height (cm)						
Range	113.0 – 177.0		116.0 – 162.0		t=1.526	0.132
Mean ± SD.	139.35 ± 14.18		134.0 ± 13.44			
Median (IQR)	136.0(131.50–151.0)		135.0(120.5–145.5)			
BSA (m2)						
Range	0.70 – 1.68		0.80 – 1.42		t=0.850	0.399
Mean ± SD.	1.15 ± 0.26		1.10 ± 0.20			
Median (IQR)	1.09 (0.97–1.39)		1.05(0.94–1.32)			

This table shows that there was no significant difference between the two studied groups regarding age, sex, weight, height and BSA.

Table (2): Comparison between the two studied groups according to laboratory parameters

Laboratory parameters	Patient (n=31)	Control (n=31)	Test of sig.	P
HB (g/dl)				
Range	4.0 – 10.30	8.20 – 14.10	t= 11.333*	<0.001*
Mean ± SD.	8.27 ± 1.23	11.75 ± 1.19		
Median (IQR)	8.20 (7.90–9.0)	11.70 (11.10–12.50)		
S.Iron (ug/dl)				
Range	214.0 – 7930.0	6.0 – 124.0	U= 0.0*	<0.001*
Mean ± SD.	2224.84 ± 1551.82	63.42 ± 27.60		
Median (IQR)	1812(1503.5–2605.5)	64.0 (46.50–80.50)		
S.Ferritin(ng/ml)				
Range	328.0 – 8105.0	13.0 – 121.0	U= 0.0*	<0.001*
Mean ± SD.	2671.06 ± 1886.86	54.29 ± 26.92		
Median (IQR)	1923(1574.5–3080)	54.0(32.0–70.0)		
RDW(%)				
Range	14.10 – 36.80	12.0 – 27.90	U= 64.50*	<0.001*
Mean ± SD.	23.04 ± 5.26	14.56 ± 2.93		
Median (IQR)	22.90(116.5–156.5)	13.80 (267.5–315.50)		
Transferrin Sat(%)				
Range	159.09 –4806.06	2.20 – 41.23	U= 0.0*	<0.001*
Mean ± SD.	1735.78 ± 1064.21	22.48 ± 10.59		
Median (IQR)	1519.3(1081.4–2120.6)	21.58(15.84–29.54)		

There was a highly significant difference between patients and controls regarding HB level, S.Iron, S.Ferritin, RDW and Transferrin saturation value.



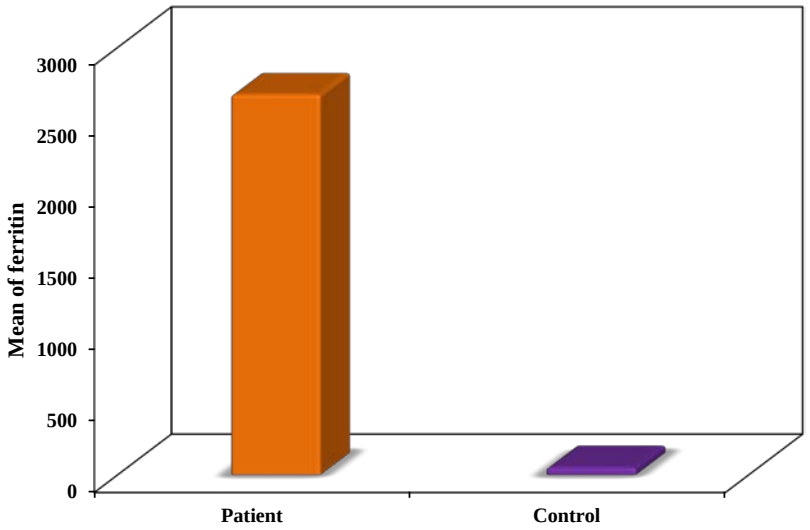


Figure (1): Comparison between the two studied groups according to HB level

Figure (2): Comparison between the two studied groups regarding serum Ferritin

Table (3): Correlation between EF and laboratory parameters in patient group

Laboratory parameters	EF%	
	r	p
S.Iron(ug/dl)	-0.121	0.515
S.Ferritin(ng/ml)	-0.181	0.331
Transferrin Sat(%)	-0.021	0.517

Non-significant correlation between the two groups regarding EF with S.Iron, S.Ferritin and transferring saturation as shown in **Table 3**.

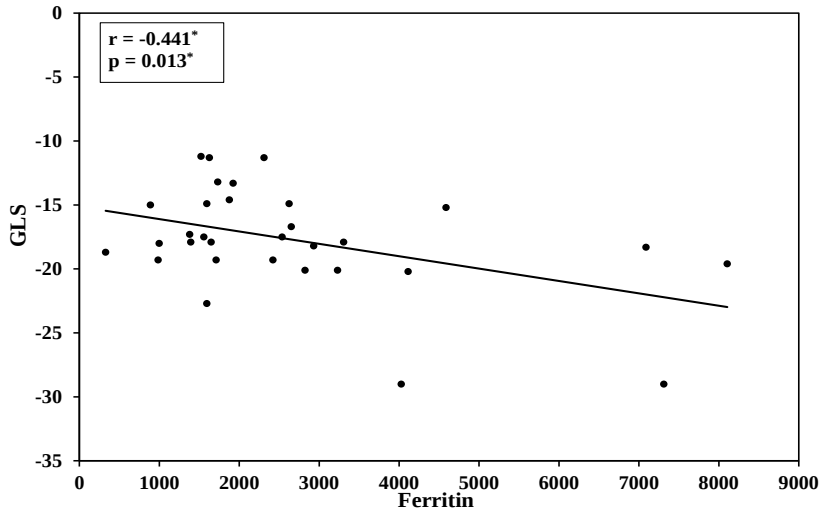
Table (4): Correlation between GLS and GCS with laboratory parameters in patient group

Laboratory parameters	GLS		GCS	
	r	p	r	P
S .Iron(ug/dl)	-0.364	0.044*	-0.424	0.018*
S.Ferritin(ng/ml)	-0.441	0.013*	-0.455	0.010*
Transferrin Sat(%)	-0.488	0.005*	-0.427	0.017*

There was a highly significant correlation between the two groups regarding GLS, GCS with S.Iron, S.Ferritin and transferring saturation as shown in **Table 4**.

Table (5): Comparison between the two studied groups according to 2D M-Mode echocardiography

M-Mode	Patient (n=31)	Control (n=31)	Test of sig.	P
IVSD(cm)				
Range	0.30 – 1.56	0.45 – 0.80	U= 407.5	0.303
Mean ± SD.	0.68 ± 0.31	0.65 ± 0.12		
Median (IQR)	0.59(0.51–0.75)	0.64(0.54 – 0.79)		
LVEDD(cm)				
Range	2.92 – 6.22	2.83 – 4.90	t=1.658	0.104
Mean ± SD.	4.35 ± 0.87	4.04 ± 0.52		
Median (IQR)	4.31 (3.71–4.95)	4.0(3.78 – 4.39)		
IVSS(cm)				
Range	0.20 – 1.43	0.58 – 1.60	t=0.742	0.461
Mean ± SD.	0.90 ± 0.26	0.94 ± 0.25		
Median (IQR)	0.87(0.74–1.0)	0.89(0.81–0.97)		
LVESD(cm)				
Range	0.99 – 4.39	0.81 – 3.56	t=1.564	0.123
Mean ± SD.	2.91 ± 0.78	2.63 ± 0.64		
Median (IQR)	3.0 (2.40–3.39)	2.69 (2.34–3.0)		
LVEF(%)				
Range	51.0 – 78.20	60.60 – 80.50	t=2.728*	0.008*
Mean ± SD.	65.32 ± 7.74	70.05 ± 5.80		
Median (IQR)	65.60 (60.15–71.10)	69.90 (65.55–75.50)		
LVFS(%)				
Range	20.0 – 46.60	31.50 – 48.80	t=1.967	0.054
Mean ± SD.	34.89 ± 6.08	37.64 ± 4.83		
Median (IQR)	34.0 (31.30–38.75)	37.0 (33.55–40.60)		
LA(cm)				
Range	1.40 – 4.10	2.0 – 2.70	t=0.813	0.422
Mean ± SD.	2.41 ± 0.70	2.30 ± 0.25		
Median (IQR)	2.30 (1.90–3.0)	2.30(2.10 – 2.40)		
Aorta(cm)				
Range	1.30 – 3.0	1.50 – 2.50	t=0.174	0.862
Mean ± SD.	2.01 ± 0.41	1.99 ± 0.28		
Median (IQR)	2.0 (1.70–2.30)	2.0(1.70 – 2.30)		
LA/Aorta				
Range	0.65 – 2.28	0.87 – 1.53	U= 473.50	0.921
Mean ± SD.	1.20 ± 0.28	1.17 ± 0.17		



Median (IQR)	1.15(1.05 – 1.33)	1.17(1.05 – 1.30)		

The EF and FS as shown in table 5 were in normal values in the two groups despite of a significant difference between them with p value 0.008 regarding EF.

Figure (3): Correlation between GLS with serum Ferritin in patient group (n=31)

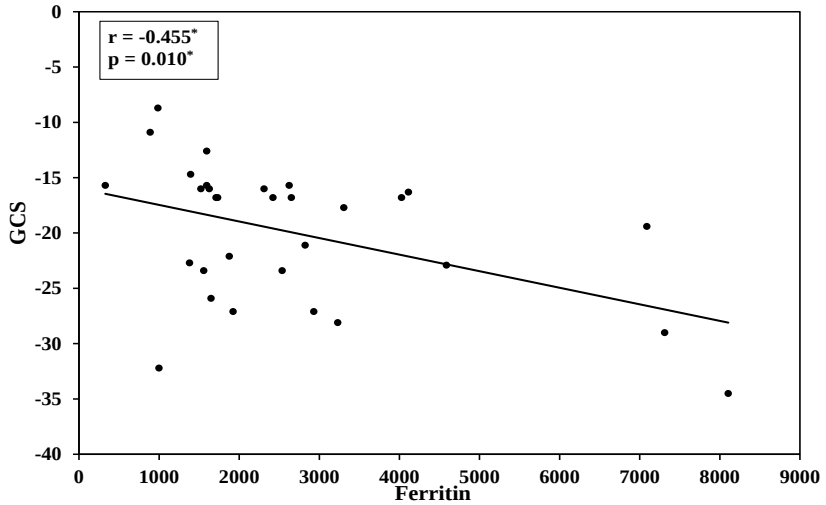


Figure (4): Correlation between GCS with serum Ferritin in patient group (n=31)

Table (6): Correlation between EF with GLS and GCS in patient group

	EF%	
	r	p

GLS%	0.023	0.904
GCS%	-0.025	0.896

Non-significant correlation between the two groups regarding EF with GLS and GCS as shown in **Table 6**.

Table (7): Comparison between the two studied groups according to Tissue Doppler

Tissue Doppler	Patient (n=31)	Control (n=31)	Test of sig.	P
Mitral E(cm/s)				
Range	8.0 – 15.30	8.20 – 10.0	t= 5.165	<0.001*
Mean ± SD.	11.76 ± 2.40	9.49 ± 0.47		
Median (IQR)	11.80(9.93–13.55)	9.53(9.30 – 9.90)		
Mitral A(cm/s)				
Range	3.49 – 9.75	4.28 – 6.0	U= 464.0	0.816
Mean ± SD.	5.67 ± 1.53	5.40 ± 0.48		
Median (IQR)	5.20(4.90–6.55)	5.32(5.18 – 5.84)		
Mitral E/A				
Range	1.36 – 3.95	1.53 – 2.19	U= 268.50*	0.003*
Mean ± SD.	2.17 ± 0.61	1.77 ± 0.18		
Median (IQR)	2.09(1.76 – 2.35)	1.75(1.63 – 1.88)		
IVCT(ms)				
Range	37.0 – 78.0	37.0 – 71.0	t= 1.801	0.077
Mean ± SD.	55.65 ± 12.08	50.87 ± 8.48		
Median (IQR)	55.0(45.5 0– 61.0)	50.0 (45.0–55.50)		
IVRT(ms)				
Range	41.0 – 111.0	39.0 – 109.0	U= 265.0*	0.002*
Mean ± SD.	59.65 ± 15.54	51.58 ± 13.67		
Median (IQR)	56.0(49.50–66.0)	48.0(45.50–52.0)		
E.T. (ms)				
Range	193.0 – 283.0	193.0 – 283.0	U= 403.50	0.278
Mean ± SD.	225.39 ± 20.99	220.03 ± 19.62		
Median (IQR)	222.0(209.50–243.0)	213.0(209.0–223.0)		
Mitral TEI Index(%)				
Range	0.34 – 0.62	0.34 – 0.62	t= 2.548*	0.013*
Mean ± SD.	0.50 ± 0.07	0.46 ± 0.06		
Median (IQR)	0.49(0.45–0.56)	0.45(0.44–0.49)		

This table shows a highly significant difference between the two groups regarding Mitral E wave, Mitral E/A ratio and Mitral Tei Index.

Table (8): Comparison between the two studied groups regarding to GLS and GCS

	Patient (n=31)	Control (n=31)	t	p
GLS				
Min. – Max.	-29.0 – -11.20	-29.40 – -13.40	3.468*	0.001*
Mean ± SD.	-17.72 ± 4.14	-20.80 ± 2.69		
Median (IQR)	-17.90 (-19.30– -14.95)	-20.60(-22.10 – -19.85)		
GCS				
Min. – Max.	-34.50 – -8.70	-42.30 – -15.70	2.184*	0.033*
Mean ± SD.	-20.0 ± 6.18	-23.42 ± 6.15		
Median (IQR)	-16.80(-23.40– -16.0)	-23.10 (-26.0– -18.70)		

There was a highly significant difference between the two groups regarding GLS with a p value 0.001 and GCS with a p value 0.033.

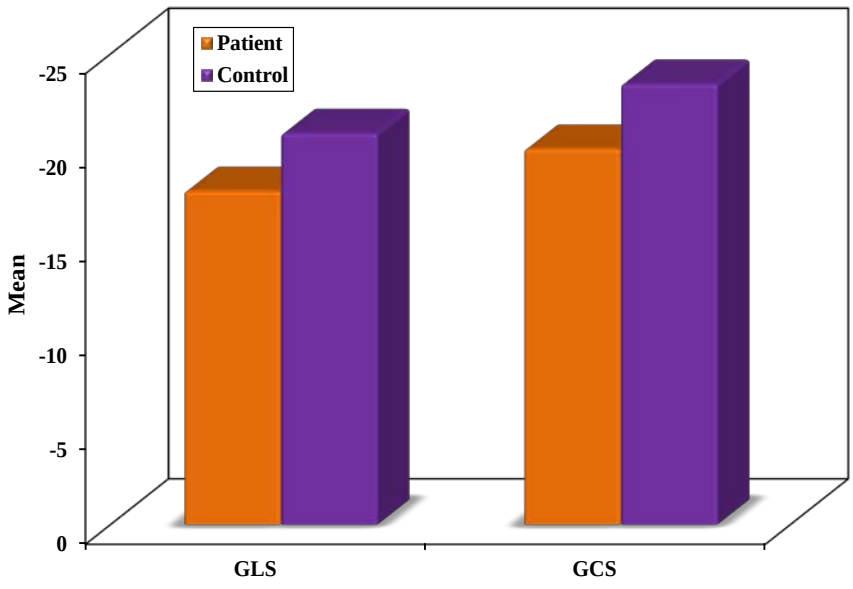


Figure (5): Comparison between the two studied groups according to GLS and GCS

Table (9): Relation between S.Ferritin level with GLS and GCS in patient group (n=31)

	S.Ferritin		t	p
	<1500ng/ml (n= 6)	**>1500ng/ml (n= 25)**		
GLS(%)				
Range	-19.30 – -15.0	-29.0 – -11.20	0.025	0.980
Mean ± SD.	-17.70 ± 1.49	-17.73 ± 4.58		
Median	-17.95	-17.90		
GCS(%)				
Range	-32.20 – -8.70	-34.50 – -12.60	1.095	0.282
Mean ± SD.	-17.48 ± 8.66	-20.56 ± 5.52		
Median	-15.20	-17.70		

There was no significant difference between patients that had S.Ferririn <1500ng/ml and patients that had S.Ferririn >1500ng/ml with GLS and GCS values.

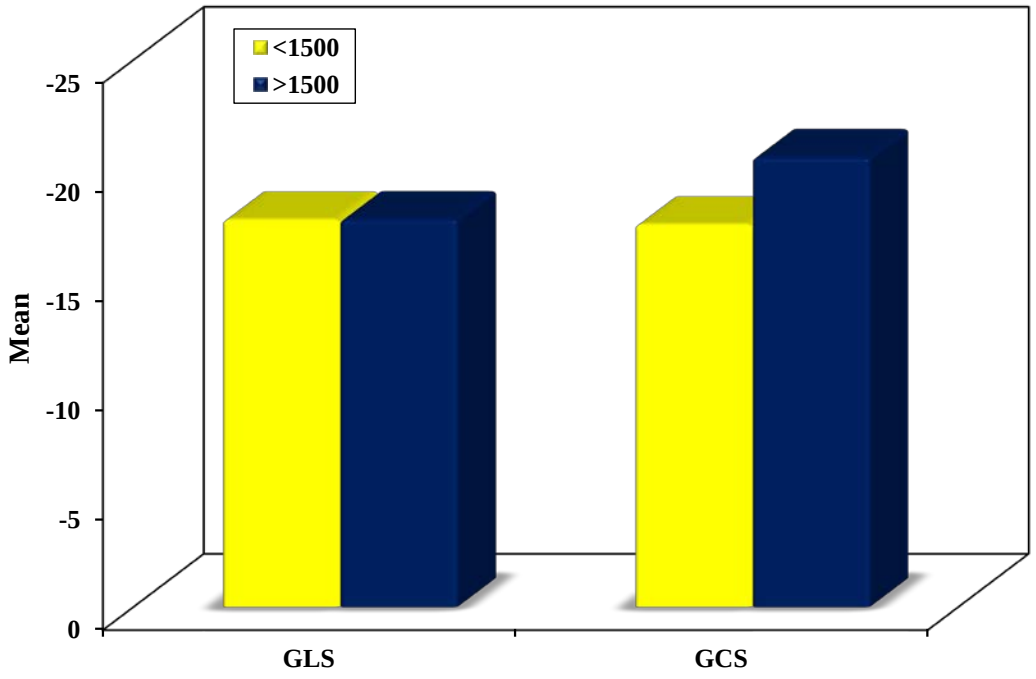


Figure (6): Relation between serum Ferritin with GLS and GCS in patient group (n=31)

DISCUSSION

By comparing the two studied groups regarding serum iron, serum ferritin level, transferrin saturation there was a statistically significant difference between the two groups and this came in agreement with the study of **Ahmed et al., 2020**.

Although one would expect a decrease in LVEF and LVFS and increase in left ventricular dimensions in beta thalassemia patients compared to control group, our results were in discordance with these expectations where mean LVEF in patients was 65.32 ± 7.74 and mean LVEF in controls was 70.05 ± 5.80 and both within normal ranges as shown in **(Table 4)** and this was in concordance to what **Ragab et al., 2015** mentioned in their study where they found no significant difference between asymptomatic 25 patients with beta thalassemia major and 20 age matched control individuals regarding LVEF.

Also **Bilge et al., 2010** who studied 32 patients with beta thalassemia major and 25 healthy controls of similar age and found that EF and FS were similar between both groups.

Our study showed a highly significant correlation between serum ferritin and transferrin saturation with global longitudinal strain and global circumferential strain as shown in **(Figures 3,4)** .This result coincides with the result of **Ahmed et al., 2020** study which stated elevated ferritin levels in thalassemia patients have been associated with both the presence and severity of ventricular dysfunction.

In our study no significant correlation between GLS and GCS values with EF was found as shown in **(Table 6)**. This came in agreement with **Ahmed et al., 2020** who stated that despite a normal LVEF with two-dimensional echocardiography, the thalassemia patients showed impairment of LV longitudinal strain.

Other investigators in concordance with our study also found that diastolic dysfunction of restrictive pattern with increased E/A ratio in patients with beta

thalassemia compared to the control group as described in **(Table 8)**. It has been assumed that myocardial iron deposition in some thalassemia patients may not directly affect left ventricular systolic function, but it may rather cause diastolic dysfunction with left ventricular myocardial restriction **(Mohammed et al., 2016)**.

Our study shows a significantly higher myocardial performance index (Tei index) in beta thalassemia patients than control group. This came in agreement with **Mohammed et al., 2016** where his study showed the (Tei index) of LV of patients was significantly higher than control group.

Although there was many studies trying to document a normal range value for global longitudinal strain (GLS) and global circumferential strain (GCS) in pediatric group **Philip et al., 2016** stated that his study where he identified 2325 children from 43 data sets, the reported reference range value of global longitudinal strain (GLS) among the studies varied from -16.7% to (-23.6%) with mean -20.2 ± 0.9%, global circumferential strain (GCS) range varied from -12.9% to -31.4% with mean -22.3 ±1.1%. This came in agreement with our study where our global longitudinal strain (GLS)value among controls varied from (-13.40%) to (-29.40%) and the mean was -20.80 ± 2.69 and our global circumferential strain (GCS) value among controls varied from -15.70% – -42.30% and the mean was -23.42 ± 6.15% as shown in **(Table 8)**.

In our study results we found that GLS value among beta thalassemia patients varied from (-11.20– -29.0 %) and the mean was (-17.72 ± 4.14%) where this value was reduced compared to controls and our global circumferential strain (GCS) value among beta thalassemia patients varied from (-8.70– -34.50 %) and the mean was (-19.96 ± 6.20%) also this value was lower than the control group as shown in **Tables (9,10)** and **(Figure 5)**.

This was in concordance with **Ahmed et al., 2020** who proved in his study that the global LV longitudinal strain rates were reduced in the thalassemia group in comparison with the control groups denoting that the results of both studies demonstrated the presence of subclinical myocardial systolic and diastolic dysfunction in thalassemia patients, with no cardiac manifestations, and was asymptomatic.

In our study results we found that GLS value among beta thalassemia patients varied from (-11.20– -29.0 %) and the mean was (-17.72 ± 4.14%) where this value was reduced compared to controls and our global circumferential strain (GCS) value among beta thalassemia patients varied from (-8.70– -34.50 %) and the mean was (-19.96 ± 6.20%) also this value was lower than the control group .This was in concordance with **Ahmed et al., 2020** that proved in his study that the global LV longitudinal strain rates were reduced in the thalassemia group in comparison with the control groups denoting that the results of both studies demonstrated the presence of subclinical myocardial systolic and diastolic dysfunction in thalassemia patients, with no cardiac manifestations, and was asymptomatic.

Similarly, **Cheung et al., 2010** showed that patients with beta thalassemia major have reduced global longitudinal strain rates, and global circumferential strain rates.

Regarding correlation between serum ferritin level and GLS % there was no significant correlation in our study either serum ferritin <1500ng/ml or >1500ng/ml with the GLS%, indicating that all patient groups has GLS affection with different serum ferritin values. So GLS calculation in all patient group is very important to be estimated for early detection of LV affection regardless the serum ferritin value as shown in **Figure (6)**, this came in agreement with **Firoozeh et al., 2019** who that stated in her study that there were no significant correlation between serum ferritin level with GLS and cardiac MRI T2*.

Limitation of the study:

- In the present study, no gold standard reference ranges for measuring global longitudinal strain (GLS) and global circumferential strain (GCS) among LV are available.
- Subjecting the patients to cardiac MRI as it is too expensive for the patients and long waiting lists to do.

Conclusion

2D speckle tracking technique is of a vulnerable value in the assessment of LV myocardial injury in beta thalassemia patient allowing early detection of heart muscle fiber affection before other echocardiographic modalities can detect getting a proper intervention before cardiac complications and heart failure develops.

RECOMMENDATIONS

- Neither the Serum ferritin nor conventional echocardiographic modalities are enough to depend on in the follow up of beta thalassemia patients regarding cardiac affection as there is a silent cardiac affection not detected by them.
- Speckle tracking as a new noninvasive tool for early detection of LV myocardial injury in any disease affecting heart muscle in general and in beta thalassemia major patients specifically based on the results of more studies.
- Screening of patients with beta thalassemia major with Tissue Doppler (TDI) and 2 D Speckle tracking using the GLS % and the GCS% values.

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قيمة النقط التتبعية للموجات الصوتية علي تقييم وظائف البطين الأيسر للقلب في مرضى انيميا حوض البحر الأبيض المتوسط

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الهدف من البحث:

1. تقييم وظيفة البطين الأيسر عند مرضى انيميا حوض البحر الأبيض المتوسط باستخدام طرق مختلفة بالموجات الصوتية على القلب.
2. التأكيد على أن النقط التتبعية للموجات الصوتية تستطيع أن تكشف الخلل الوظيفى فى عضلة القلب فى وقت مبكر.

الطريقة والأدوات: اشتملت الدراسة علي اثنين و ستون من المرضى، واحد و ثلاثون مجموعة تحكم و واحد و ثلاثون من المرضى الذين يعانون من انيميا حوض البحر الأبيض المتوسط ترددوا الي وحدة قلب الأطفال بقسم الاطفال بمستشفي الحسين الجامعى.

كل الحالات خضعت للتالي:

- تحليل كامل للتاريخ المرضي مع فحص إكلينيكي شامل.

- الفحوصات التقليدية مثل صورة دم كاملة، حديد بالدم، فيريتين بالدم.
- فحص بالموجات الصوتية على القلب ثنائية الأبعاد عبر الصدر مع التركيز على الفحص الكامل للبطين الأيسر.
- فحص بالموجات الصوتية على القلب باستخدام دوبلر تدفق اللون.
- التتبع النقطي ثنائي الابعاد واشعة الدوبلر النسيجي.

النتائج:

تمت الدراسة خلال سنتين في الفترة من اول سبتمبر 2018 حتي بداية أكتوبر 2020 واشتملت الدراسة علي 62 حالة، 31 مجموعة تحكم و 31 من المرضى الذين يعانون من انيميا حوض البحر الأبيض المتوسط وتتراوح أعمارهمم من 7 الي 16 سنه، وقد أجريت لهم مختلف الفحوصات بالموجات الصوتية على القلب، دوبلر تدفق اللون، التتبع النقطي ثنائي الابعاد واشعة الدوبلر النسيجي.

وقد أظهرت الدراسة أهمية التتبع النقطي ثنائي الابعاد فى اكتشاف الخلل الوظيفى فى عضلة القلب فى وقت مبكر.

الإستنتاجات:

1. التتبع النقطي ثنائي الابعاد ذات قيهة عالية فى تقييم اصابة البطين الأيسر فى حالات انيميا حوض البحر الأبيض المتوسط و بهاذا تسمح بالاكتشاف المبكر لأى تأثير على

عضـــلة القلـــب قبـــل اكتشـــافها بـــالطرق التقليديـــة بالموجـــات الصـــوتية و بهـــاذا تســـمح بالتـــدخل المبكـــر بـــالعلاج قبـــل حـــدوث مضاعفات او فشل بعضلة القلب.

2. التتبـــع النقطـــي ثنـــائي الابعـــاد أســـلوب واعـــد لتقيـــيم وظيفـــة عضـــلة القلـــب فـــي الأطفـــال المصـــابين بـــأمراض القلـــب عامـــة. لاســـيما المصـــابين بانيميـــا حـــوض البحـــر الأبـــيض المتوســـط فهي الأكثر سهولة في الاستخدام وأقل وقتًا.