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To Correlate Early Echocardiographic Changes with Serum Ferritin Levels in Multi Packed Cell Transfusions of β-Thalassemic Patients.

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Introduction

Thalassemias are the most common hereditary hemolytic anemias. The term is derived from the Greek word "Thalassa" meaning the great sea as the disease was first described in patients originating from littoral countries of the Mediterranean Sea. As per WHO estimates, 4.5% of world's population is carrier of hemoglobinopathies. The largest concentration of Thalassemia patients is seen in South-East Asia, Sri Lanka, Bangladesh, North-West India, Pakistan, Middle-East countries, North Africa, Greece & Italy. Frequency of Thalassemia gene in Indian population varies between 0-17% in different ethnic groups with average of over 3%. Its prevalence is high among Gujratis, Punjabis, Sindhis, and Lohanas etc. Over 40 million people are carriers of Thalassemia gene in our country & 10thousand Thalassemic children are born every year in India. **[**1**]**

The treatment regimen for Thalassemia Major includes repeated blood transfusions, Iron Chelation therapy with Desferroxamine or oral chelating agents & splenectomy. Bone Marrow transplant has shown excellent results but is too expensive as most of our patients belong to lower or middle class. Hence, in India main stray of therapy is repeated blood transfusions with or without chelation & splenectomy.

Many of the complications of Thalassemia seen in developing countries are the result of increased iron deposition from repeated blood transfusions. Endocrine & cardiac

pathology are often associated with excessive iron stores in patients with Thalassemia Major who are chronically transfused. Endocrine dysfunction may include hypothyroidism, hypoparathyroidism, gonadal failure & diabetes mellitus.**[**2**]** Cardiac failure & arrhythmia due to iron deposition is the most common cause of death. **[**3, 4**]**

Aims & Objectives

Aims:

1. To detect by colour Doppler Echocardiography, the early cardiac changes in asymptomatic non-chelated β-Thalassemic children
2. To estimate the serum ferritin levels and number of packed cell transfusions in multitransfused non-chelated β-Thalassemics

Objectives

1. To correlate the early cardiac changes detected on Echocardiography with serum ferritin values
2. To correlate the early cardiac changes detected on Echocardiography with number of packed cell transfusions.

Material and Methods

A hospital based prospective study was conducted involving 60 cases of β- thalassemia major who were evaluated for serum ferritin level, number of packed cell transfusions and cardiac status from January 2007 to January 2008.

Source of data

In this study, study group was selected from children aged between 1 to 18 year admitted to Thalassemia clinic of Vani Vilas Hospital attached to Bangalore Medical College and Research Institute, Bangalore.

Method of Collection of Data

In this study a minimum of 60 patients with Thalassemia aged between 1 to 18 years who have received multiple transfusions (≥20) and have not received chelation therapy,and with a haemoglobin of 9 gm/dlt maintained at least for 7 days were evaluated for serum Ferritin level, number of packed cell transfusions received and cardiac status by echocardiography after obtaining an informed consent. Ejection fraction, LVPWd and E/A ratio were looked for based on end systolic volume, end diastolic volume and rate of blood flow through the mitral valve. Results obtained were tabulated and P value Calculated by Chi Square test and Student's T test. This was correlated with number of packed cell transfusion & serum ferritin levels.

Inclusion criteria

Children admitted to Thalassemia clinic of Vani Vilas Hospital who have received ≥20 transfusions aged between 1 to 18 years and have not received chelation therapy and with haemoglobin of 9 gm/dlt maintained at least for 7 days before evaluation.

Exclusion criteria

1. Children with hemoglobinopathies other than Thalassemia

2. Children who have received <20 transfusions

3. Children who are chelated

4. Children having congenital or acquired heart disease in the form of RHD, Infective endocarditis etc.

Echocardiography

60 Thalassemic patients were subjected to colour Doppler Echocardiography. Cardiac evaluation was performed 7 days after transfusion so as to maintain hemoglobin of 9gm%.

The Echocardiography machine used was Hewlett Packard Sono's 2500.

Systolic & Diastolic functions of heart were analyzed.

1. Systolic function was analyzed by measuring Ejection fraction. Measurement for Ejection Fraction (EF) was taken by M-mode in parasternal long axis view.
2. Diastolic function was analyzed by noting the E/A ratio & peak velocities of E & A and by measuring the LVPWd (Left Ventricular Posterior Wall Thickness during diastole).The measurements of E & A were done by measuring Mitral flow across Mitral valve by continuous or pulse wave Doppler in Apical four chambered view.

The measurements taken were peak velocity & gradient during early diastole (E) & late diastole (A) & hence the diastolic function was analyzed by E/A ratio. Normally E/A is greater than 1(E>A) & diastolic dysfunction is present if E/A<1.

The other measurement that was noted was left Ventricular wall thickness mainly in the form of Left Ventricular Posterior wall thickness. Normally the thickness is 0.4 to 0.8. Diastolic dysfunction is present if the thickness is >0.8.

Serum ferritin levels were estimated by radio immunoassay method in the serum samples of patients.

The findings on echocardiogram (low ejection fraction & LVPWd) were correlated with the serum ferritin level, number of transfusions the children had received and pre-transfusion hemoglobin level.

60 cases were grouped depending on serum ferritin levels as 500-1000, 1000-2000, 2000-3000, 3000-4000 & >4000ng/ml and number of total cases, abnormal cases and cases with low ejection fraction were found in each group. Significance was tested by Chi square test and P value was calculated.

All the 60 cases were grouped based on the number of packed cell transfusions received into <50, 51-100, 101-150 and >150 and number of total cases, abnormal cases and cases with low ejection fraction were found in each group. Significance was tested by Chi square test and P value calculated.

All the 60 cases were also grouped based on pre-transfusion hemoglobin status as those with hemoglobin of ≤6, 6.1-8, 8.1-10 and >10gram%. Abnormal cases and cases with low ejection fraction were found in each group and significance was tested by Chi square test and P value calculated.

Mean ferritin levels were compared in cases with normal and abnormal ECHO, in cases with normal and low ejection fraction and n cases with normal and increased LVPWd. Significance was tested by using Student's t-test and P value calculated.

Mean number of blood transfusions received was compared in cases with normal and abnormal ECHO, in cases with normal and low ejection fraction and n cases with normal and increased LVPWd. Significance was tested by using Student's t-test and P value calculated.

The following statistical methods were used for the comparison of the data:

Statistical Methods: Chi-square test has been used to test the significance of abnormal ECHO findings, low ejection fraction and LVPWd in cases of different groups of serum ferritin levels, number of transfusions and pre–transfusion hemoglobin levels.

Student t test (two tailed, independent) has been used to find the significance of mean ferritin levels and mean number of transfusions in normal and abnormal ECHO cases, normal and low ejection fraction cases and normal and increases LVPWd cases.

1. Chi-Square Test

$$\chi^2 = \frac{\sum (Oi - Ei)^2}{Ei}$$

Where 'Oi' is observed frequency and 'Ei' is Expected frequency

2. Student't' test

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{s^2(1/n1 + 1/n2)}}$$

$$\text{Where } s^2 = \frac{(n1-1)\sum_{i=1}^{n1}(x1 - \bar{x}1)^2 + (n2-1)\sum_{i-1}^{n2}(x2 - \bar{x}2)^2}{n1 + n2 - 2}$$

Observed difference is statistically significant if P value is <0.05.

Results

In the present study, 60 non-chelated Thalassemia major children, who are coming regular blood transfusion to Thalassemia clinic of Vani Vilas Children's hospital attached to BMC &RI were examined & data collected as per the proforma.

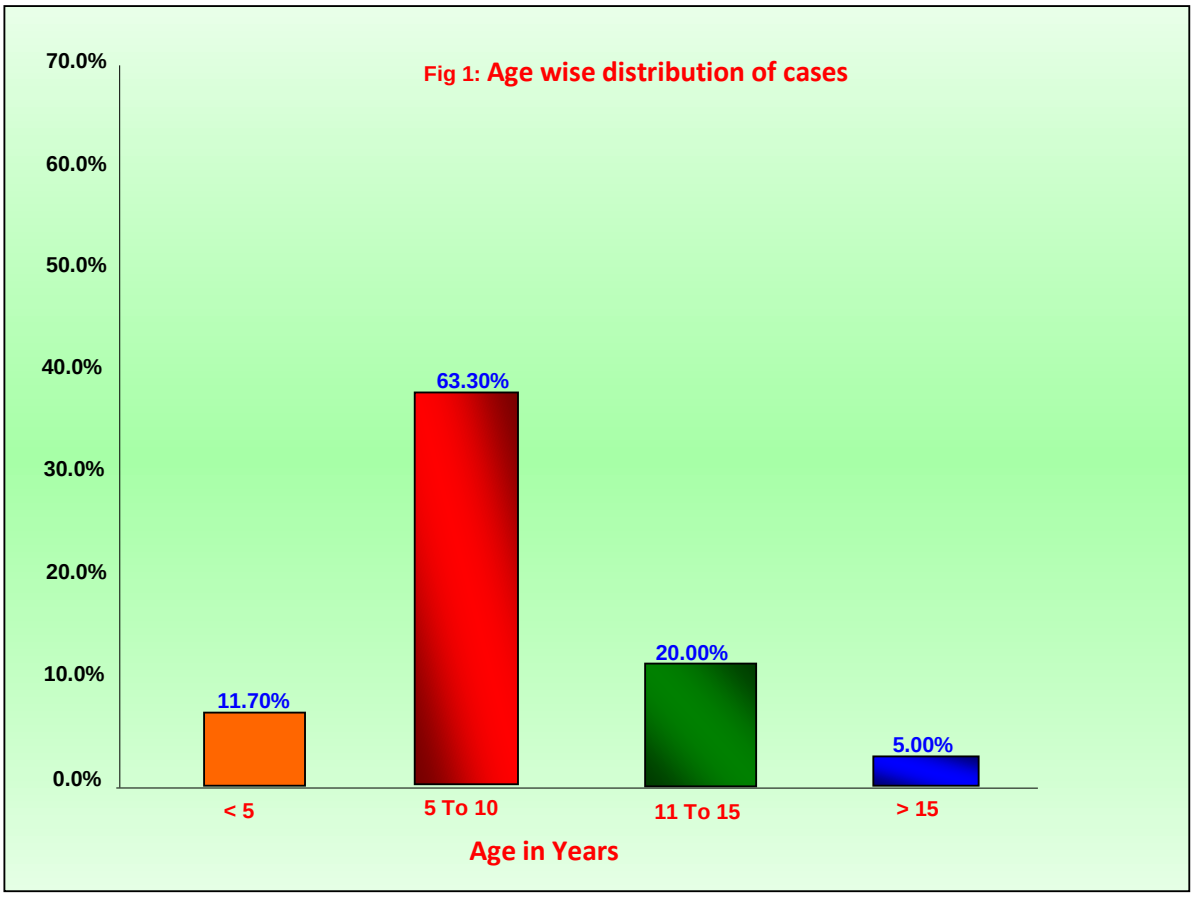
Children between 1 to 18 yrs were studied who have received at least 20 packed cell transfusions.

Age - Years	No of Cases	%
< 5	7	11.7%
5 To 10	38	63.3%
11 To 15	12	20.0%
> 15	3	5.0%
Total	**60**	**100.00%**

N=60

Table 1: Age wise distribution of cases

From the above table it is evident that 38 cases were between 5-10 years accounting for 63.33% of all cases. 12 cases were between 11-15 years accounting for 20% of all cases, 7 cases were <5 years (11.67%) & 3 cases >15years (5%).



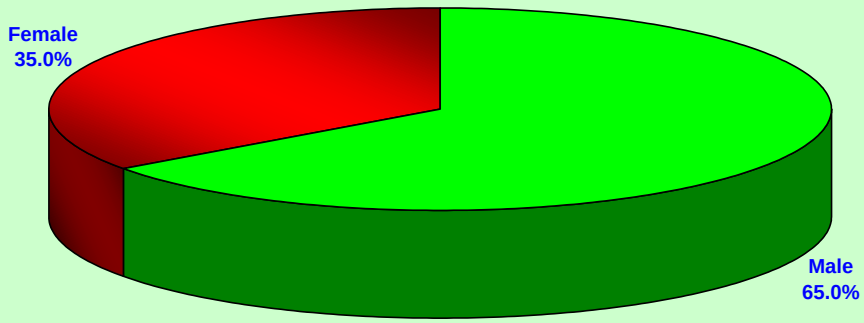
Gender	No Of Cases	Percentage
Male	39	65.0%
Female	21	35.0%
Total	**60**	**100.00%**

N=60

Table 2: Gender distribution of cases

Above table shows that, out of 60 cases 39 were males accounting to 65% of cases & 21 were females which comes to 35% of cases. Male to female ratio is 1.85:1

Fig 2: Gender Distribution of the Study population

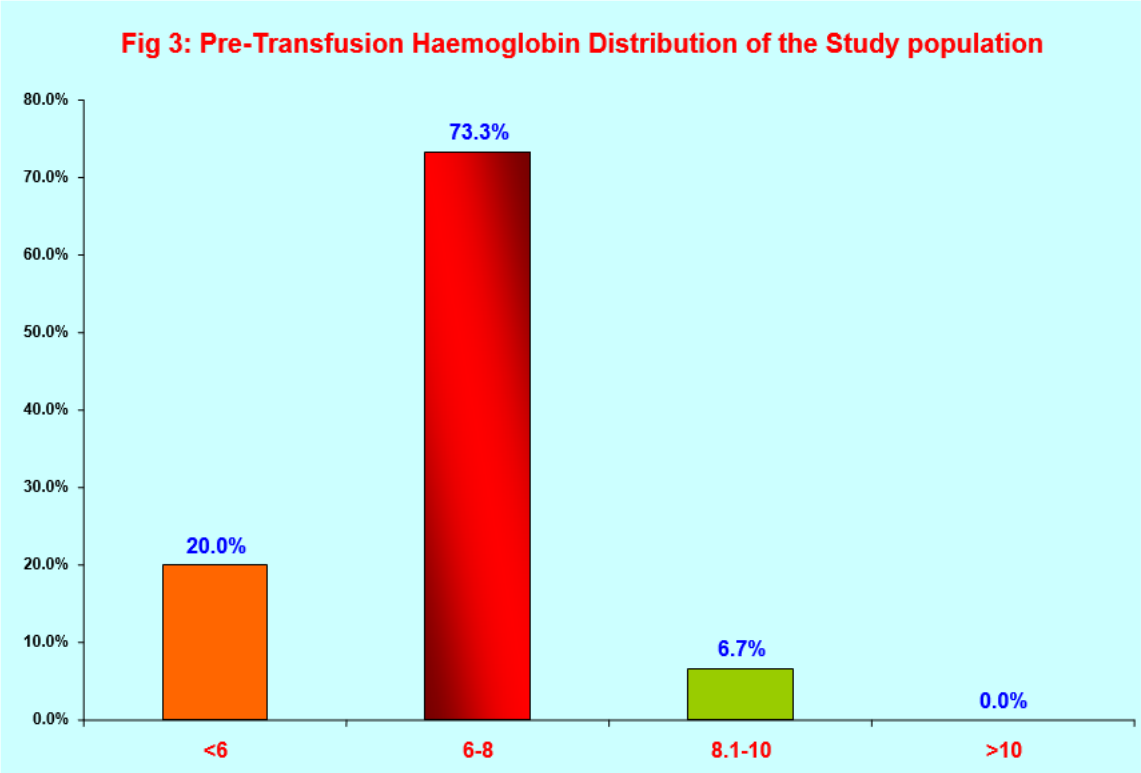


Hemoglobin	No Of Cases	Percentage
<6	12	20.0%
6 To 8	44	73.3%
>8 To 10	4	6.7%
>10	0	0.0%
Total	**60**	**100.00%**

N=60

Table 3: Pre-transfusion hemoglobin distribution of cases

From the above table it is clear that 44 cases (73.33%) had a pre transfusion hemoglobin of 6 to 8gm%. 12 cases (20%) had hemoglobin of <6gm%. 4 cases (6.67%) had a pre transfusion hemoglobin of 8.1-10 gm% and none had >10gm%.

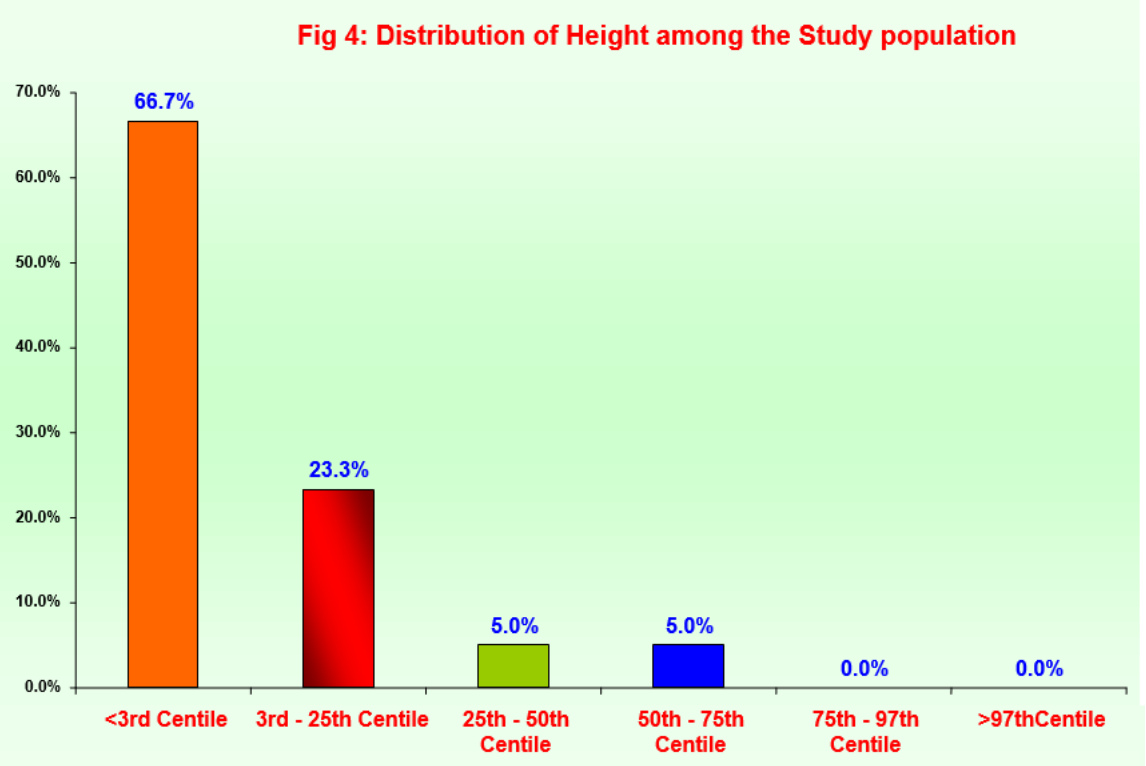


Height	No Of Cases	Percentage
<3rd Centile	40	66.7%
3rd to 25th Centile	14	23.3%
25th to 50th Centile	3	5.0%
50th to 75th Centile	3	5.0%
75th to 97th Centile	0	0.0%
>97thCentile	0	0.0%
Total	**60**	**100.00%**

N=60

Table 4: Distribution of height centiles of cases

Above table reveals that 40 out of 60 cases (66.67%) were <3rd centile in height for age, 14 cases (23.33%) were between 3rd to 25th centile,3 cases (5%) were between 25th to 50th centile & only 3 cases (5%) were in the range of 50th to 75th centile in height & no case was >75th centile.



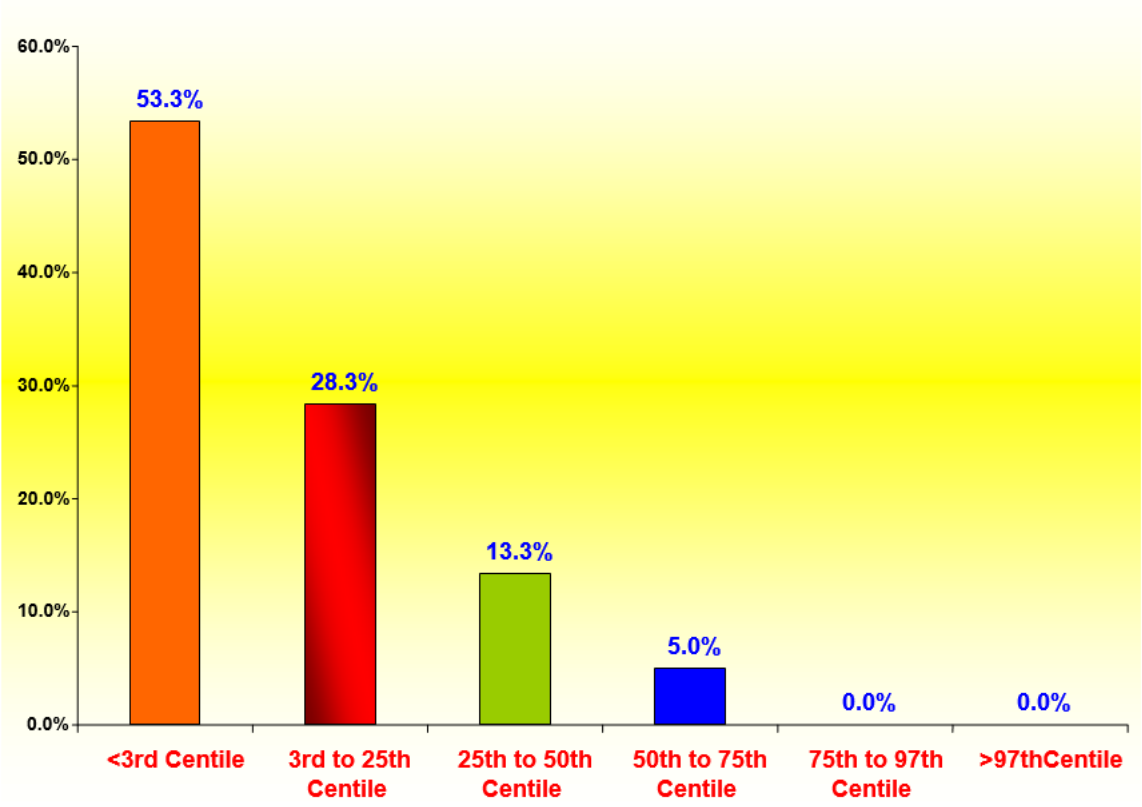
Weight	No Of Cases	Percentage
<3rd Centile	32	53.3%
3rd to 25th Centile	17	28.3%
25th to 50th Centile	8	13.3%
50th to 75th Centile	3	5.0%
75th to 97th Centile	0	0.0%
>97thCentile	0	0.0%
Total	**60**	**100.00%**

N=60

Table 5: Distribution of weight centiles of cases

Above table reveals that 32 out of 60 cases (53.33%) were <3rd centile in weight for age, 17 cases (28.33%) between 3rd & 25th centile & 8 cases (13.33%) between 25th to 50th centile in weight. Only 3 cases (5%) were in the range of 50th to 75th centile & no case was >75th centile.

Fig 5: Distribution of Weight among the Study population



Ejection Fraction	No Of Cases	Percentage
< 60%	20	33.3%
>= 60 %	40	66.7%
Total	**60**	**100.00%**

N=60

Table 6: Distribution of ejection fraction of cases

LVPWd	No Of Cases	Percentage
0.4--0.8	51	85.0%
>0.8	9	15.0%
Total	**60**	**100.00%**

N=60

Table 7: Distribution of LVPWd of cases

E/A Ratio	No Of Cases	Percentage
< 1	1	1.7%
≥1	59	98.3%
Total	**60**	**100.00%**

N=60

Table 8: Distribution of E/A ratio of cases

Tables 6, 7 and 8 show that of the 60 cases studied, 20 of them (33.33%) had Ejection fraction of <60%, 5 cases (8.33%) had LVPWd of >0.8 & only 1 case had E/A ratio of <1 respectively.

Fig 6: Distribution of Ejection Fraction of the Study population

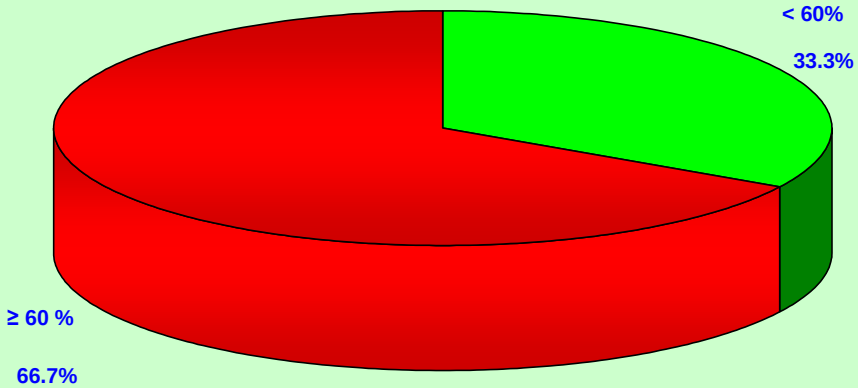


Fig 7: Distribution of LVPWd among the Study population

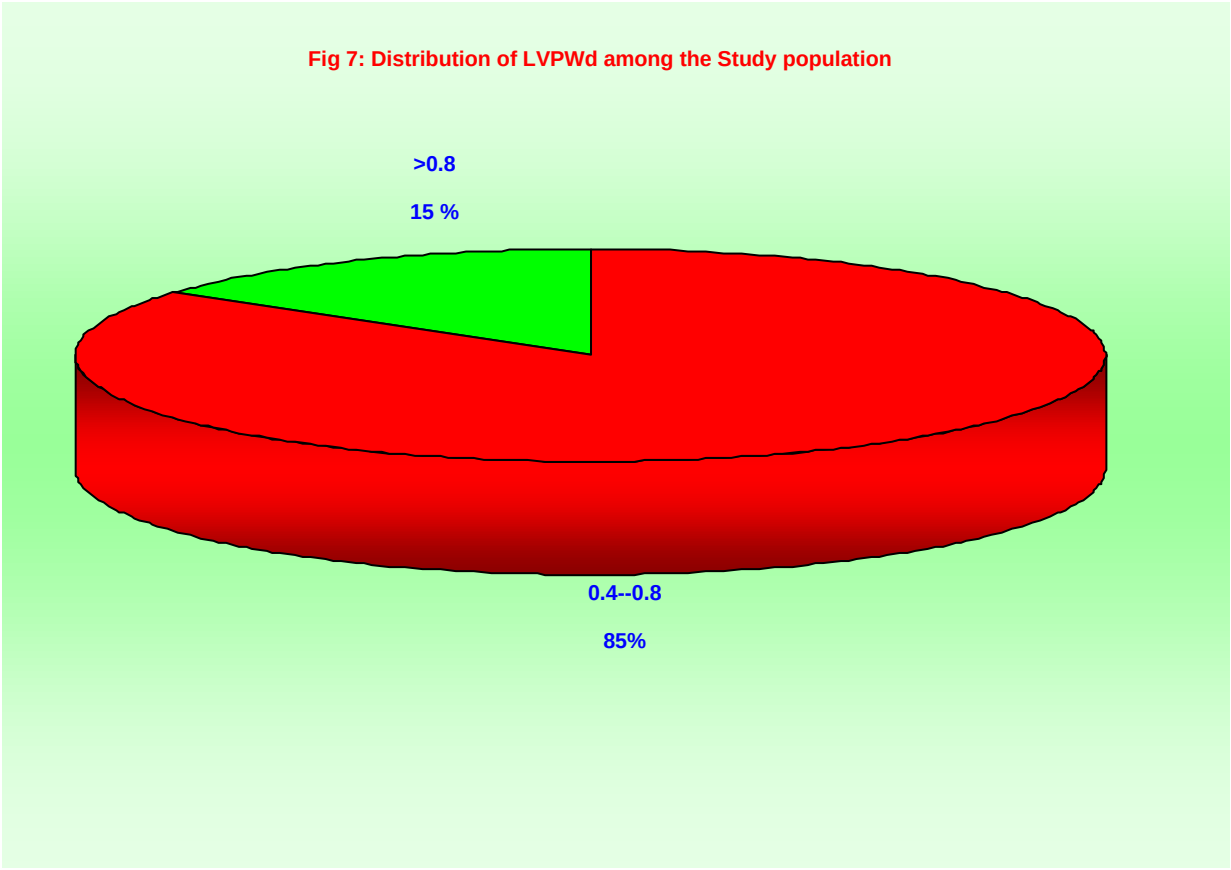
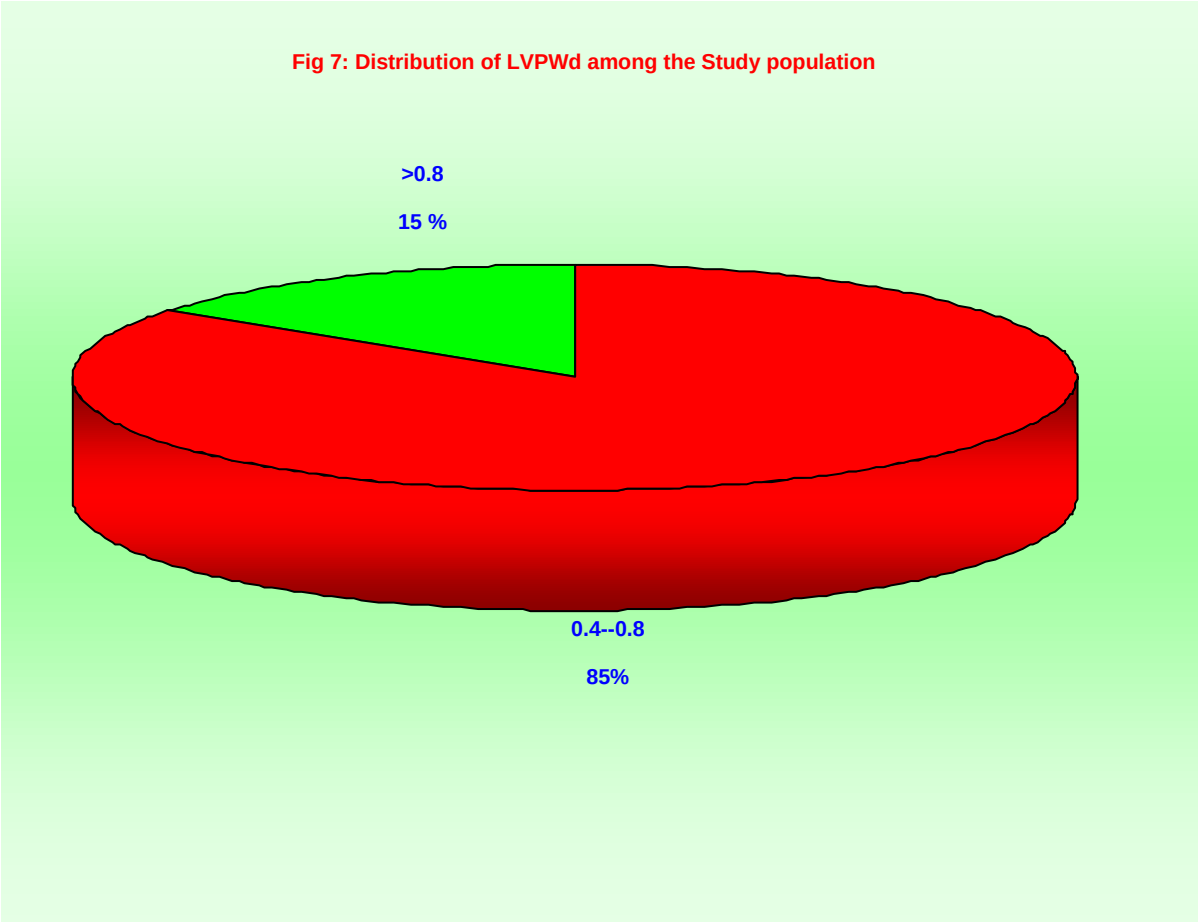


Fig 7: Distribution of LVPWd among the Study population



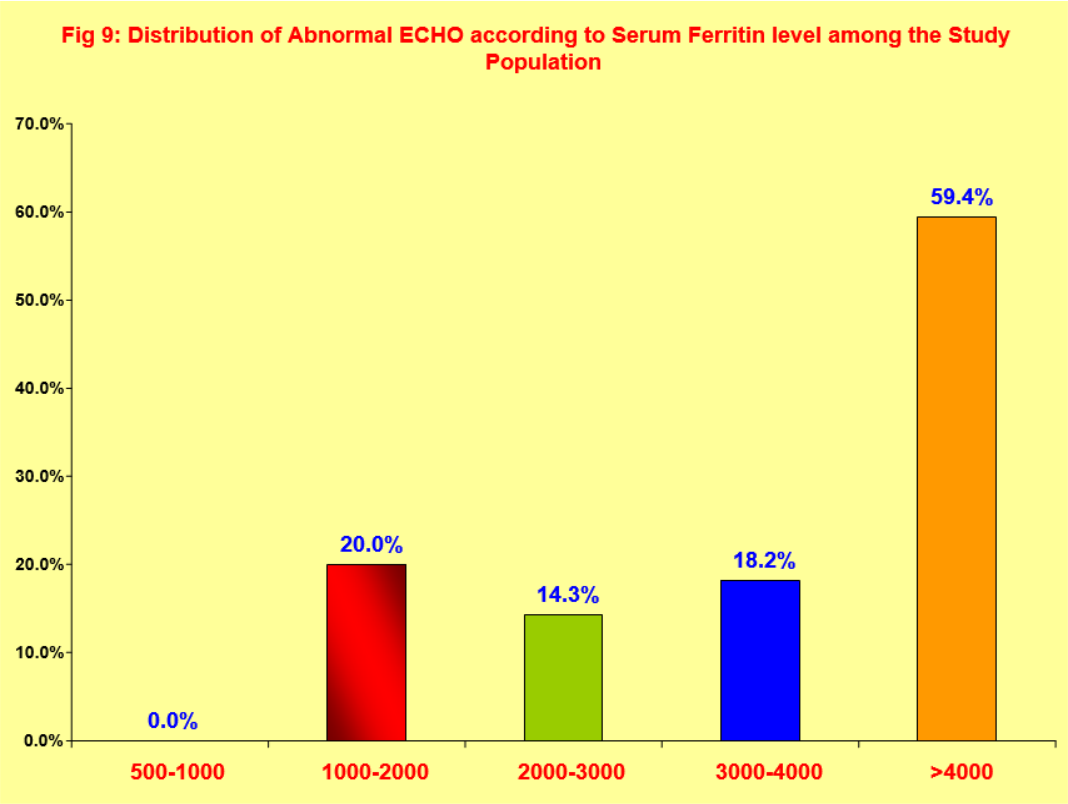
Serum Ferritin ng/ml	Abnormal ECHO	Normal ECHO	Total
500-1000	0	0	0
1000-2000	2 (20.0%)	8 (80.0%)	10
2000-3000	1 (14.3%)	6 (85.7%)	7
3000-4000	2 (18.2%)	9 (81.8%)	11
>4000	19 (59.4%)	13 (40.6%)	32
Total	**24**	**36**	**60**

N=60

Table 9: Distribution of abnormal ECHO according to Serum ferritin level of cases

χ^2=10.78 d.f=3 p value=0.01294

Table 7 shows that out of 60 cases evaluated, 24 cases showed abnormalities in ECHO. 32 cases had serum ferritin levels of >4000ng/ml & 19 of them had abnormal findings in ECHO (59.38%), 11 cases had serum ferritin between 3000-4000ng/ml & of them, 2 cases showed abnormal ECHO (18.18%), 7 cases had serum ferritin levels of 3000-2000ng/ml & of them only 1 case had abnormal ECHO (14.3%) and of the 10 cases having serum ferritin levels <2000ng/ml, 2 cases had abnormal ECHO (20%). This table has a significant P-value of 0.01294.



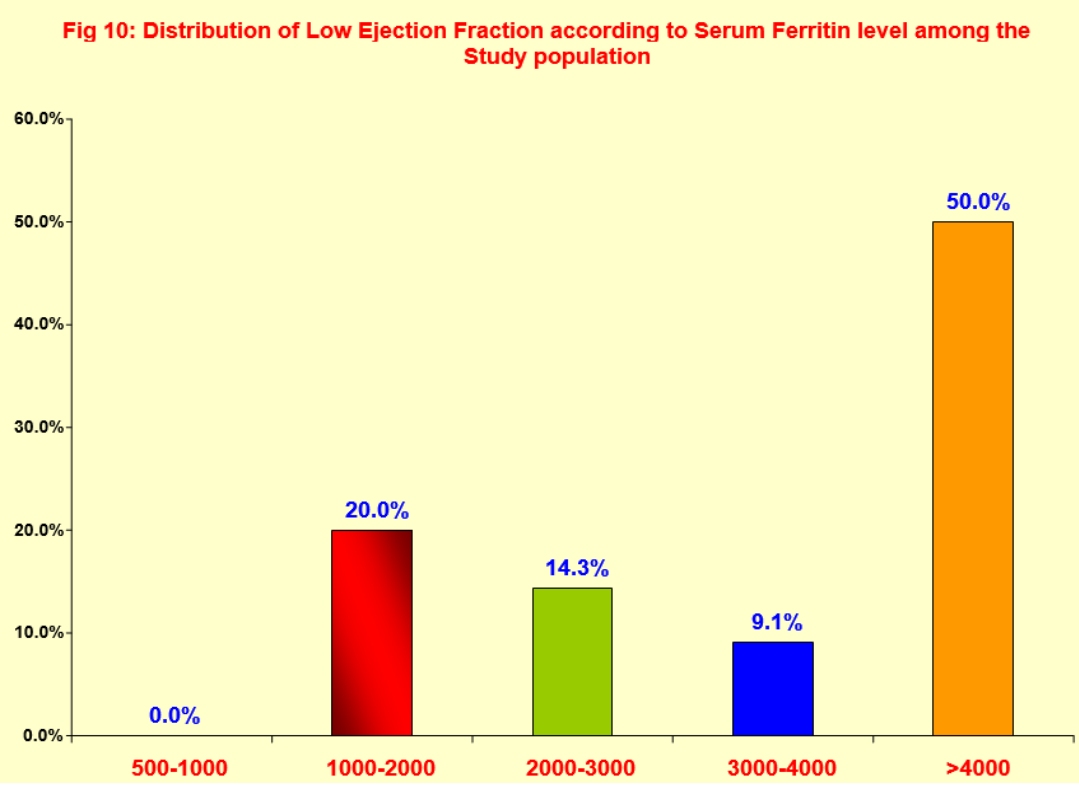
Serum Ferritin ng/ml	Low EF	Normal EF	Total
500-1000	0	0	0
1000-2000	2 (20.0%)	8 (80.0%)	10
2000-3000	1 (14.3%)	6 (85.7%)	7
3000-4000	1(9.1%)	10 (90.9%)	11
>4000	16 (50.0%)	16 (50.0%)	32
Total	**20**	**40**	**60**

N=60

Table 10: Distribution of Low ejection fraction according to Serum ferritin level in cases

χ^2=8.85 d.f=3 p value=0.0313

Table 8 reveals that of the 32 cases with serum ferritin levels of >4000ng/ml, 16 cases had ejection fraction <60 (50%). Of the 11 cases with serum ferritin levels between 3000-4000ng/ml, 1 case had ejection fraction <60% (9.09%), 7 cases had serum ferritin levels between 2000-3000ng/ml & of them, 1 case had ejection fraction of <60% (14.3%) & of the 10 cases with ferritin levels of <2000ng/ml, 2 cases had low ejection fraction (20%). This table has a significant P-value of 0.0313.



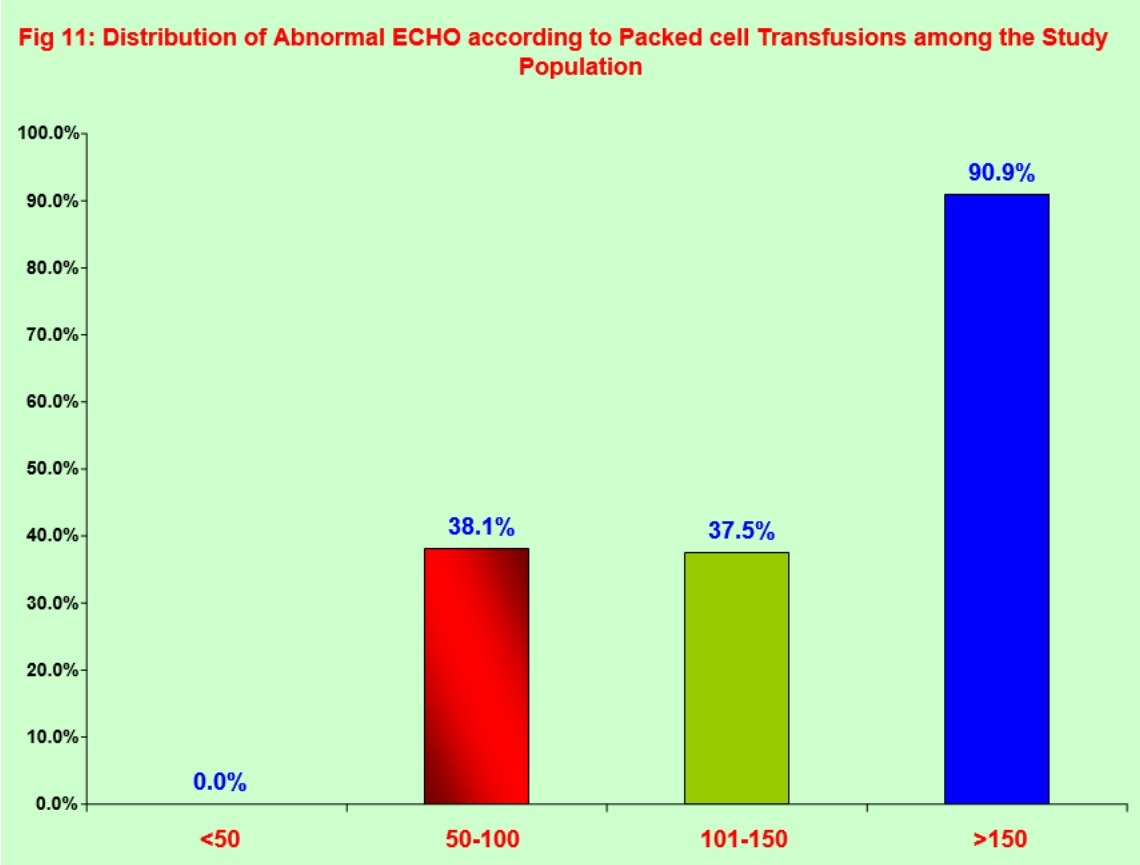
No Of Packed cell Transfusions	Abnormal ECHO	Normal ECHO	Total
<50	0	12 (100.0%)	12
50-100	8(38.1%)	13 (61.9%)	21
101-150	6(37.5%)	10 (62.5%)	16
>150	10(90.0%)	1(10.0%)	11
Total	**24**	**36**	**60**

N=60

Table 11: Distribution of abnormal ECHO according to Number of packed cell transfusions in cases

χ^2=19.95 d.f=3 p value=0.00017

Table 9 reveals that out of 60 cases, 11 cases had received >150 packed cell transfusions & 10 of them showed abnormalities on Echo (90.91%). Of the 16 cases with transfusions between 101-150, 6 cases had abnormal Echo (37.5%) & of the 21 cases with <100 packed cell transfusions, 8 cases had abnormal; Echo (38.1%). This table has a significant P-value of 0.00017.



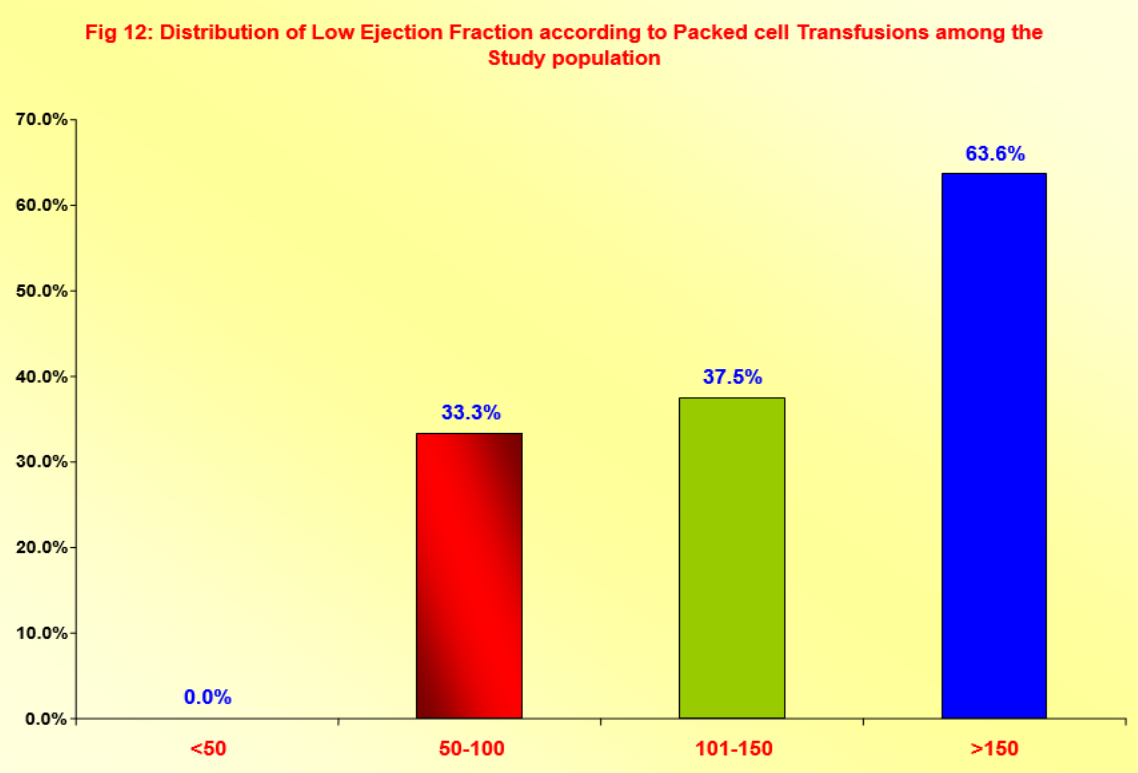
No Of Packed cell Transfusions	No Of Cases	Low EF	Normal EF
<50	12	0	12 (100%)
50-100	21	7 (33.3%)	14 (66.7)%
101-150	16	6 (37.5%)	10 (62.5%)
>150	11	7 (63.6%)	4 (36.4%)
Total	**60**	**20**	**40**

N=60

Table 12: Distribution cases with Low ejection fraction according to number of packed cell transfusions

χ^2=10.67 d.f=3 p value=0.01364

Table 10 shows that of the 12 cases who received <50 packed cell transfusions, all had an ejection fraction of ≥ 60%. Of the 21 cases who had received 51-100 packed cell transfusions, 7 cases (33.3%) had ejection fraction <60%. 16 & 11 cases had received packed cell transfusions from 101-200 & >200 respectively & of them, 6 (37.5%) & 7 (63.6%) cases had ejection fraction of <60%. This showed a significant P-value of 0.01364.



ECHO	N	Mean Ferritin ng/ml	SD
Abnormal	24	12155.1	23950.28
Normal	36	4086.77	2639.46

N=60

Table 13: Comparison of mean Serum Ferritin levels in cases with Normal and Abnormal ECHO

P value =0.0489

According to table 14, among 24 cases with abnormal ECHO, mean serum ferritin level was 12,155.1ng/ml as compared to 4086.77ng/ml in cases with normal ECHO with a significant P value of 0.0489.

Ejection Fraction	N	Mean Ferritin ng/ml	SD
<60%	20	12896.62	26186.80
≥60%	40	4522.84	3242.37

N=60

Table 14: Comparison of mean Serum ferritin levels in cases with normal and low Ejection fraction

P value= 0.0492

Among 20 cases with ejection fraction <60%, mean serum ferritin level was 12,896.62ng/ml as compared to 4522.84ng/ml in cases with ejection fraction of ≥60%, with a significant P value of 0.0492.

LVPWd	N	Mean Serum Ferritin level ng/ml	SD
0.4-0.8	51	4262.53	2142.36
>0.8	9	7125.35	5614.26

N=60

Table 15: Comparison of mean Serum ferritin levels in cases with normal and Increased LVPWd

P value= 0.0080

Table 16 shows that mean serum ferritin level in cases with increased LVPWd was 7125.35ng/ml as compared to 4262.53ng/ml in cases with normal LVPWd which is significantly more with a P value of 0.0080.

ECHO	N	Mean No Of Transfusions	SD
Abnormal	24	133.21	41.14
Normal	36	79.19	36.43

N=60

Table 16: Comparison of mean number of packed cell transfusions in cases with Normal and Abnormal ECHO

P value= 0.0001

Among 24 cases with abnormal ECHO, mean number of packed cell transfusions received was 133.21 as compared to 79.19 in cases with normal ECHO with a significant P value of 0.0001.

Ejection Fraction	N	Mean No Of Transfusions	SD
<60%	20	132.65	40.67
≥60%	40	85.03	41.17

N=60

Table 17: Comparison of mean number of packed cell transfusions in cases with normal and low Ejection fraction

P value= 0.0001

Among 20 cases with ejection fraction <60%, mean number of packed cell transfusions received was 132.65 as compared to 85.03 in cases with ejection fraction of ≥60%, with a significant P value of 0.0001.

LVPWd	N	Mean no of Transfusions	SD
0.4-0.8	51	94.59	44.78
>0.8	9	136.00	41.87

N=60

Table 18: Comparison of mean number of packed cell transfusions in cases with normal and Increased LVPWd

P Value= 0.0124

Table 19 shows that mean number of packed cell transfusions in cases with increased LVPWd is 136 as compared to 94.59 in cases with normal LVPWd which is significantly more with a P value of 0.0124.

Discussion

In the present study, a total of 60 cases of non-chelated β-thalassemics who have received >20 transfusions of packed cells were evaluated for systolic & diastolic dysfunction by Echocardiography & correlated with serum ferritin level & number of transfusions.

The age distribution in present study is between 3 to 18 years, the youngest child being 3 years of age & eldest being 18 years. The peak age is in the range of 5 to 10 years followed by 11 to 15 years. This correlates with the study of Senior54 in which the peak age was between 7 to 11 years & study of Jia-Woei55 in which the peak age was between 5 to 15 years & with the study of Pramod Sharma56 in which peak age was between 4 to12 years.

The sex ratio in present study is 1.85: 1 which correlates with the study of Senior in which the peak age group was 1.8:1, Martin B Leon57 in which the ratio was 2:1 & study of Parvakar Mishra **[**58**]** in which it was 1.4:1.

In present study, out of 60 children most of the children are stunted. 40 children i.e. 66.7% are <3rd centile on Aggarwal or WHO charts as applicable. This finding is consistent with study of Masala A **[**59**]** in which 60% of cases had height of <3rd centile.

32 children i.e., 53.3% have weight <3rd centile on Aggarwal or WHO charts as applicable. This correlates with the study of Pramod Sharma **[**56**]** in which 54.28% of children were found to be below 3rd centile.

In present study 73.3% of children had maintained pre-transfusion hemoglobin between 6-8 gm%, 20% had less than 6gm% and 6.7% of cases had pre-transfusion hemoglobin of more than 8gm%. This is similar to the study of Mahantesh Patil. **[**60**]**

Hemoglobin	Present Study (2008)	Mahantesh Patil [60] (2003)
≤6	20%	11%
61.-8	73%	78%
8.1-10	6.7%	11%
>10	0%	0%

Comparison of Pre- transfusion Hemoglobin status in various studies

In present study 20 cases (33.3%) showed ejection fraction of >60% on echo & 40 cases (66.7%) showed normal ejection fraction of ≥60%. This correlates with the study of Pramod Sharma56 in which 28.85% of patients had low ejection fraction.

STUDY	EF <60%
Present Study (2008)	33.3%
Pramod Sharma [56] (2007)	28.85%

Comparison of Percentage of cases with low Ejection Fraction in various studies

In present study, only 1 case has an E/A ratio of <1 amounting to 1.7%. This correlates with the study of A. Taksande61 who showed that there is no difference in trans mitral flow in thalassemics & normal subjects. Also in a study conducted by Kremastino62 it was shown that there is no change in E/A ratio as there is an increase in both early & late peak trans mitral flow velocity.

In present study, left ventricular relaxation is abnormal in 15% of cases which correlates with the study of Mahantesh Patil60 in which 16.6% of cases had abnormal left ventricular relaxation.

STUDY	LVPWd >0.8
Present Study (2008)	15%
Mahantesh Patil[60] (2003)	16.6%

Comparison of percentage of cases with increased LVPWd in various studies

In present study, abnormal findings on ECHO correlates well with serum ferritin levels, with 59.4% of cases showing abnormalities on ECHO among cases with a serum ferritin level of >4000 ng/ml. This was statistically significant with a P value of <0.05. Also the mean serum ferritin level in cases which showed abnormalities on ECHO is 12155.1ng/ml which is much higher compared to cases which showed no abnormal findings on ECHO (4086.77ng/ml). This difference is also statistically significant. This correlates well with the study of Pramod Sharma **[**56**]** who showed significant correlation between serum ferritin level of & abnormal findings on ECHO.

Present study also demonstrates a significant correlation between number of transfusions & abnormal findings in ECHO. As the number of transfusions increase, cases with abnormal findings in ECHO also increase. Also the mean number of transfusions received by the cases who showed abnormal findings on ECHO is 133.21 which is significantly higher than the number of transfusions received by the cases who did not show any abnormality on ECHO (79.19). This correlates well with the study of Pramod Sharma**[**56**]** & Mahantesh Patil. **[**60**]**

Present study shows that low ejection fraction is inversely related to serum ferritin levels & this finding is statistically significant in that 50% of cases with a serum ferritin level of >4000ng/ml have low ejection fraction. Also the mean ferritin level in cases with low ejection fraction is 12896.62ng/ml which is significantly higher than in those cases which have normal ejection fraction (4522.84ng/ml). This correlates with the study of Pramod Sharma, **[**56**]** Vilhekar KY **[**37**]** and Martin B**[**57**]** who showed inverse correlation between serum ferritin level & ejection fraction.

STUDY	Mean Serum Ferritin incase of low EF	Mean Serum Ferritin in case of normal EF	P value
Present study (2008)	12155	4086.77	<0.05
Pramod Sharma[56] (2007)	4916	4699.40	<0.05

Comparison of mean Serum Ferritin level in cases with normal and low Ejection fraction between various studies

Also the ejection fraction is inversely related to number of blood transfusions as evidenced by the fact that 63.6% of cases who have received more than 150 transfusions have low ejection fraction which is statistically significant. Also the mean number of blood transfusions received by the patients who have low ejection fraction is 132.65 which is significantly higher than in those cases who have normal ejection fraction (85.03). This data also correlates well with the study of Pramod Sharma **[**56**]** and Manu Sundaram. **[**38**]**

STUDY	Mean No of transfusions in case of low EF	Mean No of transfusions in case of normal EF	P value
Present study (2008)	132.65	85.03	<0.05
Pramod Sharma[56] (2007)	198	240	>0.1

Comparison of mean number of packed cell transfusions cases with normal and low Ejection fraction between various studies

In present study, LVPWd increases as the serum ferritin level increases, mean level being more in cases with increased LVPWd (4262.53ng/ml) as compared to those cases with normal LVPWd (7125.35ng/ml). This finding correlates with the study of Mahantesh Patil60 who showed that all cases (3) with serum ferritin level of >1500ng/ml showed increased LVPWd.

Also LVPWd is related to number of packed cell transfusions, mean number of packed cell transfusions being more in cases with increased LVPWd (136) as compared to those cases with normal LVPWd (94.59). This was not studied by Mahantesh Patil. **[**60**]**

Conclusion

Total of 60 cases of β-Thalassemia major who had undergone >20 packed cell transfusions were evaluated for their serum ferritin levels and by echocardiogram to detect systolic and diastolic dysfunction. It was found that:

1. As the serum ferritin increases chance of finding abnormalities in ECHO also increases significantly. Also the mean serum ferritin level in cases with abnormal ECHO findings is significantly higher than in cases with normal ECHO findings. Abnormal findings were seen in cases with serum ferritin level of >1000ng/ml.
2. As the number of packed cells transfused increases chance of finding abnormalities on ECHO also increases significantly. Also the mean number of packed cell transfusions received in cases with abnormal ECHO findings is significantly higher than in cases with normal ECHO findings.
3. The ejection fraction of cases with high serum levels is significantly lower than those cases with lower serum ferritin levels. Also the mean serum ferritin level in cases with low ejection fraction is significantly higher than in cases with normal ejection fraction. Low ejection fraction was seen in cases with serum ferritin level of >1000ng/ml.
4. The ejection fraction in cases who have received more number of packed cell transfusions is significantly low than in those who have received less number of packed cell transfusions. Also the mean number of packed cell transfusions received in cases with low ejection fraction is significantly higher than in cases with normal ejection fraction.
5. These findings show a linear relationship between serum ferritin level, number of packed cell transfusions and that of abnormal findings on ECHO and LVPWd.
6. The findings also show an inverse relationship between serum ferritin level, number of packed cell transfusions and ejection fraction.
7. Hence all the abnormalities found on ECHO are related to serum ferritin levels and number of packed cell transfusions the case has received and not affected by haemoglobin level of the case.

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