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Original Research Article

Left Ventricular Wall Stress in Severe Anemia: An Echocardiographic Study

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ABSTRACT

Background and objectives: Anemia is one of the common health problems more so in developing countries. Echocardiography is a sophisticated, non-invasive imaging tool that has contributed significantly to the assessment of LV function in patients with chronic severe anemia. The left ventricular contractility can be estimated by ESS/ESVi ratio (load independent index) obtained from echocardiographic parameters. This ratio is considered to be superior to EF for assessment of cardiac contractility. Hence present study was undertaken with objective to assess LV systolic dysfunction, by ESS/ESVI ratio.
Methodology: Present study was conducted in Al-Ameen Medical College and District Hospital, Bijapur. 31 anemic patients (aged 18-40 yrs) with Hb ≤ 7 gm% and equal no. of age and gender matched normal subjects were selected. All anemic patients were subjected for hemoglobin estimation and M mode 2D Echocardiography. ESS/ESVi ratio was derived from echo parameters.
Results: Statistically significant variations were found in ESS/ESVi in anemic patients compared to controls. However it did not correlate with Hb levels.
Interpretation and conclusion: The finding of decreased ESS/ESVi in anemic patients compared to controls may be as a consequence of hyperdynamic circulatory state. Anemia is known to cause vascular and cardiac changes mainly increased preload and decreased afterload. These factors increase systolic wall stress. Over time this stress weakens the LV and leads to LV systolic dysfunction. Being a load independent index of myocardial contractility, ESS/ESVi serves as a better parameter for assessing LV dysfunction

Keywords: Chronic anemia, left ventricle, end systolic wall stress, ESS/ESVi, echocardiography.

INTRODUCTION

Anemia is one of the common health problems more so in developing countries. Anemia reduces tissue oxygen delivery and causes a compensatory cardiovascular response. In mild cases patients are asymptomatic. When anemia is more significant, dyspnea and fatigue may occur. Severe anemia can produce left ventricular (LV) dysfunction and overt heart failure. In chronic anemia, the heart undergoes structural changes in response to a persistently reduced hematocrit and in the end develops functional impairment. (LV)

dysfunction occurs frequently with chronic severe anemia, in the form of concentric LV hypertrophy, LV dilatation with or without LV hypertrophy, or systolic dysfunction.[1] The clinical findings of a hyperkinetic state in anemia, although frequently quite striking, can be rapidly reversed by partial correction of the anemia in almost every instance.

Hyperdynamic state of anemia is known to cause increased preload and reduced after load. Therefore indices of myocardial performance that are independent of loading conditions should be used to assess cardiac performance in anemia. The end systole pressure/volume relation is an index of myocardial performance that is independent of preload and after load. Only few studies have evaluated LV contractility by load independent indices such as LV end systolic wall stress to LV end systolic volume index in patients with anemia.[2]

Echocardiography is a sophisticated, non-invasive imaging tool that has contributed significantly to the assessment of patients with chronic severe anemia. Only few studies have assessed the left ventricular function by non invasive techniques. The left ventricular contractility was estimated by ESS/ESVi ratio which was obtained from parameters measured by echocardiography. Present study was undertaken with the objective of assessing the status of left ventricular functional impairment, at an early stage by echocardiographic derived parameter of wall stress-ESS/ESVi ratio.

MATERIALS AND METHODS

The present study was conducted in the department of physiology Al-Ameen Medical College, Bijapur. Thirty one (31) patients (20 females, 11 males) with severe anemia (Hb ≤ 7gm%), between 18yrs to 40 yrs age visiting Al-Ameen medical college hospital and District Hospital Bijapur were selected. Equal number of age & gender matched individuals were controls.

Patients presenting with history of acute anemia and other causes of hyperdymanic circulatory state were excluded from the study. All anemic patients underwent history taking and a thorough clinical examination. Physical parameters were recorded. Their hemoglobin levels were estimated. Transthoracic Echocardiography was done using PHILIPS Envisor C (model no MCMD02AA) diagnostic Ultrasound System using 3.5 MHz transducer, probe (PA 4- 2) by physician experienced in Echocardiography. Measurements were made according to the recommendations of the American Society of Echocardiography (ASE) at end diastole and end systole.[3] Echocardiographic parameters viz- LVPWs, LVIDs, ESV were recorded.

The ESS/ESVI ratio provides an excellent measure of LV systolic function and measures LV systolic wall stress.[2,4]
Left ventricular end systolic stress was calculated by the formula.[5]

$$ESS = \frac{0.334 \times P \times LVIDs}{LVPWs\,(1+\frac{LVPWs}{LVIDs})}$$

Where P is simultaneous cuff systolic brachial arterial pressure (mmHg),
LVIDs is Left ventricular inner dimension at end systole,
LVPWs is Left ventricular Posterior wall thickness at end systole.

End systolic volume (ESV) was indexed to body surface area to get End systolic volume index (ESVi).

The ratio of ESS/ESVi was then calculated and expressed as Kdyn/cm^2 per ml per m^2.
Student's unpaired't' test was performed (using Graph pad Prism 5 statistical software) to analyze the wall stress ratio changes between the control group and anemic patients. Correlation analysis was

applied to correlate hemoglobin levels and various echo parameters. A 'p' value <0.05 was considered statistically significant.

RESULTS

TABLE.NO.1: Shows the mean ± SEM of Hb, PR, SBP, DBP in anemic patients and controls.

sPARAMETER	ANEMIC PATIENTS (n = 31) MEAN±SEM	CONTROLS (n = 31) MEAN±SEM	p value
Hb (gm/dl)	4.958 ± 0.22	13.46 ± 0.13	$p < 0.0001^{***}$
PR (beats/min)	88.06 ± 1.08	78.83 ± 0.74	$p < 0.0001^{***}$
SBP (mmHg)	109.29 ± 1.39	112.96 ± 1.28	$p > 0.05$
DBP (mmHg)	66.58 ± 1.38	74.64 ± 1.09	$p < 0.0001^{***}$

TABLE.NO.2: Shows the mean ± SEM of Echocardiographic parameters in anemic patients and controls.

PARAMETER	ANEMIC PATIENTS (n = 31) MEAN±SEM	CONTROLS (n = 31) MEAN±SEM	p value
LVIDs (cms)	3.46 ± 0.012	2.86 ± 0.06	p < 0.0001***
LVPWs (cms)	1.015 ± 0.01	1.00 ± 0.01	p > 0.05
ESV (ml)	46.92 ± 3.73	24.8 ± 1.65	p < 0.0001***
EF (%)	59.47 ± 1.25	67.48 ± 0.89	p < 0.0001***
FS(%)	27.93 ± 1.03	32.3 ± 0.82	p < 0.01**
ESS/ESVI ratio (kdyn/cm^2 per ml per m^2)	2.309 ± 0.11	3.783 ± 0.18	p < 0.0001***

TABLE.NO.3: Shows the correlation analysis of Hb with various Echocardiographic parameters in anemic patients.

SL. no	PARAMETER	ANEMIC PATIENTS (N=31)		
		R	p	S/NS
1	Hb vs LVIDs	-0.364	0.04	S*
2	Hb vs LVPWs	-0.128	0.49	NS
3	Hb vs ESV	-0.415	0.02	S*
4	Hb vs EF	0.062	0.73	NS
5	Hb vs FS	0.07	0.70	NS
6	Hb vs ESS/ESVI	0.345	0.056	NS

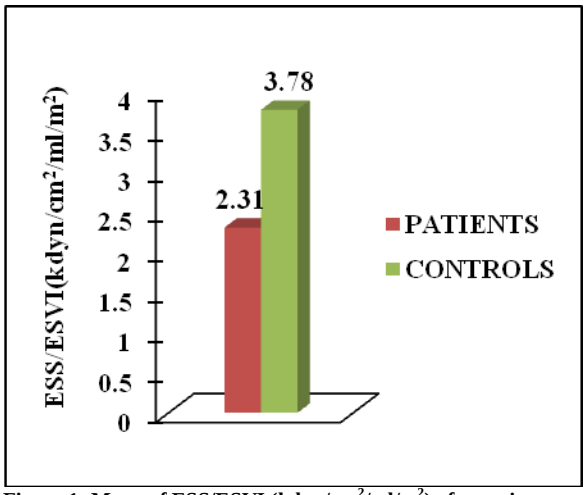

Figure 1: Mean of ESS/ESVI (kdyn/cm^2/ml/m^2) of anemic patients and controls.

Thirty one patients with severe anemia having hemoglobin concentration less than 7 gm/dl, between 18 and 40 yrs of age and equal no. of age and gender matched normal subjects were selected for this study. Student's unpaired 't' test was used to analyze the variation in the parameters in anemic patients and controls. Correlation analysis was done in patients to correlate Hb with ESS/ESVi ratio.

Table No. 1 Shows the mean ± SEM of Hb, PR, SBP, DBP in anemic patients and controls. The mean value of pulse rate of anemic patients was higher as compared to that of controls with a statistically significant difference; ($t = 7.01$, $p < 0.0001$). There was no statistically significant difference between the mean of SBP levels of anemic patients and controls; ($t = 1.936$, $p > 0.05$). The mean DBP level in anemic patients was lower as compared to the controls with a statistically significant difference; ($t = 4.585$, $p < 0.0001$).

The mean ± SEM of hemoglobin in anemic patients was 4.958 ± 0.22 gm/dl; in controls 13.46 ± 0.13 gm/dl.

Table No. 2 Shows the mean ± SEM of Echocardiographic parameters in anemic patients and controls.

The mean of ESV in anemic patients was more when compared with that of controls with a statistically significant

difference; (t=5.413, p < 0.0001). In anemic patients the mean value of EF & FS were lower when compared with that of controls. This difference was statistically significant; (t=5.201, p < 0.0001) & (t = 3.33, p < 0.01) respectively.

The mean value of ESS/ESVI ratio in anemic patients was found to be lower when compared to that of controls. This difference was statistically highly significant; (t= 6.895, p < 0.0001) (Fig. 1).

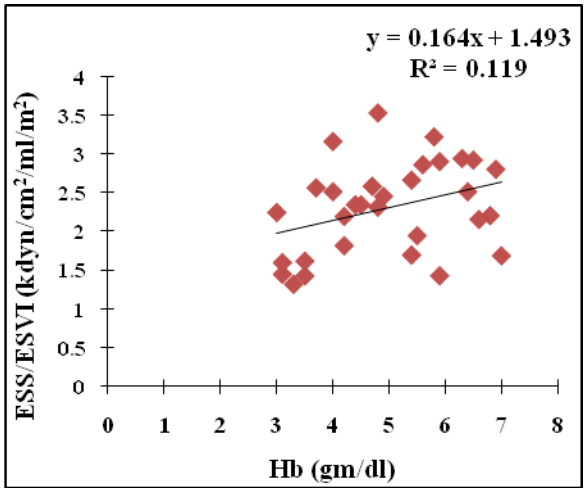

Figure 2: Correlation between Hb and ESS/ESVI ratio in anemic patients (n=31); the correlation coefficient(r) is 0.345, p value > 0.05.

Table no.3 shows the correlation analysis of Hb with various Echocardiographic parameters in anemic patients. The LVIDs showed statistically significant negative correlation with hemoglobin (r = -0.364, p < 0.05). LVPWs and hemoglobin did not correlate with a statistical significance (r = -0.128, p > 0.05). Significant negative correlation was found between ESV and hemoglobin levels (r = -0.415, p < 0.05). EF & FS showed no significant correlation with hemoglobin (r = 0.062, p > 0.05) & (r = 0.07, p > 0.05) respectively.

There was no statistically significant correlation between ESS/ESVI ratio and hemoglobin in anemic patients; (r = 0.345, p > 0.05) (Fig. 2).

DISCUSSION

Singh K, Singh PI conducted a study and observed that there was an elevation of heart rate in anemics.[6] Our finding of an elevated pulse rate in anemic patients suggest the possibility of increased activity of sympathetic part of autonomic nervous system due to reduced oxygen delivery to the tissues.[4]

There was no significant difference in the mean ± SD of SBP of 31 chronic severe anemia patients and controls.[7] The systolic blood pressure did not differ significantly between patients with sickle β thalassemia and healthy controls (I Moyssakis et al. 2005).[8] Our findings are similar to other studies.

In a study conducted by RB Panwar et al. 1991, it was observed that the ESV index was more in anemic patients than controls. It was also observed that the ESV index was deranged more in patients with tachycardia than without tachycardia.[9] The ESVi in thalassemia patients was 36.9±10.8ml/m^2 and in controls 28.15±2.6 ml/m^2 with a statistical significance of p < 0.0001 (G Bosi et al. in 2003).[10] Riku H et al 1999, noted a decrease in the end systolic volume index in patients with iron deficiency anemia when observation was made before and after treatment of anemia in a study conducted in 2000 on 24 patients of IDA with a mean age of 30 yrs.[2]

The finding of an increased ESV in anemic patients in our study may be due to early feature of onset of impaired left ventricular function in these patients. We also found a negative correlation between hemoglobin levels and ESV, which may be due as a consequence of chronic anemia.

The most accepted expression of global LV function is LVEF. It is a simple measure of how much percentage of end-diastolic volume is ejected from the left ventricle with each contraction.[11] Fractional shortening (FS) is the percentage

change in LV dimensions with each LV contraction. It is also a measure of systolic function. Bahl VK et al. 1992, observed a significant decrease in EF &FS of anemic patients as compared to that of controls in a study conducted on 31 patients with chronic severe anemia and equal number of healthy controls. [7] Ejection fraction & fractional shortening of anemic patients with tachycardia was found to be significantly lower when compared with that of controls (RB Panwar et al. 1991).[9]

Our finding is similar to that of other studies. The EF which is considered to be an index of systolic function being lower in anemic patients may indicate that the systolic function in these patients is slightly compromised.

The ESS/ESVI ratio is considered to be superior to EF for assessment of cardiac contractility. In a study conducted by Athanasios Aessopos et al. 2004, there was no significant difference in EF & FS of anemic patients when compared to healthy controls. However it was found that the ESS index was significantly ($p<0.001$) lower in anemics as compared to healthy controls.[4] ESS/ESVI increased significantly ($p<0.0001$) after iron therapy as compared to pre therapy in a study on iron deficiency anemia patients when they were examined by M mode 2 dimensional echocardiography (Riku H et al 1999).[2] The ratio of end-systolic wall stress to end-systolic volume index (ESS/ESVI) has been used to evaluate cardiac contractility. This ratio is reduced implying functional compromise in patients with hemoglobin levels of less than 6 g/dL.[12]

This index is independent of preload and after load and thus is believed to accurately reflect LV contractility.[2,4] Our finding of lower ESS/ESVi ratio in anemic patients may be due to reduced LV contractility.[2] The reduced ESS/ESVi ratio probably implies cardiac systolic functional compromise as a consequence of chronic anemia.

Thus the findings of decreased EF, FS, ESS/ESVI ratio in anemic patients in our study are as a consequence of hyperdynamic circulatory state leading to vascular and cardiac changes. The cardiac changes are mainly due to increased preload and decreased afterload.

These changes may be attributed to ventricular remodeling that occurs following sustained hemodynamic overloading of the heart which may be due to volume overload. These factors increases systolic wall stress and result in eccentric left ventricular hypertrophy characterized by increased LV dimensions.[13] Over time the stress of volume overload weakens the left ventricle and leads to LV systolic dysfunction [14] as indicated by decreased EF, FS, and ESS/ESVi ratio in anemic patients in our study implying onset of cardiac dyafunction. These hemodynamic changes in chronic severe anemia if continued for prolonged period may finally lead to cardiac failure.

CONCLUSION

The finding of our study of decreased ESS/ESVi ratio in anemic patients compared to controls are as a consequence of hyperdynamic circulatory state leading to vascular and cardiac changes. These changes may be attributed to ventricular remodeling that occurs following sustained hemodynamic overloading of the heart which may be due to volume overload caused by anemia. Over time the stress of volume overload weakens the left ventricle and leads to LV systolic dysfunction. Being a load independent index of myocardial contractility, ESS/ESVi serves as a better parameter for assessing LV dysfunction

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