Original Research Article

Study of ECG changes in anaemia and correlation with respect to severity of anaemia

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Abstract

Introduction: Anemia has a universal incidence and is very common in tropical countries. The most common cause of anemia is iron deficiency associated with hypochromic microcytic anemia. Chronic Anemia is associated with increased cardiac output when Hb is < 7g/dl. When Hb falls further (2-3gms/100ml) there will be circulatory congestion and angina pectoris may occur thus emphasizing the sensitivity of the myocardium to chronic hypoxia leading to various changes in the electrocardiographic recording.

Materials and methods: 100 patients comprising of both outpatient and inpatients attending JJMMC and its attached hospital from July 2017 to May 2018 were selected based on inclusion criteria which includes cases of anemia i.e. Hb < 8 gm% and those aged < 40% because to reduce changes of taking up coronary artery disease patients (both males and females).

Results: Out of 100 cases of severe anemia 52 cases showed ECG changes. 23 patients were having Hb < 6 gm % with 78% of whom had ECG Changes. Sinus tachycardia was the most common ECG change observed accounting to 41% and sinus bradycardia and biventricular hypertrophy were the least observed ECG finding among study population (1% each). In present study cases, only 13 patients had reversal of ECG changes after correction.

Conclusion: I) Severe anemia produces ECG changes, which mainly involve the rate, ST segment and T wave changes. II) The incidence of ECG changes seemed to be closely related to severity of anemia.

Keywords: Anaemia, ECG Changes, Reversibility.

1. Introduction

Anaemia has a universal incidence and is very common in tropical countries. The most common cause of anaemia is Iron deficiency, the other causes being folate and vitamin B_{12} deficiency. In tropical –countries the commonest cause for anaemia is hook worm infestation which is characteristically associated with hypochromic microcytic anaemia [1].

Anaemia is the most common disease that may increase the cardiac output at rest. Chronic anaemia usually increases cardiac output when the haemoglobin level is 7g/dl of blood or less. The major physiological consequence of anaemia is the reduced oxygen carrying capacity of the blood. In anaemic patients the most important mechanism in maintaining an adequate oxygen supply to the tissues is an increase in cardiac output. In general the cardiac output increases roughly in linear fashion with increased severity of anaemia. At very low haemoglobin levels, when oxygen extraction has reached a maximum, an increased cardiac output is the only means of ensuring adequate tissue oxygenation. When haemoglobin falls further (2 or 3 grams/100ml) the leveling off of the cardiac output and the in ability of tissue "extraction of oxygen to increase any further must lead to significant tissue hypoxia. With this, degree, of anaemia, circulatory congestion and angina pectoris may occur thus / emphasizing the sensitivity of the myocardium to chronic hypoxia; this may lead to various changes in the electrocardiographic recording which have been described in various studies.[2]

In 1940 Szekley *et al* found a very high incidence of electrocardiographic changes in chronic severe anaemia,

similar high percentage of ECG changes were reported by other researcher had a 85% incidence of ECG - abnormalities in other studies had 76.8% incidence.[3-5] Major changes reported were (1) sinus tachycardia (2) LVH pattern (3) Depressed ST segment (4) inversion of T wave. Other changes were U wave changes, prolonged P-R interval and QT interval, left ventricular strain, RVH premature atrial or ventricular beats and P wave changes. Biventricular hypertrophy was observed. The ECG changes have been ascribed to severe anaemia; they are corrected as the anaemia is relieved. In 1964 Gonzalves De Crasio et al studied ECG changes in 100 patients with- chronic anaemia. His study failed to demonstrate a constant pattern of ECG alterations in cases of chronic anaemia. Alterations were observed only occasionally and to a mild degree. In his study, there was a 19% incidence of ECG abnormalities.[6]

Lindo's studies in 1955 consisted of 60 patients. His cases were all with a haematological diagnosis of sickle cell anaemia. In his series ST changes were very common.

Recently Mehta et al have reported that depression of ST segment produced by exercise in patients with iron deficiency anaemia could be prevented from reappearing before any rise in Hb occurs by giving iron; thus concluded that these changes may not be due to hypoxia but due to deficiency of iron itself. According to NK Singh et al out of 5 patients who developed ST depression in post exercise ECG, 4 were cases of aplastic anaemia with normal serum iron levels, thus concluded that ST depression is consequent upon .hypoxia and not serum iron levels.[7]

The review of literature shows that older and recent studies report high incidence of ECG abnormalities in severe anaemia, which is proportionate to the severity of anaemia and showed no correlation to aetiology. The changes that do occur are similar in most of the series.

Aim of the study:

The study was undertaken to find out 1) The incidence and nature of ECG abnormalities in patients with Anemia, 2) Correlating ECG changes with respect to increasing severity of Anaemia.

2. Methodology

For the purpose of study, 100 cases of anaemia comprising of both outpatients and in patients attending our Bapuji Hospital, Davanagere, from July 2017 to May 2018 were selected.

2.1 Inclusion criteria
1) Cases of anaemia with hemoglobin value less than 8 gm% as determined by cyanmeth haemoglobin method.
2) Age less than 40 years because to reduce changes of talking up coronary artery disease patients (both male and female).

2.2 Exclusion criteria
1) Patients age more than 40 years.
2) Patients with following;
    a) Risk factors of coronary artery disease like
        - Heavy smoking
        - Obesity, high serum cholesterol
        - Diabetes
    b) Ischemic heart disease
    c) Congenital heart disease or valvular heart disease
    d) Thyrotoxicosis
    e) Respiratory diseases like COPD, pulmonary TB,

All patients with an Hb value below 8 gm% were included in the study. The cause of the anaemia was ascertained from the history and the type of anaemia from further investigations like peripheral smear, complete hemogram, stool examination and urine examination.

A resting ECG is taken for all selected patients and abnormalities in the resting ECG were noted. ECG is taken in all 12 leads and analysed as follows:-
1. Rate
2. Rhythm
3. P waves
4. Axis
5. PR interval
6. Q waves
7. QRS complex
8. ST segment changes
9. 'T' wave
10. QTc interval

The heart rate was determined in lead II, the duration of T' wave was measured from the beginning of the T' wave to end of 'P' wave. The longest 'P'[5] wave duration in any limb lead was determined; it was usually in lead II.

The-axis of the 'P' vector-in the- frontal plane was determined by using the standard hexaxial reference system.

QRS complex duration was determined in the lead which demonstrated the largest value. QRS axis in the frontal plane was determined on the basis of hexaxial reference system.

QT interval was measured from the beginning of the QRS complex to the end of the 'T' wave in the lead in which it was longest.

QTc was calculated using the formula

$$QTc = \frac{QT\ (measured)}{R\text{-}R\ interval\ (seconds)}$$

ST Segment Elevation (or) depression was measured taking the T-P- line as isoelectric line T wave changes were recorded.

3. Observation and results

Total number of cases of Anaemia with hemoglobin Levels below 8gm/dl were studied. Their ECG abnormalities were recorded.

Among the 100 cases, 52 were females (52%) and 48 cases were males (48%).

The age group ranges from 10-40 years.

Table 1: Age incidence

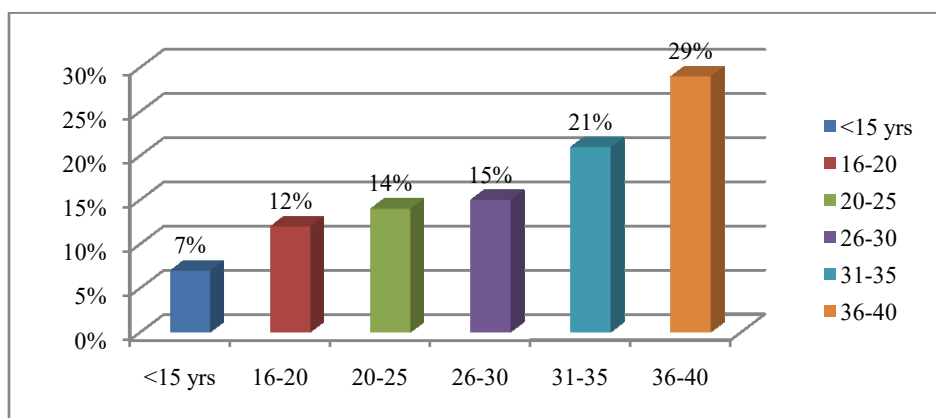| Age (in years)	No. of persons studied
<15 yrs	07%
16-20	12%
20-25	14%
26-30	15%
31-35	21%
36-40	29%

Figure 1: Age incidence

The most common cause for anaemia was nutritional. The causes of anaemia in the 100 cases were shown in Table 2.

Table 2: Causes of anaemia

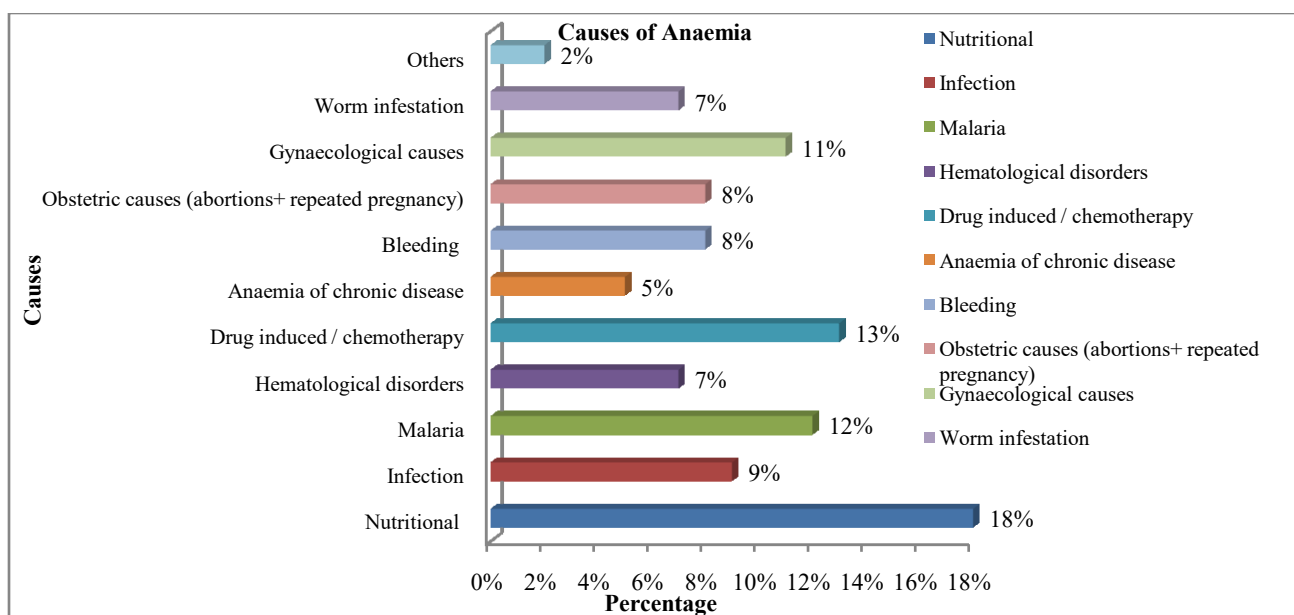| Cause	Number of cases	Percentage
Nutritional	18	18%
Infection	9	9%
Malaria	12	12%
Hematological disorders	7	7%
Drug induced / chemotherapy	13	13%
Anaemia of chronic disease	5	5%
Bleeding	8	8%
Obstetric causes (abortions+ repeated pregnancy)	8	8%
Gynaecological causes	11	11%
Worm infestation	7	7%
Others	2	2%

Figure 2: Causes of anaemia

Out of 100 cases of anaemia 52 cases showed ECG changes.

Table 3: Percentage of ECG change

	Number of cases	Percentage
Cases with ECG changes	52	52%
Cases without ECG changes	48	48%

Table 4: The ECG changes are shown in relation to age

Age (In Years)	Number of Cases	Percentage
<15	3	3%
16-20	8	18%
21-25	9	9%
26-30	8	8%
31-35	10	10%
36-40	14	14%

Figure 3: Relationship of ECG changes to age

The ECG changes observed as follows:

Rate:

In 41 patients out of 100 cases sinus tachycardia was observed, as incidence of 41%.

In 1 patient out of 100 cases sinus bradycardia was present, as incidence of 1%.

Diagnostic criteria of normal sinus rhythm:

1) P wave of sinus origin (Normal mean axis of P-wave)
2) Constant and normal PR Interval
3) Constant 'P' wave configuration in a given lead
4) Rate between 60 and 100 beats/minute.
5) Constant P-P(or) R-R interval

Sinus tachycardia is diagnosed when all the 5 criterias for the diagnosis of normal sinus rhythm are present except that the rate is faster than 100 beats/minute.

Sinus bradycardia is diagnosed when all the 5 criteria for the diagnosis of normal sinus rhythm present except that the rate is slower than 60beats/minute.

Rhythm:

In all the 100 cases studies the rhythm was regular sinus rhythm.

P-Wave:

The 'P' wave configuration was normal in all 100 cases. The 'P' wave axis was within normal range in all 100 cases. The duration of 'P wave range from 0.04 to 0.08 seconds. The 'P' wave voltage was normal in all 100 cases. The amplitude ranged between 0.5 mv to 1.5 mv.

PR - interval:

In all the 100 cases the PR interval was normal, ranged between 0.12-0.20 seconds.

QRS Complex:

The QRS complex duration was normal in all 100 cases. The duration ranged from 0.06 to 0.08 seconds. All 100 cases showed normal axis which ranged between 0° to 90°.

ST Segment:

ST Segment depression noted in 22 cases out of 100 cases. All other cases showed isoelectric ST segment.
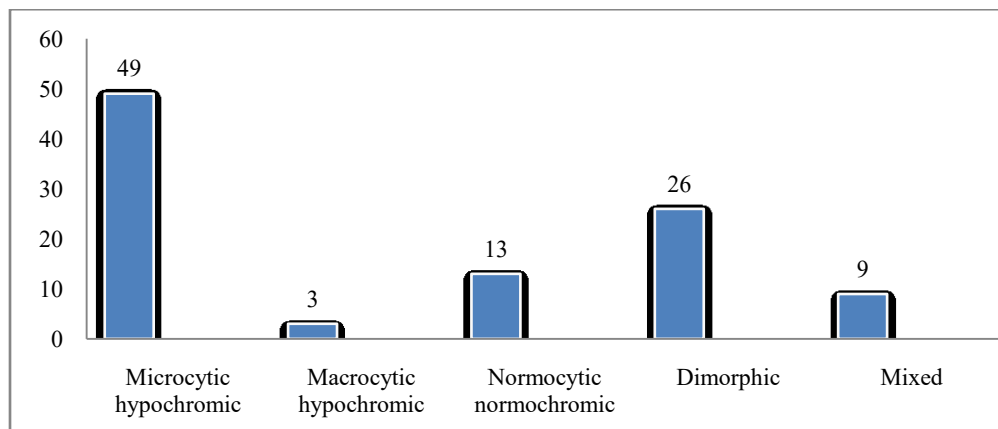
Corrected QT interval (QTC)

All 100 cases studied showed normal QTc which varied from 0.34 to 0.44 seconds.
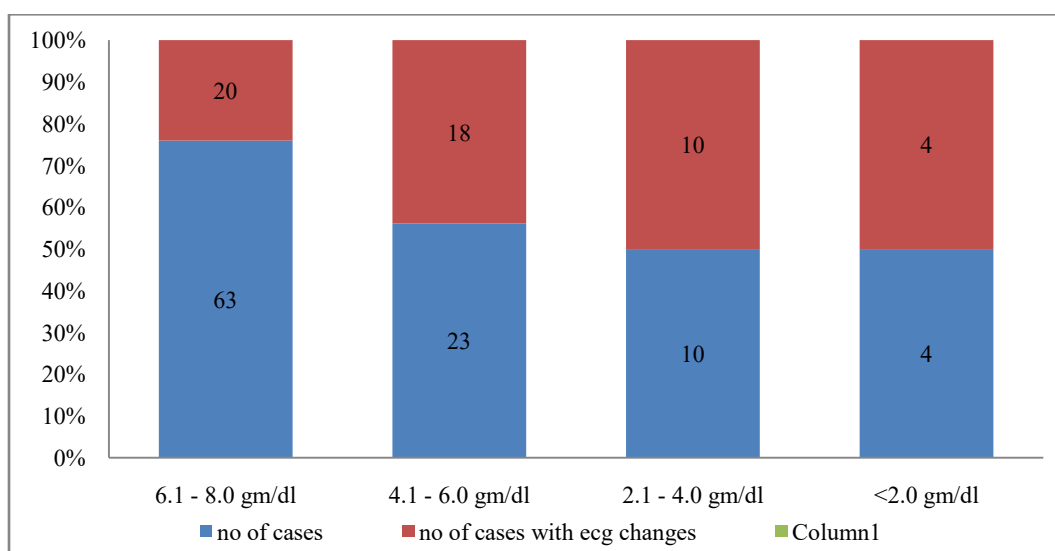
T. wave:

The T wave was inverted in 11 cases (11%), rest of the cases showed normal T wave.

Table 5: Distribution of cases according to type and severity of anaemia

Type	No. of cases	Hemoglobin (in grams %)			
		< 2 gm%	2-4	4-6	6-8
Microcytic hypochromic	49	3	6	14	26
Macrocytic hypochromic	3	-	1	-	2
Normocytic normochromic	13	-	-	3	10
Dimorphic	26	1	3	4	18
Mixed	9	-	-	2	7

Figure 4: Distribution of cases according to type and severity of anaemia

Table 6: Relation between severity of anaemia and ECG changes

Hb (gm/dl)	No. of cases	Percentage (%)	No. of cases with ECG changes	Percentage (%)
6.1 - 8.0	63	63	20	31.7
4.1 - 6.0	23	23	18	78.2
2.1 - 4.0	10	10	10	100
< 2.0	04	4	04	100
	100		**52**	$X^2 = 29.632$ **P< 0.0001**

Figure 5: Relation between severity of anaemia and ECG changes

The incidence of ECG changes seemed to be closely related to Hb % level. The Hb level was less than 6 gm% in most of the cases with ECG changes.

Statistical analysis of relation between severity of anemia and ECG changes by using chi –square test showed P value <0.0001 which is statistically significant.

Table 7: ECG changes observed

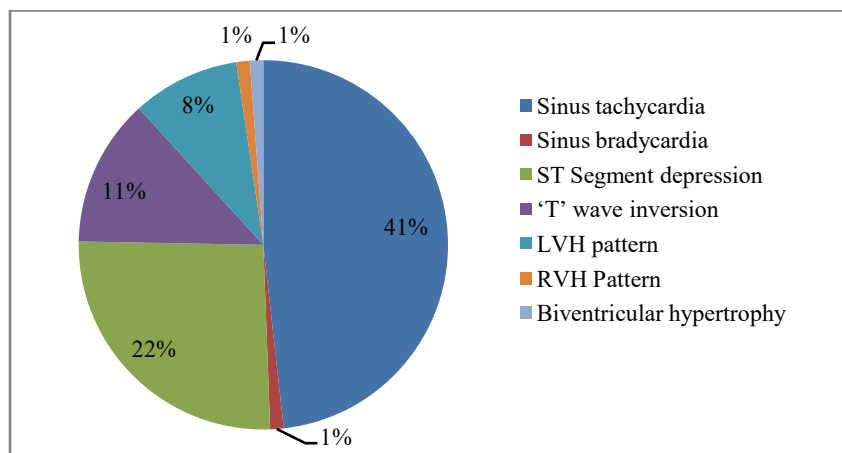| Changes	No of cases	Percentage (%)
Sinus tachycardia	41	41
Sinus bradycardia	1	1
ST segment depression	22	22
T wave inversion	11	11
LVH pattern	8	8
RVH pattern	1	1
Biventricular hypertrophy	1	1

Figure 6: ECG changes observed

100 Anaemic patients with an Hb level less than 8gm/dl aged between 10 and 40 years have been studied to assess the ECG abnormalities and their incidence.

Out of 100 cases of severe anaemia 52 cases showed ECG changes. The abnormalities in Electrocardiogram noted in this study are ® Sinus tachycardia in 41 cases (41%)

• Sinus bradycardia in 1 case (1%)
• ST Segment depression in 22 cases (22%)
• T Wave inversion in 11 cases (11%)
• LVH pattern in 8 cases (8%)
• RVH pattern in 1 case (1%)
• Biventricular Hypertrophy in 1 case (1%)

The incidence of ECG changes seemed to be directly proportional to the severity of Anaemia only 13 cases were studied after correction which showed reversion of rate in all 13 cases.

4. Discussion

Anaemia is very common in this part of the country. Cardiovascular Changes of anaemia may not be an uncommon feature. ECG changes in Anaemia have been variously reported.

In this study, of the 100 cases studied with Anaemia 52 cases showed ECG changes (52%). Singh and Colleagues from Varanasi, in 1986 had recorded an incidence of 76.6% ECG changes in severe anaemia; their study consisted of 60 patients with Hb levels below 8gm/dl. High incidence appears to be due to a larger number of patients with more severe anaemia and ECG changes were quite frequent and pronounced in patients with severe anaemia and it showed a direct relationship to the severity of anaemia. Sanghvi and his colleagues from Jaipur have recorded an incidence of 85%, ECG changes in patients with severe anaemia. Their study consisted of 100 patients with Hb values (Below 8 gm /dl). This high incidence is probably due to very low levels of hemoglobin.[8]

The present series of 100 cases of severe anaemia Hb (<8gm/dl) showed an incidence of 52% ECG changes. The ECG changes present in this study were,

4.1 Heart Rate:

In this study Heart Rate ranged between 52 and 150.41% showed sinus tachycardia and 1% sinus bradycardia. Tachycardia can be explained, because, in anaemia, tachycardia at rest is characteristic of the cardiovascular adjustment. Few cases of sinus tachycardia which were followed and reverted back to norma1sinus rhythm following correction of anaemia.

In L.M. Sanghvi's series the Heart rate varied from 50 to 125 bp min cadence of sinus tachycardia being 49% and sinus bradycardia being 9%.[9]

4.2 Rhythm :

Basic rhythm was sinus in all the 100cases.Therewerenoprematurebeats. In Sanghvi's series all the 100 cases showed basic rhythm with Occasional atrial premature beats of 5%.Both disappeared following correction of the anaemia in all cases.

In N.K. Singh's series of 60 cases, the incidence of atrial premature beat was 1.6% and ventricular premature beat was 1.6%, the incidence of Ventricular premature beat in normal population is. 25-50% in young and 70% in middle aged healthy subjects.

4.3 P Wave:

The P waves in this Series are normal in amplitude, duration and axis in contrast to the series reported by N. K. Singh which showed P Wave changes in 3.3%.

4.4 PR-Interval

In the present study all the 100 cases showed a normal PR Interval which ranged between 0.12-0.20 seconds. Singh reported an incidence of prolonged PR Interval in 3.3% of Cases and Sanghvi reported prolonged PR interval in 4% of his cases with persistence of the prolongation following treatment. Myocardial fatigue due to tachycardia may be responsible for prolongation of PR interval.

4.5 QRS Complex:

Duration in the present study the QRS duration was in the normal range in all the 100 cases. This was the case in all other series reported.

4.6 Axis:

QRS axis was normal in all the100 cases.

4.7 Configuration:

In the present study QRS configuration altered in 10 cases incidence of 10%, out of which 8cases showed LVH pattern, l case showed RVH pattern, and1case showed Biventricular hypertrophy pattern. In the rest of 90 cases QRS configuration was normal.

Singh reported an incidence of LVH in 20% cases, which persisted, in all cases, even after correction of the anaemia LVH may be ascribed to a considerably increased cardiac output in patients with Hb<6gm/dl.

4.8 ST Segment:

In the present study out of 100 cases 22 showed ST Segment depression (22%). Singh reported an incidence of 30% and Sanghvi reported an incidence of 54%. ST Segment depression may be due to myocardial hypoxia consequent to anaemia, cardiac dilatation and stretching of myocardial fibres and temporary coronary insufficiency etc.

4.9 'T' Wave:

In the present study, the incidence of T wave inversion was 11%. Sanghvi reported an incidence of 62%. T Wave changes with persistence in 27%. Lindo reported an incidence of 31% and Singh reported an incidence of 23.3% T Wave changes. The mechanisms of production of T Wave abnormality may be same as that of ST Segment change. The persistence of 'T' Wave inversion may be due to persistent and probably irreversible cardiac changes. [10-11]

Table 9: Comparison of ECG changes

	N.K. Singh	L.M. Sanghvi et al	Lindo et al	Present Study
Sinus tachycardia	53.3%	49%	5%	41%
Sinus bradycardia	-	9%	-	1%
Atrial Ectopics	1.6 %	65%	-	-
'P' Wave changes	3.3%	24%	3.3%	-
PR interval prolonged	3.3%	4%	3.3%	-
QT Interval prolonged	20%	1.8%	-	-
LVH	30%	15%	6%	8%
RVH	11.6%	-	-	1%
Biventricular pattern	-	-	-	1%
ST Depression	30%	54%	15%	22%
T wave inversion	23.3%	62%	31%	11%

It is not possible to say that the se ECG changes were due to hypoxaemia as there are various other factors influencing the ST configuration and QRS complex. In this study cases with coronary risk factors were excluded. The interesting feature, however has been the reversal following correction, of anaemia. In present study cases after correction were only 13; it was to conclude on these dates alone.

5. Conclusion

From the present study it can be seen that,

1) Severe anaemia produces ECG changes, which mainly involve the rate, ST segment and T wave changes.
2) The incidence of ECG changes seemed to be closely related to the severity of Anaemia.

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