



## Electrocardiographic and Echocardiographic Changes in Cerebrovascular Accidents

Authors

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### Abstract

**Objectives:** To study the different changes in ECG and echocardiographic patterns in the cases of cerebrovascular accidents and to assess whether these different changes have got any prognostic significance in these cases.

**Method:** 100 patients of acute stroke were considered and ECG and 2D echo of these patients was done within 24 hours of admission. In hospital follow-up was done to know the prognosis of all the patients.

**Results:** ECG abnormalities noted among cerebral infarct group were presence of U-waves (51.47%), prolonged QTc (36.76%) were most common followed by T-wave inversion (30.88%), and ST segment depression (30.88%). In cases of hemorrhagic stroke, ST depression (56.26%) and U-wave (56.26%) were the most common abnormalities. LV dysfunction was the most common 2D echo abnormality in both the stroke types – 23.53% and 56.26% i.e., in infarct and hemorrhage groups respectively.

Mortality was high in patients with abnormal ECG (79%) ( $p>0.5$ ). 79% of patients survived with abnormal ECG. So was statistically insignificant ( $p>0.5$ ). Mortality was high in patients with abnormal 2D echocardiography (90.91) ( $p<0.001$ ).

**Conclusion:** ST segment depression, QTc prolongation and U-waves are the common ECG abnormalities in hemorrhagic strokes. QTc prolongation and U-waves are the common ECG abnormality in ischemic stroke. LV dysfunction is the most common 2D echocardiographic abnormality in stroke patients. ECG abnormalities in stroke patients do not have any prognostic significance. LV dysfunction has prognostic significance in predicting mortality in CVA.

**Keywords:** Stroke; ECG; 2D echocardiography.

### Introduction

Cerebrovascular accident (CVA) or stroke is the most common life threatening disorder. It is the third leading cause of death in the developed countries after cardiovascular disease and cancer<sup>1</sup>. Cerebral infarction is responsible for about 80% of all first ever in a lifetime strokes. Primary intracerebral hemorrhage (PICH) for 10% and subarachnoid hemorrhage for 5%. The incidence of stroke worldwide is 179 per 1,00,000 population in various parts. In Western countries overall prevalence rate is 794 per 1,00,000 population.

CVA or strokes are capable of causing crippling morbidity in young as well as elderly individuals. They also have marked social, psychological and economic implications. Due to its wide prevalence and its high cost in economic terms as well as human disability, cerebrovascular accidents have evoked much interest in medical fraternity. Many studies have shown CVA associated with ECG changes and wall motion abnormalities on 2D echo.

The changes of ECG in CVA were reported in many studies. (Bayers et al<sup>2</sup>, 1947; Burch et al<sup>3</sup>,

1954; Dimant J et al<sup>4</sup>, 1977). Changes occurring in ECG following stroke were T-wave, U-wave, ST-segment, QT-interval and various arrhythmias, these ECG changes may resemble those of myocardial ischemia or sometime myocardial infarction. Earlier it was thought that CVA is preceded by changes in cardia, but Burch et al<sup>3</sup> (1954) disproved this view and found ECG changes in young patients with CVA in whom others causes like IHD for ECG changes could not be accounted. Along with ECG changes many studies have shown wall motion abnormalities on 2D echo following stroke, especially with subarachnoid hemorrhage (Davies KR et al<sup>5</sup>, 1991; Sakka SH et al<sup>6</sup>, 1999). Hence, study was undertaken to know the ECG and 2D echocardiographic changes (wall motion abnormalities) in different types of cerebrovascular accidents. To know whether such changes have any prognostic significance.

#### Aims and Objectives

- To study the different changes in ECG and Echocardiographic patterns in the cases of cerebrovascular accidents.
- To assess the different changes have got any prognostic significance in these cases.

#### Methodology

The material of the study comprised of 100 patients admitted in Basaveshwar Teaching & General Hospital, Gulbarga between March 2004 to February 2006.

#### Inclusion Criteria

Cases of CVA (CT scan proved) admitted within 72 hours after the onset of stroke were selected for the study, patients admitted beyond 72 hours after onset of stroke were excluded as the incidence of ECG changes beyond this period were infrequent.

#### Exclusion Criteria

Traumatic cases producing neurological deficits, infection, neoplastic cases producing CVA. CVA cases with known underlying cardiac diseases, which produce ECG and echocardiographic changes.

After admission a detailed history regarding the temporal profile of the stroke including history of risk factors like hypertension, diabetes mellitus, smoking, history of IHD and rheumatic heart disease were obtained.

Detailed neurological examination including fundoscopy and cardiovascular examination were carried out in all the cases.

The diagnosis of CVA was made on the basis of following criteria:

- Clinical examination
- CT scan of brain

A 12 lead ECG and 2D echocardiography was done within 24 hours of admission. All patients were subjected to investigations like:

- Complete blood count
- Erythrocyte sedimentation rate
- Renal function test
- Serum electrolytes
- Lipid profile

In hospital follow-up was done to know their prognosis under two categories:

1. Live
2. Dead

Results were analyzed with reference to age, sex and risk factors and clinical examination. Each case was subjected to 12-lead ECG and 2D echo within 24 hrs of admission and the following criterions were applied in their analysis.

#### ECG Criteria

- Heart rate less than 60/ min was regarded as bradycardia and heart rate exceeding 100/ min was regarded as tachycardia.
- ST segment depression of 0.5 mm or elevation of more than 1 mm were taken abnormal.
- T-wave was considered abnormal when inversion of T-waves in which it should have been upright i.e., I, II V<sub>3</sub>-V<sub>6</sub> may be variable in III, aV<sub>L</sub>, V<sub>1</sub> and V<sub>2</sub>.
- QTc prolongation: The QT interval is measured from the beginning of the QRS complex to the end of T-wave, the rate corrected QTc is obtained by dividing the actual QT by the square root of the RR-interval (both measured in seconds). QTc is

taken as prolonged if it more than 0.44 m-seconds.

- U-wave was taken as significant when exaggeration of U-wave voltage was noted when appeared in more than 2-leads when appeared in leads in which it was not normally seen (other than V<sub>3</sub>-V<sub>4</sub>).
- LVH: If the sum of the depth of the S-wave in lead V<sub>1</sub> and the height of the R-wave in either lead V<sub>5</sub> or V<sub>6</sub> exceeds 35 mm, an R-wave of 11 to 13 mm or more in lead aV<sub>L</sub> is another criteria for LVH.

**2D Echo Criterion**

Ultra mark 6 2D echo with color Doppler was used:

- LV ejection fraction was used to assess LV systolic function. Doppler indices (A>E across mitral valve) were used look for LV diastolic dysfunction.
- Mitral valve opening using planimetry was used to look for mitral stenosis apart from this valve thickening and doming of AML and paradoxical motion of PML were used.
- Flow across aortic valve was used to look for aortic stenosis including opening (severe AS if AVO <8 mm).

- Color imaging and doppler were utilized for any regurgitation.
- 2-dimensional imaging was used to rule out left atrial thrombus.

**Results**

During the period of March 2004 to February 2006, 52491 were total hospital admissions, among this 12,623 were medical admissions and 385 were stroke patients, among this stroke patients were selected for the present study who met inclusion and exclusion criterion were analyzed with regard to 2D echo and ECG changes in stroke patients and the following observations were noted. The incidence of stroke in the present study was more common in 5<sup>th</sup> and 6<sup>th</sup> decade and there was slight male (58%) preponderance compared to females (42%) making male-female ratio of 1.4:1.

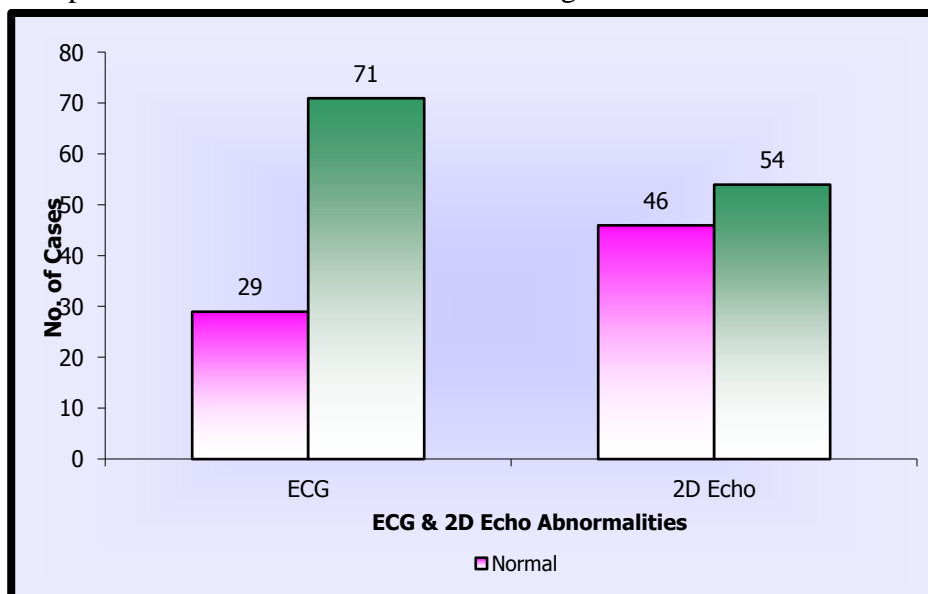
**Table-8:** Relationship of CVA with ECG & 2d Echo Changes

|         | Normal |       | Abnormal |       |
|---------|--------|-------|----------|-------|
|         | Total  | %     | Total    | %     |
| ECG     | 29     | 29.00 | 71       | 71.00 |
| 2D Echo | 46     | 46.00 | 54       | 54.00 |

Chi Square=6.16 d.f=1 p<0.02

The above table shows the abnormalities of ECG (71%) and 2D Echo (54%) were more common in stroke patients and was statistically significant.

**Figure-11:** Relationship of CVA with ECG & 2D Echo Changes



**Table-9:** Relationship between stroke types and ECG changes

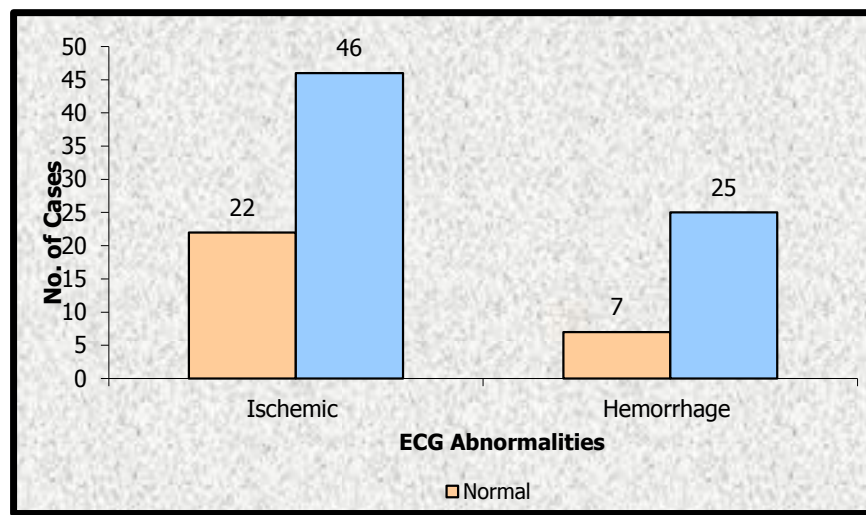
| Type of Stroke | Total No. of Cases | ECG Changes |       |          |       |
|----------------|--------------------|-------------|-------|----------|-------|
|                |                    | Normal      |       | Abnormal |       |
|                |                    | No          | %     | No       | %     |
| Ischemic       | 68                 | 22          | 32.35 | 46       | 67.64 |
| Hemorrhage     | 32                 | 7           | 21.8  | 25       | 78.12 |

Chi Square=1.16 d.f=1 p > 0.05

In the above table, it is evident that ECG abnormalities were more common in patients of stroke. ECG abnormalities were more in

hemorrhagic stroke (78.12%) compared to infarct (67.64%), which is statistically insignificant (p>0.05).

**Figure-12:** Relationship between stroke types and ECG changes



**Table-10:** Relationship between stroke types and 2D Echo changes

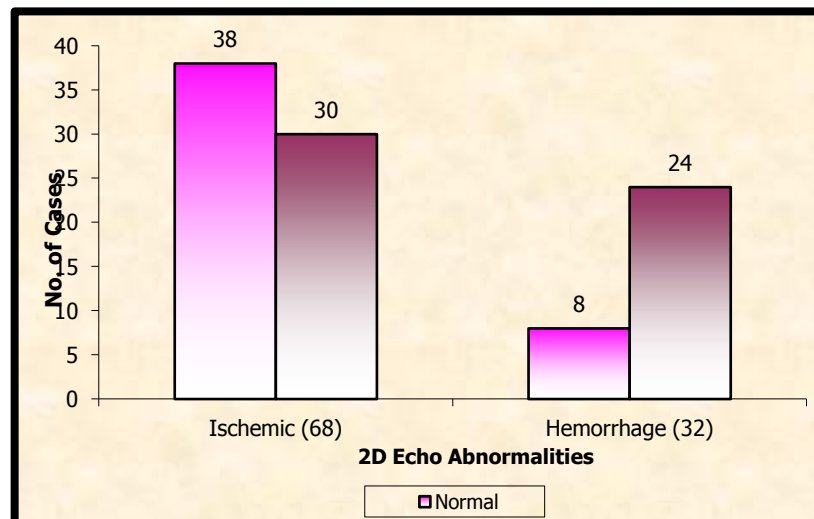
| Type of Stroke  | Total No. of Cases | ECG Changes |       |          |       |
|-----------------|--------------------|-------------|-------|----------|-------|
|                 |                    | Normal      |       | Abnormal |       |
|                 |                    | No          | %     | No       | %     |
| Ischemic (68)   | 68                 | 38          | 55.88 | 30       | 44.12 |
| Hemorrhage (32) | 32                 | 8           | 25.00 | 24       | 75.00 |

Chi Square=8.35 d.f=1 p<0.01

The above table showing 2D echo abnormalities in patients of stroke and was more common in patients of hemorrhagic stroke (75%) compared to

infarct (44.125) and was statistically significant (p<0.01).

**Figure-13:** Relationship between stroke types and 2D Echo changes



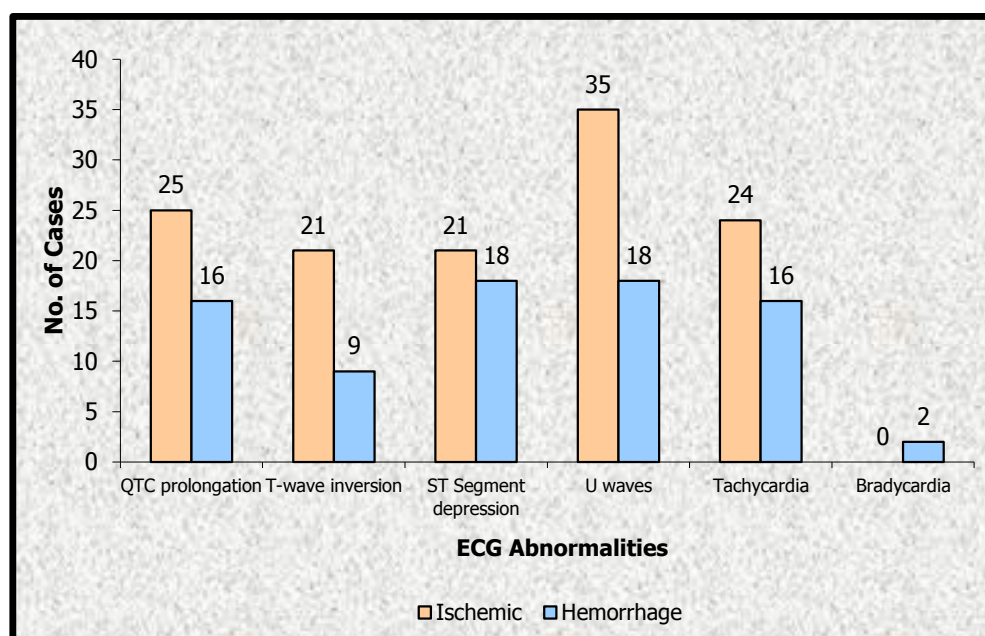
**Table-11:** ECG changes in stroke patients

| ECG changes           | Ischemic (n=68) |       | Hemorrhage (n=32) |       |
|-----------------------|-----------------|-------|-------------------|-------|
|                       | No              | %     | No                | %     |
| QTC prolongation      | 25              | 36.76 | 16                | 50.00 |
| T-wave inversion      | 21              | 30.88 | 9                 | 28.13 |
| ST Segment depression | 21              | 30.88 | 18                | 56.26 |
| U waves               | 35              | 51.47 | 18                | 56.26 |
| Tachycardia           | 24              | 35.29 | 16                |       |
| Bradycardia           | 0               | 0     | 2                 |       |

From the above table, it is evident that ECG abnormalities among infarct group, U-wave (51.47%), QTc prolongation (36.76%) were the most common abnormalities followed by T-wave inversion (30.88%) and ST-segment depression

(30.88%). In cases of hemorrhage group ST segment depression (56.26%) and U-wave (56.26%) were the most common abnormalities followed by prolonged QTc (50%) and T-wave inversion (28.13%).

**Figure-14:** ECG changes in stroke patients



**Table-12:** 2D Echo changes in stroke patients

| ECG changes              | Ischemic (n=68) |       | Hemorrhage (n=22) |       |
|--------------------------|-----------------|-------|-------------------|-------|
|                          | No              | %     | No                | %     |
| LV dysfunction           | 16              | 23.53 | 18                | 56.26 |
| LA thrombus              | -               | -     | -                 | -     |
| Mitral valve abnormality | 14              | 20.59 | -                 | -     |
| Aortic valve abnormality | 3               | 4.41  | -                 | -     |
| Normal                   | 38              | 55.88 | 8                 | 25.00 |

From the above table, it is evident that 2D echo abnormalities among the infarct group, LV dysfunction (23.53%) was most common, followed by mitral valve (20.59%) and aortic valve (4.41%) abnormality in cases of hemorrhagic strokes again LV dysfunction (56.26%) was most commonest abnormality.

Normal echo was seen in 55.88% of infarct and 25% in hemorrhagic stroke.

Figure-15: 2D Echo changes in stroke patients

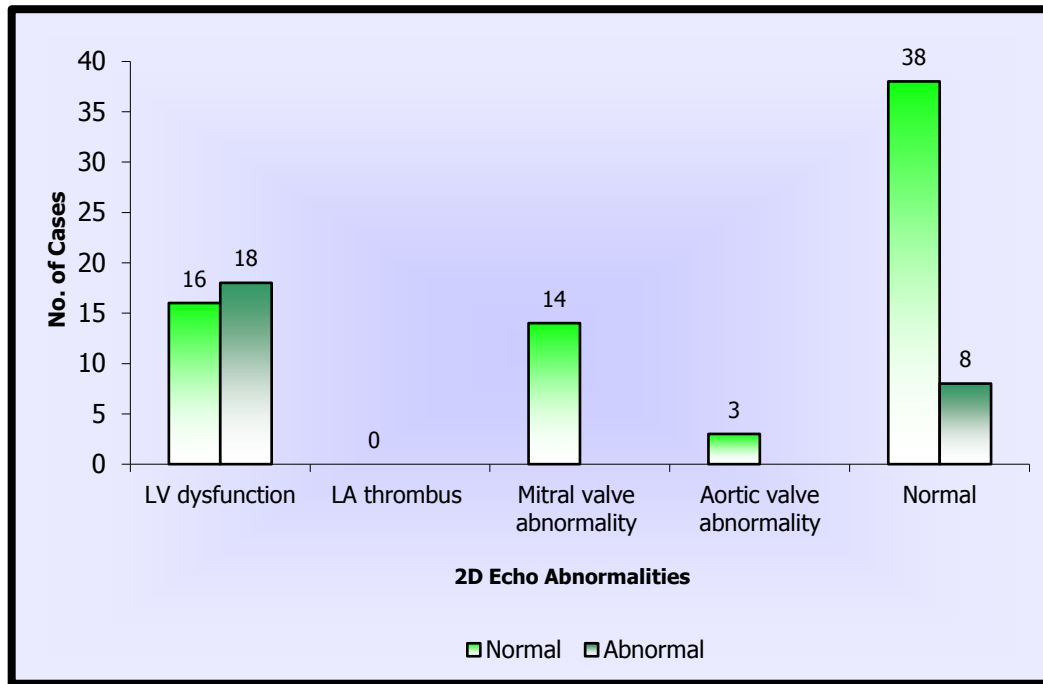


Table-13: Mortality in stroke types and its co-relation with ECG changes

| Type of ECG changes   | Ischemic (n=68) |       |      |       | Hemorrhage (n=32) |       |      |       |
|-----------------------|-----------------|-------|------|-------|-------------------|-------|------|-------|
|                       | Alive           |       | Dead |       | Alive             |       | Dead |       |
|                       | No              | %     | No   | %     | No                | %     | No   | %     |
| QTc prolongation      | 21              | 35.50 | 4    | 44.4  | 10                | 52.63 | 6    | 46.15 |
| T wave inversion      | 17              | 28.80 | 4    | 44.4  | 6                 | 31.50 | 3    | 23.00 |
| ST Segment depression | 19              | 32.20 | 2    | 22.2  | 10                | 52.60 | 8    | 61.50 |
| U Wave                | 31              | 52.54 | 4    | 44.44 | 13                | 68.42 | 5    | 33.46 |

From the above table, it is evident that mortality was higher in patients with prolonged QTc in both infarct (4.44%) and hemorrhagic stroke (46.15%) and with T-wave inversion mortality was high in cases of infarct (44.4%) compared to hemorrhage

was less (23%) and with ST depression mortality was high in hemorrhagic stroke (61.5%) compared to infarct (22.2%) and with U-wave mortality was high in infarct (44.44) compared to hemorrhage (33.46%).

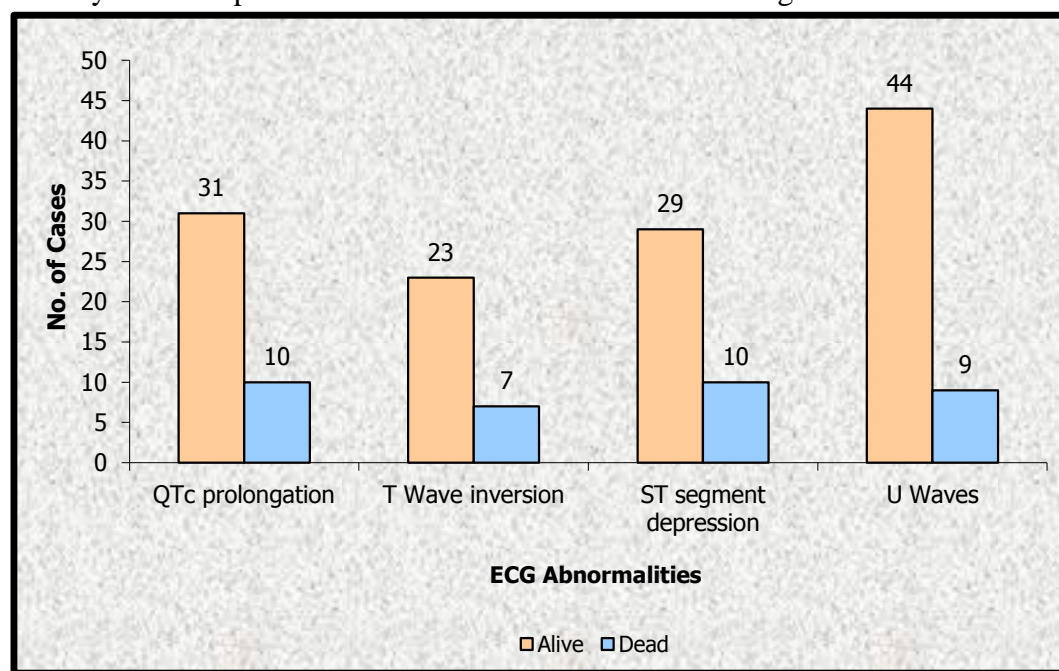
Table-14: Mortality in stroke patients and its correlation with ECG changes

| Type of ECG Changes   | Stroke patients |       |             |       | P Value | Chi-square |
|-----------------------|-----------------|-------|-------------|-------|---------|------------|
|                       | Alive (n=78)    |       | Dead (n=22) |       |         |            |
|                       | No              | %     | No          | %     |         |            |
| QTc prolongation      | 31              | 39.74 | 10          | 45.45 | p>0.05  | 0.23       |
| T Wave inversion      | 23              | 29.48 | 7           | 31.8  | p>0.05  | 0.044      |
| ST segment depression | 29              | 37.17 | 10          | 45.45 | p>0.05  | 0.49       |
| U Waves               | 44              | 56.41 | 9           | 40.90 | p>0.05  | 1.65       |

The above table shows, mortality was higher in patients of stroke with QTc prolonged (45.45) and ST segment depression (45.45%) followed by U

waves (40.90) and least was with T-wave inversion (31.8%), but none of them were statistically significant.

**Figure-16:** Mortality in stroke patients and its correlation with ECG changes



**Table-15:** Mortality in stroke types and its co-relation with 2D Echo changes

| 2D Echo Changes          | Ischemic |       |      |       | Hemorrhage |       |      |       |
|--------------------------|----------|-------|------|-------|------------|-------|------|-------|
|                          | Alive    |       | Dead |       | Alive      |       | Dead |       |
|                          | No       | %     | No   | %     | No         | %     | No   | %     |
| LV dysfunction           | 12       | 20.33 | 4    | 44.40 | 6          | 66.66 | 12   | 92    |
| LA thrombus              | -        | -     | -    | -     | -          | -     | -    | -     |
| Mitral value abnormality | 12       | 20.33 | 2    | 22.22 | -          | -     | -    | -     |
| Aortic valve Abnormality | 3        | 5.00  | 0    | 0.00  | -          | -     | -    | -     |
| Normal                   | 38       | 64.40 | -    | -     | 6          | 66.20 | 2    | 15.38 |

The above table shows, mortality was higher in hemorrhagic stroke with LV dysfunction (92%) compared to infarct group (44.4%) followed by

mitral valve abnormality in case of infarct group (22.22%).

**Table-16:** Mortality in stroke patients and its co-relation with Echo changes

| 2D Echo changes          | Stroke patients |       |             |       | P Value | Chi-square |
|--------------------------|-----------------|-------|-------------|-------|---------|------------|
|                          | Alive (n=78)    |       | Dead (n=22) |       |         |            |
|                          | No              | %     | No          | %     |         |            |
| LV dysfunction           | 18              | 23.00 | 16          | 72.72 | p>0.001 | 18.85      |
| LA thrombus              | -               | -     | -           | -     | --      | --         |
| Mitral valve abnormality | 12              | 15.38 | 2           | 9.09  | p>0.05  | 0.56       |
| Aortic valve abnormality | 3               | 3.84  | -           | -     | --      | --         |
| Normal                   | 44              | 56.41 | 2           | 9.09  | p<0.01  | 15.47      |

Above table shows mortality in patients of stroke was higher with LV dysfunction (72.72%) (p<0.001) and was statistically significant followed by mitral valve abnormality (9.09) (p>0.05).

**Discussion**

A hospital based prospective study was done to know the ECG and 2D echo changes had any

prognostic significance in stroke patients. In this study, CT scan was mandatory in the inclusion criteria to prove the stroke and type of stroke. Among the 100 patients 58 were males and 42 were females (sex ratio was M:F – 1.4:1), age ranged from 24-92 years and the mean age of patients of alive and dead were 58.73 and 54 years respectively. The cases of stroke were more common in the 5<sup>th</sup> and 6<sup>th</sup> decade, making 55%,

which is comparable to Venkataramana et al<sup>45</sup> study in which the percentage of stroke cases above the age of 51 years was 41% and in the Carlo<sup>46</sup> study (2003) was 71.8%. Stroke is one of the leading causes of death in many countries. Although there was a lack of unanimity, several factors have been reported to increase the risk of stroke. Reports from different countries have implicated different factors associated with high risk of stroke. To evaluate the risk factors, a prospective survey of a given population of the years as done in the Framingham Study was essential. The only epidemiological study of Abraham et al (1970) who found hypertension, diabetes mellitus, hypercholesterimea and syphilis to be the risk factors associated in hemiplegia patients. Shaper et al<sup>47</sup> in 1991 concluded that, hypertension, cigarette smoking and pre-existing IHD was found to be the major risk factors. In the present study, hypertension was present in majority of the cases i.e., 45%, which is comparable with that found in the studies of Smith<sup>48</sup> (2005) and Carlos<sup>46</sup> (2003) i.e., 87% and 48% respectively and next commonest risk factor was smoking (28%) and history of stroke (22%), which are comparable with that found in Smith (2005) i.e., 35.22% and 39.30% and diabetes mellitus was present in 13% of the patients in the present study and the least was hyperlipidemia.

In this study, 68% of the patients has ischemic stroke, which was comparable with that found in the studies of Daniele et al<sup>51</sup>, Roy et al<sup>44</sup> and Mikolich et al<sup>52</sup> i.e., 78.20%, 71.00% and 93.33% respectively. 32% had stroke in the present study comparable with 21.80%, 29% and 6.66% in the Danieleco et al, Roy et al and Mikolich et al study group.

Increased QTc was seen in 32% of cases in Goldstein et al<sup>36</sup>, while in our study it is 41%. T-wave inversion was seen in 15% by Goldstein et al while in our study it is 30%. ST-segment depression was seen in 13% in Goldstein while in the present study it was 20%. U-wave was seen in 28% in Goldstein et al, while in our study it was seen in 53%. Tachycardia was seen in 2% in

Goldstein et al while in our study it was 40%. Bradycardia was seen in 8% in Goldstein et al, while in the present study it was 2%. In the present study, LV dysfunction in ischemic stroke was present in 23.53% of cases, which is comparable to the series of Gagliardi et al<sup>53</sup> and Uma et al<sup>54</sup> who reported 22% and 26% respectively. Mitral valve abnormality was present in 14% comparable to Uma et al who present 30%. Aortic wall abnormality in present study was 3% compared to the other studies it varied, Gagliardi et al and Uma et al 18.5% and 20% respectively.

In infarct group 2D echo was normal in 55.88% (38 out of 68 patients) while LV dysfunction was seen in 23.53% (16 out of 68 patients) and mitral valve abnormality in 20.59% (14 out of 68 patients) and aortic wall abnormality in 4.41% (3 out of 68 patients) and no patients had LA thrombus. In the hemorrhage group a high number of patients 18 out of 22 i.e., 56.26% had LV dysfunction. None had LA thrombus, mitral valve or aortic valve abnormality and 25% were normal (8 out of 22). In the either group LV dysfunction was the most common abnormality noticed. The percentage of normal ECGs in patients who survived stroke is 35% (24 out of 78), while 22.72% (5 out of 22) succumbed to stroke, 79% (54 out of 78) of stroke survivors had abnormal ECG, while 77.27% (17 out of 22) of patients who died of stroke had abnormal ECG ( $p>0.5$ ) and is statistically insignificant.

Among stroke survivors 56.41% (44 out of 78) had normal 2D echo findings while 43.59% (34 out of 78) had abnormal 2D echo study, while among patient died due to stroke had 90.91% (20 out of 22) abnormal 2D echo finding, wherein only 9.09% (2 out of 22) patients had normal echo findings so the mortality in abnormal 2D echo was high and was statistically significant ( $p<0.001$ ).

### Conclusion

ST segment depression, QTc prolongation and U are the common ECG abnormalities in hemorrhagic strokes. QTc prolongation and U-



waves are the common ECG abnormality in ischemic stroke. LV dysfunction is the most common 2D echocardiographic abnormality in stroke patients. ECG abnormalities in stroke patients do not have any prognostic significance. LV dysfunction has prognostic significance in predicting mortality in CVA.

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