Cerebral seizure is the essential therapeutic component of electroconvulsive therapy (ECT). Hence, it is important to ensure this when modified ECT is administered to contain the motor seizure manifestation. Recording of electroencephalogram (EEG) during the treatment is recommended (McCreadie et al., 1989).

In addition to ascertaining the occurrence of EEG or motor seizure, the duration of seizure is important. Reports indicate direct relationship between cumulative seizure duration and therapeutic response to ECT (Kramer, 1983). Recent reports recommend definition of seizure adequacy using the duration criterion; a seizure of 25 seconds duration on EEG is considered adequate (American Psychiatric Association, 1990).

The procedures of estimate the duration of electrocerebral seizure pattern need to be standardized. We describe here a procedure by which the seizure endpoint on EEG can be reliably identified and hence estimation of the seizure duration.

MATERIAL AND METHOD

Modified ECTs using 200-250 mg of thiopentone, 30-50 mg of succinylcholine and 1 mg of atropine were administered to patients with affective psychosis after obtaining informed consent.

Stimulus was applied bilaterally using a sine wave ECT device (Gangadhar et al., 1988). This device was linked to the EEG recorder of MECTA model D. Motor seizure was also monitored using the BP-cuff method (Fink and Johnson, 1982). A marking was made on the EKG channel at the time of noting the last clonic movement on the cuffed forearm. EEG was recorded from Cz site of 10-20 system referenced to right mastoid, with the ground electrode on the forehead. The EEG stripchart recording was terminated by the clinician not involved in the present exercise. Forty seven EEG records with motor seizure endpoint markings were selected for the present exercise.

Three psychiatrists (B.N.G., N.J. and R.A.T.) independently rated the EEG records in their office, away from the treatment room. The rating included identification of last spike defined as a negative wave of less than 70 msec width and amplitude at least twice that of the pre-stimulus EEG sample. At the speed of the stripchart recording (13.3 mm/sec), 70 msec corresponds to 0.93 mm. The width of the spike at the zero-line crossings should hence be within one millimeter division of the stripchart. Unpredictable baseline (DC) shifts in the EEG amplifier during the recording make the location of zero-line crossing less precise. Hence, a confidence scoring of either 'certain' or 'doubtful' was to be marked for such identifications. EEG seizure duration was estimated from the start of post-stimulus EEG trace to the point of last spike. Motor seizure duration was estimated from the start of the EEG signal following stimulation to the point of marking made on the EKG channel (vide above). All measurements were approximated to nearest 0.5 second.

The raters did a preliminary exercise of rating ten other seizure EEG records and compared their procedures of identification before starting the independent rating on the present 47 records. The raters would be referred to as a, b, & c in next sections.

RESULTS

Mean seizure duration measured on these 47 records did not differ between the three raters (Table 1). EEG seizure durations of any pair of raters correlate significantly (Table 2). Reliability coefficient among three raters was computed using Spearman-Brown
Table 1. EEG seizure duration of the three raters

|                | Raters |       |       |       |
|----------------|--------|-------|-------|-------|
|                | a      | b     | c     |       |
| EEG seizure duration* (in seconds) | 30.98  | 32.38 | 31.96 |       |
| Mean           | 30.98  | 32.38 | 31.96 |       |
| SD             | 6.93   | 6.44  | 6.01  |       |
| Range          | 17-51.5| 19.5-51| 19.5-49|       |
| Difference in the means of EEG and motor seizure duration* (in seconds) | 5.86   | 7.03  | 6.83  |       |
| EEG v/s motor seizure duration Pearson - ¥ | 0.77** | 0.70** | 0.76** |       |
| Identified last spike certain: doubtful | 36:11  | 32:15 | 41:6  |       |

* One way measure ANOVA, F = 2.96, d.f. = 2, 92, N.S. ** p < 0.001.

Table 2. Comparison of rater pairs on EEG seizure duration

|                | a&b | a&c | b&c | all three |
|----------------|-----|-----|-----|-----------|
| Pearson - ¥*   | 0.90| 0.91| 0.91| --        |
| Difference     |     |     |     |           |
| <1 sec         | 23  | 19  | 37  | 17        |
| <5 sec         | 44  | 45  | 44  | 43        |
| Range of difference (in seconds) | 0 - 13.5 | 0 - 13.5 | 0 - 11 | 0 - 13.5 |
| Modal difference (in seconds)(n) | 0.5(17) | 0.5(11) | 0(25) | --       |
| Confidence rating similar: dissimilar | 36:11** | 36:11** | 36:11** | 28:19|

* All correlation significance p < 0.001. Figures in 2 refer to cumulative number of records. ** Proportion of similar ratings being more than chance p < 0.05.

On 43 occasions (91%) any pair as well as all the raters could determine the EEG seizure endpoint and duration thereof by the method described within a margin of 5 seconds. The modal difference was 0.5 second in two pairs of raters and 0 in the other pair. Each pair had similar confidence rating with respect to identification of last spike on over 75% of records (Table 2).

EEG seizure duration correlated positively and significantly with the motor seizure duration in all three raters (Table 1). The mean EEG seizure duration of the three raters was significantly longer than the mean motor seizure by 5.86 to 7.03 seconds. From the correlation between EEG and motor seizure durations of rater A, following linear regression equation was arrived at to predict the EEG seizure durations (x) from the motor seizure duration (y) (x = 11.5079 + 0.775y). This equation predicts an 'adequate' EEG seizure (duration of 25 seconds or more) when motor seizure is 18 second or more. Inadequate seizure (EEG seizure < 25 seconds) was recorded by all three raters on six records (13%). Only one of these had a motor seizure duration more than 18 seconds (20 seconds).

DISCUSSION

Adequacy of seizure during ECT has been defined using duration criterion (American Psychiatric Association, 1990). This points to a need for reliably assessing the seizure endpoint and hence seizure duration on EEG recorded during ECT. Methods to determine EEG seizure endpoint are not satisfactory. Least uncertainty of seizure endpoint identification would occur if all seizure terminated abruptly (Fit switch) to the postictal isoelectric line. However 60% of seizures do not have such EEG termination (Fink and Johnson, 1982).

Surveying the literature, it is evident that authors have applied differing definitions of EEG seizure endpoint. A recent study (McCreadie et al., 1989) defined seizure endpoint as the onset of isoelectric line and in its absence, the last spike. Spikes are necessary and unequivocal components of EEG seizure. Standard definitions of spikes are available in literature; a spike has less than 70 milliseconds width, has a sharp peak and is distinguishable from background EEG activity (Ktonas, 1987). We have operationally defined this latter feature in terms of amplitude; the amplitude prophecy formula (Winer, 1971). The reliability coefficient was 0.92, indicating high agreement among three raters.
the spike should be double that of prestimulus EEG sample. The last spike which meets the above criteria is considered to herald seizure termination.

It can be argued that estimates of seizure duration by this method may lead to underestimation of EEG seizure duration. Spikes are unequivocal indicators of seizure activity and hence, seizure duration estimates using this method include duration of unequivocal seizure. High amplitude slow wave following the last spike if present and if included may contribute to over-estimation of the seizure duration.

Applying this definition, seizure duration could be measured within a margin of 5 seconds in 43 (91%) records by all three raters. In three of the other four records where the difference was more than 5 seconds (maximum 13.5 secs) between two raters, a third rater differed by less than 1 second from one of them. Possible reasons for the differences among raters could be, a) artefacts in the EEG record, b) baseline (DC) shift in the EEG amplifier making the location of zero-line crossings imprecise and c) inaccurate measurements of the pulse width when the zero-line crossings do not occur within a millimeter division of the stripchart.

Single channel bipolar recording with frontal electrode sites picks up muscle artefact and has been considered unsatisfactory for reliably reflecting EEG seizure activity (Brumback, 1982). Hence the EEG was recorded with unipolar electrode placement (Cz referenced to mastoid). Mastoid reference instead of the standard A2 (earlobe) of the 10-20 system was chosen to reduce the electrode movement artefacts occurring during manipulation by the anaesthesiologist for ventilation. Alternative definition of pulse width at the level of the spike might overcome the problem of baseline shifts in the EEG amplifier. EEG recording at faster (30mm/sec) paper speed offers better resolution which might reduce the errors.

Emphasis has often been placed on the model of ECT device employed for EEG monitoring. For example, Reis (1985) reported poor interrater reliability among five raters (average \( r = 0.48 \)) for estimates of EEG seizure duration from the records of MECTA model D (used in this study). In a later study (Warmflash et al., 1987), high interrater reliability \( r = 0.98 \) was achieved between two raters on seizure EEGs recorded using MECTA model D. Using a later model of MECTA (SR1) while one study reported poor interrater agreement with difference between raters ranging from 0-87 seconds (Guz et al., 1989), another study reported high interrater agreement with difference between raters being one second or less in most records.

(Kramer et al., 1989). In a more recent study (Mc-Creadie et al., 1989), using an independent EEG amplifier coupled to ECT device, high interrater reliability of EEG seizure duration determination \( r = 0.92 \) is reported.

The presence of motor seizure end point marking on the EKG channel though marked by a psychiatrist not involved in this exercise is a potential source of rater bias and hence could have increased the interrater reliability of EEG seizure duration estimates. Such may be unlikely as Reis (1985) observed poor interrater reliability of EEG seizure duration from records with marking of motor seizure endpoint.

The 47 records from 18 patients necessarily had 2-4 records from same patients. Independency of observations in a statistical sense is hence not strictly assumed. The findings hence, need to be confirmed on an independent sample of EEG records - each record from a different patient. There is also a need to compare the method described here with other definitions available with respect to validity and interrater reliability.

Lastly, the mean EEG seizure duration was longer by about seven seconds than mean motor seizure duration (raters were not blind to this value). This observation is consistent with other studies (Fink and Johnson, 1982 and Warmflash et al., 1987). A motor seizure duration of 20 seconds or more by cuff method would predict adequate (25 seconds) EEG seizure.

In summary, using a standard definition to detect the last spike on the seizure EEG, three raters could determine this, and hence the EEG seizure duration, within a margin of 5 seconds in 91% of records. Interrater reliability was 0.9 or above \( p < 0.001 \) between any pair of raters. The EEG seizure duration significantly correlated with motor seizure duration and was longer than motor seizure by 6-7 seconds.

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