Common Ictal Patterns in Patients with Documented Epileptic Seizures

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ABSTRACT:

BACKGROUND:

The ictal EEG patterns are the electrical triggers of 'epileptic seizures' and they are different from the familiar 'inter-ictal' discharges that are encountered during the normal 'non-seizing' states of epileptic patients. This study concentrates on the 'seizing discharges' among in-patients with documented seizures through a 'simultaneous EEG-Video' monitoring (telemetry) facility

OBJECTIVE:

To identify the common ictal patterns in patients with documented epileptic seizures

METHODS:

Two hundred consecutive telemetries at King's College Hospital in London over the period of nine months starting from Jan 2007 back to May 2006 were reviewed and the common ictal patterns were evaluated by using 'simultaneous EEG-Video' monitoring (telemetry) facility

RESULTS:

Three main ictal patterns were observed in the 81 patients with documented epileptic seizures. 'Rhythmic theta ictal pattern' was observed in 46.9% of patients, all showed focal seizures whereas 26.1% of patients showed the 'decremental ictal pattern' (fast activity). Focal seizures were presented in 81.8% and 18.2% with generalized ones. 'Polyspike-wave' activity was observed in 9.8% of patients and all of them have genrralized seizures

CONCLUSION:

At least three commonly encountered ictal patterns were identified. They are distinct, may be readily recognizable and showed their prevalence in King's telemetry.

KEYWORDS: telemetry, video-EEG monitoring, epilepsy, ictal patterns.

INTRODUCTION:

The role of surface electroencephalogram (EEG) in *focal epilepsy* is to help anatomical definition of the *epileptogenic zone*; this 'theoretical' concept describes the region of cortex responsible for generating seizures. Clinically, several cortical zones may be defined, which serve as markers for the epileptogenic zone. The location of each of these zones may be defined by various diagnostic techniques. When these zones overlap to describe the same cortical area, they localize the epileptogenic zone with increased confidence; we may consider the *ictal onset zone*, the *irritative zone*, the *symptomatogenic zone*, the *functional deficit zone* and *anatomic lesion* if exists.

The *ictal onset zone* is the cortical region generating ictal (seizure) onset.[1] This does not include the additional regions of the epileptogenic zone necessary for seizure propagation and spread, nor othoner potential 'ictal generators' within the epileptogenic zone. It can be identified by Surface EEG and ictal SPECT (Single Photon Emission Computed Tomography) The ictal onset zone is often smaller than the epileptogenic zone. When considering surgery, resection of the entire epileptogenic zone must be considered so that remaining potential ictal generators or areas with potential epileptogenicity, are not left behind.[1]

The *irritative zone* is the cortical region generating interictal epileptiform discharges; it is usually larger than the epileptogenic lesion and zone. This zone may be defined by surface EEG, or intracranial EEG. If the interictal activity is in deeper cortical or subcortical regions, it may be defined by MEG (MagnetoEncephaloGram) and fMRI.[1]

The *symptomatic zone* is the region of cortex that generates the clinical symptomatology of habitual clinical seizures but its removal is not necessary to

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make the patient seizure free. This zone may frequently be differed from the epileptogenic zonehowever as ictal onset may occur in functionally 'silent' regions of cortex and seizure becomes apparent only after spread. [1]There is significant variability however in the localizing value of different ictal semiologies since the seizures may propagate through different cerebral cortical regions. Cortical stimulation studies have often shown that the region producing *auras* is much larger than the EZ. [2]

The *functional deficit zone (FDZ)* is the region of cortex showing *hypometabolism* on FDG-PET (Positron Emission Tomography); it is usually much larger than the epileptogenic lesion and/or zone and it can be in regions outside the EZ. With quantitative FDG-PET, some patients with temporal lobe epilepsy (TLE) have subtle regions of hypometabolism in the frontal lobe. [2] In addition, patients with *TLE* usually have *frontal lobe* dysfunction on neuropsychological testing as shown by Hermann et al.[3]

The *anatomic lesion* which may be identified by an MRI is usually a potential epileptogenic focus. However, a lesion may not necessarily be epileptogenic. Furthermore, the epileptogenic zone may include only a part of a lesion, or extend beyond the anatomic boundaries of a given lesion.[4]

Recording at least three and preferably five seizures has been advocated to more confidently describe a patient's habitual seizures; the exact number required is unclear, and appears to vary dependent upon location and seizure type.[4,5]The first habitual seizure recorded appears predictive of the epileptogenic zone.[6]Current practice is to capture at least three habitual seizures.[7]Once recorded, seizures may then attempt to be lateralized and/or localized if surgical candidacy is to be considered.

Surface ictal EEG recordings have been shown to be accurate and reliable in lateralizing seizures.[8]Electrographic onset before clinical onset of a seizure increases the confidence of localizing the epileptogenic zone before spread to the symptomatic zone; when EEG findings are seen after clinical onset, then a mesial or inferior focus not initially seen on the surface may be present.[1]There are a number of interesting views about *ictal activity*; among them are the following:

1-Focal rhythmic bursts of theta frequency discharges with evolution to increasing amplitude and slowing is the most commonly observed pattern in focal seizure onset.[9]

2-A focal electro-decremental pattern with a reduction in the interictal activity may support a deeper region of ictal onset; faster frequencies seen at ictal onset may indicate closer proximity to the ictal focus.[10,11,12]

Focal electro-decremental events are of excellent localizing value, reflecting intense neuronal depolarization or high frequency firing.[13]However, generalized electro-decremental events preceding focal seizures are probably not truly ictal and may represent generalized cerebral changes that predispose to focal seizure development.[14]

3-Consistent focal repetitive spikes or rhythmic slowing also aids in localization and lateralization.[10]

Specific ictal onset patterns have been seen to occur more frequently within particular regions of cortex (e.g., temporal *vs* extra-temporal); however these patterns alone cannot implicate origin from a specific region. The temporal lobe ictal patterns appear to be more consistent, however, than extra-temporal patterns.[9]These include rhythmic theta activity in temporal seizures, repetitive epileptiform activity in lateral frontal seizures, suppression or paroxysmal fast activity in mesial frontal seizures, and bilateral changes with a tendency towards false localization or lateralization in parietal/occipital seizures.[11,15-17] In TLE, the ictal EEG typically consists of 5-to 7-Hz rhythmic sharp waves; this pattern may be observed after a nonspecific onset but is equally localizing if it occurs within 30 seconds of the first EEG change.[2]An ictal onset pattern that begins with delta frequency activity may suggest possible temporal neocortical epilepsy. Meanwhile extra-temporal seizures can begin with generalized voltage attenuation, lateralized slowing, or focal or lateralized beta activity. Extra-temporal seizures are more difficult to localize than temporal seizures. In many cases, lateralized ictal EEG activity is sufficient if the clinical semiology and the lesion are concordant with each other. [2]

Some scalp-derived EEG patterns have been subjected to rigorous study with respect to their localizing or lateralizing utility. Rissinger et al [12]demonstrated the value of an easily identified 5-Hz (or faster) rhythm maximum at one sphenoidal or temporal electrode early in the course of a seizure. This rhythm was present in 52% of patients and, of these 82% had an ipsilateral temporal lobe onset determined by depth recordings.

4-The classical 3 c/sec spike-wave pattern of 'petit mal' seizures or 'absences' whether childhood

absence, juvenile absence epilepsies or other absences is more familiar than other ictal patterns since it is usually recorded during the seemingly inter-ictal states of epileptic patients.

This study aimed to identify the common ictal patterns in patients with documented epileptic seizures using EEG-Video' monitoring (telemetry) facility at King's College Hospital in London.

PATIENTS AND METHODS:

Two hundreds of consecutive telemetries were utilized. The work was done at King's College Hospital in London. Telemetry which is the 'simultaneous EEG-Video monitoring' facility is the cornerstone in presurgical evaluation for epileptic patients prior to 'Epilepsy Surgery'. The telemetries reviewed covered the period from 29-January-2007 back to 24-May-2006. The work (the task of reviewing) took about ten months starting on November 2006 until the end of august 2007. A number of questions were considered for the sake of this research and a trial to answer them through the reviewing task was made.

Four questions regarding ictal EEG discharges are very important to be answered:

(a) Do distinctive EEG ictal scalp patterns exist?
(b) How frequently are those patterns encountered?
(c) Are these patterns readily recognizable?
And ***(d)*** how reliable are those patterns for localizing and lateralizing seizures?

Statistics:

The results were expressed as absolute numbers and percentages and the data were analyzed in respect to the descriptive statistical analysis.

RESULTS:

The total number of the patients/telemetries reviewed was (200). The number of female patients was 117 (a percentage of 58.5%) whereas the male patients were 83 (a percentage of 41.5%). The column designated as 'The type of test' in the database, divides the two hundred telemetries as follows (Fig 1):

- Scalp telemetry: 171 telemetries (85.5%).
- Ambulatory EEG: 17 patients (8.5%).
- ECoG (Electrocorticography): 5 patients (2.5%).
- Intracranial telemetry: 3 patients (1.5%).
- Day case EEG: 3 patients (1.5%).
- Polysomnography: 1 patient (0.5%).
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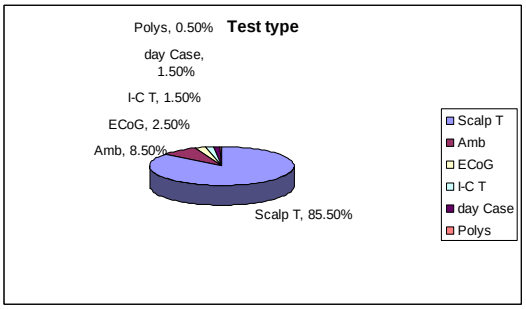

Figure 1: Pie chart showing percentages of test types of 200 cases.

Table 1 shows the characteristics of the study; the proportion of females was higher than males. The type of test was shown with scalp telemetry being the highest percentage. Although ambulatory EEG, the electrocorticography, and the polysomnography tests were reviewed regarding EEG details, they were excluded from the study since not accompanied with video recordings.

Table 1: Characteristics of the study.

Characteristics	No. of Patients	(%)
Gender		
Male	83	41.5
Female	117	58.5
Type of Test		
Scalp telemetry	171	85.5
Ambulatory EEG	17	8.5
Electrocorticodraphy	5	2.5%
Intracranial telemetry	3	1.5
Day case EEG	3	1.5
Polysomnography	1	0.5
Total	200	100

Table 2 shows the types of ictal EEG onset patterns distributed among the 81 patients with documented seizures.

Table 2: Ictal EEG onset patterns of 81 patients with documented epileptic seizures.

	Patients with the pattern (No.)	Patients with the pattern (%)	Patients with focal seizure	Patients with generalized seizure
Rhythmic sharp theta	38	47%	38	0
Fast activity/dec p	22	27%	18	4
Polyspike-waves	8	10%	0	8
Spike-waves	6	7.4%	3	3
Spike/sharp waves	4	5%	3	1
Slow spike-wave	2	2.4%	0	2
Slow activity	1	1.2%	0	1
Total	81	100%	62	19

Table 2 shows a number of observations regarding ictal EEG patterns:

1. Thirty eight or 46.9% of patients showed the ictal pattern of *rhythmic sharp theta* activity; *all* patients with this ictal pattern showed focal seizures.
2. Fast activity or *decremental pattern* observed in 22 or 27.1% of patients: 18 patients with this pattern (81.2%) showed focal seizures and 4 patients (18.2) generalized tonic seizures.
3. Eight patients (9.8%) showed the ictal pattern of *polyspike-wave* activity all were encountered with *generalized* seizures.
4. Six patients with *spike-wave* ictal onset: three showed focal seizures and 3 generalized.
5. The other 7 patients are documented with spikes or sharp waves in 4 whereas 2 patients showed atypical absences with slow spike-wave and one tonic seizure with slowing activity

DISCUSSION:

Although the current practice is to capture at least three habitual seizures in order to more confidently describe their characteristics including semiology and concomitant EEG discharges, [7] the telemetry at King's shows 22% of patients with documented seizures to have only one habitual seizure, 15% to have 2 seizures and another 15% with 3 seizures; however 29% of patients with documented seizures have [many], notably jerks, SPS (simple partial seizures), absences, or brief tonic seizures. It is this factor of 'many seizures' that makes the author to relay the results relative to patients rather than to seizures despite that it would be more accurate if it has been done the other way. Surface ictal EEG recordings have shown to be accurate and reliable in lateralizing seizures to the right or to the left side of brain. [8]But accurate interpretation of ictal scalp EEG is of fundamental importance for patients considered for resective epilepsy surgery and further confirmative aids may be needed.

Four questions are very important in this context: (a) Do distinctive EEG ictal scalp patterns exist? (b) How frequently are these patterns encountered? (c) Are these patterns readily recognizable? And (d) how reliable are these patterns for localizing and lateralizing seizures? [18]

These results showed that the most prevalent ictal pattern is the rhythmic sharp theta in a proportion of 47% of patients; it is usually regional in location and always giving rise to focal seizures (table 2). This is in concordance with several studies; Risinger et al [12] demonstrated the value of an easily identified 5-Hz (or faster) rhythm maximum at one sphenoidal or temporal electrode early in the course of a seizure; this rhythm was present in 52% of patients and, of these, 82% had an ipsilateral temporal lobe onset determined by depth recordings. Walczac et al [8] studied a similar pattern (defined as a theta or alpha frequency rhythm lasting > 10 s and occurring within 40 s of seizure onset); the lateralizing value (to the left or right side) was 97-99% accurate in the records that clearly contained this pattern. Also our results are identical with [9,19] who showed that focal rhythmic burst with evolution to increasing amplitude and slowing is the most commonly observed pattern in focal seizure onset. The results of this study showed that this pattern gives rise to temporal lobe seizures in 65% of patients concerned, depending in our classification on topography and semiology recorded in telemetry.

The second most prevalent ictal pattern in our series was the fast activity or decremental pattern with a proportion of 27%; more than 50% of patients with this pattern showed frontal lobe seizures, depending in classification, again on ictal topography and semiology.

Eight patients (10%) of our series of patients with documented epileptic seizures showed ictal pattern of polyspike-wave activity; all of these patients showed generalized seizures. Noteworthy to say, that all of these patients (100%) also showed polyspike-wave activity in wake interictal EEG. This finding may suggest that polyspike-wave activity could be a good predictor for generalized seizures whenever seen in ictal or in interictal EEG recordings.

Specific ictal seizure patterns have been seen to occur more frequently within particular regions of cortex (e.g. temporal *vs* extra-temporal); however, these patterns alone cannot implicate origin from a specific region. [(1)] The temporal lobe ictal pattern appears to be more consistent, however, than extra-temporal patterns. [(9)] It seem to be that the results are in concordance with other studies that suggest a trend for a link of rhythmic theta activity to temporal seizures, and suppression or paroxysmal fast activity to mesial frontal seizures.[(11, 15-17)]

The classical 3 c/sec spike-wave pattern of 'absences' is not usually encountered in telemetries because those patients are diagnosed at the out-patient clinics and need not to be admitted for the sake of diagnosis, classification, or pre-surgical evaluation since there is no place for surgery in those 'idiopathic generalized epilepsies'.

CONCLUSION:

The study concludes that there are at least three commonly encountered ictal patterns at King's telemetry; 1- the rhythmic theta, 2- the decremental and 3-the polyspike-wave patterns which may be distinct (and this is the answer for the 1st question among the four ones put in 'patients and methods'), readily recognizable and showed their prevalence soundly (and these are the answers for the 2nd and 3rd questions). However the fourth question may be difficult to be answered since accurate localization may need 'outcome' from epilepsy surgery as a gold standard for the accuracy of scalp ictal EEG in identifying epileptic foci.

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