Dynamics of Epileptic Phenomena

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Abstract—In this talk I present some data illustrating the idea hat Epilepsies are dynamical diseases. Dynamical scenarios of transitions between normal and paroxysmal states in Absence epilepsy are presented. We assume that some epileptic neural network are bistable i.e., they feature two operational states, or attractors ictal and interictal, that co-exist. The transitions between these two states may occur according to a random process or as a result of deterministic time-dependent mechanisms. We analyze data from animal models of absence epilepsy, human epilepsies and *in vitro* models. The distributions of durations of ictal and interictal epochs can be fitted with a gamma distribution. The analysis showed that the following statements hold. 1) The dynamics of ictal epochs differ from those of interictal states. 2) Seizure initiation can be accounted for by a random process; 3) Seizure termination is mediated by deterministic mechanisms. These results imply that exact prediction of Absence seizure occurrence is not possible but termination of an ictal state by appropriate counter stimulation should be feasible.

In addition we examine that in other forms of Epilepsy, namely in Mesial Temporal Lobe Epilepsy (MTLE) the dynamics of transitions to seizures presents different dynamics than in the case of Absences. In these cases the distance between "normal steady-state" and "paroxysmal" attractors is, in general, rather large, such that random fluctuations, of themselves, are commonly not capable of triggering a seizure. However, in these brains, neuronal networks have abnormal features characterized by unstable parameters that are very vulnerable to the influence of endogenous and/or exogenous factors. In these cases, these critical parameters may gradually change with time, in such a way that the attractor can deform either gradually or suddenly, with the consequence that the distance between the basin of attraction of the normal state and the separatrix tends to zero. This can lead, eventually, to a transition to a seizure.

We present an overview of these basic models, based on neurophysiologic recordings in human patients combined with signal analysis, and on simulations performed by using computational models of nonlinear neuronal networks. We pay especial attention to recent model studies and to novel experimental results obtained while analyzing EEG features preceding these MTLE seizures applying Phase Clustering algorithm.The possibilities of modulating the process leading to the transition to a seizure by dirct electrical stimulation are discussed.