Ph.D Bioengineering Thesis Work @ Christian Medical College Vellore (2009 – 2016)

Title: Computational Network Modelling of Excitatory and Inhibitory Responses in Hippocampal CA3 Neurons.

I associated with the Neurophysiology Unit, Dept. of Neurosciences at CMC Hospital for the Ph.D research work. I was involved in the initial setting up of the lab facilities and conducting animal experiments along with other colleagues to study epileptic activity generation in hippocampus and thereafter started focussing on computational biophysical modelling.

The aim of my work was to understand in possible detail the mechanisms of epileptic activity generation in the highly vulnerable hippocampus and suggest therapeutic methods using computational models, which could be validated with extended research studies. The specific objectives of the study were to understand how:

1) the hippocampal CA3 network becomes epileptic due to dysfunction of OLM Interneurons (hippocampal sclerosis),
2) in addition to (1), elevated extracellular potassium levels (chemical environment) lead to epileptic activity
3) drugs like gabapentin eliminate epileptic activity in this network, by acting on HCN channels.

A published computational model of CA3 neuron network is chosen from the ModelDB database of the software NEURON which simulates the theta-modulated gamma oscillations. Necessary modifications in connectivities and other parameters are done to this model to address our questions. The programs are developed using NEURON and Python. The data obtained is analyzed using the software pClamp by Molecular Devices Inc. The oscillatory activity underwent considerable changes on simulating pathological conditions. Comparisons with baseline activity were done first and thereafter with published data for validating the model.

M.S Bioengineering Thesis Work @ Christian Medical College Vellore (2007 – 2009)

Title: Functional assessment, kinematic analysis & surface EMG patterns in Focal Hand Dystonia – Writers' Cramp.

Writers' cramp reportedly is an extremely task specific disorder in which patients have significant disability while writing even in the absence of motor deficits. Modalities like sensory tricks, biofeedback, drugs, botulinum toxin etc have been tried for treatment but without much success. The main focus of the study are handwriting characteristics and associated surface EMG patterns.

A standard paragraph was provided to 5 normal and 5 dystonic subjects for writing, and recorded simultaneously in the computer using an electronic writing tablet. Surface EMG is acquired from 8 muscles (4 agonist – antagonist pairs) of the writing hand during writing. Offline analysis is then done to understand the involvement of muscles during the task. Features looked at are: the time taken for writing, general activity of muscle groups, involvement of proximal muscle groups, co – contraction, variabilities in activities of individual muscles and agonist – antagonist pairs. Ag/AgCl electrodes are used in bipolar configuration for EMG aquisition. Op-Amp based preamplifiers and second stage amplifiers are developed. A commercially available writing tablet GNote 7000 V2 was used for capturing the handwriting. Customized software developed in the Dept. of Bioengg, CMC Vellore, named 'CMCDaq' was used to acquire and analyze EMG signals.

Extended Work: This work was extended while pursuing Ph.D as part of Research Assistantship. EMG data was collected from the contralateral limb also from a set of 20 writers' cramp patients and 16 normal subjects. 16-channel SEMG obtained during different phases of a writing task was used to study timing, activation patterns, and spread of muscle contractions. Anticipation, delayed relaxation and mirror EMG activation were noted in FHD. This part of the work has formed a D.M – Neurology Thesis at CMC Vellore. We have also published this study in the reputed journal Muscle and Nerve in 2013.