Gastrointestinal (GI) Electrophysiology

Motions (motility) of the gut play a critical role in maintaining a healthy digestive system. An electrophysiological event, termed slow wave, co-regulates motility by influencing the contractility of smooth muscle cells in the GI tract.

Slow waves are autonomously generated by a type of pacemaker cells called the interstitial cells of Cajal (ICC) (Fig. 1).

Current Challenges in Clinical Practice

GI disorders are common in the modern day world. However, modern GI physiology and clinical practices still rely on relatively rudimentary measurements of gut functions.

Can a better understanding of slow wave electrophysiology lead to more accurate diagnosis and effective treatments of GI disorders?

High-Resolution (HR) Electrical Mapping

Flexible printed circuit (FPC) electrodes were designed to record slow waves from the serosal surface under intra-operative conditions. Up to 256 electrodes, with 4.0-7.6 mm inter-electrode distances, were used at a time (Fig. 2).

A series of signal processing techniques were applied to the recordings and the activation sequences of slow wave propagation were reconstructed in activation times (AT) maps.

HR mapping of gastroparesis (a digestive disorder that occurs in ~20% of diabetes) has demonstrated slow wave dysrhythmias, when compared to baseline activity (Fig.3).

Multi-scale Mathematical Modelling

Mathematical modelling has become a valuable in-silico research tool, as there is an ever-increasing need to gain an integrative and quantitative understanding of how slow waves achieve coordinated functions across multiple biophysical scales (Fig. 4).

Simulation of Ectopic Activation

A bi-directionally coupled ICC networks model was developed to simulate the ectopic activation of gastric slow waves. Ectopic activation demonstrated demonstrated velocity anisotropy due to the differential preferential conduction in each ICC network from different depths of the GI wall (Fig.5).