Novel Techniques To Analyse Gastric Slow Wave Recordings

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Introduction

The motility of the gastrointestinal (GI) tract is governed by a rhythmic electrical activity, termed the slow wave [1]. Gastric slow wave dysrthymias have been associated with several motility disorders, such as gastroparesis and gastroesophageal reflux [2]. However, the clinical significance of gastric dysrthymias still remains uncertain [2].

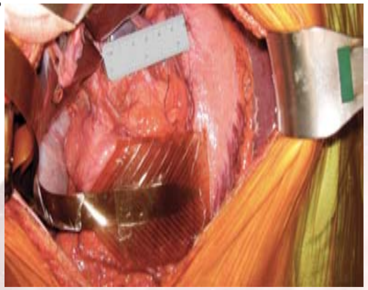
Current algorithms and software have concentrated on detecting the activation phase of the slow wave event [3]. However, the recovery phase is also an important aspect to understand the mechanism of the slow wave event, because the Activation-Recovery interval (ARi) is hypothesised as a parameter that is associated with gastric dysrhythmias. In this study, a a novel recovery-phase detecting method is applied to investigate this relation.

Signal Acquisition

Experimental porcine slow wave signals were acquired by high-resolution multi-electrode mapping (A). Ethical approval was obtained from the University of Auckland animal ethics committee.

A

B



(A) High-resolution multi-electrode mapping made by flexible printed circuit board (PCB). (B) The dense array of electrodes were located on the greater curvature of the porcine's stomach.

References

[1] O'Grady, G. et al. *Am.J.Gastroint.Liver Physiol.* 2010,*299*(3),G585-G592. [2] Paskaranandavadivel, N. et al. Improved signal processing techniques for the analysis of high resolution serosal slow wave activity in the stomach (pp. 1737-1740) IEEE EMBC,2012. [3] Paskaranandavadivel, N. Techniques for quantification and interpretation of gastric slow wave activity [dissertation]. The University of Auckland; 2013

Signal Processing

The signals were analysed by the software package GEMS (Gastrointestinal Electrical Mapping Suite) that was developed in MATLAB version [1]. The activation map was visualised by GEMS as well. A novel method was developed in MATLAB to detect the recovery phase of slow wave. This algorithm utilized the smoothed non-linear energy operator(SNEO) to amplify the larger deflections in the signal.

Noise removal (baseline and high frequency noise)

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Manual review of satisfied signal for detecting recovery time

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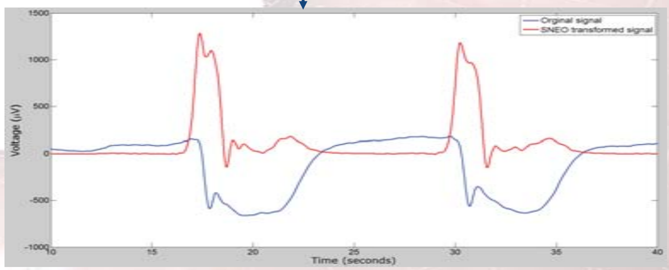
Signal re-transform by modified SNEO(V)

$SNEO(V) = V_n V_n + V_{n+4} V_{n-4}$

↓

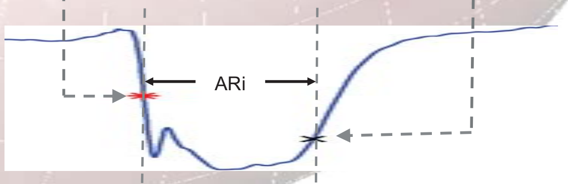
A



Activation time = Maximum derivative in window

Recovery Time = Maximum instantaneous energy in window

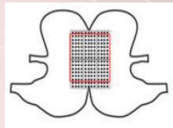
B



A flow chart demonstrating the procedures for detecting recovery phase. (A) Example of Slow wave signal and its transformed form. (B) An illustration of fiducial markers for activation and recovery index of a single slow wave event.

Results

A



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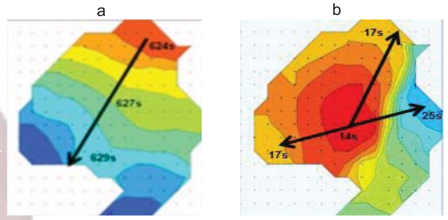

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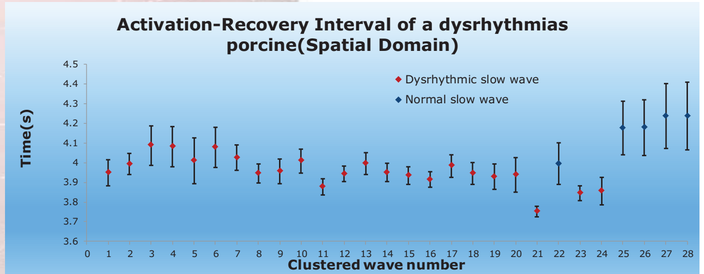

Experimental results of a porcine study that presented both dysrhythmias and normal slow wave activities. (A) Position diagram showing the electrodes were placed on the greater curvature of stomach, near the normal pacemaker region of the stomach. (B) Activation maps of normal slow wave (a) versus dysrhythmic slow wave in the same position (b). Each black dot represented an electrode and each isochrones corresponded to 1s of propagation. An ectopic pacemaker (abnormal pacemaker region) propagated in elliptic path as shown in B(b). (C) illustrates the change in mean ARi between each clustered wave. Each clustered group denotes the spatial information of slow wave propagation over the recording region. The dysrhythmic slow wave had shorter ARi compare with normal slow wave. (Average 4.2±0.1s for normal slow wave and 3.9±0.1s for dysrhythmic slow wave, P<0.001).

Conclusions

- A novel method has been developed to detect the recovery phase of slow wave and explored a new path to analyse the mechanism of slow wave event.
- Results from the porcine study revealed that the ARi of dysrhythmic slow wave patterns were shorter than the ARi of normal wave pattern in general.
- Further experimental and mathematical modelling studies are required