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Numerical study on the design of electrodes for monitoring enteric electrical activity using Wireless Capsule Endoscopy

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Wireless Capsule Endoscopy (WCE) is an innovative technology for the diagnosis of gastro-intestinal (GI) tract diseases through an ingestible pill, able to measure biological parameters and acquire images of the GI tract[1]. Beside this, measuring electrical activity is on interest to gather insight in functional gastric disorders. In this study electrodes, to be integrated within the capsule, are designed to measure an electrical signal. A numerical model of intestinal cavity tract (1 mm^2 section) has been built in Comsol Multiphysics (v. 6.0), considering: intestinal wall with villi, simplified spherical active cells (100 cells/mm^2 density[2]), intestinal lumen (1.5 cm high). Moreover, golden electrodes embedded within the alumina pill have been modeled in three capsule's positions: adherent to the bottom intestinal wall (Panel A in Fig. 1); (2) at lumen center; (3) adherent to the top intestinal wall. A numerical simulation has been performed using electric currents module, assigning in phase spontaneous electrical signal and one electrode as the ground (V = 0 V), to assess the minimum detectable signal.

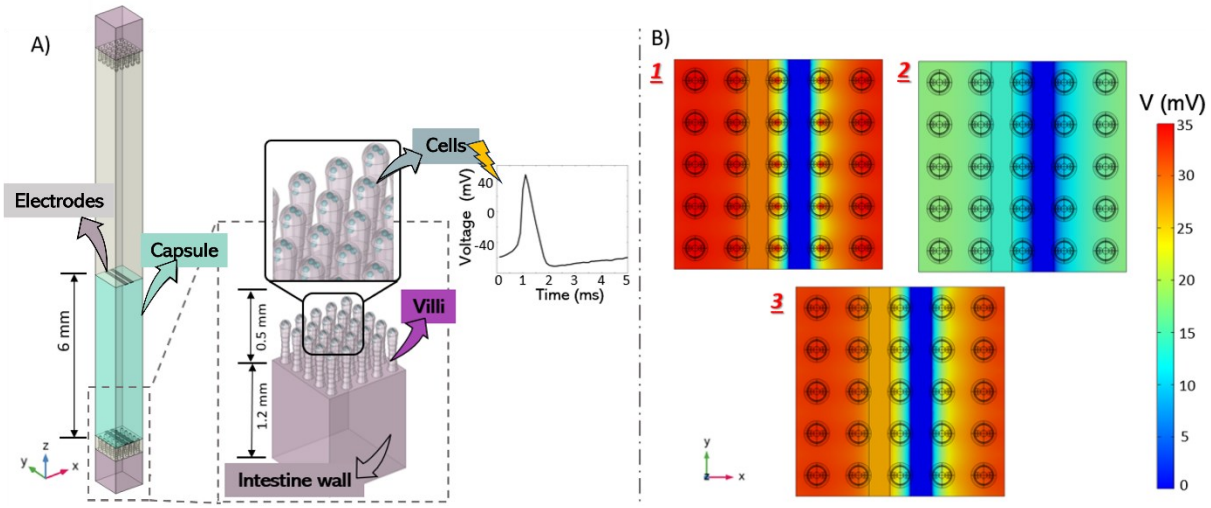

Figure 1. Panel A: capsule inside the complete intestinal tract model. Panel B: Electric Potential V maps in three capsule's positions, considering a slice crossing the electrodes on a xy top view.

Results (Panel B, Fig. 1) show electric potential V maps, in which higher values are measured when the pill is near the cells, i.e. (1) and (3) conditions, whereas lower values are registered when the capsule is at the lumen center (2). Nonetheless, the minimum signal intensity is measured in (1) and (3) conditions, by the active electrode part further away from the intestinal wall, and it is about 2.5 mV. Such preliminary minimum detectable signal estimation allows to affirm that this electrodes technology can be exploited for future WCE application, aimed at sensing the enteric cells activity for cognitive functions investigation.

References

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2. Graham, K. D. *et al.* Robust, 3-Dimensional Visualization of Human Colon Enteric Nervous System Without Tissue Sectioning. *Gastroenterology* **158**, 2221-2235.e5 (2020).