Biomechanical Model for the Simulation of Colonic Pit Patterns

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Abstract

The colonic epithelium is formed by thousands of small cavities, called crypts and the extremely tiny pits, in the mucosa of the colon, are the crypt orifices. In normal crypts, the pits are roundish and grouped in a regular pattern. However in aberrant crypts, the shape and pattern of the correspondent orifices have different forms, as for example, star-like, elliptical, sulcus-like, branch-like, tubular, or roundish but smaller than the typical size [1]. The normal crypts are small tubular glands, containing different types of cells, that obey to a programmed cell mechanism in such a way that colonic cells renew themselves continuously each five-six days, in humans. The aberrant crypts occur as a consequence of an abnormal behavior of this programmed cell mechanism, inside the crypts, and are thought to be the precursors of colon cancer [2].

The different patterns of colonic pits can be visualised by clinicians in real time, during a colonoscopy exam, by using an appropriate enhancement technique that involves the direct application of certain dyes in the colon. Moreover, it is also well known that there is a correlation between histopathology and distinct pit patterns.

The goal of this talk is to describe a biomechanical model representing the colonic pit and its surrounding material, and simultaneously, to simulate the evolution of the colonic pit pattern in time, when there is a disruption of the healthy cell mechanism. It is adopted the two-dimensional crypt geometry introduced in [3], which enables a representation of a three-dimensional crypt in a two dimensional setting, in such a way that it emulates a top view of the crypt and its orifice, as in a clinician's visualisation during a colonoscopy exam.

The biomechanical model couples the cell dynamics occurring inside the crypt with the mechanical behaviour of the material surrounding the crypt orifice. This material around the crypt is considered to be visco-elastic. By using numerical simulations, we show that when a modification of the programmed cell mechanism is implemented, the irregular and abnormal colonic pit patterns, described before, are retrieved.

Keywords: Cells dynamics, Visco-elasticity, Colonoscopy, Aberrant crypts.

References

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