

Intestinal propulsion of a solid non-deformable bolus

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Abstract

A mathematical model of a segment of the gut with an enclosed pellet is constructed. The gut is represented as a thin deformable soft biological shell with the pellet modeled as a non-deformable solid. Mechanical properties of the gut wall were represented as longitudinal and circular smooth muscle layers embedded in stroma that satisfies the general type of nonlinear orthotropy. Deformations of the wall are finite. Bolus propulsion is numerically simulated by generation and propagation of an electromechanical wave along the syncytia. Pharmacological manipulation is applied to model 5-HT type 3 antagonist (Lotronex, GlaxoSmithKline) and 5-HT type 4 agonist (Zelnorm, Novartis, AB) drugs on the dynamics of bolus progression. The results lead to new quantitative insights into the complex spatio-temporal patterns of gastrointestinal transit. It is demonstrated that the reciprocal relationship in contraction of the longitudinal and circular smooth muscle syncytia is necessary to provide the "mixing" type of movements during the preparatory phase of propulsion. Strong simultaneous contractions of the both smooth muscle layers are required to expel the "mixed" pellet from the segment. The model is implemented as an interactive software system, Gut Discovery© (www.aincompany.com), and accurately predicts the effects of drugs on gut motility. © 2005 Elsevier Ltd. All rights reserved.

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Keywords

Nonlinear waves of deformation, Pellet propulsion, The gut mathematical model