A multicellular model of primary saliva secretion in the parotid gland. (English)

Summary: We construct a three-dimensional anatomically accurate multicellular model of a parotid gland acinus to investigate the influence that the topology of its lumen has on primary fluid secretion. Our model consists of seven individual cells, coupled via a common lumen and intercellular signalling. Each cell is equipped with the intracellular calcium ($\text{Ca}^{2+}$)-signalling model developed in our work [ibid. 81, No. 5, 1394–1426 (2019; Zbl 1415.92075)] and the secretion model constructed in our work [ibid. 81, No. 3, 699–721 (2019; Zbl 1415.92070)]. The work presented here is a continuation of these studies. While previous mathematical research has proven invaluable, to the best of our knowledge, a multicellular modelling approach has never been implemented. Studies have hypothesised the need for a multiscale model to understand the primary secretion process, as acinar cells do not operate on an individual basis. Instead, they form racemous clusters that form intricate water and protein delivery networks that join the acini with the gland’s ducts—questions regarding the extent to which the acinus topology influences the efficiency of primary fluid secretion to persist. We found that (1) The topology of the acinus has almost no effect on fluid secretion. (2) A multicellular spatial model of secretion is not necessary when modelling fluid flow. Although the inclusion of intercellular signalling introduces vastly more complex dynamics, the total secretory rate remains fundamentally unchanged. (3) To obtain an acinus, or better yet a gland flow rate estimate, one can multiply the output of a well-stirred single-cell model by the total number of cells required.

MSC:
92C30 Physiology (general)

Keywords:
salivary epithelia; parotid gland; fluid secretion; plasma membrane; multiscale modelling; $\text{Ca}^{2+}$ signalling; ion channels

Full Text: DOI

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