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A Mathematical Analysis of a Model in Capillary Formation: The Roles of Endothelial, Pericyte and Macrophages in the Initiation of Angiogenesis

Authors : Serdal Pamuk, Irem Cay

Abstract : Our model is based on the theory of reinforced random walks coupled with Michealis-Menten mechanisms which view endothelial cell receptors as the catalysts for transforming both tumor and macrophage derived tumor angiogenesis factor (TAF) into proteolytic enzyme which in turn degrade the basal lamina. The model consists of two main parts. First part has seven differential equations (DE's) in one space dimension over the capillary, whereas the second part has the same number of DE's in two space dimensions in the extra cellular matrix (ECM). We connect these two parts via some boundary conditions to move the cells into the ECM in order to initiate capillary formation. But, when does this movement begin? To address this question we estimate the thresholds that activate the transport equations in the capillary. We do this by using steady-state analysis of TAF equation under some assumptions. Once these equations are activated endothelial, pericyte and macrophage cells begin to move into the ECM for the initiation of angiogenesis. We do believe that our results play an important role for the mechanisms of cell migration which are crucial for tumor angiogenesis. Furthermore, we estimate the long time tendency of these three cells, and find that they tend to the transition probability functions as time evolves. We provide our numerical solutions which are in good agreement with our theoretical results.

Keywords : angiogenesis, capillary formation, mathematical analysis, steady-state, transition probability function
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