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Abstract

This research work focused on the early interactions between tumor-immune systems and observes the outcome of their influence on the tumor dynamics. For better understanding, we choose mathematical modeling approach to scrutinize the interaction between developing tumor and immune system. In addition, control of the kinetics of immune surveillance, which is the ultimate goal of tumor immunology, is also considered.

Findings:

The first model is based on the interaction between the tumor cells and normal cells in the presence of immune cells. Following observations are made:-

- The model demonstrates the phenomena 'tumor dormancy', where tumor remains in constant size (i.e. there is a balance between the cell proliferation and apoptosis of tumor cells) for the extended period.
- By increasing the source rate (α) of immune cells, we achieved the dormant state of tumor cells faster in comparison to the analysis done without increasing the source rate. For the clinical point of view, the dormant state is significant than the recurring state.
- We are able to obtain a parameter which can be efficient for tumor treatment, i.e. the apoptosis rate of immune cells. The parameter, apoptosis rate of immune cells is able to transit the system from the co-existing equilibrium to tumor free equilibrium.

The second model is based on the kinetics of growing tumor interactions with the host immune cells. In this model, we are considering that the effector immune cells have been divided into two categories as resting effector cells and hunting effector cells. The major findings of this model are:

- In the absence of convergence mechanism in the body, (i.e. resting cells are not converting into hunting cells), then tumor cells reach to its carrying

capacity which may lead to a highly dangerous state ,i.e., the only tumor exists at this stage but it has the high probability of tumor escape and cancer development.

- In this model, the parameter a_5 denotes the growth rate of resting effector cells which act as a controller of tumor development. By elevating it, there was a transition from the recurring state to the dormant state. In the process of tumor development, the dormant state is also termed as an equilibrium state.

The third model is an extension of the second model. Here, we assumed that there is a normal rate of flow of resting cells in the body instead of logistic growth of resting cells inside the tumor site. The findings of this model are:-

- The tumor shows "recurrence phenomenon". The tumor was born in the body, it remains silent for 35 years and after that, it was in a diagnostic state. Our period of recurrence is more than the periods referred so far as 15 years in the case of melanoma.

- We observed a delay in the recurrence period of tumor when we elevate the number of hunting effector immune cells initially.

- The source rate (s) of resting cells can control the tumor dynamics. As we increase the value of the parameter s, the tumor burden starts deteriorating from its maximum growth.

- We have been able to achieve the equilibrium state of the tumor, i.e. tumor dormancy.

Summary:-

In the study of three mathematical models, we observe that the source rate of immune cells can control the tumor progression. We note that tumor could achieve an equilibrium state (i.e. dormant state) from recurring state by elevating source rate of effector immune cells to the tumor site. Dormant state is a silent state which becomes the aim of physicians to get required. Clinical trials can be developed to achieve either an equilibrium state or eliminated state (cured).