Lab -2

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CS-302, Modeling and Simulation

In this lab we've attempted to understand and analyze drug interaction with human body by modeling the system using absorption and elimination rates, dosage frequency, and amount of the drug. And hence analysed the behavior by modeling one and two compartment model.

I. INTRODUCTION

Medicinal administration in terms of drug introduction in human body with respect to drug dosage is a very sensitive and important domain. Which includes parameters like Minimum Effect Concentration(M.E.C.) and Maximum Toxic Concentration(M.T.C.) for a particular drug. Since any concentration of the drug below MEC or above MTC is harmful for the patient, the dosage given to a patient needs to maintain the concentration in (MEC, MTC). Here we have modeled the dosage of drugs like Aspirin and Dilantin using one and two compartment models.

II. MODEL

1. Single Compartment Model:
   For this model, we make the assumption that a human body is a single compartment, and it has a certain absorption constant. We also assume that the drug content disperses instantaneously and that concentration of drug is directly proportional to given dosage of drug and the elimination constant. Finally, we derive the following model.

$$\frac{dQ}{dt} = -K \cdot Q \tag{1}$$

   Here K is elimination constant which is written in the form of half-life,

$$K = \frac{ln(2)}{t_{1/2}} \tag{2}$$

2. Two Compartment Model:
   Here, we take digestive system as the first compartment and the area which the drug targets is taken as the second compartment. A two compartment system is shown below in the image. Here, when

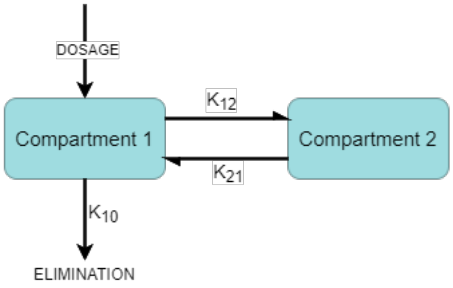

FIG. 1: Two compartment Model

the dosage of drug is given first it goes into the first compartment which have two types of elimination constant where by k_{10} it is eliminated completely and by k_{12} it dissipated into compartment 2. The compartment 2 has an elimination constant k_{21} by which it dissipated into compartment 1. Hence, we deduct the model as,

$$\frac{dQ_1}{dt} = -(k_{10} + k_{12}) \cdot Q_1 + k_{21} \cdot Q_2 \tag{3}$$

$$\frac{dQ_2}{dt} = k_{12} \cdot Q_1 - k_{21} \cdot Q_2 \tag{4}$$

III. RESULTS

While administering drugs, if the concentration of the drug in the body falls below MEC or goes above MTC, then it would cause harm rather than heal. Conventionally, dosage is expressed in terms of μg and concentration in terms of μg/ml. Generally, weight of the drug is specified in milligram(mg), and hence we multiply it by a factor of 1000 in our simulations to convert it to μg/ml.

Results and Analysis of Single Compartment Model:

- In our first case, Dilantin is administered with a dosage frequency of 8 hours and drug dose of 100 mg, while assuming volume to be 3L, and absorption factor is taken as 0.12. From the results, we observe that the drug concentration gradually increases and saturates at approximately 17.5 μg/ml.

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The same can be validated by the summation of a GP, which saturates at 18 μg/ml.

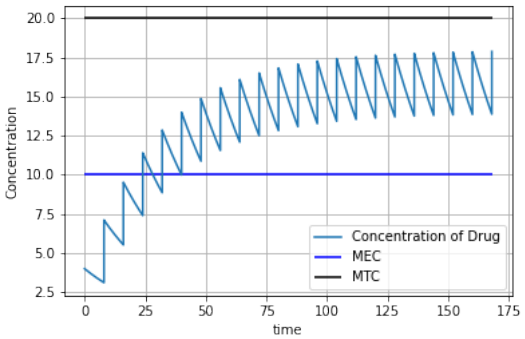

FIG. 2: Single compartment Dilantin Model for freq = 8 hrs and drug dosage = 100 mg

- In the second case, Dilantin is administered with a dosage frequency of 24 hours that is once a day with drug dose 300 mg, while assuming volume to be 3L and absorption factor equals 0.12. From the obtained graphs, we observe that drug concentration gradually rises and saturates at 22.5 μg/ml. The same can be validated by the summation of a GP, which results in 22.6 μg/ml.

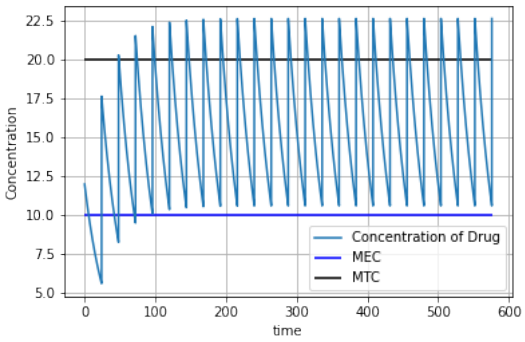

FIG. 3: Single compartment Dilantin Model for freq = 24 hrs and drug dosage = 300 mg

Hence, we can conclude from Fig. (3) that this kind of drug administration is harmful because at saturation, drug concentration is greater than MTC.

- In the third case, we take loading administration for Dilantin with loading dosage as 400 mg, 300 mg, 300 mg each 2 hours apart and then continuing the Dilantin 100 mg 8 hours apart. Simulating this scenario while keeping the earlier made assumptions, we get the following graph.

  As we can see from the Fig. 4 taking loading dosage of Dilantin is harmful as for a big time interval concentration of drug is greater than the MTC.

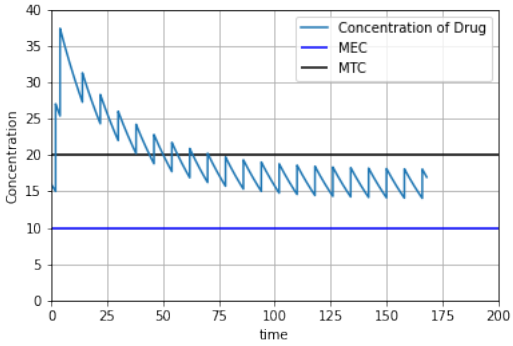

FIG. 4: Loading administration of Dilantin with single compartment model

Results and Analysis of Two Compartment Model:

- In the first case, we take the single dose of aspirin of 100 mg with absorption factor 0.12 and volume equals to 3L with elimination constants k_{10}, k_{12} and k_{21} as 1.4913/da, 1.4854/da and 2.5922/da respectively. Results obtained from the simulations are shown below in Fig. 5.

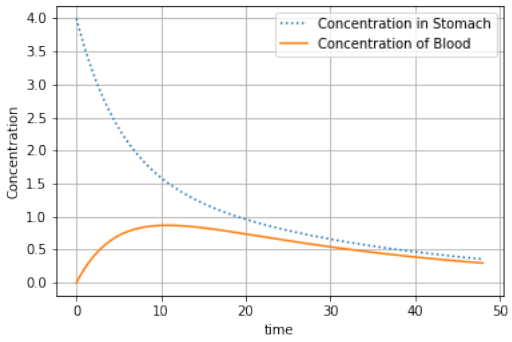

FIG. 5: Single dose aspirin with two compartment model

- In the second case, we give 100 mg dosage of aspirin with each dose 6 hours apart that is the frequency of dosage is 6 hours. Keeping the same assumptions made before we get the following graph.

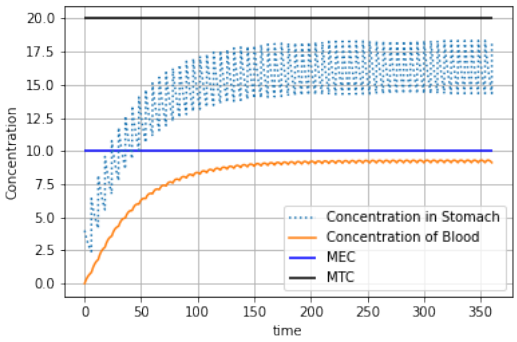

FIG. 6: Two compartment model of aspirin with 6 hours frequency

- In the third case, we give 3 aspirin of 100 mg dosage at the start and the after two hours we give another 2 aspirin of 100 mg. Keeping the same assumptions made before we get the following graph.

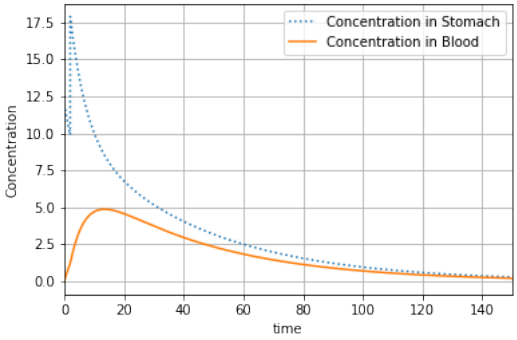

FIG. 7: with Two compartment Model

- In the case, we take loading administration for Dilantin with loading dosage as 400 mg, 300 mg, 300 mg each 2 hours apart and then continuing the Dilantin 100 mg 8 hours apart. Simulating this scenario while keeping the earlier made assumptions with two compartment model, we get the following graph,

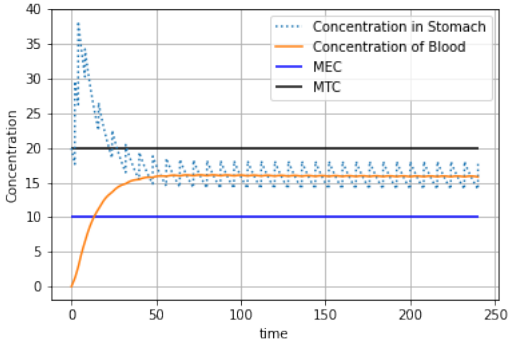

FIG. 8: Loading dosage with two compartment model

IV. CONCLUSIONS

To sum up our discussions, we have analyzed the system of drug administration in human body and its flow across organs. We realize the importance of adherence to proper dosage guidelines in terms of frequency and dosage amount for observing intended effect of drug on the human body. And how irregularity and non-adherence to the prescribed doses may lead to toxic adversities in bodies or may lead to no effect of drug at all.