An Analysis of Mamathmogen in the body

An Exploration of Drug Therapy

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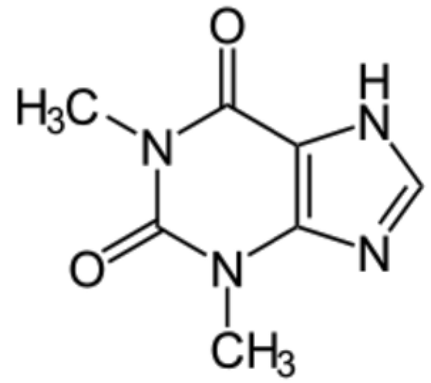

Abstract

Drug therapy relies heavily on precise dosage and timings in order to minimize adverse effects when above $10mg/l$ whilst also keeping the concentration in the therapeutic range of above $5mg/l$. In our poster we will cover the following models: repeated smaller doses, expanding the range, varying volume distribution and weight, slowing the breakdown and other methods of administering. This poster aims to provide these models for use of a doctor in administering the drug to a patient. Our model has built towards the following optimal method: a $300mg/l$ can be administered every 15 hours using another drug to slow the drug's breakdown via the liver and make it so less than 80% will be broken down. From this we can see that doctors can have daily appointments with a patient who lives close or in a hospital/surgery, this allows the patient to live a normal life and sleep properly without injections needed every 5 hours as the initial model suggested. The findings suggest that mamathmogen is an effective drug for hospital patients on its own but must be accompanied by second drug, in order to slow the breakdown, for it to be viable for regular use.

Introduction

Mamathmogen is a drug that is used to treat asthma, the drug is effective when above $5mg/l$ but has adverse clinical effects when above $10mg/l$ and these become more severe and frequent when above $20mg/l$. We suspect repeat dosages will be needed as 80% of mamathmogen gets metabolized within the liver and removed when introduced to the bloodstream, so concentration decreases rapidly. From this 80% being metabolized by the liver we can see that an exponential decay will occur in the form ae^bx where a is the initial concentration of the drug in the blood and where b will be negative and shows the rate of metabolism of the drug in the liver. In this poster we will provide different methods of delivering the drug to a patient in order to find the most appropriate dosage and time of administration.

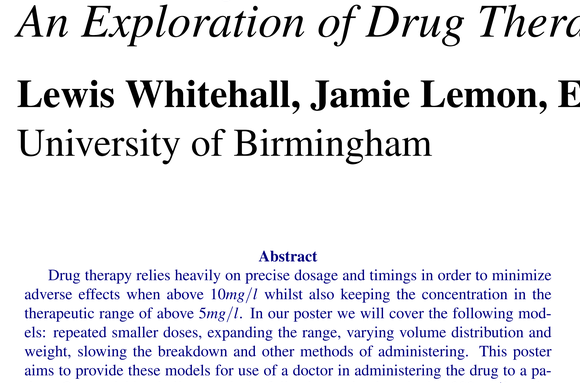

Figure 1: Exponential decay of a single dose

Assumptions

In this project we make a number of assumptions in order to put ourselves in a position to create a set of mathematical models.

1. The drug is administered properly and on time for every dose.
2. The doctors use the exact measurements given and act as logical agents
3. The drug is absorbed in a normal and expected fashion.
4. The patient does not build tolerance towards the drug.
5. The volume of distribution V is proportional to the body weight W of the patient shown by $V = kW$ where k is a constant depending on the drug administered, in this case $k = \frac{1}{2}$.

Repeated smaller doses

One way to administer the drug mamathmogen is to have an initial larger dose of $300mg$ followed by regular smaller doses every 5 hours. This is due to after 5 hours the concentration in the blood being $5mg/l$ the lowest recommended concentration of mamathmogen needed. At $t = 0$ with a $300mg$ dose, the concentration is $11.481mg/l$. Using this to calculate the weight of the patient, we can then work out the required quantity of the regular smaller dosages.

$$\begin{aligned} Volume &= quantity \div Concentration \\ Volume &= 300 \div 11.481 \\ Volume &= 26.13l \\ Volume &= 1/2 \times Weight \\ Weight &= 2 \times 26.13 \\ Weight &= 52.3kg \end{aligned}$$

The quantity of mamathmogen required to get from $5mg/l$ to $11.481mg/l$ $= (11.481 - 5) \times 26.13 = 169.3mg$ therefore every 5 hours administer $169mg$ of mamathmogen to return to the initial concentration of $11.481mg/l$ keeping the mamathmogen levels at a constant level between 5 and $11.481mg/l$.

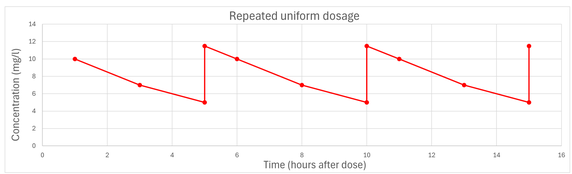

Figure 2: Repeated uniform dosage

This intravenous method is only suitable for people in hospital, so would only be useful in this situation not for the majority of the population.

Expanding the range

Is an injection each 5 hours really convenient? Patients will need sleep, and people won't want to be getting/ administrating injections that often. If we are willing to push the boundaries of the therapeutic range, we can increase times between dosage to 12 hours, with an initial dosage of about 400mg.

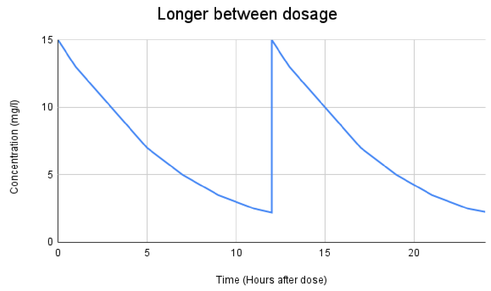

Figure 3: Expanding the range

This will only be suitable for patients not in a severe condition and so don't mind going a bit below the therapeutic range for a while, and they don't have pre-existing medical conditions that will make it worse to go above 10mg/l.

Other methods of administering Mamathmogen

While most of our models examine how to best administer the drug intravenously we have also considered that a repeated drip dosage may be more appropriate. The below model shows the concentration during the first hour after an initial injection of 261.3mg of Mamathmogen followed by a repeated drip of 7.2mg every 10 minutes.

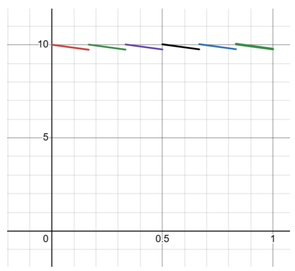

Figure 4: concentration of mamathmogen for the first hour under a constant drip

This leaves a concentration of 10 mg/L after 24 hours hence there will be no need for further injections as long as the drip is maintained correctly.

Volume distribution and weight

Apparent volume distribution and weight are related by $V = \frac{1}{2}W$ therefore the dose needed to achieve the required initial concentration of the drug can be inferred from the weight of the patient.
The volume of distribution relates the amount of drug in the body (the dosage) to the concentration (of the drug in the blood) that is measured.

It is seen that

$$\begin{aligned} volume\ of\ distribution &= \frac{dosage\ amount}{concentration\ in\ the\ blood} \\ \frac{1}{2}weight &= \frac{dosage\ amount}{concentration\ in\ the\ blood} \\ Concentration\ in\ blood &= 2 \times dosage\ amount \times \frac{1}{weight} \end{aligned}$$

This means that the more a patient weighs, the higher dosage they need to achieve the the required concentration of the drug in the blood, but time taken for the concentration in the blood to decrees should not be affected.

reference

https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/volume-of-distribution: :text=Volume

Slowing the breakdown

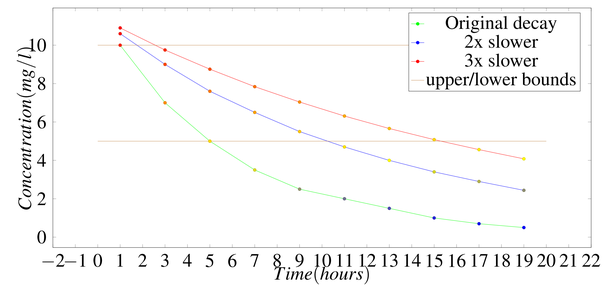

Figure 5: Graph showing the affects of using another drug to slow the breakdown of Mamathmogen

Using another drug will allow a longer period of time between each injection which will be much more suitable than injecting a patient every 5 hours. This also allows the initial injection to still be 300mg/l which will reduce the chances of side effects which will be more suitable for patients in severe condition that cannot have larger doses. The best outcome of using another drug would be to slow the breakdown of mamathmogen by three times the normal rate which would mean injections can be administered every 15 hours to keep the concentration between 5mg/l-10mg/l.

Summary

All things considered, we believe the most efficient method to introduce mamathmogen to the bloodstream is to administer another drug to slow down the release. This will offer a more practical method to combat asthma, but is limited to finding a drug suitable. These drugs are used often within medical environments but we will need to engineer one that is optimally compatible with mamathmogen.

Generative AI was not used to formulate any of the content within this poster. Generative AI has been used to review our ideas, and to asses credibility of our suggestions.