Residual Gastric Stomach Volume via Dye Dilution

Sean Chakraborty, Tien Tran, Elizabeth Kolb, Elaine Raymond
Advisor: Dr. Schultz
University of Houston, Houston, TX

OBJECTIVE

- To evaluate the validity and feasibility of a dye dilution method for determining the remaining stomach volume (RSV) in clinical settings using George's dye dilution method.
- To evaluate a commercially available colorimeter for measuring the dye concentration in a feeding tube.

BACKGROUND

- Nasogastric feeding tubes are commonly used for providing nutrition and medication to patients who are unable to eat or drink by directly delivering nutritional liquid from the nose directly to the stomach.
- Statistics from the Journal of Parenteral and Enteral Nutrition have shown that up to 60% of critically ill patients in the ICU may require enteral feeding.
- Currently, there is a lack of proper measurement of how much nutritional fluids can be fed before a patient reaches their upper limit of their residual gastric volume.
- By implementing dye within the nasogastric feeding process, we could apply a combination of Beer-Lambert's law and dye dilution equations to accurately measure the residual volume in a patient's stomach.

PRINCIPLES

$$A = \varepsilon b c \quad \textbf{(Eq. 1)}$$

A = Absorbance at a given wave
ε = Molar absorptivity (L/mol*cm)
b = Distance light passes through solution
c = Concentration of solution

$$A = -\log\left(\frac{I}{I_0}\right) = -\log\left(\frac{\%\,T}{100}\right) \quad \textbf{(Eq. 2)}$$

%T = Percent transmittance
I = Light intensity of 525 nm, the wavelength of solution
I_0 = Light intensity of water

$$V_1 = \frac{V_2(c_2 - c_3)}{c_3 - c_1} \quad \textbf{(Eq. 3)}$$

C_1 = Stomach dye concentration
V_1 = Stomach volume
C_2 = Formula dye concentration
V_2 = Formula Volume
C_3 = Mixture concentration

METHODS & MATERIALS

- Multiple concentrations of Allura Red are created, ranging between dye to water ratios of 0 to 1 to test upon.
- The formula, currently tested along with the dye solution as V2C2 is dropped into the simulated stomach via the feeding tube.

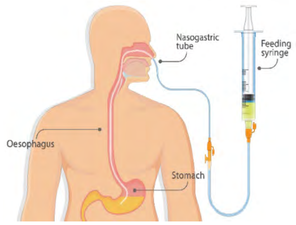

Figure 1: A typical overview of nasogastric feeding tubes.

- The syringe, connected to a three-way valve, pulls this liquid from the simulated stomach model as $C_3(V_1 + V_2)$.

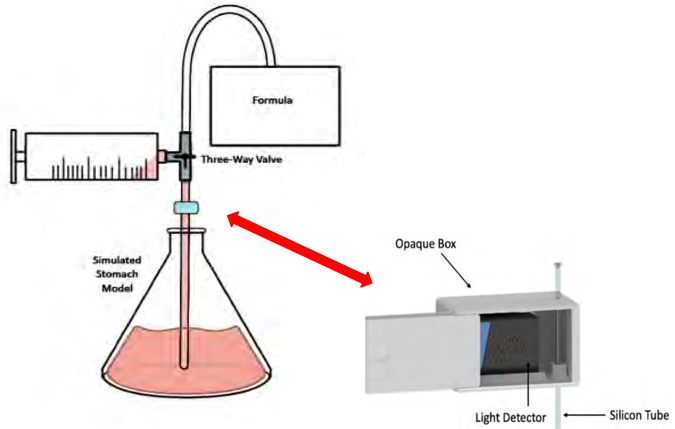

Figure 2: A schematic of the apparatus used to calculate the intensity of concentration from a mixture of the dye solution and simulated stomach formula. Attached to the tube, in light blue, is a 3D printed box containing the colorimeter.

- From here, an enclosed box - with a black interior to reduce stray light and strip of aluminum to increase colorimeter readings – contains a colorimeter to record the light intensity at a wavelength of 525 nm.
- This recorded light intensity data is then used to calculate the absorption of the dye concentration **(Eq. 2)**
- Beer-Lambert's Law **(Eq. 1)** is then applied using the absorption data to calculate the concentration of the simulated stomach.
- Finally, the volume of the simulated stomach can be calculated based upon the concentration data obtained through colorimeter measurements **(Eq. 3)**.
- Tests were accomplished with both cuvettes and tubing.

RESULTS

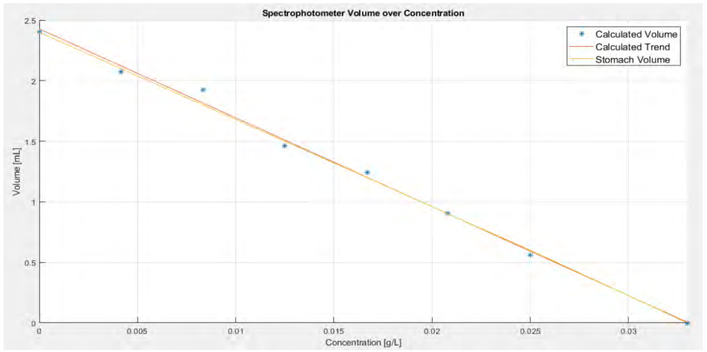

Figure 3. A comparison between the volume through the recorded absorbance of the spectrophotometer and the actual volume of the simulated stomach.

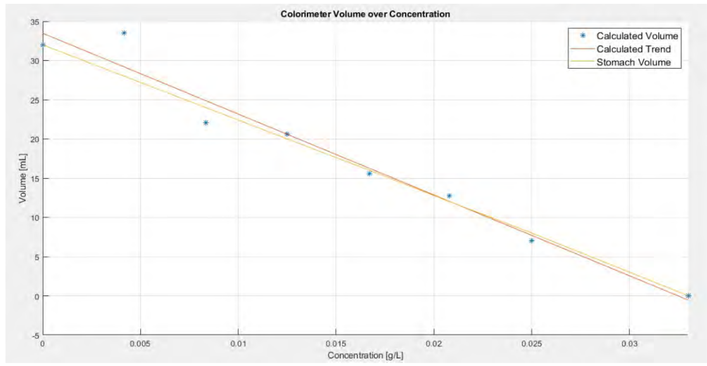

Figure 4. A comparison between the volume through the recorded absorbance of the colorimeter and the actual volume of the simulated stomach.

- Results show successful application of Beer's Law and Dye Dilution equations to calculate the residual stomach volume.
- Graphs show both the calculated volume and true stomach volume in relation to the concentration C_3 of the mixture as seen in equation 3. As the concentration increases, the resultant volume V_1 decreases.
- % Error for the spectrophotometer was less than 3% while the % error for the colorimeter was less than 8%.

CONCLUSION

- Our apparatus design and protocol has shown the feasibility of applying a dye dilution method along with the principles of Beer-Lambert's law to evaluate the volume present in the stomach.
- Further improvements can be made with application of a more thorough tubing system and a more compact colorimeter design. Additionally, feasibility could be further tested using less transparent solutions to mimic feeding tube liquids more accurately.