AutoNutriFlow:
Utilizing Sensors Gastroenteric Feeding Tubes

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Introduction: Up to 90% of patients in the ICU suffer from muscle atrophy due to insufficient protein and caloric intake using feeding tubes[1]. Muscle atrophy can be detrimental to patients during recovery, rehabilitation, and post-release from the hospital, as it makes it increasingly difficult for patients to perform daily tasks. Currently used feeding tubes lack advanced technological features to enhance the performance of the system. These tubes require health care professionals to manually calculate the correct nutrient flow rate using charts which requires large amount of work and has a high risk of possible errors. Additionally, these charts do not take into account when patients are untethered from their feeding tubes to undergo routine tests such as x-rays and MRIs so frequently patients receive not enough nutrients. Therefore, this project focuses developing an automated feeding tube to remove potential human errors while preventing muscle atrophy and ensuring proper nutrition intake. Our automated feeding tube identifies and corrects the existing gastroenteric feeding tube inefficiencies. The two main objectives are: 1) design an automated feeding pump that automatically calculates and adjusts the feeding tube flow rate, using individual patient's physiological characteristics; and 2) monitor the pressure in the duodenum using a pressure sensor to prevent overfeeding.

Materials and Methods: The prototype has been created using a traditional dual lumen feeding tube, a 6V brushed DC motor, an Arduino Uno (the micro controller), and a MEMS pressure sensor. The MEMS pressure sensor is designed to be placed at the distal end of the tube where it is threaded through the patient's nose and deposited into the duodenum. The tube, connected to an external pump, can then deposit the nutritional solution into the duodenum. A negative feedback loop is encoded into the device, so at high bowel pressure the pump will stop until the pressure falls below the threshold. The Arduino Uno is connected to a laptop to display the user interface. The graphical user interface (GUI) and flowrate adjustment codes are developed on Arduino Software (IDE). The GUI will display patient information and pump performance data. The GUI allows the user to turn the pump on and off, monitor the flow rate and intestinal pressure, and will record the time if the feeding tube is disconnected. The time the patient is disconnected from the feeding tube system is used to recalculate and adjust the flowrate accordingly once the patient is reconnected to the device to ensure delivery of complete nutritional needs. The flowrate adjustment data used for coding is extracted from the PEPuP Protocol for 24-hour volume-based enteral feeding which is the common method used in the hospitals to determine the feeding flowrate.

Results and Discussion The first prototype is currently being developed. The flowrate range is set from 1–300 mL/hr in 1 mL increments and accuracy to within ±10%. An encoder is used for the pump to monitor the accuracy of the flowrate. The schematic diagram below (**Figure 1.)** is an overview of the feedback loop that the pump will respond to in order to automate the flow rate. The timer button will measure the time away from the feeding and adjust the flow rate to ensure the minimum calories per day is met accordingly. If the pressure is below a value, the pump will continue flow rate as initially set. If the pressure rises above the threshold,18.6 mmHg the average pressure in the duodenum, the feeding will stop all together until the value is lowered below the threshold.[2]

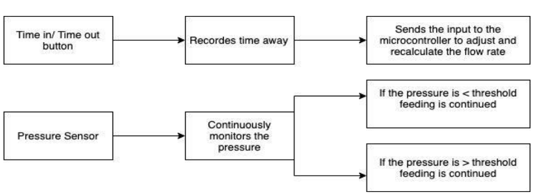

Figure 1. The flowchart to the left shows how the feedback control system functions. The pump follows the caloric requirement, taking into consideration the time left in the day, the pressure of the stomach, and the time the patients are out of the room in order to ensure delivery of caloric needs.

Conclusions: In summary, the overall objective of this project is to design an automated feeding tube that positions itself in the duodenum and estimates residual volume in the stomach using a pressure sensor that is connected to a programmed feeding pump. This automated feeding pump can enhance the efficiency of the feeding of patients in the ICU which will lead to a decrease in the incidence of muscle atrophy.

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References: [1] K. Koukourikos, et al. "Muscle Atrophy in Intensive Care Unit Patients" Journal of Academy of Medical Sciences of Bosnia and Hezegovnia. (2014).
[2]Chen, J. H., et al. Intraluminal pressure patterns. Scientific reports, (2017) Vol. 7, 41436.