Pneu-Mo: A Pneumothorax Patient Monitoring System

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Introduction

Pneu-Mo is a new pneumothorax patient monitoring system that aims to solve the many problems tied to the traditional three-chamber chest drainage system used in pneumothorax treatments. The biggest issue with the current industry standard three-chamber chest drainage system is that the device is not able to display and track pneumothorax patients' conditions, specifically the rate air leaks from the lung. This results in the patient needing many unnecessary x-ray and CT scans to observe their current condition, which leads to prolonged stays at hospitals, in addition to the expensive costs of scans.

Objectives

Our solution to these problems is a system that combines hardware and software. The hardware device is attachable and adaptable to any three-chamber chest drainage system on the market, and wirelessly transmits real-time statistics regarding the patient's condition to proprietary software that displays such information.

Materials and Methods

Microcontroller and Bluetooth:
Our current iteration of the prototype uses an Arduino Nano as the main microcontroller for processing the air flow readings and communicating with our software wirelessly. We downsized from an Arduino Uno to fit the components within the 3D printed hardwell shell, but we look to transition towards using cheaper and low-power microcontroller alternatives in the near future. The data transfer is handled by an HC-05 Bluetooth module, which has proven to be reliable in our testing.

Airflow Measurement:
We currently use a mass air flow sensor to measure the air flow in Standard Liter per Minute (SLM) units.

Hardware Component:
The Pneu-Mo hardware component is encased in a 3D printed shell that is waterproof, reusable, and attachable to any three-chamber chest drainage system on the market, which allows the device to be easily introduced into current healthcare systems at a low cost.

Breakdown of System and Components

Figure 1: Pneu-Mo System Diagram
The Pneu-Mo system comprises a hardware device attached to the three-chamber chest drainage system and software that runs on an external device to wirelessly monitor the patient's condition in real-time. Our system allows doctors and other healthcare workers to monitor the condition of a pneumothorax patient without being present with the patient.
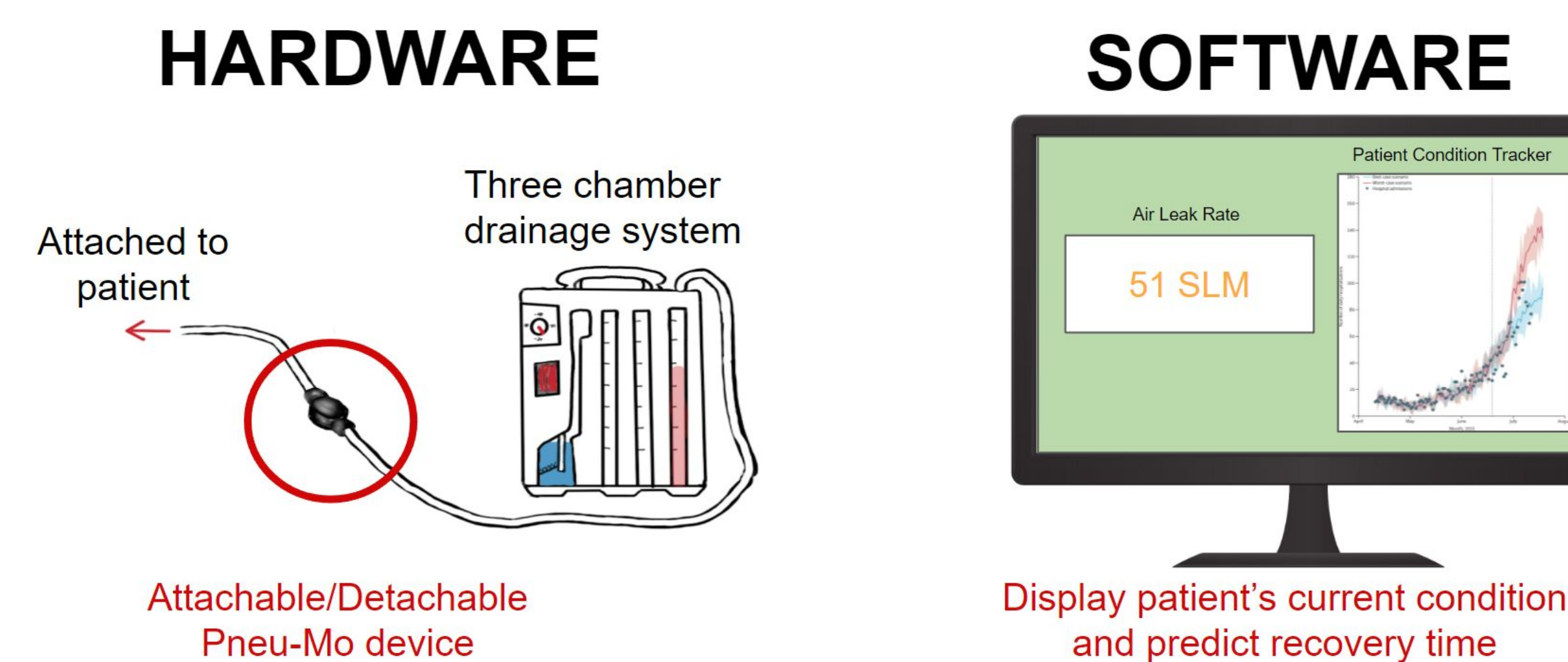

Figure 2: Diagram of Hardware Components
The following diagram shows the different components stored within the hardware device, which connects to the patient's chest tube on one end, and the three-chamber chest drainage system on the other end. The Arduino Nano, HC-05 Bluetooth transceiver, and battery are water sealed, with the mass air flow sensor being the only component exposed to fluids. The device is able to operate while connected to a power outlet and also temporarily on a backup battery in situations where the patient needs to be transported.
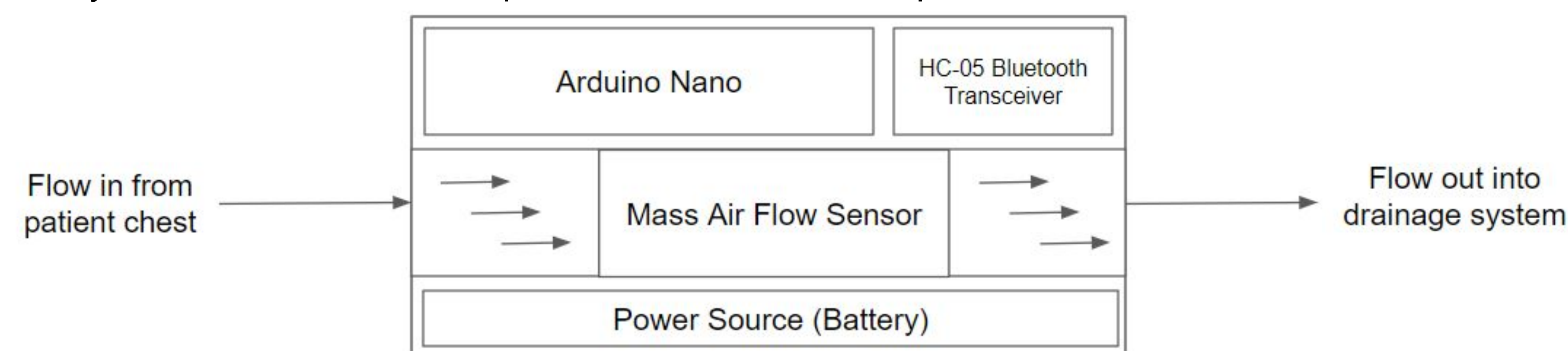

Figure 3: CAD Design of Hardware Shell
The electronics and sensor of the Pneu-Mo device is contained in an outer shell. Below is the CAD of the outer shell. The threads on each sides of the shell are for a changeable component, which we will use to vary the tube sizes. This component can be seen on the right.
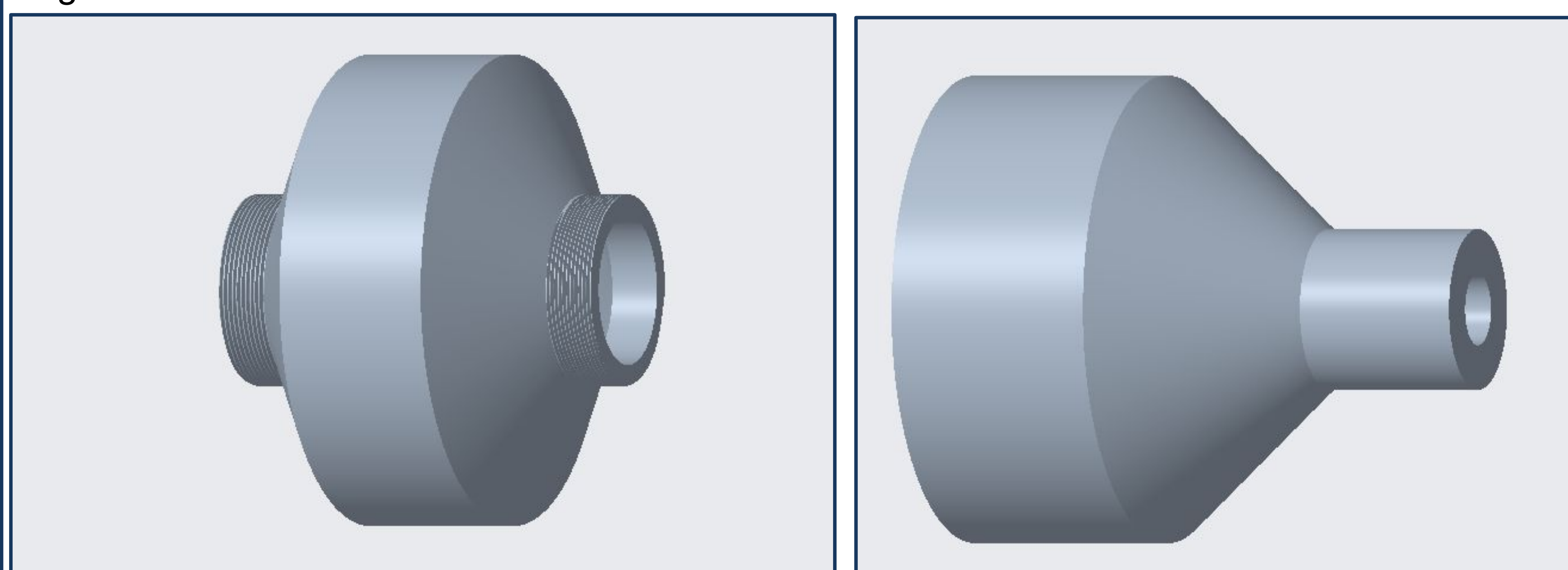

Figure 4: Software User-Interface
For use as a visual user-interface for the patient, doctors and nurses, the following app has been developed. Through the Pneu-Mo app, users can view real time statistics based on received data from the HC-05 Bluetooth module. In addition to visually plotting the data, the interface is also capable of live-tracking and updating of the plot. Pause, play, and stop buttons can be used to control the output of the plot.
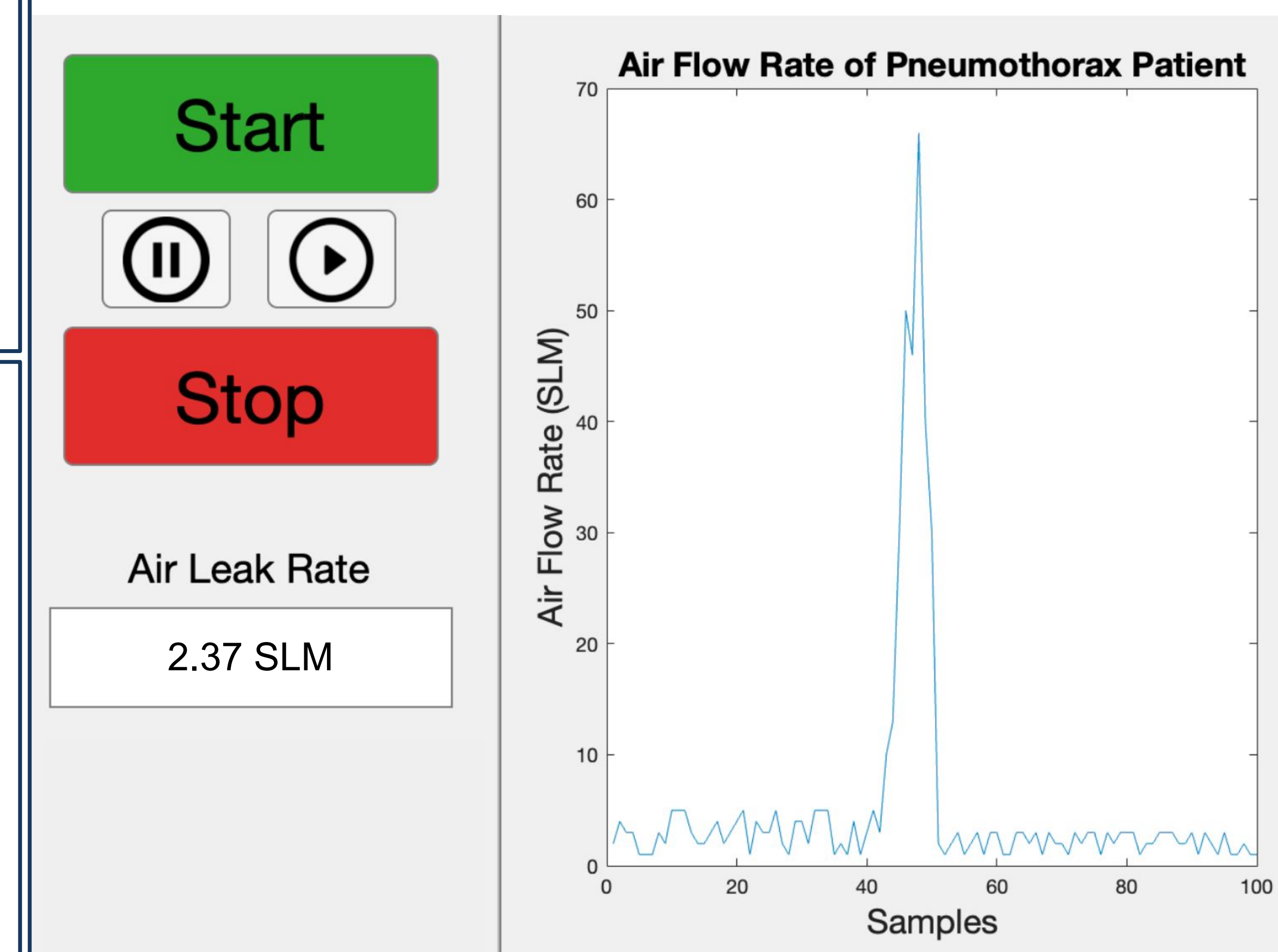
Conclusion and Next Steps

The Pneu-Mo system is an effective solution for monitoring pneumothorax patient conditions throughout their treatment. With a hardware prototype and basic software interface developed, our next steps are to:

Reduce Costs and Improve Durability:
The current mass air flow sensor has a high cost price and is prone to damage when exposed to fluids over extended periods, We have developed an alternative solution using a low cost differential pressure sensor to measure air flow and can be sealed off from fluids.

Implement Recovery Time Prediction:
We look to utilize the tracked air leakage data from the patient and apply Machine Learning techniques to predict patient recovery time, with the hopes that we can further reduce patient treatment time.