Quantitative Comparison of Ventilation Parameters of Different Approaches to Ventilator Splitting and Multiplexing – Supplemental Digital Content

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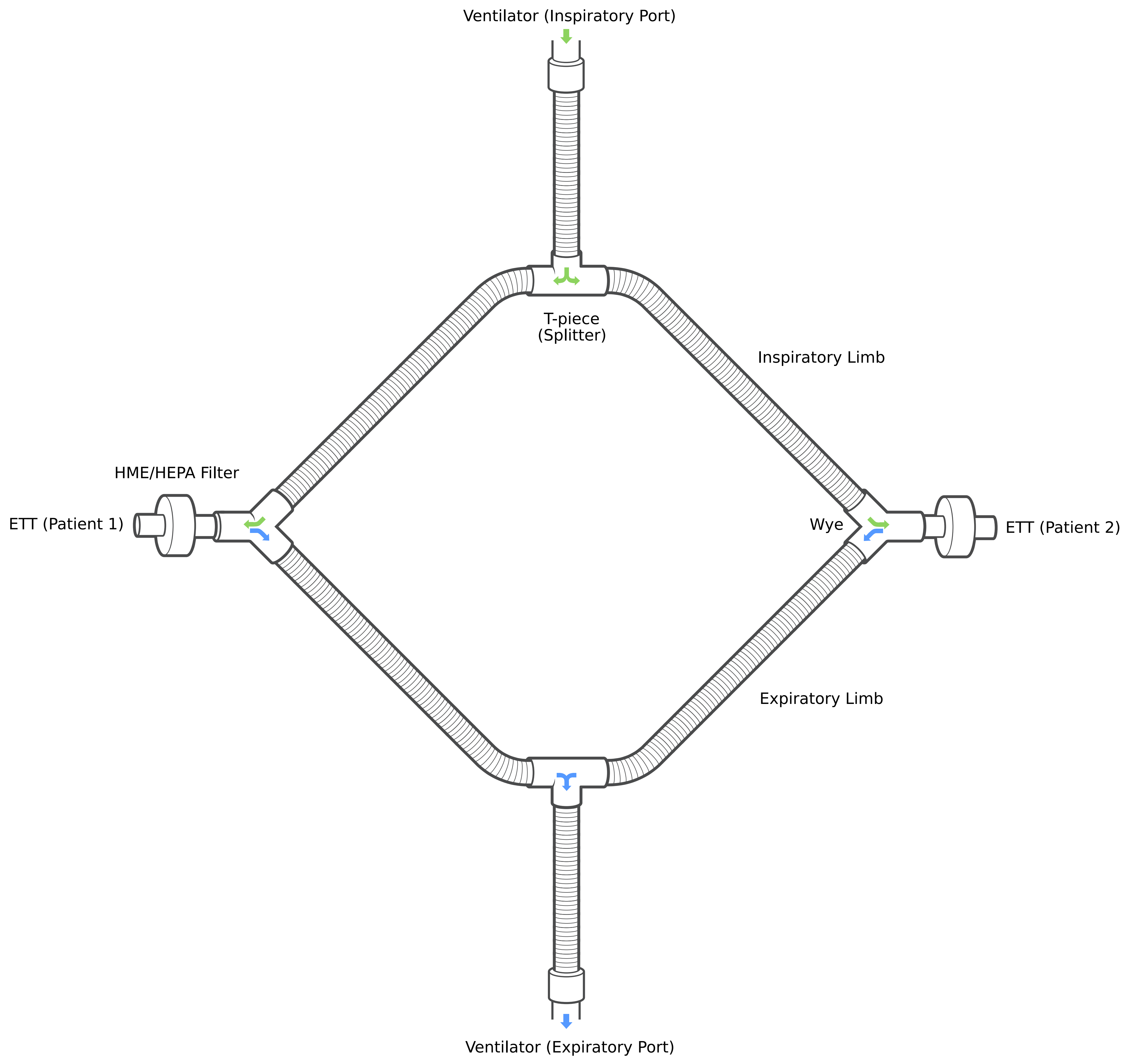
Detailed Methods

A dedicated testbed, equipped with pressure and flow sensors strategically placed in multi-ventilation circuits, facilitated comprehensive data acquisition. Four pressure sensors (HSCDRRN001PDAA5; Honeywell) connected to a USB-6001 multifunction I/O device (USB-6001; National Instruments) and up to nine flow sensors (SFM3300-D; Sensirion), were employed. MCP2221A chips served as I2C interfaces for flow sensor signal reception, connected to a central computer via USB Mini-B breakout boards. Real-time data collection was achieved using a custom Python script executed on the central computer, programmed to record five respiratory cycles per run at a rate of 20kHz. This setup allowed continuous monitoring of respiratory pressures and airflow during mechanical ventilation, ensuring detailed datasets for subsequent analysis.

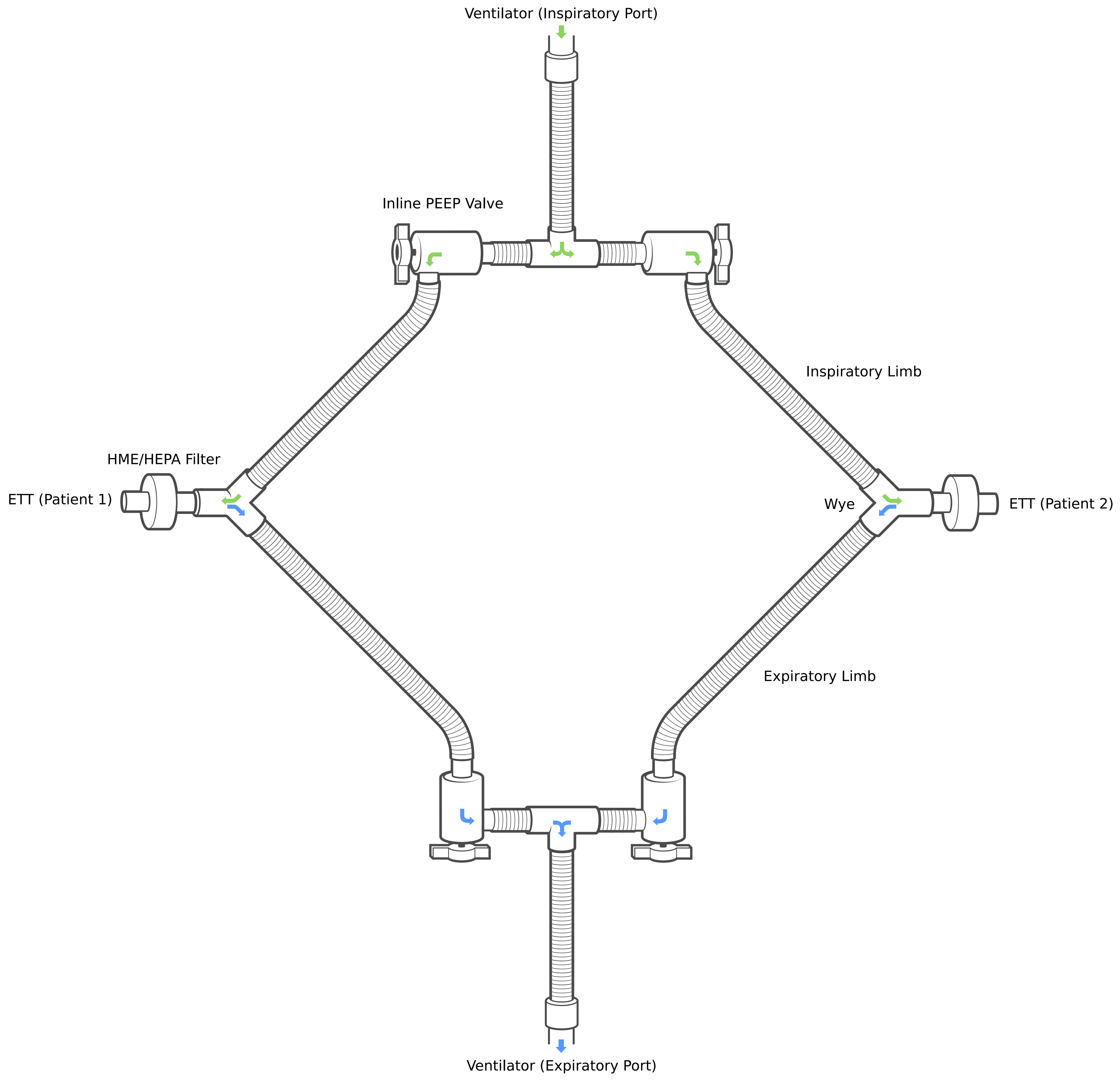
A developed MATLAB script processed saved data, employing a 1-D digital filter to eliminate noise from pressure sensor data. It extracted maximum and minimum values for each respiratory cycle, determining PIP and PEEP. The script generated time-series plots of pressure readings (similar to Figure 2 in main manuscript) and tidal volume plots by integrating and subtracting flow sensor readings. These visualizations unveiled data trends and anomalies.

The ventilator was maintained at the following settings for all experiments: a respiratory rate setting of 20 bpm, a 1:2 I:E ratio, an inspiratory time (T_{insp}) of 1.0, and an oxygen fraction of 21% (i.e., standard room air). To initiate each experimental run, the simulated lungs were completely deflated, and the system was allowed to stabilize for a minimum of two minutes before the data collection.

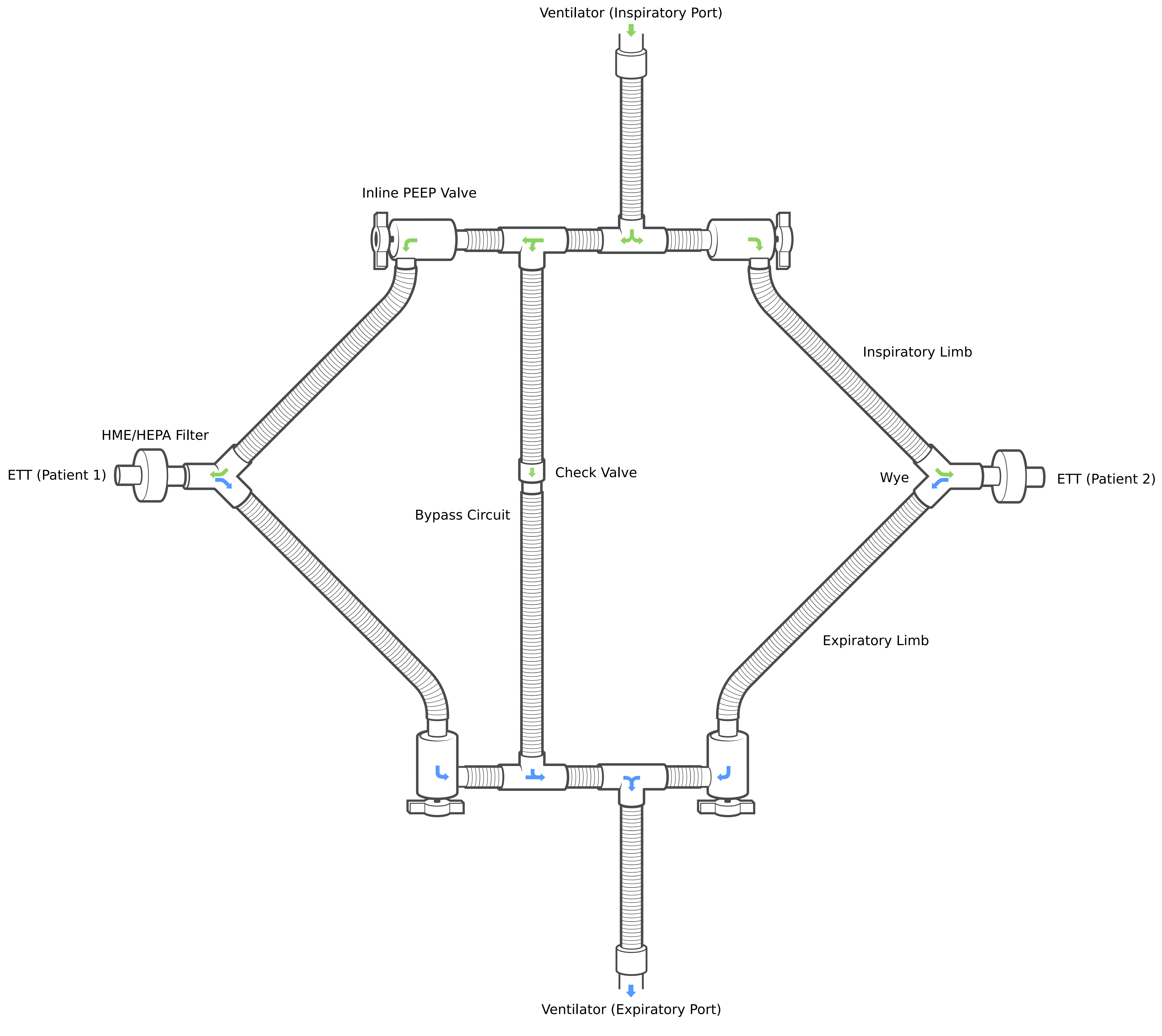
Simple Split Ventilation



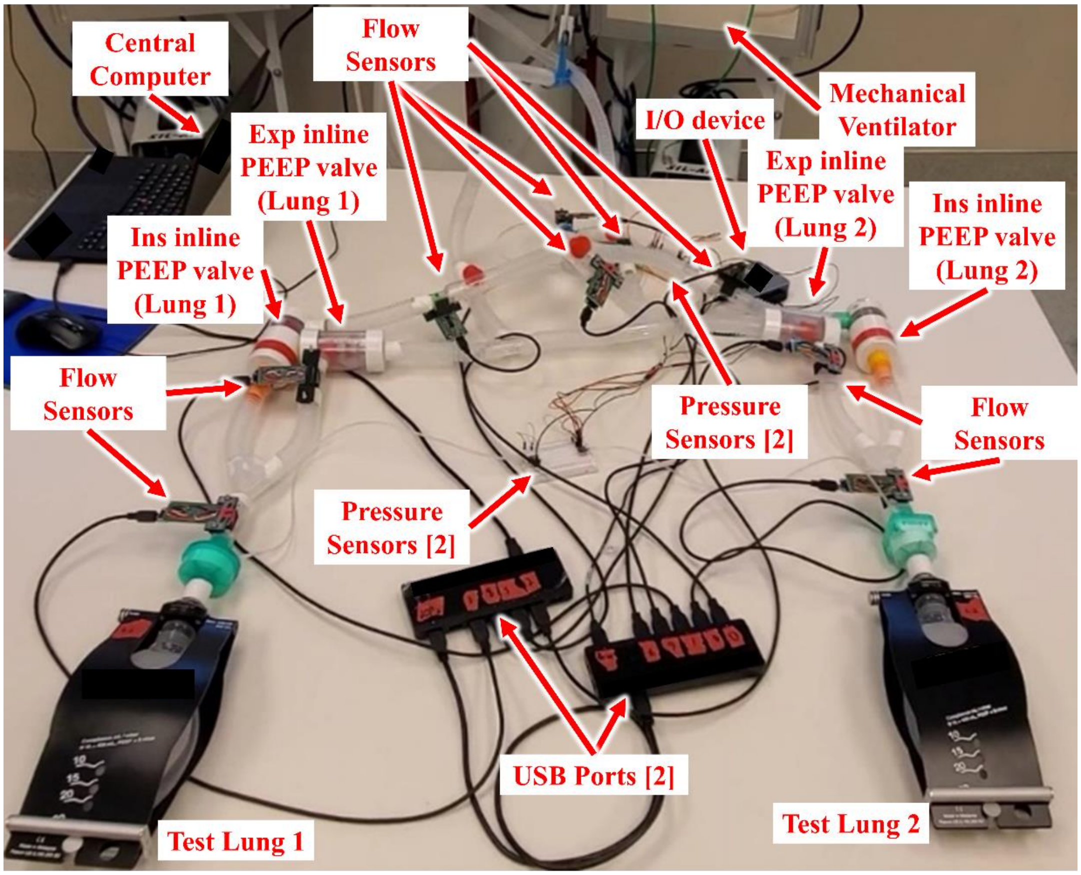
Simple Differential Ventilation



Differential Multiventilation



eFigure 1. Schematic illustration of Simple Split Ventilation (SSV), Simple Differential Ventilation (SDV), and Differential Multiventilation (DMV) [1].



eFigure 2. Example of the experimental setup for Differential Multiventilation (DMV) testing.

References

[1] Roy S, Bunting L, Stahl S, et al: Inline Positive End-Expiratory Pressure Valves: The Essential Component of Individualized Split Ventilator Circuits. *Critical Care Explorations* 2020; 2: e0198.