BronchEye: Bronchoscopy Complication Management

Managing bleeding events in the airway for improved patient safety

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JOHNS HOPKINS BIOMEDICAL ENGINEERING

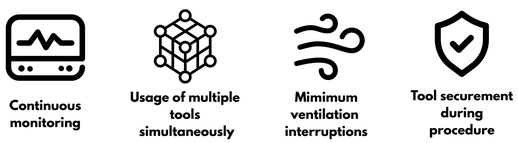
Problem Overview

Hundreds of thousands of interventional pulmonary operations are performed after endotracheal intubation in the US annually. These procedures use both a **camera to visualize the airway** and another **tool to operate** on it.[1,2] In robot-assisted bronchoscopies (RAB), the current gold-standard for such operations, **clinicians cannot use both tools simultaneously**. This can **delay management of complications**, such as airway bleeding, as pulmonologists switch between instruments.[3,4,5]

Manufacturers have attempted to design multiport adapters that allow for the insertion of multiple surgical instruments simultaneously. However, these solutions either **obstruct airway visualization**, **compromise the airtightness** of the ventilation circuit, or allow only a **limited range of tools** to be used.

Need Statement

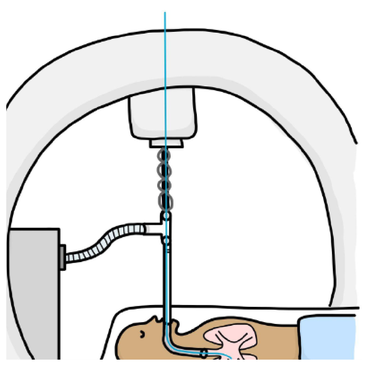
Interventional pulmonologists need to be allowed for simultaneous visualization and tool usage in order to reduce the number of interruptions in ventilation and serious complications during pulmonary procedures.



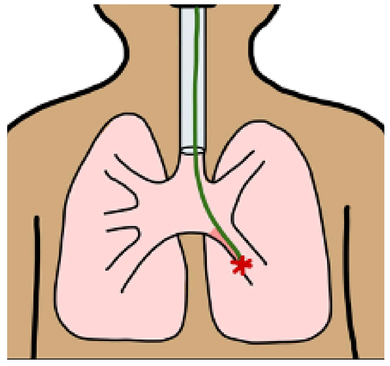
Solution Approach

Our approach **enables visualization** within the lungs and central airway while preserving **full tool functionality** and **ventilation**. It integrates seamlessly into existing workflows without introducing additional steps or burden for bronchoscopists, allowing **continuous monitoring of bleeding events** and reducing rates of RAB complications.

Opportunity for Improvement



RAB workflows only allow for insertion of one tool at any point during the procedure



Bleeding caused by a tool cannot be detected at onset due to the lack of visualization

800%[6,7]
increase in RAB, 2019-2023

661,241[8,9]
relevant operations annually in the US

$4.78B[10, 11]
in direct costs from complications

Results

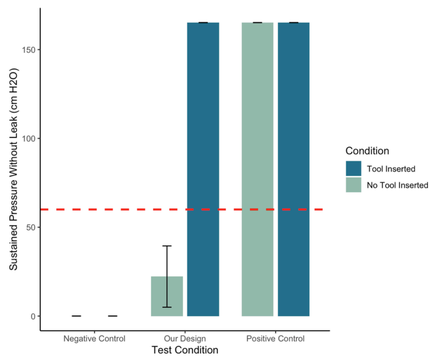


Figure 1: Results of continuous airflow bubble test.

This test verified that our design can remain airtight under multiple testing conditions.

The prototype was tested both when surgical instrument(s) were inserted inside the design, and when they are removed.

The results showed the design successfully sustained a pressure significantly above the acceptance criteria of 60 cm H2O before bubbles formed.

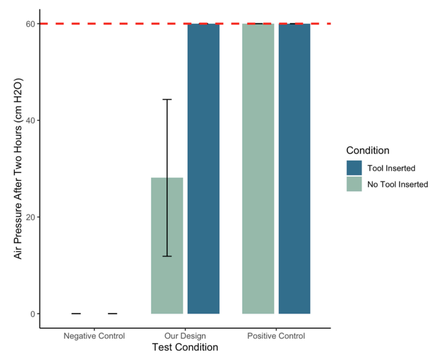


Figure 2: Results of pressure decay test.

This test verified that our design can remain pressurized under various testing conditions.

The prototype was tested when surgical instruments were inserted in the design, and when removed.

The results sustainance of a pressure above the acceptance criteria of 60 cm H2O for the duration of two hours in the tool inserted condition

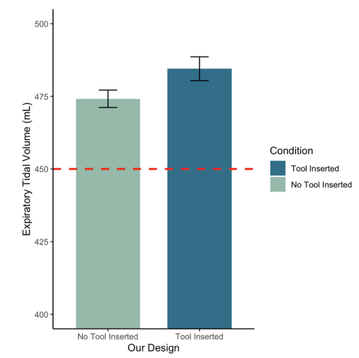


Figure 3: Results of ventilator test.

This test verified that our prototype limits air loss at simulated airflow rates and pressure levels.

The prototypes were tested both with a camera inserted and not inserted.

This test verified that our design maintained airflow above 95% of the administered air volume when a camera was inserted.

Conclusion

- Our design can pressurize without air leaks up to 165 cm H2O, significantly exceeding regulatory standards of 60 cm H2O and typical maximum pulmonary pressures of 25 cm H2O.
- Without a camera inserted into our design, acceptance criteria were not always met, but this risk is mitigated by the inclusion of an additional component to be added when no tool is inserted.
- Additionally, over a two hour simulated operation, our design does not depressurize when a tool is inserted.
- When connected to a ventilator circuit, end-expiratory tidal volume remains above 95% of administered volume, indicating minimal air loss and the potential for safe ventilation.
- With our design verified to meet each of our most significant user needs, we plan to continue iterating and conducting tests while moving towards technology licensing and research dissemination.

References

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