INTRODUCTION

Electrosurgery is a method of cutting tissue using a high frequency electrical current. Electrosurgery is effective because it limits the blood loss during procedures by sealing the tissue through cautery as it cuts. Unfortunately, electrosurgery generates smoke which limits a surgeon’s visibility and exposes operating personnel and patients to potential health hazards.

The smoke plume created from one gram of cauterized tissue is equal to six unfiltered cigarettes. Surgical smoke plumes are composed of 95% water and 5% organic particulate matter. This makes the plume a perfect carrier of dangerous viruses and bacteria. There have been documented cases of HPV, HIV, and hepatitis spreading during surgery. Surgical smoke plumes have also been linked to chronic sinus infections and cancer of the throat, nose, and mouth.

OBJECTIVE

The focus of our project is to combine suction and cautery capabilities into a single device for smoke evacuation during electrosurgery.

Devices currently on the market to address this problem have several shortcomings. The smoke evacuation is inefficient and a large amount of smoke escapes, creating a health hazard. Additionally, the smoke creates a barrier for line-of-sight during procedures. Our design integrates suction inlets on a standard cautery pen (see below) to evacuate smoke at the source.

KEY COMPONENTS

CONTROLS

BLADE

INLETS

SOLIDWORKS SIMULATION

Flow simulation was performed on multiple concepts to visually compare flow characteristics and inlet flow velocity. Concepts were evaluated for highest inlet velocity, and most even coverage of fluid flow.

DESIGN OPTIMIZATION

In order to optimize our design, we analyzed the head loss in the system (hose, adapters, suction pen). The predicted head loss was compared to the pump head of the vacuum being used. After setting up a MATLAB code to iterate on the calculations, we were able to calculate the ideal inlet size to maximize inlet velocity. These calculations can be applied to different pump head values to optimize for any pump.

CONCLUSION

The new design integrates suction ports into a cautery which allows for inline smoke evacuation during a surgical procedure. The size of the inlet ports are optimized for a specific vacuum and should be adjusted for optimal performance with other vacuum sources. Future work may focus on design improvements to prevent clogging of suction vents, connection to the vacuum system, or ergonomics and industrial design of the device.

PHYSICAL TESTING

Physical testing was performed on raw chicken as an analog in a controlled environment to be repeatable. Particulate matter created by the smoke was measured using a handheld air quality monitor. Each prototype was tested independently, measuring PM2.5 particulate in $\mu g/m^3$ with the goal of minimizing the particle contaminants.

The contaminant readings showed that our optimized design performed better than our first design and the sponsor’s design. It also performed better and much more consistently than the current method of using a separate suction device.

![Graph showing particulate matter readings for different designs](image)