Neurosurgical Electrocautery Forceps
Mid-Semester Design Report
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Abstract

Electrosurgical instruments date back to 1891, when doctors first harnessed the ability to use electricity to coagulate blood and cut tissue during surgery. The "bovie" was the first electrically charged metallic instrument in clinics back then. Crude and unreliable in its ways, doctors and nurses were often subject to shock and electrocution risks in the operating room. These conditions are incomprehensible by today's standards, and that is why we see a radically different instrument today. One that does not heat up to cauterize, but instead passes radio frequency between the tips to do the cauterizing or coagulating work. Cauterization is a procedure performed often used to remove lesions or control bleeding and may be performed thermally, electrically, or by laser.

Introduction

Neurosurgery is a precise practice, with exceptionally fine tools, and steady surgeons. Dr. Behnam Badie, MD, felt his instruments were compromising his technique, and came to the biomedical engineering program to search for an answer. The instrument he has ideas for is an electocautery forceps, also known as bipolar, foot controlled, coagulating forceps.

An electrocautery forceps currently consists of hand-held forceps connected to a radio frequency generator. The forceps design is commonly called "micro bayonet" due to its curved, bayonet-style structure. The generator is activated using a foot pedal, usually located on the floor beneath the operating table(some common designs of foot pedals can be found in Figure 1). When the pedal is not depressed, the forceps can be used to grab and pierce tissue. When the pedal is depressed, it activates a flow of radio frequency between the two tips of the forceps, and acting similar to a microwave by heating up and coagulating any blood in between the tips of the forceps.

Figure 1

One problem with the foot pedal is that the surgeon sometimes needs to pause his procedure during the surgery in order to find and depress the foot pedal. A second, more prevalent problem is that there is often multiple foot pedals for other various instruments beneath the operating table. This has led to the activation of the incorrect devices and failure to activate the correct device in time.

To avoid this, Dr. Badie would like to see a new design that allows the forceps to be activated from some mechanism on the forceps themselves. He feels this improvement will allow him to grab tissue, coagulate any blood, and release in one fluid movement.

In order to maintain the precision and accuracy with a new design, some limitations were made clear. The switch must be relatively small, or placed correctly in order to give the surgeon full view of what he is operating on. The switch should be accessed ideally with only one finger, preferably the forefinger, and without requiring the surgeon to move his hand position. In order to avoid any extra movements, the switch should be activated by light pressure. Any switch used cannot have any sharp edges that could catch on the surgeon's gloves, clothes, gauze, etc. Since the current design runs off a generator powered by a wall outlet, any change in the generator must also be powered by a wall outlet. Finally, it is preferable that a new instrument should not have to be made for each surgery, and therefore the design should be resistant to the sterilization process (i.e. – steam at 250°F for 15-20 minutes, gas, or autoclave).

There is, however, still information needed. New design ideas have been produced and one of the main deciding factors in choosing which one will be pursued is the comfort of the surgeon's hand on the instrument. The design ideas will need to be taken to Dr. Badie to determine which is to his liking. Another deciding factor is the dimensions of the forceps, where again comfort of the surgeon comes into play. Since forceps come in many different shapes and sizes, we will need to obtain a model that we can take actual measurements from.

Background

In the design of any new device, the necessary background research must be performed first. During our research, both a better understanding of the instrument and new concepts were sought out. Searches for existing tools related to ours were done over the Internet and at the libraries. We found a variety of supply companies that carried forceps similar to what we are studying. ASSI (Accurate Surgical & Scientific Instruments), Conmed, and Vallylabs were companies that had forceps most similar to Dr. Badie's.

Bipolar cautery uses high frequency (radio frequency) electric energy to melt and coagulate tissue placed between two directly apposed electrodes. Because the electrodes are closely approximated, low voltages of electricity are adequate. It is highly effective for use in hemostatic ligation of small vessels and vascular tissue, and can be preformed quickly.

Electrosurgery units are used to cut or coagulate tissue, or a combination of the two. The surgical outcome depends on the waveform generated by the ESU. A pure cut waveform is continuous, undamped and sinusoidal in shape. The fluid in the cell heats to the vaporization state resulting in the cell exploding.

Coagulation, known as the coag mode, occurs when the cell fluid is allowed to cool between heating, as explained by a Bio-Tek Instruments, Inc. article. The waveform consists of a dampened cut wave that oscillates on and off, similar to the defrost mode on your microwave. This heats the cell fluid, but allows it to cool in between, thus avoiding cell rupture and only causing blood to coagulate, or clump.

Bipolar electrocautery eliminates the need for a patient grounding pad, which is what is currently used in monopolar electrocauteriztion. Bipolar cautery exceeds monopolar cautery further because the current does not pass through the entire body, thus eliminating the danger of burns distant to the site of the forceps tips. Because of these characteristics of bipolar cautery, its depth of injury to surrounding tissue is minimal and it produces little smoke.

Design Ideas

Button Prior to Split

One design produced by the group is to place a circular button enclosed by a "bubble" at the base of the tweezers, just before the forceps divide(Fig 2). While watching our client hold the forceps, this seemed like a location out of the way of the surgeon's hand as well as within reach, although a certain amount of finger flexibility may be necessary. Our thoughts are that the "bubble" button should be made out of a durable rubber or plastic. With the button position at the base of the forceps, the wires would theoretically not interfere with the surgeon's hand placement as well as be out of the way so as to not be vulnerable to catch upon objects.

Figure 2

Plate Mount Across Top

An alternate solution is attaching a metal plate on the inside of the arm just after the forceps separate (Fig 3). The plate will span the distance across the top of the forceps in the closed position (Fig 4) and will be slightly raised so as not to hinder the opening and closing movements of the tweezers. The button will be placed on top of the plate. By using the plate, the button can be placed further up the tweezers, within easier reach of the surgeon. Possible problems with this solution are the metal bending or getting in the way of the tweezers movement. A slight variation of this design is to have a plate attached to the forceps in such a way that it can be moved the length of the forceps accordingly (via slide or clip) to each surgeon's preference. Instead of the plate being soldered onto the forceps, it will have to be attached in such a way that it will able to be moved, but sturdy and not accidentally moved during surgery. In both of these designs the surgeon would simply have to close the forceps and push the button to activate the cauterizing effect.

Figure 3

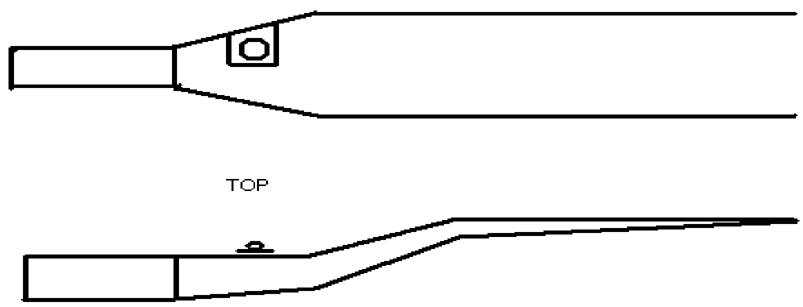

Figure 4

Valleylab's Handswitching Model

A final option would be the use of an existing product made by Valleylab. Their product is titled as "coagulation forceps – bipolar handswitching, non-insulated" and can be seen in Figure 5. This current product allows the surgeon to both grasp tissue and cauterize tissue separately without the need for a foot pedal. The cauterization is activated by a set pressure exerted on the forceps as the surgeon squeezes the forceps together. This allows the surgeon to grasp tissue with light force and not cauterize the tissue, or to exert additional force if he or she chooses to cauterize the tissue.

Figure 5

Top Selection

We have selected the design with the plate mounted across the top for its versatility and ability to fulfill all of Dr. Badie's specifications. It is versatile enough for both left and right handed surgeons, as well as surgeons of different hand sizes. The design with the button mounted at the base may prove difficult for some surgeons to reach, and therefore seemed less optimal. The current product we found from Valleylab does fit many of the specifications, but was discarded for now because we felt it did not offer the flexibility that the plate mount across the top does, in terms of allowing the surgeon to use any range of pressure any time he or she chooses.

Conclusion

In an environment such as that of neuro-surgery OR, many minor parts of the tools used can cause large problems. Much time was spent brainstorming of possible scenarios, environmental conditions, and possible mechanical defects that could contribute to potential problems when operating this instrument. When being used normally this tool will be exposed many conductive materials including blood, and body tissues. These pose the treat of either causing a short in the electronics or of building up over time in the internal parts of the button causing a potential malfunction. To remedy this the entire tool, except the conducting tips, could be enclosed in a temperature resistant rubber or plastic. This solution would not only prevent materials from reaching the tool but also would also lessen slippage in the surgeon's hands, increase appearance, and cover any sharp edges which could cut gloves or damage tissue. Another major problem would be if the button were stuck in the "on" position resulting in permanent current flow. If the surgeon was unaware of this and continued to use the tool, cauterization would occur on any tissues touched. Two safety devises were thought of. The first and simplest would be to include a small light, wired in series and located somewhere within the range of vision of the surgeon. The light would turn on whenever current was passing though notifying the operator of the cauterizing effect. The second would be a timer which only allows current to run for a given time. Current must be stopped and started again in order for the timer to restart. If the button was turned permanently "on" the timer would only allow current to pass for a normal length of time before shutting it off. Another safety devise, which was part of our design ideas, was a sliding switch. If a button is located in a poor position, which causes extra movement by the surgeon to operate it, tissues could be jerked or torn. By incorporating the button on a movable devise ensures that the tool could be operated in the most comfortable manner by allowing the surgeon to adjust it according to their liking.

References

1.) *Application Note: Electrosurgery Analyzer Primer*. Bio-Tek Instruments, Inc. http://www.biotek.com/biomed_frame.asp?content=biomed_application.asp?appid=95.

2.) Badie, Behnam, MD, Lapsiwala, Samir, MD. Personal Interview. 24 Sept. 2001.

3.) O'Neal, Burke. Personal interview. 28 Sept. 2001.