

Optimization of Thermocautery in Excisional Dermatologic Surgery

JOSHUA E. LANE, MD,* EDWARD M. O'BRIEN, PhD, PE,[†] AND DAVID E. KENT, MD*

PURPOSE Electrosurgery is routinely used in cutaneous surgery for hemostasis. Thermocautery can be used in patients with implantable cardiac devices. This technique relies on heat without electrical current passing through the patient to produce hemostasis. The temperatures and utility of a commercially available, adjustable thermocautery unit are examined.

METHODOLOGY Tip temperature of the commercially available thermocautery unit (Geiger model 150, Geiger Medical Technologies, Council Bluffs, IA, USA) was measured in air and tissue via a type E thermocouple (0.002 in. diameter) around the unit's tip. Time intervals of 20 to 30 seconds were recorded at device settings 1 to 9 in air and 3 to 8 on surgical patients (Institutional Review Board approval obtained).

RESULTS In vitro analysis demonstrated predictable temperatures at increasing settings in air: 350 to 900°C. Analysis in vivo during surgery demonstrated similar findings. Tissue contact decreased tip temperature by approximately 50% from in vitro values, and use in a bloody field caused a further decrease in the tip temperature.

CONCLUSION The thermocautery unit examined is an effective and safe unit to achieve hemostasis. In addition, the temperature may be adjusted as opposed to hand-held units that operate at in vitro temperatures exceeding 1,400°F. Hemostasis at approximately 100 to 400°C provided optimal hemostasis.

Geiger Medical Technologies (Council Bluffs, IA) loaned the thermocautery unit for purposes of this study.

Electrosurgery is routinely used in cutaneous surgery to achieve hemostasis.^{1,2} The presence of implantable cardiac devices (ICDs) requires routine preoperative history to determine the specific type of device that a patient has and what electrosurgical instrumentation may be used. An estimated 4% of Mohs surgery patients have ICDs.¹ Electrosurgical devices can interfere with the function of pacemakers and implantable cardioverter defibrillators, resulting in potential arrhythmias.² A survey of 166 Mohs surgeons

noted 25 episodes of interference of cardiac devices from electrosurgery.¹ The use of thermocautery is both safe and efficacious in these patients. To date, no specific data on temperature or performance parameters of a thermocautery unit in vitro or in vivo exist. The current study examines the utility of a commercially available, tunable, electrically powered thermocautery unit for hemostasis. This device offers the cutaneous surgeon an additional tool in the hemostatic armamentarium that may be used in patients with ICDs.

Methods and Materials

This study and its design were approved by the local Institutional Review Board. The Geiger thermocautery unit (model 150) was provided for this study by Geiger Medical Technologies (Council Bluffs, IA, USA) (Figure 1). A type E thermocouple (0.002 in. diameter) (Omega Engineering Inc., Stamford, CT, USA) was wrapped around the thermocautery tip (Figure 2). Time intervals of 20 to 30 seconds were recorded at device settings 1 to 9 in

*Division of Dermatology, Department of Internal Medicine, Mercer University School of Medicine, Macon, Georgia; [†]Department of Biomedical Engineering, Mercer University, Macon, Georgia



Figure 1. Tunable, electrically powered thermocautery unit (Geiger model 150).

air and 3 to 8 on surgical patients (Figure 3).

This thermocautery unit allows continuously adjustable heat settings that were measured. Initial measurement included temperature recording at each setting for a

30-second interval, including the time to achieve stable temperature, maximum stable temperature at each setting, and cool-down time.

The small mass of the 0.002 in. diameter thermocouple did not

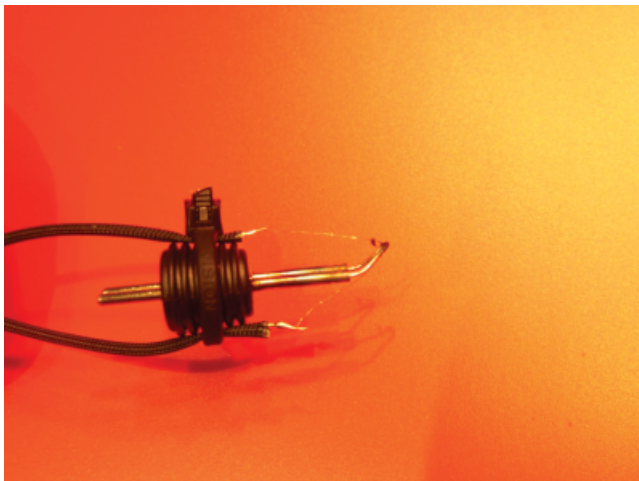


Figure 2. Type E thermocouple (0.002 in. diameter) wrapped around the thermocautery tip.

measurably change the tip temperature. The small voltage from the thermocouple was amplified by a factor of 100 and low-pass filtered with a 4 Hz fourth-order Butterworth filter (Figure 4). Sampling occurred at 10 times/second. The temperature was calculated using the ITS-90 Type E Thermocouple Direct Polynomial³ for the range of 0 to 1,000°C:

$$\begin{aligned}
 T = & 1.7057035 \times 10^{-2}(E) \\
 & - 2.3301759 \times 10^{-7}(E^2) \\
 & + 6.5435585 \times 10^{-12}(E^3) \\
 & - 7.3562749 \times 10^{-17}(E^4) \\
 & - 1.7896001 \times 10^{-21}(E^5) \\
 & + 8.4036165 \times 10^{-26}(E^6) \\
 & - 1.3735879 \times 10^{-30}(E^7) \\
 & + 1.0629823 \times 10^{-35}(E^8) \\
 & - 3.2447087 \times 10^{-41}(E^9)
 \end{aligned}$$

where T has units of degrees centigrade and E has units of microvolts.

Results

In vitro analysis demonstrated predictable temperatures at increasing settings in air: 350 to 900°C (Figure 5). The temperature of the unit at a maximum dial setting of 10 was estimated to be 1,000°C. The temperature at this setting was approximated because the fine wire type E thermocouple melted at this setting. Analysis in vivo during surgery demonstrated findings similar to the in vitro data (Figure 6). Tissue contact with the surgical wound decreased the tip temperature by approximately 50% from in vitro values, and an increased bloody



Figure 3. Use of tunable, electrically powered thermocautery unit in cutaneous surgery.

field further reduced these temperatures (Figure 7). It is well known that the presence of fluid

alters the efficacy of electrosurgery. This was also true when using the thermocautery unit in a



Figure 4. Thermocautery tip coupled to thermocouple and monitoring equipment.

bloody surgical field as depicted by comparing Figure 6 (dry surgical field) with Figure 7 (bloody surgical field). As can be seen in Figure 8, the time to achieve target temperature was approximately 5 to 7 seconds and cool-down time was approximately 10 to 15 seconds. Figure 9 compares the cool-down time for the thermocautery tip in room air, wet gauze, and water immersion. Water immersion resulted in a near-instantaneous cool-down time, while placement of the tip on wet gauze decreased cool-down time to less than 5 seconds.

Discussion

Electrosurgery is the standard for obtaining hemostasis in dermatologic surgery. Multiple types of electrosurgery exist and a brief review is warranted. The primary types used by cutaneous surgeons include electrodeiccation, electrofulguration, electrocoagulation, electrosection, and electrocautery (thermocautery). Dermatologists are most familiar with electrodeiccation (Hyfrecator), electrocoagulation (Bovie), and hand-held thermocautery units.

Electrosurgical units are classified and subclassified in a number of ways. The two primary types of electrical current are direct (as used in electrolysis) and alternating. Direct current corresponds to electron flow in a single direction—this is typically powered by a battery.^{4,5} Alternating current corresponds to a constantly

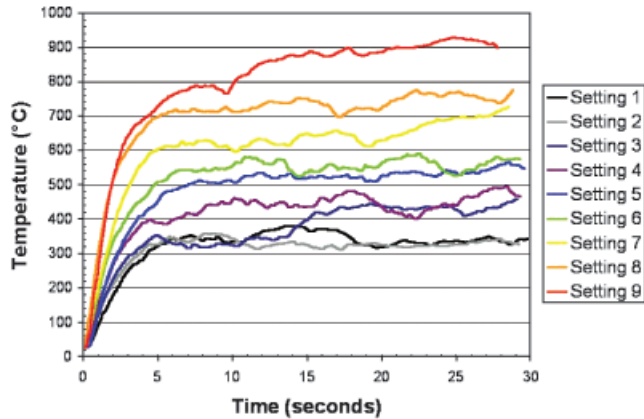


Figure 5. Temperature readings at thermocautery settings 1 to 9 in vitro (setting 10 not measured due to melting of a thermocouple wire).

changing direction of electron flow and is typically powered by 50 or 60 Hz electrical outlets.⁴ Electrosurgical devices produce voltages and currents in frequencies ranging from 500 to 2,000 kHz.^{4,6,7} The output waveform generated by specific electrosurgical devices defines their effect on tissue. These waves are classically categorized as damped or undamped. A similar effect can be achieved by interrupting undamped waveforms. Undamped waveforms are characterized by pure sine wave currents that result

in tissue separation with little hemostatic properties. Undamped waveforms are characteristic of cutting current as used in electrosection. The action on tissue yields a focused increase in heat that results in tissue rupture.⁸ Damped waveforms are marked by a decrease in the amplitude of subsequent wave oscillations with a resultant increase in tissue destruction and hemostatic properties.^{5,8} The faster the sine wave damps to zero correlates with subsequent hemostasis.⁵ The action of damped waveforms on

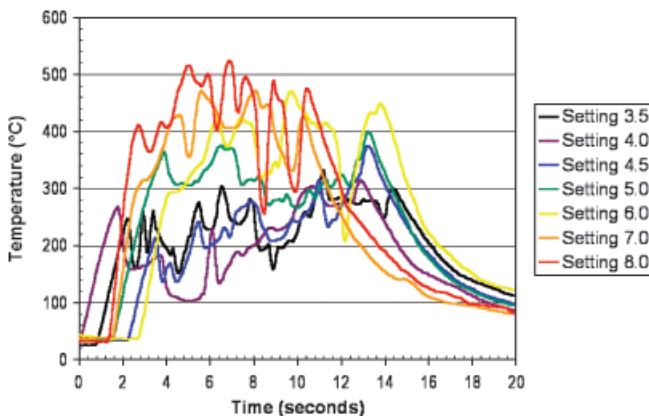


Figure 6. Temperature readings at different thermocautery settings in vivo in dry surgical field.

tissue yields oscillation of molecules with concomitant heat generation that leads to tissue coagulation and dehydration, resulting in sealing of blood vessels.⁸

Categorization of electrosurgical devices also includes monopolar versus bipolar and monoterminal versus biterminal. These terms are not interchangeable and often produce confusion. Monopolar and bipolar are used most correctly to define electrosurgery based on direct current, including electrolysis and electrocautery.^{5,8} Electrosurgical devices based on alternating current utilize current that enters and exits tissue variably, thus meaning that the dispersing electrode cannot truly be monopolar or bipolar.⁴ Despite this, the terms monopolar and bipolar have been used to denote the number of tissue contacting tips of a surgical electrode.⁹ While this is not correct in the electrical definition of terms, it has remained the most common means of interpretation. Thus, monopolar devices have a single treatment electrode while bipolar devices (i.e., bipolar forceps) have two treatment electrodes.

The terms monoterminal and biterminal refer to the use of a dispersive electrode (ground plate). Monoterminal refers to use of a treatment electrode in the absence of a dispersive electrode while biterminal refers to use of both a treatment and a dispersive electrode.^{4,9} Monoterminal tech-

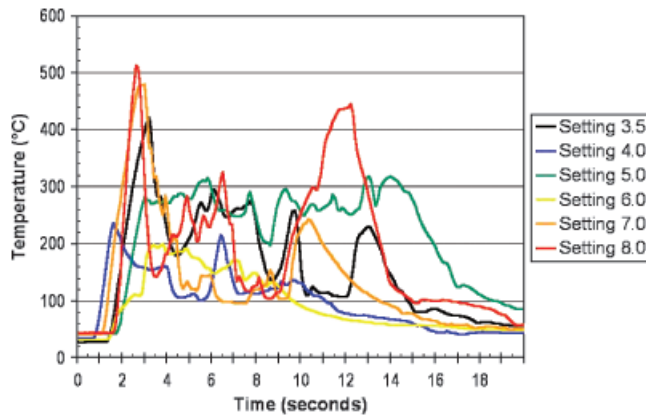


Figure 7. Temperature readings at different thermocautery settings in vivo in a bloody surgical field.

niques include electrodesiccation and electrofulguration (spark generated), while biterminal techniques include electrocoagulation and electrosection.

Electrodesiccation and electrofulguration represent monoterminial modalities characterized by damped, high-voltage, low-amperage current. Both utilize current ranges from 0.5 to 0.75 A with a voltage in excess of 2,000 V.⁵ Electrodesiccation occurs when the treatment electrode contacts the skin with resultant dehydration.⁹ Electrofulguration

occurs when the treatment electrode is held several millimeters from the skin surface. A high voltage allows a spark to bridge the air gap, with resultant superficial carbonization.

Electrocoagulation and electrosection are characterized by low-voltage and high-amperage current in a biterminal modality (grounding plate).⁹ Damped waveforms that are a characteristic of electrocoagulation result in effective hemostasis, while undamped waveforms in electrosection provide a pure cutting current

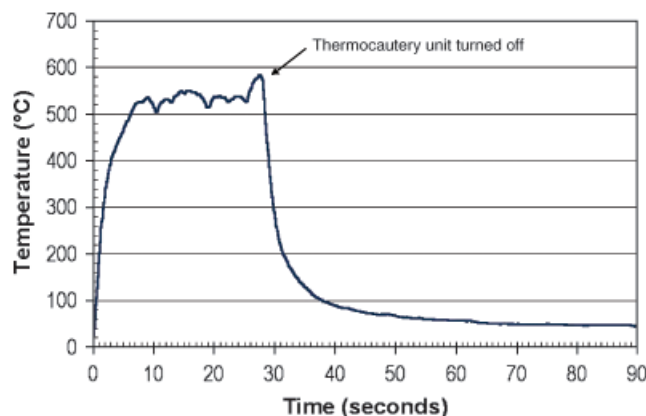


Figure 8. Time course for heating and cooling of the thermocautery tip in room air.

with little hemostatic properties. The Bovie electro-surgical unit is capable of producing both coagulating and cutting current and blending of each. It produces a current of 0.2 to 0.7 A and voltage less than 2,000 V.⁵

Thermocautery relies on heat generated by a high-resistance wire that completes an electrical circuit. Increased power results in increased heat generated by the wire or tip. Most hand-held thermocautery units are useful for small bleeding sites; however, the presence of a bloody field quickly overcomes the ability of such units. Electrically, wall-powered thermocautery units allow a greater efficacy of use in such fields as the energy source is more stable. Current applied to bloody surgical fields can also cause unnecessary tissue damage.¹⁰ Electro-surgical devices work best in less bloody fields—electrical current dissipates through blood and becomes less effective.^{8,10–12} Battery-powered (disposable) thermocautery units do not provide the same consistency in thermal output as with the more constant output from electrically wall-powered units because their power source fluctuates with use.

Thermocautery is commonly used in cutaneous surgery.^{1,2} It is useful for hemostasis of small bleeding sites as well as for patients with ICDs.¹³ A smoke evacuator may be used to decrease the risk of human papillomavirus or other infectious organisms.^{14–16} The use

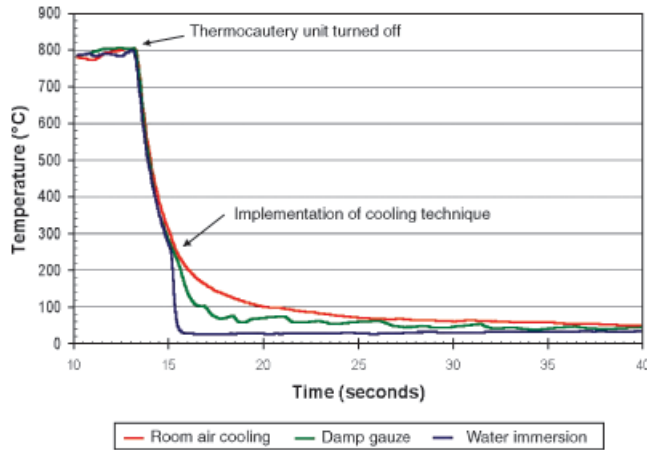


Figure 9. Comparison of tip cooling with room air, wet gauze, and water immersion.

of standard hand-held, battery-powered thermocautery devices carries limitations in efficacy for small bleeding vessels as the heat generated is high (1,400°C) and the temperature is not tunable. The present study examined the utility of a tunable heat thermocautery unit in cutaneous surgery.

Based on use of the Geiger thermocautery unit in numerous patients in multiple settings, we found the most useful device setting to range from 4 to 5. These settings correspond to temperatures of approximately 200 to 400°C in a dry field and 100 to 300°C in a bloody field. This allowed for the most effective searing of vessels without cutting or burning through tissue. Use of the thermocautery unit was effective in both “dry” and “wet” fields; however, it is most effective, like all electro-surgical devices, in less saturated environments. The unit quickly reaches peak temperature at various settings, with the average time approximating 7 sec-

onds. Importantly, the time to reach a safe cool-down temperature ranges from 10 to 15 seconds. The time required for the tip to cool below the burning point of paper and/or cloth is approximately 4 to 5 seconds. This is significant given the potential fire hazard of hot thermocautery tips. A useful technique to safeguard potentially hot thermocautery tips is to momentarily touch the tip to a wet gauze or place the unit’s tip on a wet gauze on the surgical field or tray when not in use.

Thermocautery differs primarily from other electro-surgical modalities as it utilizes heat instead of electricity to achieve hemostasis. Thus, thermocautery units do not produce electrical current that interferes with ICDs. El-Gamal and colleagues¹ reported 25 episodes of “interference” of cardiac devices by electro-surgery.¹

Types of interference included skipped beats, pacemaker reprogramming, firing of ICD, asystole,

bradycardia, decreased battery life, and tachyarrhythmia.¹ Pacemakers may be categorized as fixed rate or demand type. Fixed-rate pacemakers fire at a set rate regardless of external activity, while demand-type pacemakers fire at specific parameters based on the intrinsic environment.⁴ Electro-surgical devices have no effect on fixed-rate devices but can have catastrophic effects on demand-type devices. The greatest risk of pacemaker-related complications is with the use of electrosection.^{2,4,17}

Use of bipolar forceps with pacemakers is safe and reproducible as reported in the literature.⁹ However, there is no uniform consensus for the use of bipolar forceps with ICDs in the absence of appropriate cardiac monitoring. Most authors report the use of thermocautery to be safe with ICDs as no electrical current is produced.¹³ Use of the Shaw hemostatic scalpel (Oximetrix Inc., Mountain View, CA, USA) in pacemaker operations confirms the utility of tunable thermocautery, as the resultant temperature is similar to that in the present study.¹⁸ The Shaw hemostatic scalpel is a thermocautery device that utilizes a heated blade to bring about hemostasis as it cuts.¹⁸ Erdman and colleagues¹⁸ report a typical temperature approximating 170°C when using the Shaw scalpel. This corresponds to the optimal temperature utilized in the present study with thermocautery. The Geiger thermocautery unit produced a

temperature range of 100 to 300°C at optimal settings in a bleeding surgical field.

In summary, the use of a tunable, electrically wall-powered thermocautery unit serves as an additional tool in the surgeon's armamentarium to achieve hemostasis in cutaneous surgery.

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Address correspondence and reprint requests to: David E. Kent, MD, 308 Coliseum Drive, Suite 200 Macon, Georgia 31217, or email: dekent@dsspc.com