

## Settling the Confusion in Electrosurgery

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Electrosurgery and its offshoot, radiofrequency ablation (RFA), are standard tools in many of today's surgical procedures. Their primary functions are to cleanly and effortlessly cut tissue, control bleeding, and therapeutically destroy target tissue. Use of electrosurgery ranges from simple, office-based dermatology procedures such as removal of skin lesions to multiple devices used during complex surgical procedures such as open-heart surgery. The technology behind electrosurgery can be daunting for users without an understanding of electrical engineering fundamentals. To make matters worse, confusing terms and perceptions have evolved over the years. Let's make some sense out of this confusion.

### ELECTROSURGERY IS NEITHER CAUTERY NOR ELECTROCAUTERY

To control bleeding, electrosurgery uses heating. The concept that heat can control bleeding was used by Egyptians as early as 3000 B.C. to treat tumors and ulcers of the breast<sup>1</sup>. An iron was heated in a fire and applied to the bleeding area with a "fire-stick". This process, known as *cautery*, is derived from the Greek word *καυτήριον* (kaftírio), meaning hot iron. Cautery is the passive transfer of heat from a heated instrument to destroy tissue or control bleeding.

Rather than relying on an iron heated by a flame, modern day cautery uses an electrical wire heated by a voltage source and is therefore termed electrocautery. Figure 1 shows an example of an electrocautery device that is powered by a self-contained battery. The electrical wire has high resistance which causes it to heat up, much like the heating element in a toaster. In electrocautery, NO electrical energy flows into the patient. In electrosurgery, electrical energy DOES flow into the patient, and it is the resistance of the patient's tissue (and saline, if used) that causes heating. Cautery, electrocautery, and electrosurgery are often used interchangeably in the literature and spoken word. This is entrenched in medicine and our job is not to change this misnomer but rather to ensure users are aware of the distinctions.



**Figure 1. TOP: Bovie Model HIT0 battery operated electrocautery handle with disposable H100 low-temperature fine tip; BOTTOM: Detail of disposable tip.**

([http://www.boviemedical.com/products\\_aaroncauterics\\_low.asp](http://www.boviemedical.com/products_aaroncauterics_low.asp))

<sup>1</sup> Ch. 2. *Fundamentals of Electrosurgery Part I: Principles of Radiofrequency Energy for Surgery* by Malcolm G. Munro in *The SAGES Manual on the Fundamental Use of Surgical Energy*, L.S. Feldman et al. (eds.), Springer Science + Business Media, 2012

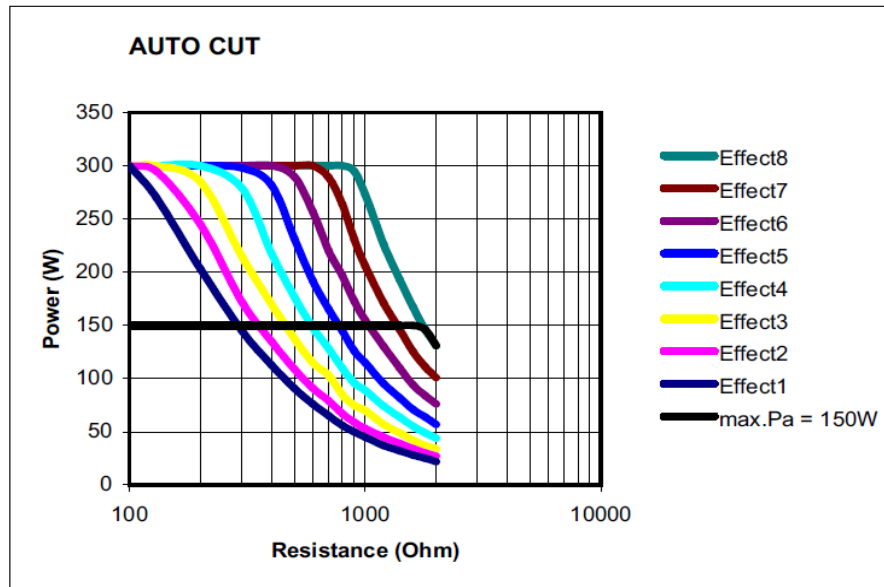
## 100 WATTS IS NOT 100 WATTS

The surgical staff sets up the electrosurgery generator for a particular procedure and adjusts the output power to 100 W. They activate the generator while applying an active electrode tip to the patient and assume 100 W is being applied, but this is not always the case. The electrosurgery generator is designed to produce output power over a range of *load resistances* and the 100 W setting is the maximum power that will be produced. The load resistance is determined by a number of factors, predominantly tissue type (fat, liver, muscle, etc.), electrode tip geometry, electrode tip area contact with tissue, use of saline, and effects of electrosurgical change on tissue. For example, the last factor means that as tissue heats up and desiccates tissue (water is driven from the tissue) during the electrosurgical process, its resistance increases. If tissue burning and resultant carbonized eschar forms on the electrode tip (see Figure 2), resistance will increase even more. Electrosurgery generator manufacturers are required by safety standards to include power versus load curves for the different output modes of their generators, (examples in Figure 3 and Figure 4). In Figure 3, the user can select the type of load curve (Effects 1 – 8).

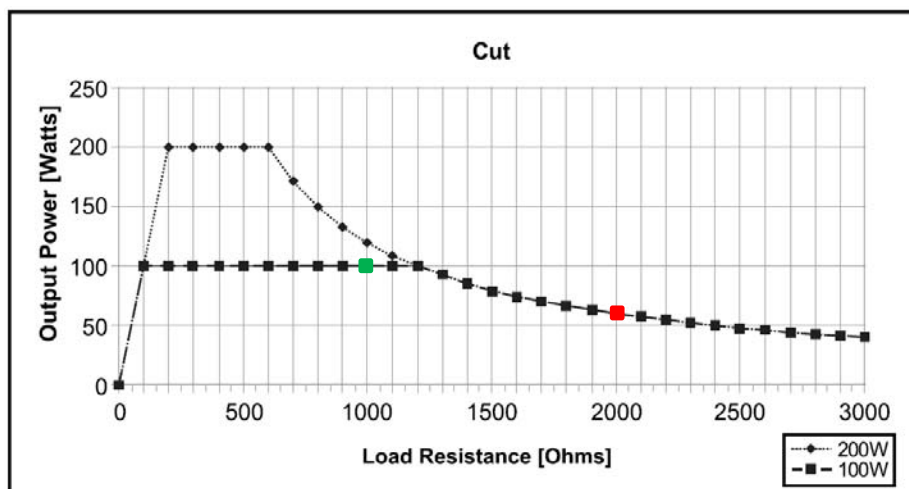


**Figure 2. Electrosurgical tip showing eschar buildup. Eschar is an annoyance that has to be frequently removed by the surgeon for peak performance.**

As an illustrative example, let's assume we are in cut mode, generator output power set to 100 watts, and initially the load resistance is at 1000 ohms (green square in Figure 4). After several seconds of cutting, the tissue has been desiccated and eschar has formed on the tip. Let's assume this has caused the tissue (load) resistance to increase to 2000 ohms (red square in Figure 4). Note that the actual output power is now about 60 watts, not the expected 100 watts. The takeaway here is to know how your generator responds to these different conditions, and always use the lowest power setting to get the desired tissue effect. If you are not getting the desired effect, do not indiscriminately increase the output power without first checking for other conditional changes such as eschar or reduced tissue contact area.



**Figure 3. Power versus resistance (load) curve showing user-selectable effects (1 – 8) (Erbe Vio 300 D User Manual, 2009).**

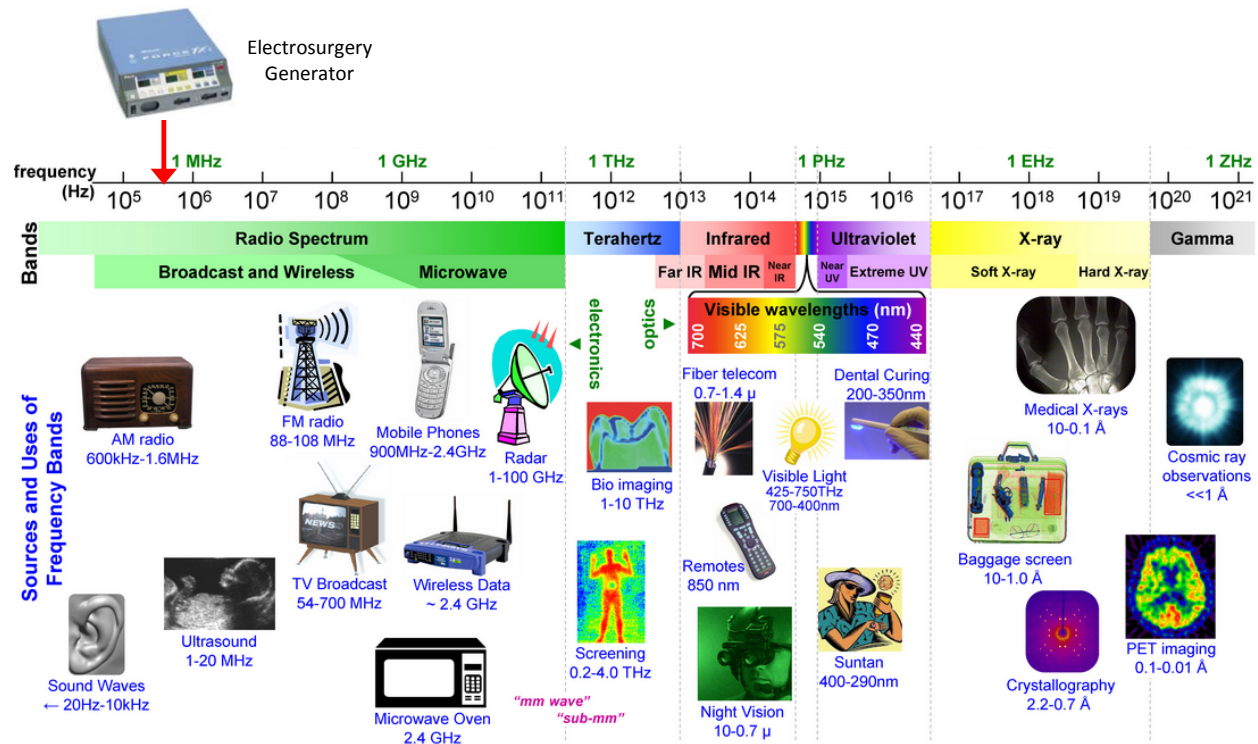


**Figure 4. Power versus resistance curve showing change in actual output power from 1000 ohms to 2000 ohms for an output power setting of 100 Watts (Aaron Medical Model 2250 User's Guide).**

## **RADIOFREQUENCY ABLATION IS NOT A RADIO**

When the term *radio*frequency (sometimes radio frequency) is mentioned, we might think of tall antenna towers radiating or broadcasting through the air to far away radio receivers (such as AM-FM radios and cell phones). Electrosurgery and radiofrequency ablation generators do not have antennas nor do they radiate (intentionally). The frequency of the output power of the generators is roughly in the 100 kHz to 750 kHz range. Engineers and physicists established a chart of the electromagnetic spectrum to define the different frequency ranges of electromagnetic energy (Figure 5). The range of

100 kHz to 750 kHz is in what is known as the radio spectrum, hence the nomenclature “radiofrequency”. As a reference point, the lowest frequency on a standard AM radio is 550 kHz. To achieve their tissue effects, electrosurgery and RFA generators do not radiate into air but rather conduct through the “wires” of the connecting cables and body tissue.



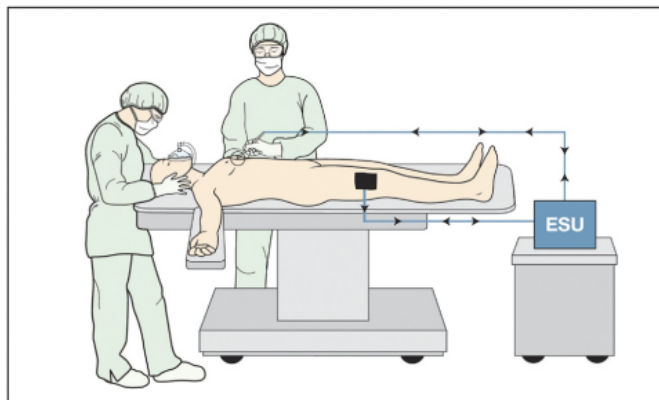
**Figure 5. Chart of the electromagnetic spectrum, showing the location of electrosurgery frequency (from Southeastern Universities Research Association ([www.sura.org](http://www.sura.org)), 2006).**

## WHAT’S THAT THING ON THE THIGH CALLED?

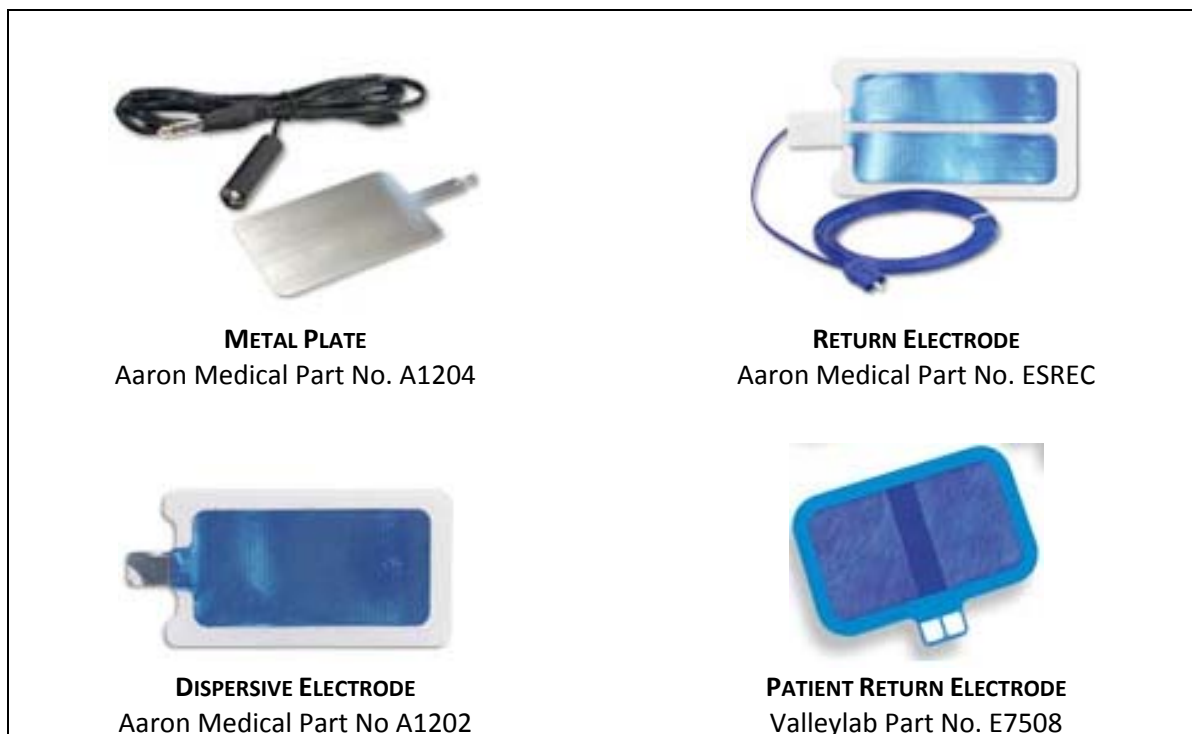
For monopolar electrosurgery and RFA procedures (the difference between monopolar and bipolar is for another time), a device must be properly attached to the patient’s skin to complete the electrical path (Figure 6). Often it is attached to the patient’s back, thigh, or some area not close to where the tip electrode is being applied.

Monopolar electrosurgery has an active tip or electrode where the electrosurgery power is applied to get a desired tissue effect (such as cutting or coagulation). The electrode surface area is small so the power is concentrated. The inactive or neutral electrode, where no tissue effect is desired, has a large surface area so power is dispersed over a large area. When electrosurgery first came into use, completion of the electrical path was done with a malleable metal plate that was the same ground as the ground on the electrical outlet (third pin) the generator was plugged into. As safety of electrosurgery improved, a separate and isolated ground or return path was used. A soft, conductive pad-like material is now often used instead of the metal plate.

This “thing” is referred to by an assortment of names in the literature and in the surgical suite. If you re-read the prior paragraph, you will see where some of the names below come from: *return electrode*, *ground pad*, *neutral*, *ground*, *dispersive*, *patient plate*, *metal plate*, and combinations of electrode, plate, pad, “the pad” and so on (Figure 7). So, it doesn’t matter too much what you call it. Just be sure it is applied correctly so the full area is evenly applied to avoid patient burns.



**Figure 6. The thing on the thigh (from Implementing AORN Recommended Practices for Electrosurgery, AORN Journal Volume 95, Issue 3, March 2012, Pages 373–387 Lisa Spruce, Melanie L. Braswell**



**Figure 7. Different names for the same thing, even from the same manufacturer.**



## IN CLOSING

Hopefully these few revelations of misnomers have made electrosurgery a bit less formidable for you. Unfortunately there are more, but that is for a future article. Users, inventors, developers and investors of electrosurgical technology need to be more aware of how they communicate their thoughts in advancing this exciting area of surgical treatment. Feel free to contact ElectroSurge for further discussions.

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