

ABSTRACT

Electrosurgery is the application of a high radio frequency of alternating polarity, electrical current to biological tissue as a means among many functions like cut, coagulate, desiccate, or fulgurate tissue in surgical practice . Many surgeons have faced during their lifetime one or more of the complications of these devices . It is either electrical, laser, ultrasonic and mechanical.

Keywords: surgery, electrosurgery, electrical.

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Electrosurgery is the application of a high radio frequency of alternating polarity, electrical current to biological tissue as a means among many functions like cut, coagulate, desiccate, or fulgurate tissue in surgical practice (1). Many surgeons have faced during their lifetime one or more of the complications of these devices (2). It is either electrical, laser, ultrasonic and mechanical.

Devices operated by electricity: The frequently asked question is why electricity used in surgery doesn't make the same harm occurring when somebody come with contact of electric current in household environment and the reason is that electrosurgery uses a frequency range of half to 2 million Hz that is not giving time for ion exchange across cell membranes to cause depolarization of cells, while household current uses a frequency of 60 Hz which result in depolarization and thus ends with ventricular fibrillation(3).

Use of current like this one flowing through patient's body and producing effect is called electrosurgery, unlike the effect produced when a metal is heated by the current and then the hot metal is touched to the tissue producing the effect called electrocautery. The electrical current used in medical practice in general is three types (4):

1. Direct current(DC) : is a unidirectional used in acupuncture and endothermy
2. Alternating current (AC) flows in sinusoidal fashion and is used in electorsurgery(5).
3. Pulsed current (PC) here high amount of electrical energy is discharged in a very short time and used in EMG and nerve stimulation(6).

There are two important concepts regarding the flow of the current through the tissues:

1. One of the most important issues in electrosurgery is that electrical current in its way through living tissue chooses the way of least resistance which in the human body is determined by the amount of water contained in the tissue. Thus the most conductive tissues are blood followed by nerve, adipose tissue

and the least is bone according to their content of water. It follows that when we use the current on human tissue it result in dryness of the tissue due to evaporation of water by heat resulting in increased resistance to the flow of the current , so the current will try to find another path to complete its circuit i.e. the path of the current may not be straight one and probably unpredictable(7).

2. The surface areas through which the current flows is important in predicting the effect of the current on the tissue which is defined as amperes/area (amperes/cm²). It implies that the highest effect is reached with the smallest surface areas. That's why electrosurgery use the small ends like the tip of a pencil on the active electrode and use large surface area in the patch of the earth plate so that the current will pass on a wide surface area and produce the least effect and complete the return of the current back to the generator after travelling in the body (8).

The path of return of the current to the generator after travelling through the living tissues is two types (9):

1. Monopolar the current here passes from the electrode to the tissue producing its effect and then returns back through the ground plate (earth plate) which is a

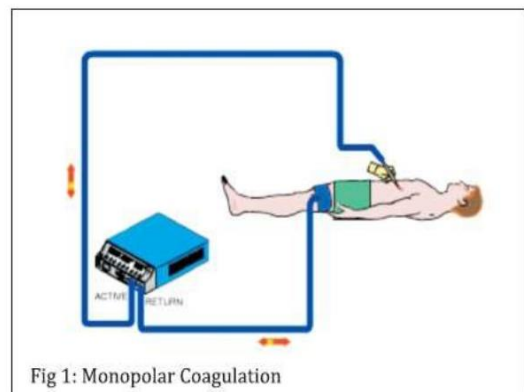


Fig 1: Monopolar Coagulation

wide conductive plate in contact with patient's body (figure-1-).

2. Bipolar both the positive and the negative electrodes are near each other grasping the tissue between them thus no need for a ground

plate and its potential complications. In bipolar current the amount of tissue damage is decreased, the depth of penetration of current is less than monopolar and the amount of smoke produced is less. Hemostasis with bipolar is less than monopolar because when the tissue between the jaws of the bipolar desiccates current will flow sideways before coagulation occurs (Figure-2-).

Figure-2- Bipolar coagulation



Use of the unipolar and bipolar electrodes is also of two types (10) :

1. Open circuit : the electrode is positioned very near to the tissue to be treated but doesn't make actual contact with the tissue, or the tissue which is in contact with the electrode has been charred due to the effect of heat so it is nonconductive and thus no contact with the electrode and the circuit will be an open circuit.
2. The electrode is positioned in contact with the tissue and the circuit here is considered as a closed circuit

Effects of electrosurgery: There are three observable effects which are the cutting effect, the coagulation and or fulgration and desiccation (11,12).

1. Cutting effect(Figure-3-) is achieved by using a current of low voltage but 100% "on". The active electrode should be a very short distance from the tissue (no contact). If there is contact, the generated heat will lead to dryness of the tissue due to evaporation of water (desiccation). To achieve cutting we need the generation of sparks between the electrode and the tissue, these sparks will generate heat which is transferred to the cells and buildup of heat intracellularly which will explode the cell so cutting is produced but in this case poor hemostasis occurs. The type of electrode best used in cutting is the

small pinpointed electrode to increase the current density through decreasing the surface area of the current. Fulgration also requires no contact between the electrode and the tissue but the current is set to the coagulation type higher voltage than cutting but lower than that of coagulation with short bursts called the blended current. The short bursts will produce sparks causing melting of the tissue in the form of coagulative

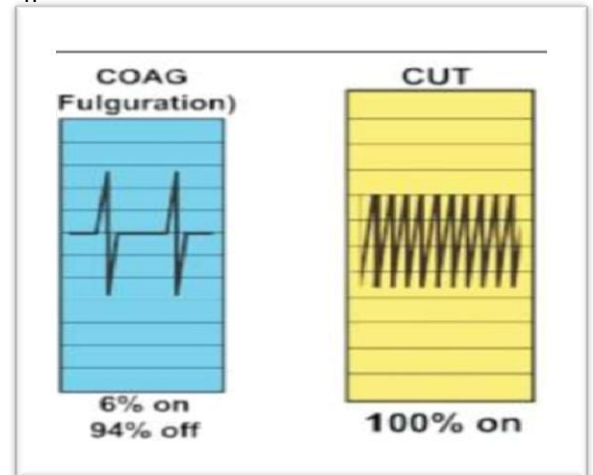


Figure-3- Coagulation and cutting waveform.

2. Desiccation is the state when the electrode comes in contact with the tissue leading to evaporation of the water due to heat generation and dryness of the tissue. This can be achieved with both cutting and coagulation currents by contact with the electrode (no sparks generated) and here low power current is used.
3. Coagulation current (Figure-3-) uses a higher voltage current than cutting but of 6% "on" and 94% "off", it produces little cutting but very good hemostasis. Hemostasis is better due to combination of factors
 - a. The desiccation of the wall of the blood vessel
 - b. Coagulation of plasma protein
 - c. the shrinking of the dead tissue
 - d. stimulation of clotting mechanism
 The type of electrode must be wider than that used in cutting therefore the current density is lower.

Complications of electrosurgery:(13,14,15)

1. Ground Pad Failures: the ground pad should be located the nearest possible to the area of surgery in the patient's body. Its large surface area decreases the current density leading to no thermal damage. The contact between the pad and the skin should be uniform to prevent thermal damage.
2. Demodulated currents: generators may produce currents not in the range used by electrosurgery i.e. 250000-2000000 Hz which may produce neuromuscular activity and is usually of no significance except in cardiothoracic procedures. Modern

generators are provided with filters to remove such currents. These demodulated currents are produced most commonly when the electrode is touched to a metal like "buzzing a hemostate".

3. Tissue injury: if the current passes through structures of small cross sectional area the current may have higher density and produce excess heat and damage eg. During dissection of the testis it will be attached to the body only by the cord, when applying energy to the testis current will return back through the cord which is small in section and may produce harm. Also during laparoscopic cholecystectomy when trying to apply energy to an adhesion between the gall bladder and the duodenum, the adhesion is wider near the gall bladder than the duodenum so greater current density will be transferred to the duodenum injuring it.
4. Direct Coupling: touching a conductive instrument by the active electrode will conduct the current, so attention must be paid not to touch by mistake a retractor or a hemostate or any metallic object in the operative field.
5. Surgical Glove Injuries: 15% of new surgical gloves have breach, this percentage increases to 50% in used gloves. The high voltage in repetitive form breaks the insulative capacity of the glove conducting the current to the surgeon and leading to burn. Or the insulative resistance of the glove is insufficient due to manufacturer fault or due to long exposure to saline (sweat).
6. Explosion: sparks produced by electro-surgical devices may produce explosions when ether or explosive anesthetic agents. Intestinal gas may explode with sparks in cases of unprepared bowel surgery

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