Physics of Medical Devices

sixth lecture

Electrosurgical Unit

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Background:

Electrosurgical units are the most common type of electrical equipment in the operating room. A basic understanding of electricity is needed to safely apply electrosurgical technology for patient care.

Introduction

A basic understanding of electricity is needed to safely apply electrosurgical technology for patient care.[1] Electrosurgery is one of the most commonly used energy systems in laparoscopic surgery.[2] The surgical team should have a good understanding of the principles of electrosurgery and tissue effects to avoid complications. The risk of complications is linked to the surgeon's fundamental knowledge of instruments, surgical technique, biophysics, relevant anatomy, and safe technical equipment. The risk of complications is linked to fundamental surgical knowledge of instruments, surgical technique, biophysics, and relevant anatomy. Appropriately applied, electrosurgery is safe and effective. Electrothermal injury may result from direct application, insulation failure, direct coupling, and capacitive coupling.

Basic Principles Of Electrosurgery

Energy in wattage (power) is the product of current and voltage. Power is the amount of current times the voltage level at a given point measured in wattage or watts (W). It corresponds to the rate of work being performed, $W=V\times I$.

Ohm's law, $I=V/R$, shows the relationship between the properties of electrosurgical energy.

Current (I) is what flows on a wire or conductor like water flowing down a river. Current flows from negative to positive on the surface of a conductor. Current is measured in amperes (A) or amps.

Voltage (V) is the difference in electrical potential between 2 points in a circuit. It is the push or pressure behind current flow through a circuit and is measured in volts (V).

Resistance determines how much current will flow through a component. Resistors are used to control voltage and current levels. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow. Resistance is measured in **Ω** ohms.

Principles of Electrosurgery

Often “electrocautery” is used to describe electrosurgery. This is incorrect. Electrocautery refers to direct current (electrons flowing in one direction), whereas electrosurgery uses alternating current. Modern day electrosurgery is the utilization of alternating current at radiofrequency levels. During electrocautery, current does not enter the patient's body. Only the heated wire comes in contact with tissue. In electrosurgery, the patient is included in the circuit and current enters the patient's body.

Fig (27) Electrosurgical unit

The configuration and parts of the system

The electrosurgical Generator (ESU)

Electrosurgical units (ESU) use a high-frequency electrical current to cut tissue and control bleeding by causing coagulation. Tissue resistance to the high-density current causes a heating effect which results in tissue

destruction. Electrical current is delivered and received through cables and electrodes. The electrodes may be activated by either a hand piece switch or a footswitch Electrical energy is converted to heat in tissue as the tissue resists the flow of current from the electrode. Three tissue effects are possible with today's electrosurgical units—cutting, desiccation, and fulguration.[7] Achieving these effects depends on the following factors: current density, time, electrode size, tissue conductivity, and current waveform.[6,8]

1. Current density

As expected, the greater the current that passes through an area, the greater the effect will be on the tissue.[4]

2. Time

The length of time a surgeon uses an active electrode determines the tissue effect. Too long an activation will produce wider and deeper tissue damage. Too short an activation will result in absence of the desired tissue effect.[9]

3. Electrode Size

With respect to electrode size, smaller electrodes provide a higher current density and result in a concentrated heating effect at the site of tissue

contact. Following the same principle, the patient return electrode used in monopolar electrosurgery is large in relation to the active electrode in order to disperse the current returning to the electrosurgical unit and minimize heat production at this return electrode site.[6–8]

4. Tissue Conductivity

Various tissue types have a different electrical resistance, which affects the rate of heating. Adipose tissue and bone have high resistance and are poor conductors of electricity, whereas muscle and skin are good conductors of electricity and have low resistance.[7,10]

5. Current Waveforms

The final determinant of how tissue responds to electrosurgery is the current type. Electrosurgical units produce 3 different waveforms: cut, blend, and coagulation

Types of electrosurgical unit:

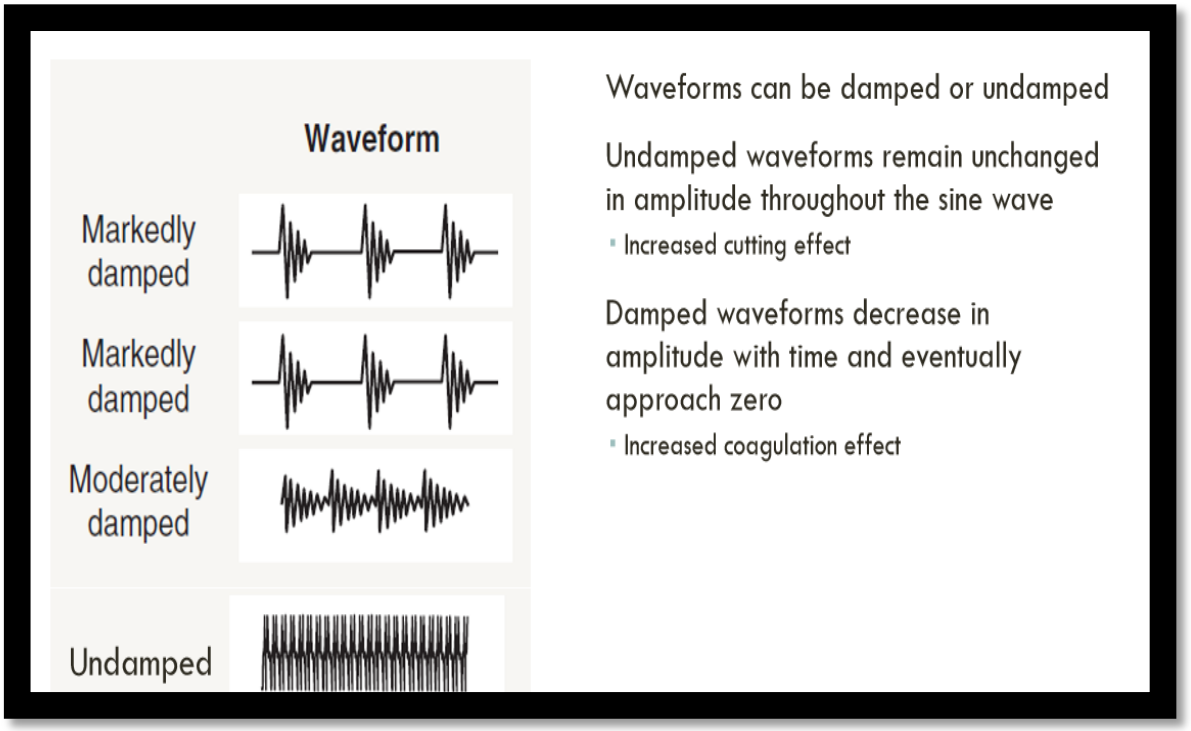
•Mono-Polar Technique (flow of current)

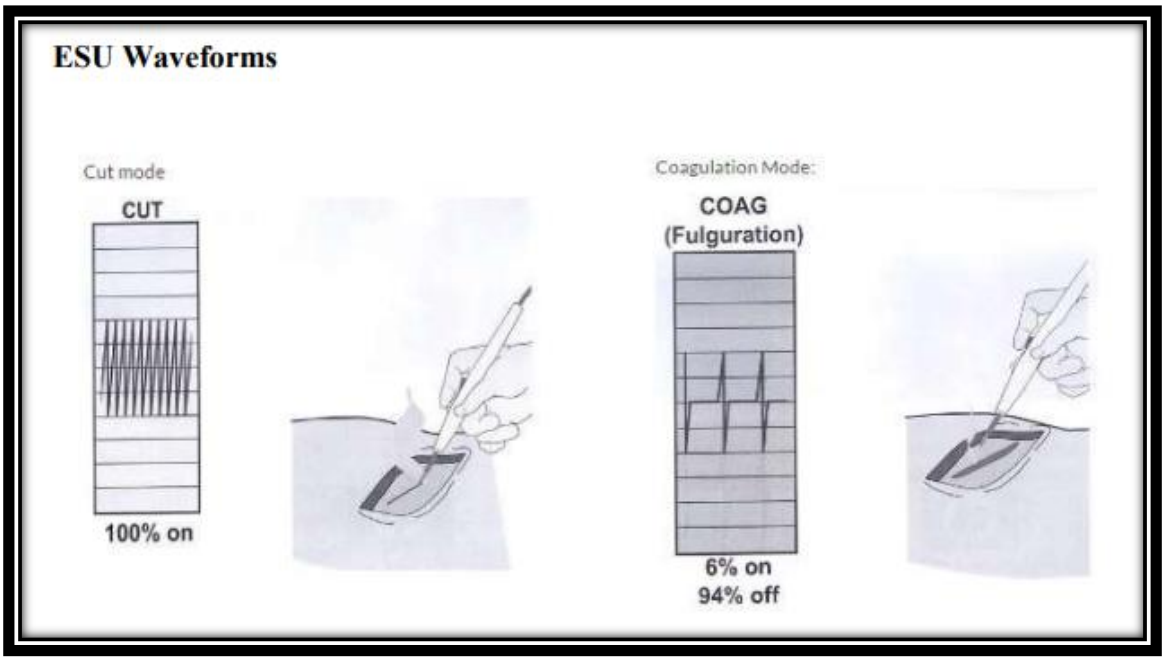
- Active Electrode tip
- Patient
- Neural Electrode
- Generator

Bipolar Technique

- Generator
- Active Electrode

Electrosurgical waveforms




ESU Waveforms
Cut mode
CUT
100% on
Coagulation Mode:
COAG
(Fulguration)
6% on
94% off