AL- MUSTAQBAL UNIVERSITY COLLEGE
BIOMEDICAL ENGINEERING DEPARTMENT

Biomedical Instrumentation Lab

BME 514

Lecture 2

- Electro Surgical Unit (ESU) -

Dr. Zaidoon AL-Shammari
Lecturer / Researcher
zaidoon.waleed@mustaqbal-college.edu.iq

Electrosurgical Unit

Properties of Electricity

Several properties of electricity must be understood in order to understand electro-surgery.

- Current flow occurs when electrons flow from one atom to the orbit of an adjacent atom.
- Voltage is the “force” or “push” that provides electrons with the ability to travel from atom to atom.
- If electrons encounter resistance, heat can be produced. The resistance to electron flow is called impedance.

Properties of Electricity

- A completed circuit must be present in order for electrons to flow.
- A completed circuit is an intact pathway through which electrons can travel.
- The original source of these electrons is the earth (ground).
- To complete the circuit the electrons must return to ground.
- Any grounded object can complete the circuit, allowing the electrons to flow to ground.

Purpose

- Electrosurgical units (ESUs) are used in hospital operating rooms for surgical cutting and coagulating the blood for controlling bleeding at the surgical site.

- These units are a crucial piece of equipment in the majority of operative settings and are the most useful and common instruments used by surgeons today.

- The applications of electrosurgery in the medical field are in diverse areas such as general surgery, dermatology, cardiology, plastic surgery, neurosurgical procedures and many others.

Principle

- The principle of work for electrosurgery unit, is involves the generation of electrically induced heat through the passage of high frequency AC currents through the biological tissue.

- The technique utilizes high frequency current to incise, destroy, and remove tissue and to seal blood vessels, thereby minimizing blood loss and operating time.

- Electro surgical machines depend on the heating effect of electric current.

- The active electrode in the form of a needle, which the surgeon holds, has a very small surface area as compared to the large pad (ground) electrode.

Principle

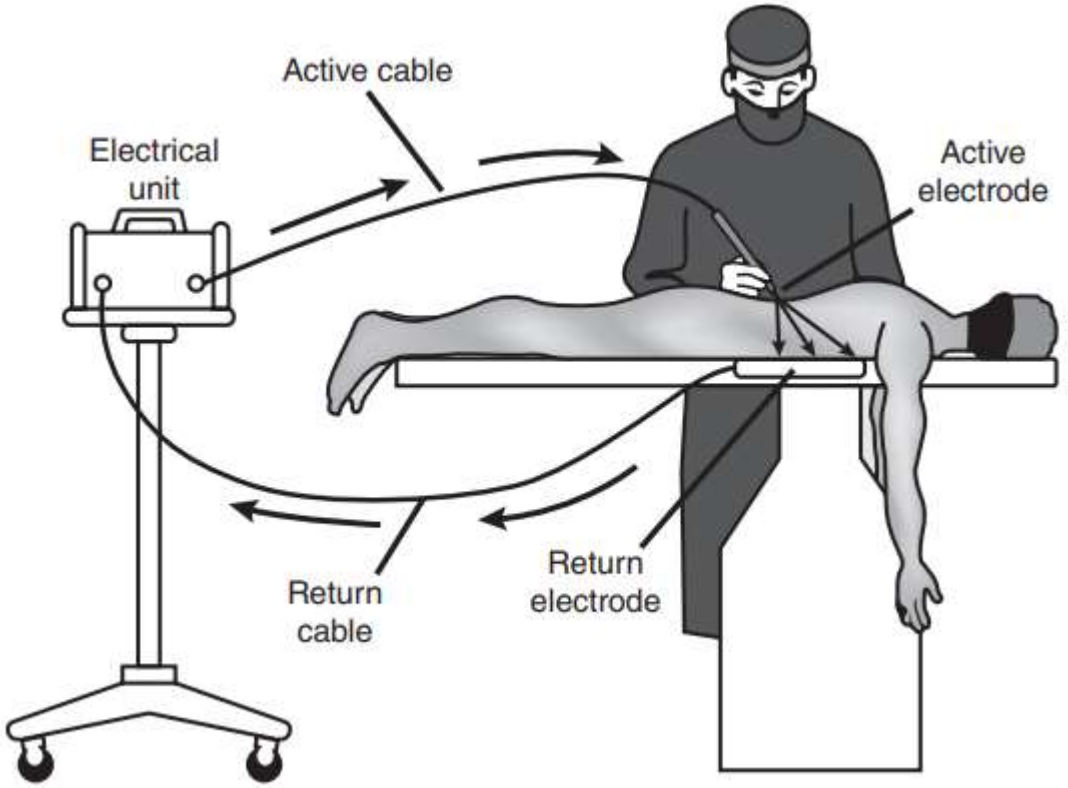
- When high frequency current flows through the tip of the needle electrode into the tissue, there is a high density of current at this point.

- The high current density heats the tissue to such an extent that the cells, which are immediately under the electrode, are torn apart by the boiling of the cell fluid.

- The current density falls off significantly further away from the active electrode.

- The larger passive electrode establishes a large area contact with the patient and the RF current is therefore dissipated resulting in negligible heat production at the site distal to the surgical site.

Principle of operation



Principle of operation for electrosurgery

Component

The electrosurgery machine typically includes

- High frequency power-producing generator with monitoring functions.
- Hand piece with electrodes to apply the energy to the surgical site.
- Connecting cables.
- Foot switch to control output.

Frequency Spectrum

- Standard electrical current alternates at a frequency of (50 – 60) cycles per second (Hz).

- Electrosurgical systems could function at this frequency, but because current would be transmitted through body tissue at (50 – 60) cycles, excessive neuromuscular stimulation and perhaps electrocution would result.

- Because nerve and muscle stimulation cease at 100,000 cycles/ second (100 kHz), electro-surgery can be performed safely at “radio” frequencies above 100 kHz.

- An electrosurgical generator takes (50 – 60) cycle current and increases the frequency to over 200,000 cycles per second. At this frequency electrosurgical energy can pass through the patient with minimal neuromuscular stimulation and no risk of electrocution.

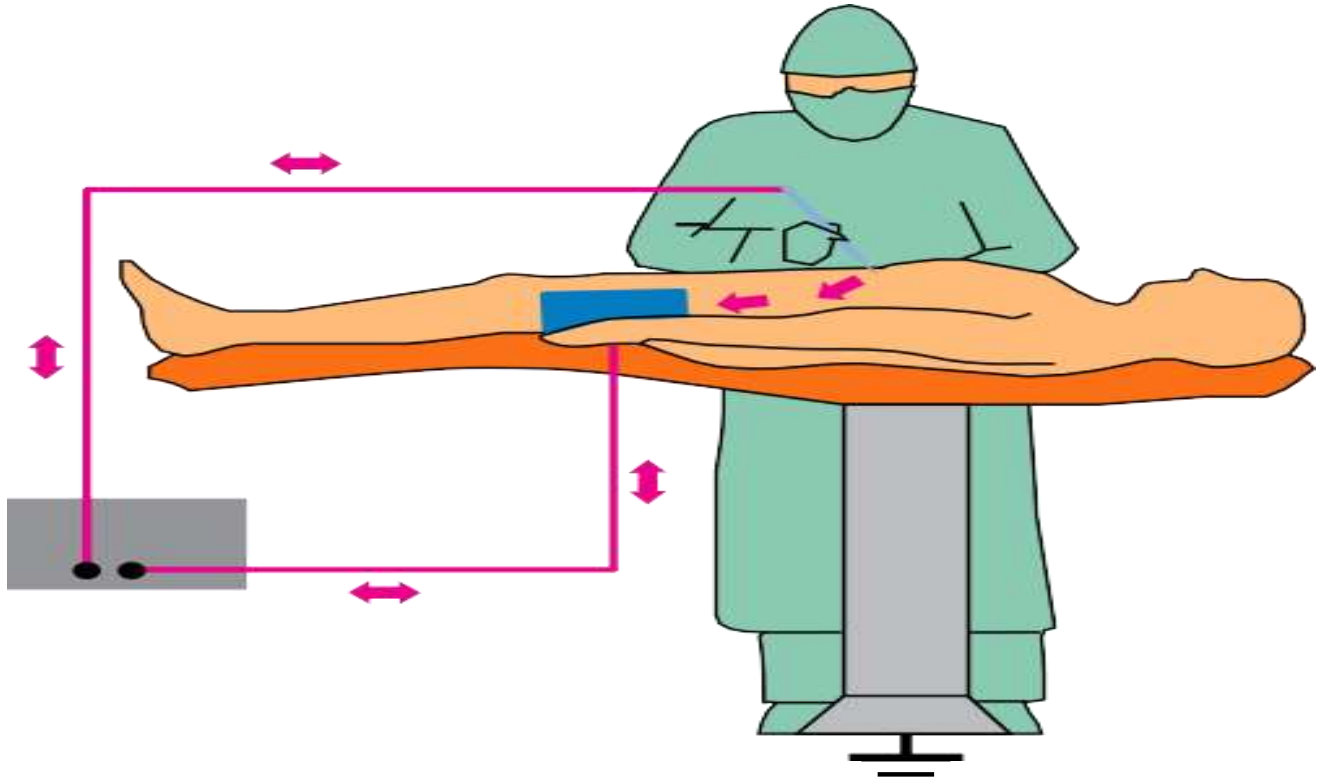
Types of electrodes

I. Monopolar Electrosurgery

- Monopolar is the most commonly used electrosurgical modality. This is due to its versatility and clinical effectiveness.
- In monopolar electro-surgery, the active electrode is in the surgical site.
- The patient return electrode is somewhere else on the patient's body.
- The current flows from the active electrode through the patient to the neutral electrode (dispersive electrode) from which it returns to the generator.

Monopolar Circuit

This picture represents a common monopolar circuit.



Monopolar Circuit

There are four components to the monopolar circuit

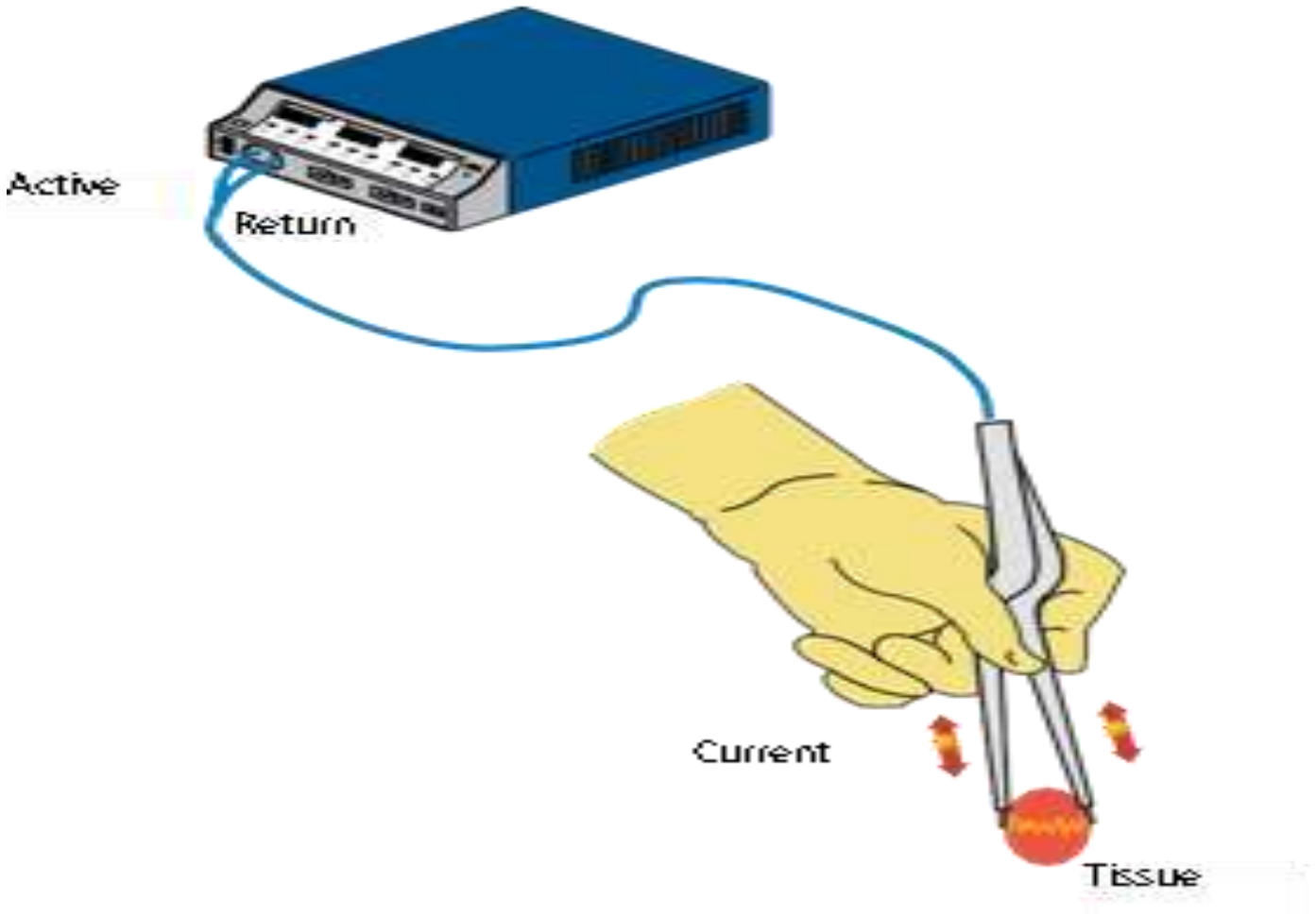
- Generator.
- Active Electrode.
- Patient.
- Patient Return Electrode.

Types of electrodes

II. Bipolar

- In bipolar electro-surgery, both the active electrode and return electrode functions are performed at the site of surgery.
- Active output and patient return functions are both accomplished at the site of surgery.
- Current path is confined to tissue grasped between forceps tines.
- Patient return electrode should not be applied for bipolar only procedures.
- The risk of inadvertent burning of the patient at the patient plate is very low.

Bipolar Circuit



Tissue Effects

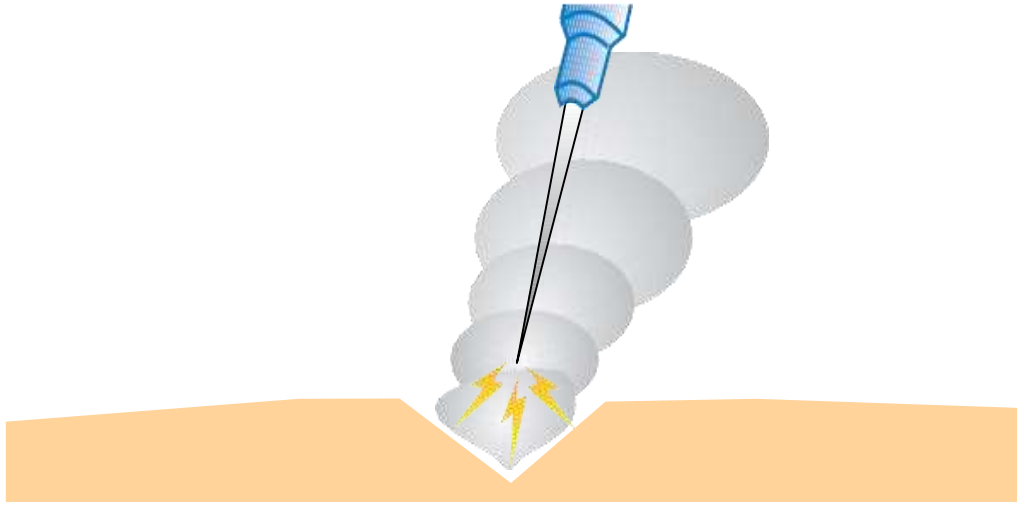
- Electrosurgical generators are able to produce a variety of electrical waveforms.
- As waveforms change, so will the corresponding tissue effects.
- Using a constant waveform, like “cut,” the surgeon is able to vaporize or cut tissue. This waveform produces heat very rapidly.
- Using an intermittent waveform, like “coagulation,” causes the generator to modify the waveform so that the duty cycle (“on” time) is reduced.

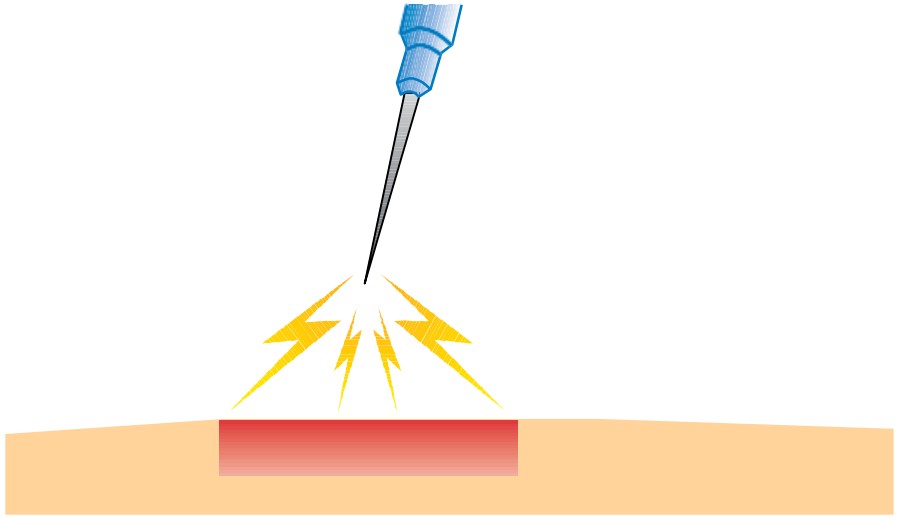
Tissue Effects

- Electrosurgical coagulation of tissue is caused by the high frequency current flowing through the tissue and heating it locally so that it coagulates from inside.

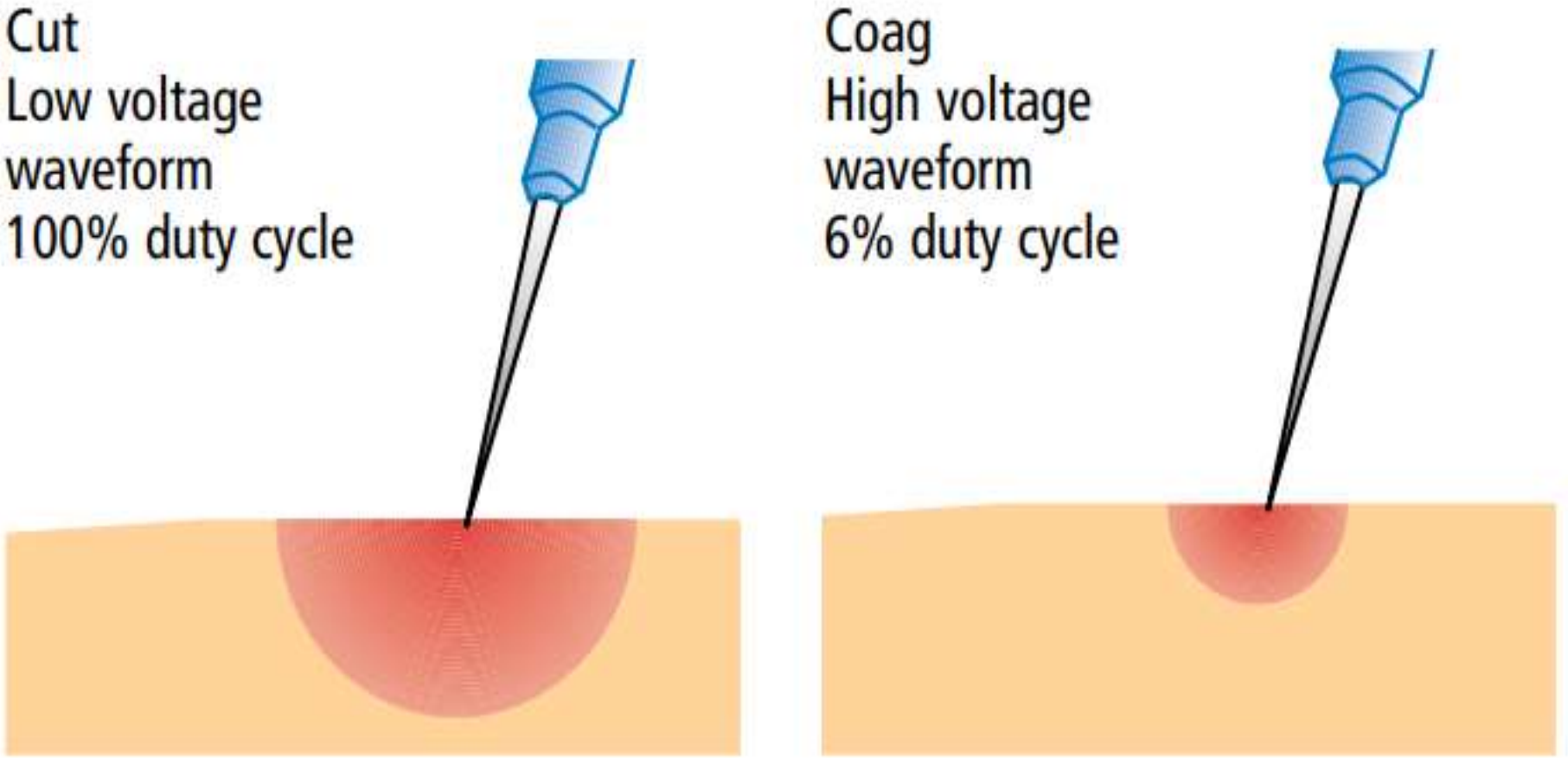
- Depending upon the intensity and duration of the current, a high local increase in heat will be obtained.

Tissue Effects

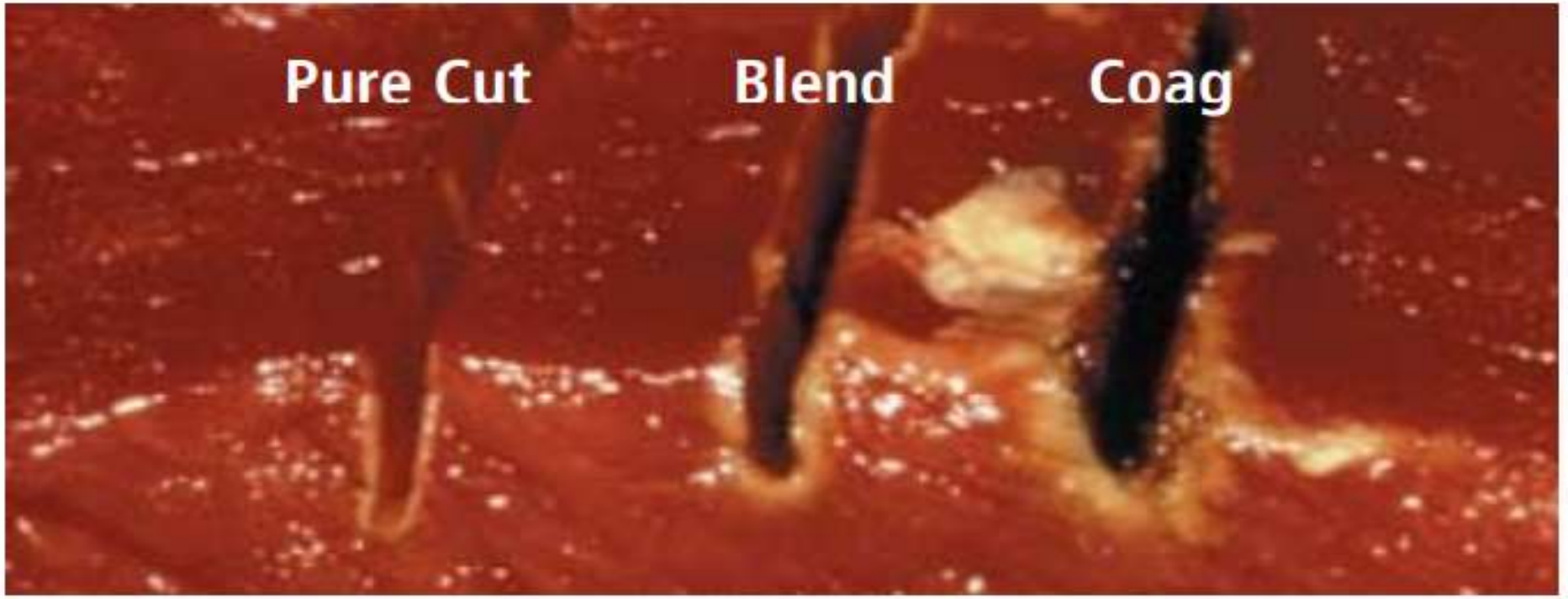




Tissue Effects



Tissue Effects



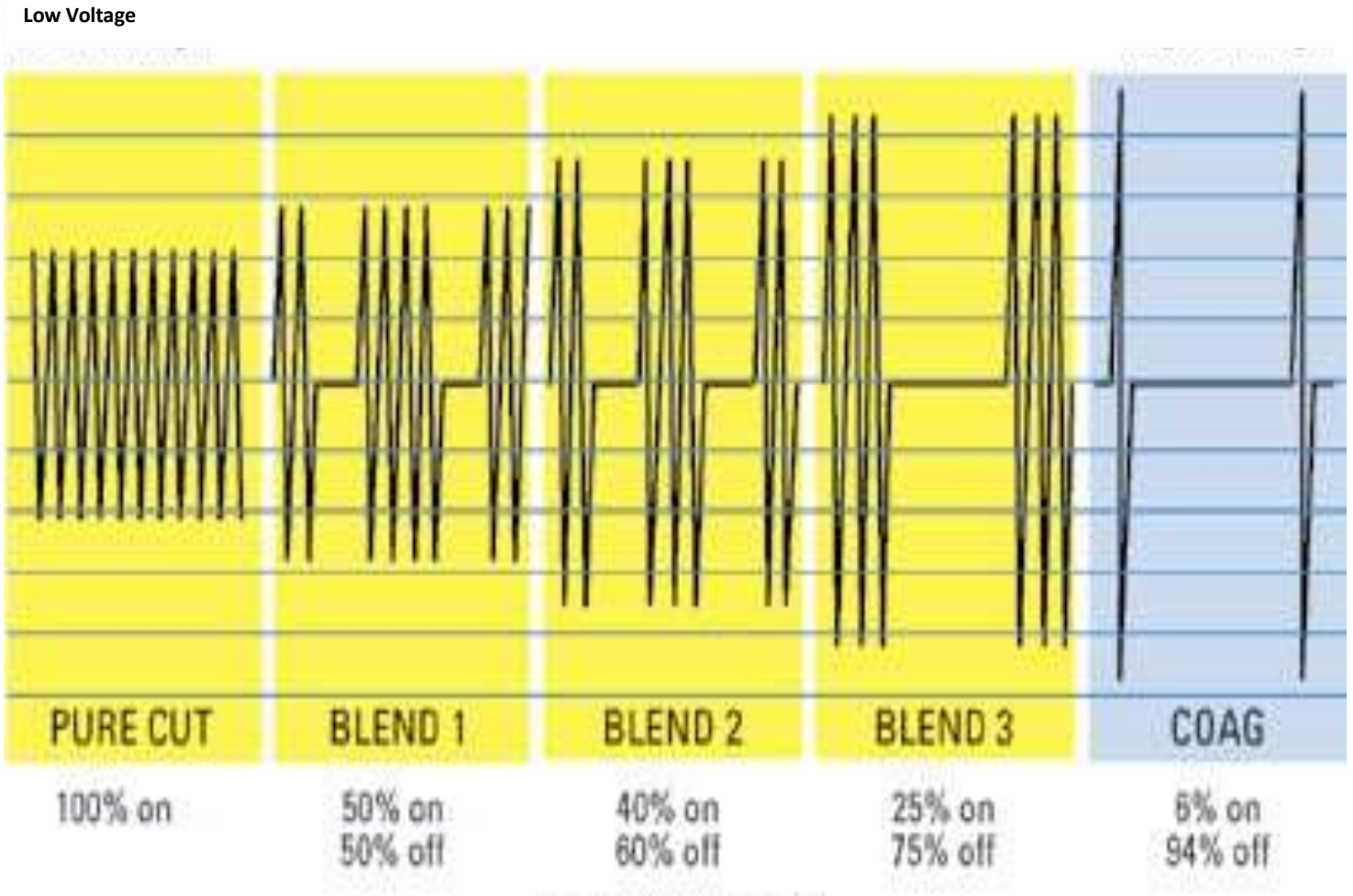
Cut, Blend, and Coagulate

- As you go from Blend 1 to Blend 3 the duty cycle is progressively reduced.
- A lower duty cycle produces less heat.
- Consequently, Blend 1 is able to vaporize tissue with minimal hemostasis whereas Blend 3 is less effective at cutting but has maximum hemostasis.
- Low heat produced more slowly creates a coagulum.

Cut, Blend, and Coagulate

- The advantage of using continuous sine wave current is that it does not allow for tissue cooling.
- Blended Currents A combined waveform is usually referred to as ‘blended’, which is used during specialized requirements.
- The cutting current usually results in bleeding at the site of incision, whereas the surgeon would require bloodless cutting.
- Surgeons have the option to combine the cut and coagulate currents to produce different tissue effects.
- A blended current is not a mixture of both cutting and coagulation current but rather a modification of the duty cycle.

Cut, Blend, and Coagulate



Variables Impacting Tissue Effect

In addition to waveform and power setting, other variables impact tissue effect. They include:

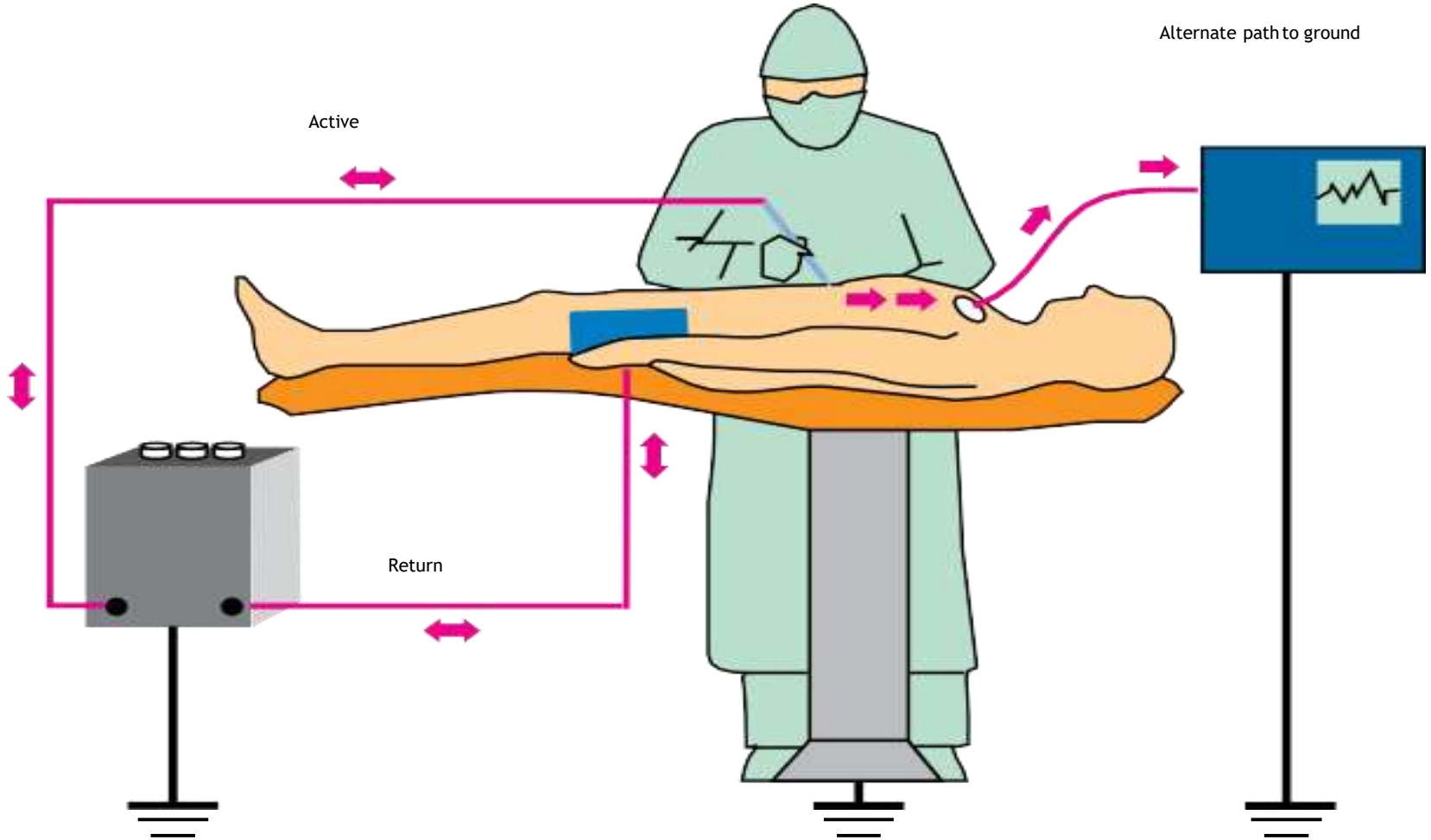
- Size of the electrode: The smaller electrode, the higher current concentration.
- Time: At any given setting, the longer the generator is activated, the more heat is produced.
- Type of Tissue: Tissues vary widely in resistance

Grounded Electrosurgical System

- Generators operate by taking alternating current and increasing its frequency from 50 or 60 cycles/second to over 200,000 cycles/second.

- Once the current entered the patient's body, it would return to ground through the patient return electrode.

Grounded Electrosurgical System



Advantage

- Electric cutting does not require any application of force.
- It facilitates elegant and effortless surgery.

The risks of electrosurgical unit

The risks associated with electrosurgery fall into four main categories:

- Burns.
- Electrical interference with the heart muscles (ventricular fibrillation).
- The danger of explosions caused by sparks.
- Electrical interference with pacemakers and other medical electronic equipment.