ΠΑΝΕΠΙΣΤΗΜΙΑΚΟ ΓΕΝΙΚΟ ΝΟΣΟΚΟΜΕΙΟ ΑΤΤΙΚΟΝ

Πηγές Ενέργειας

Σπυρίδων Χριστοδούλου

ΧΕΙΡΟΥΡΓΟΣ

Principles of Electrosurgery

Types of Energy Used for Surgery

- ✓ *Laser*
- ✓ *Radiofrequency (RF)*
- ✓ *Microwave*
- ✓ *Ultrasound*
- ✓ *True cautery*

Principles of Electrosurgery

Types of Energy Used for Surgery

- ✓ *Laser*
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Principles of Electrosurgery

Objectives

- ✓ *Understand nomenclature involved in RF electrosurgery*
- ✓ *Identify the basic function of an electrosurgical generator or unit (ESU)*
- ✓ *Identify differences between monopolar and bipolar instruments*
- ✓ *Know how RF energy causes effects in cells and tissue*
- ✓ *Identify the different effects of ranges of temperatures on cells and tissues*

How does RF Electrosurgery work?

Alternating current applied to cell

continually switching polarity

↓

Intracellular ions oscillate

↓

Results in frictional forces

that elevate cell temperature

↓

Used to create cellular and tissue effects Vaporization,

Desiccation/Coagulation, Fulguration

Ultrasonic Energy Systems

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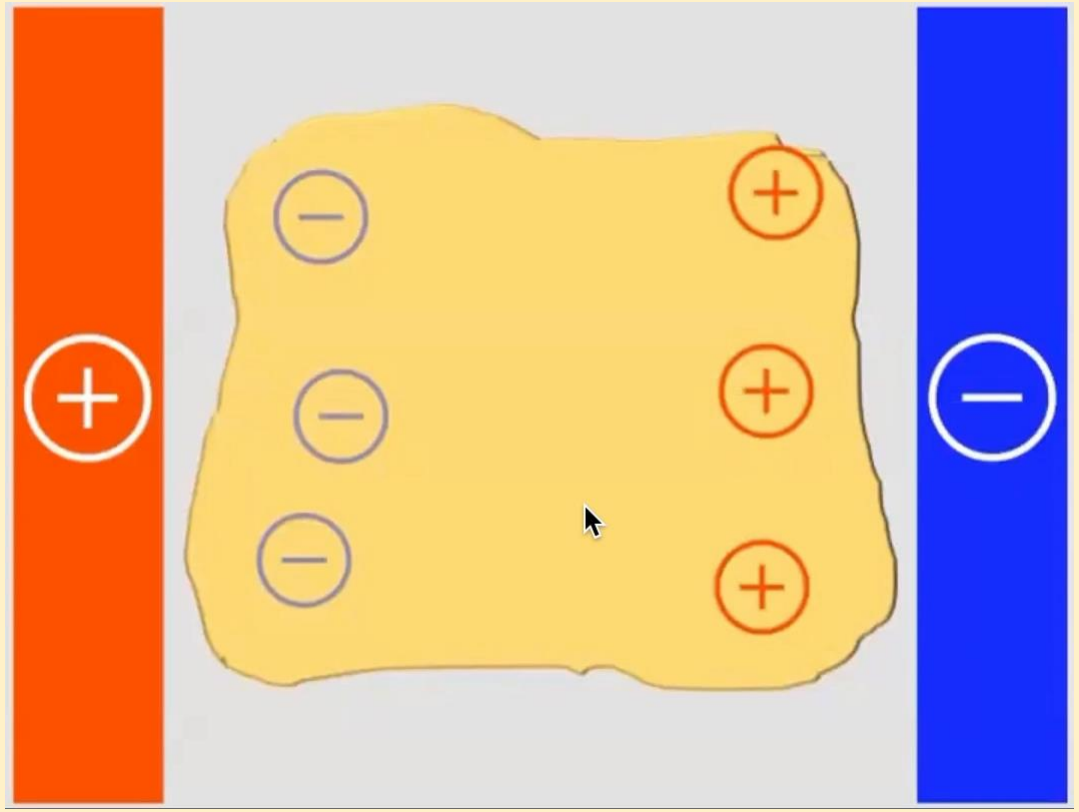

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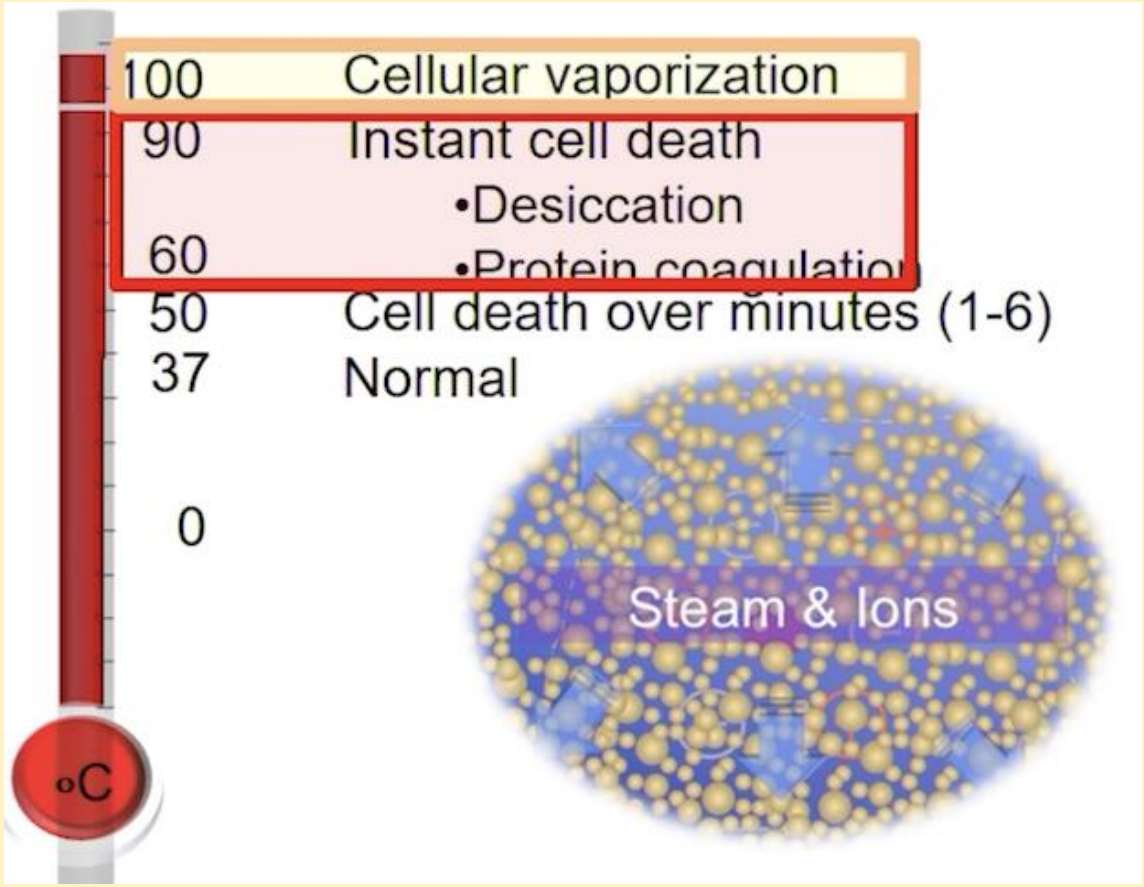
Principles of Electrosurgery

Temperature and Cellular Impact



Principles of Electrosurgery

Electrosurgical Unit (ESU):

What does it do?

Principles of Electrosurgery

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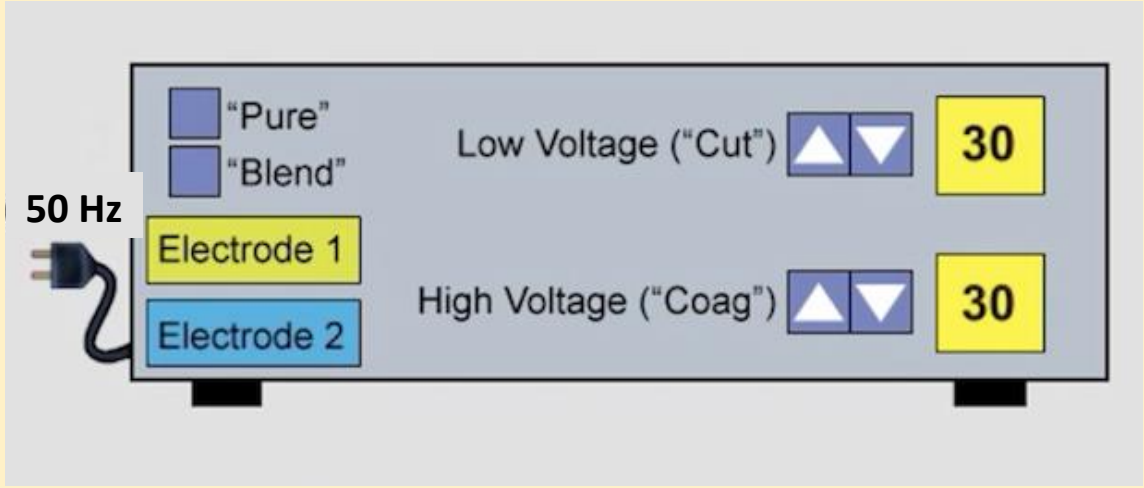
What does it do?



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Principles of Electrosurgery

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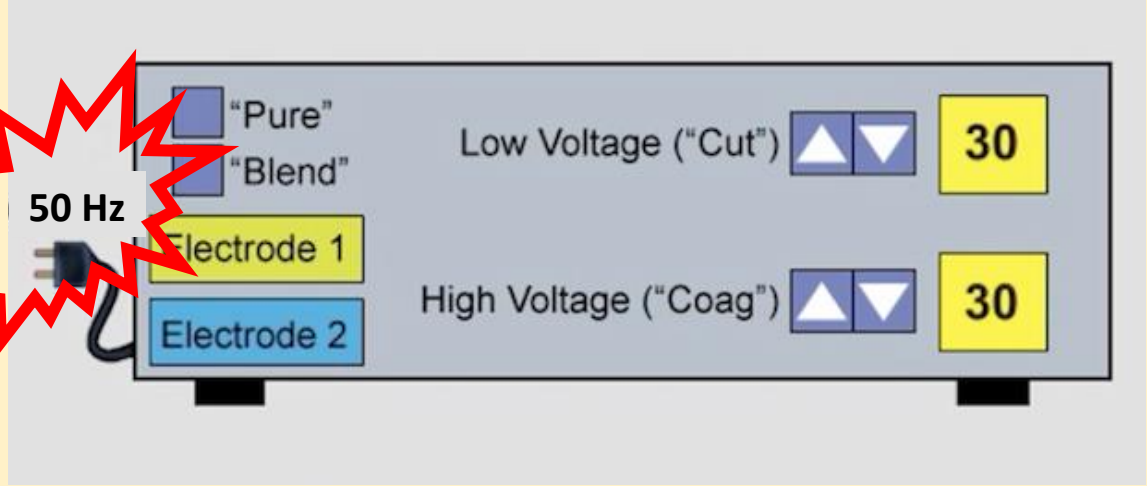

Conversion of low frequency wall output (50 Hz)

to RF output (~500 000 Hz)

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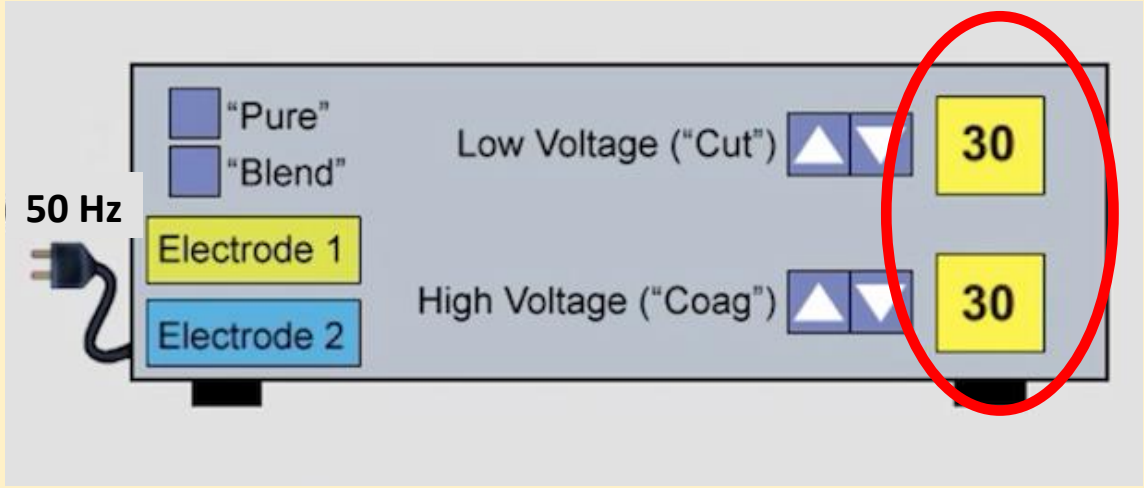
Principles of Electrosurgery

Electrosurgical Unit (ESU):

What does it do?



✓ **Conversion of low frequency wall output (50 Hz) to RF output (~500 000 Hz)**

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Principles of Electrosurgery

Electrosurgical Unit (ESU):

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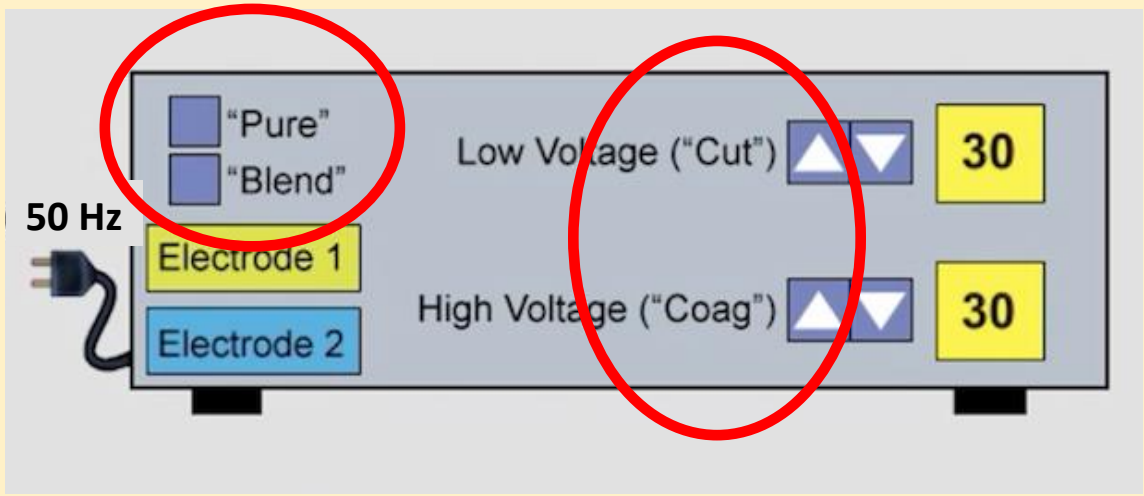

- ✓ Conversion of low frequency wall output (50 Hz) to RF output (~500 000 Hz)
- ✓ Control of duty cycle

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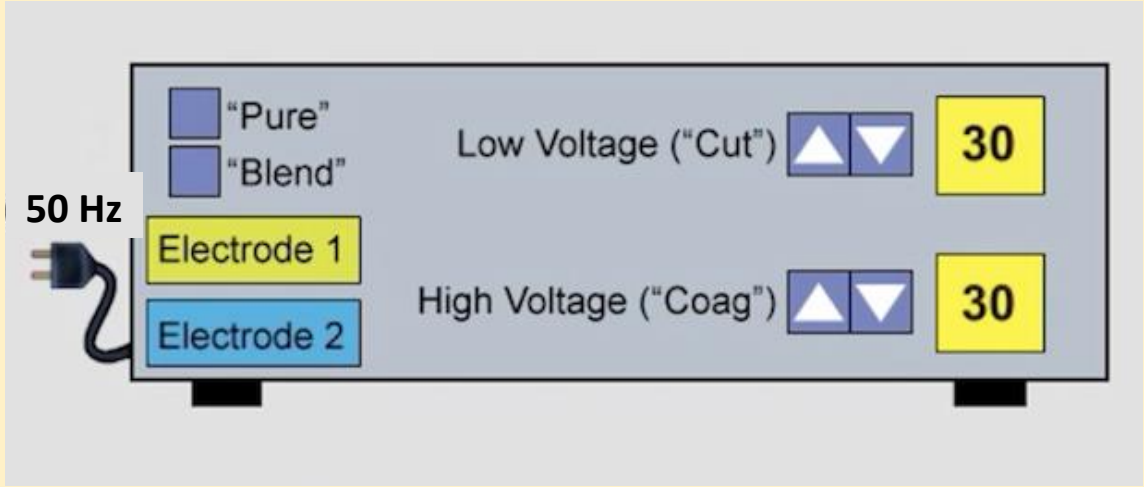
Principles of Electrosurgery

Electrosurgical Unit (ESU):

What does it do?



All currently produced ESUs create isolated circuits

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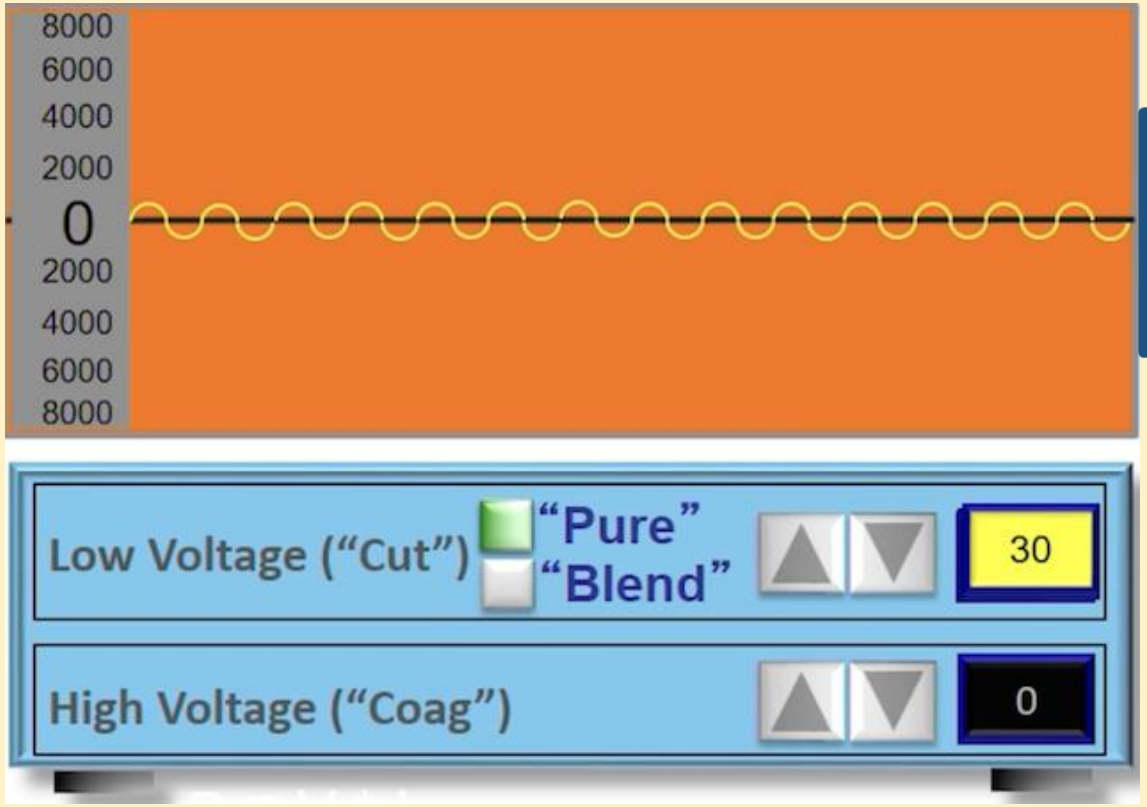
Principles of Electrosurgery

Basic Waveforms: Cut

The SAGES manual on the fundamental use of surgical energy (FUSE)

Principles of Electrosurgery

Basic Waveforms: Cut



Continuous

Relatively low voltage

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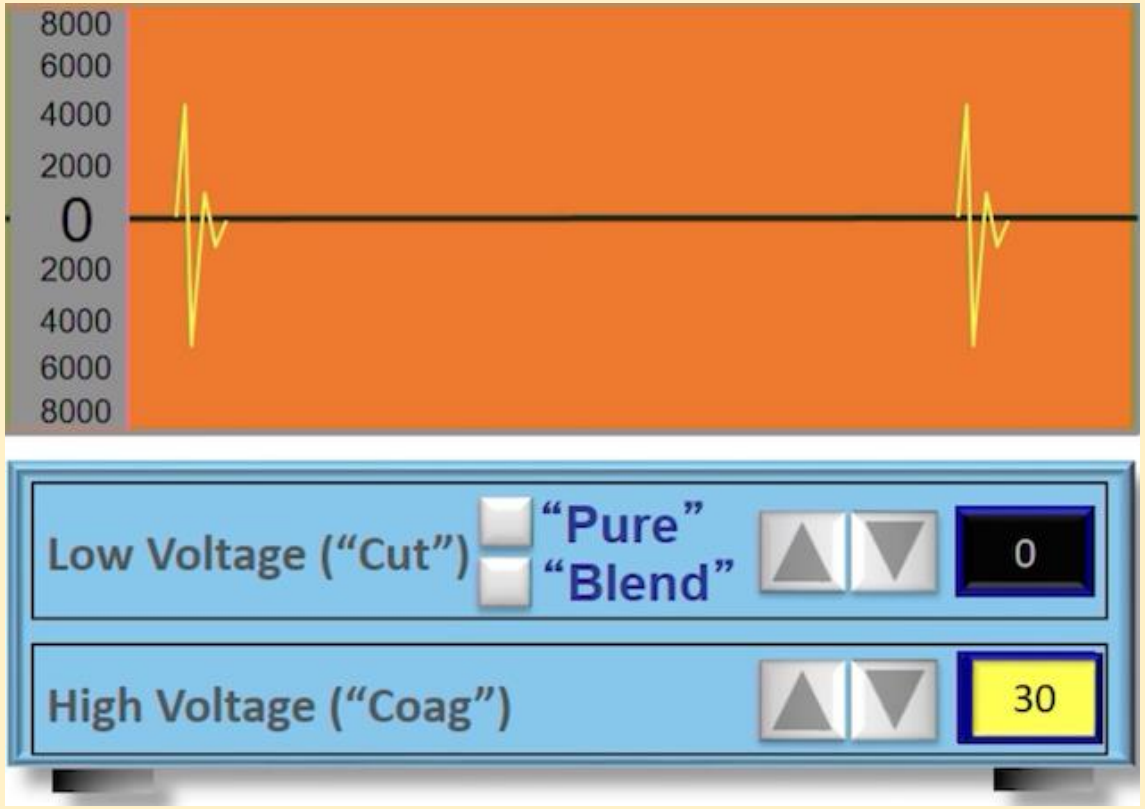
Principles of Electrosurgery

Basic Waveforms: Coag



The SAGES manual on the fundamental use of surgical energy (FUSE)

Principles of Electrosurgery

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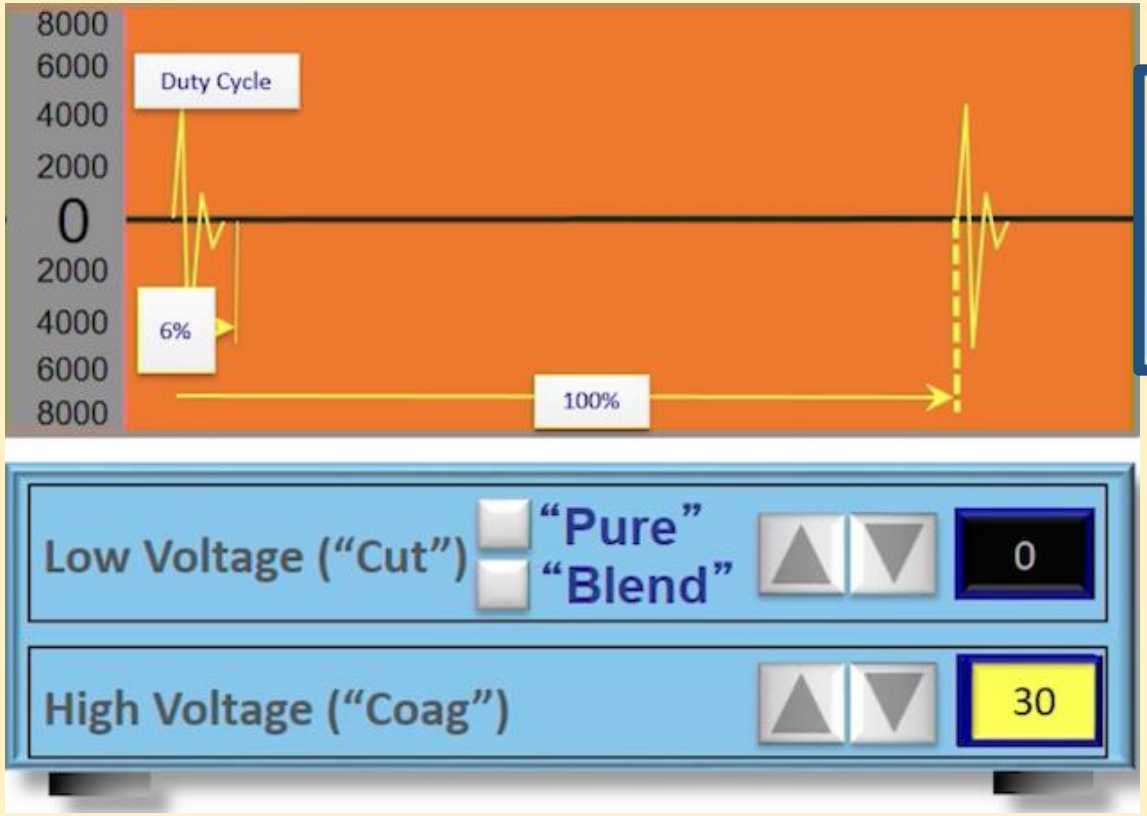

Interrupted

Current only "on" ~6%

Relatively high voltage

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Principles of Electrosurgery

Basic Waveforms: Blend

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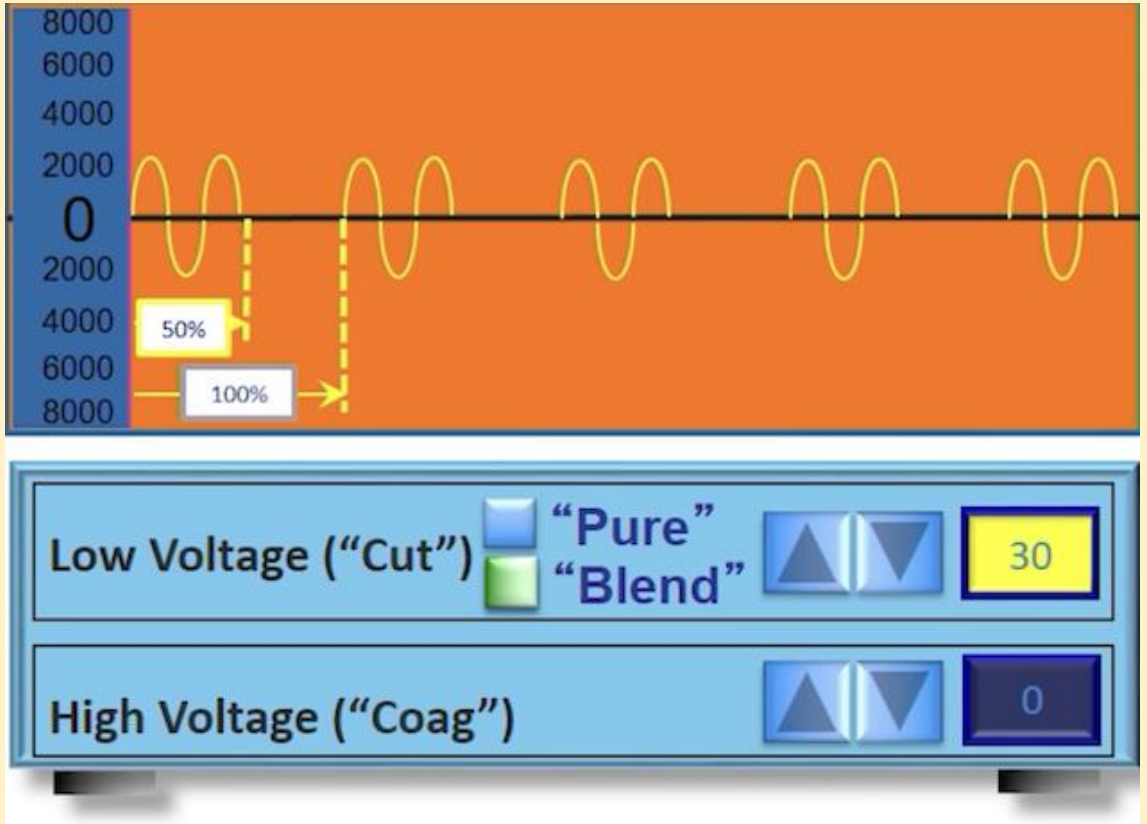
Principles of Electrosurgery

Basic Waveforms: Blend



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Principles of Electrosurgery

All RF Electrosurgery is "Bipolar'

… What differentiates systems is location and purpose of the second electrode

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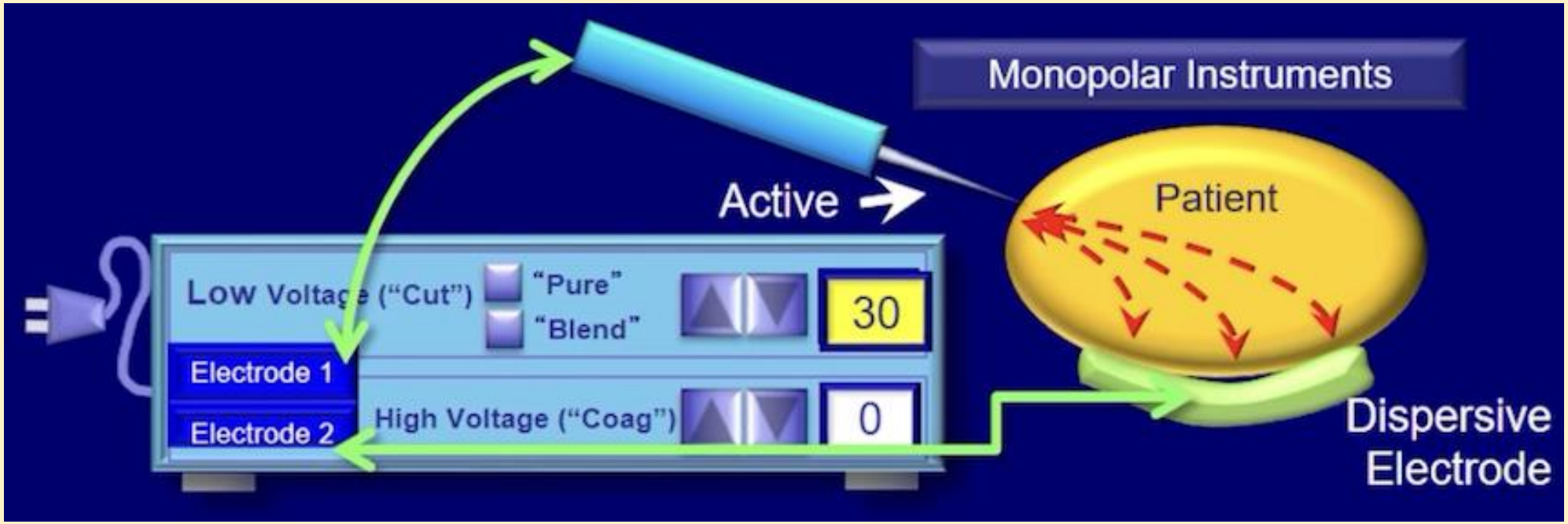
Principles of Electrosurgery

Monopolar vs Bipolar Instrumentation



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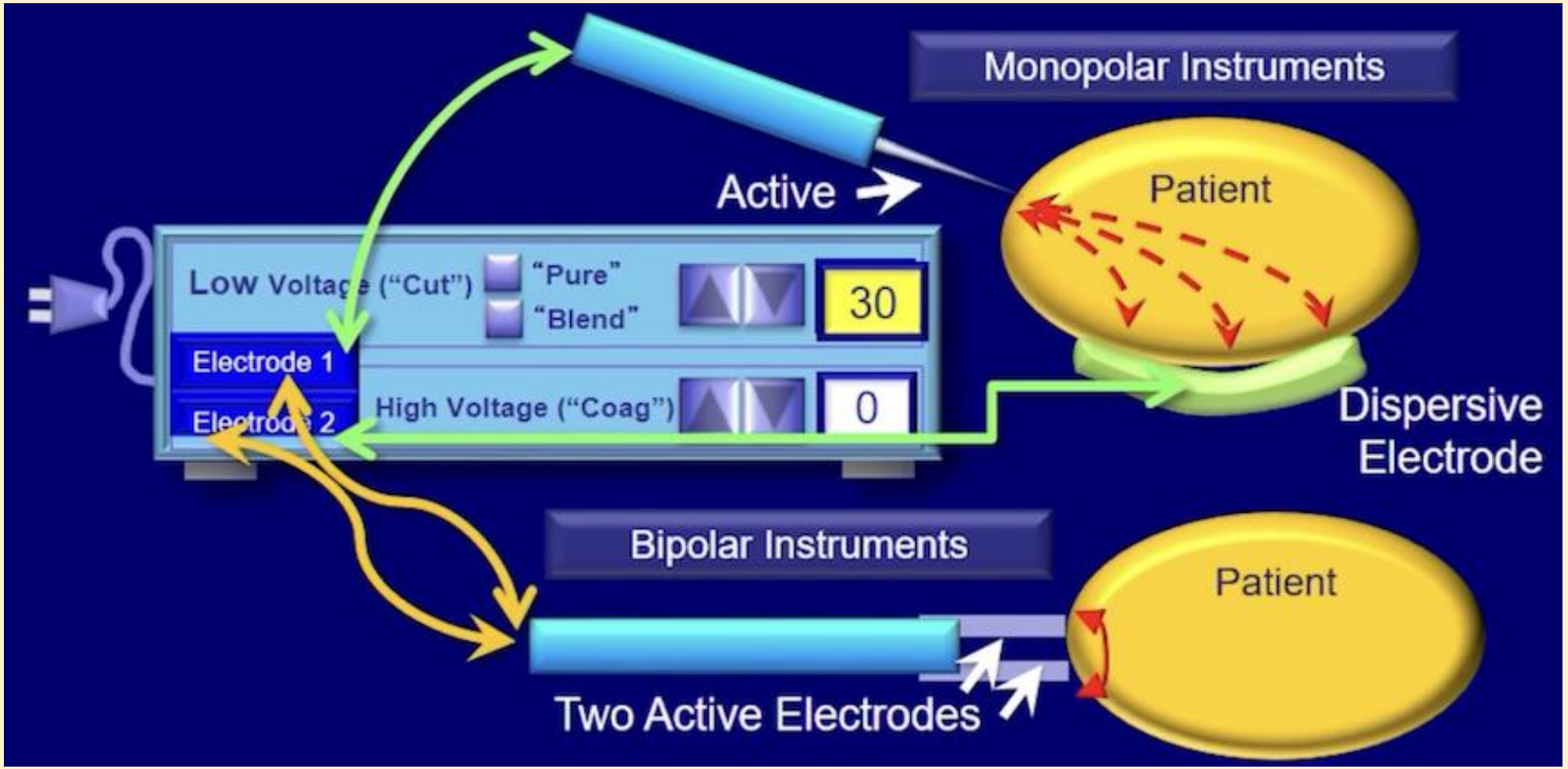
Principles of Electrosurgery

Monopolar vs Bipolar Instrumentation



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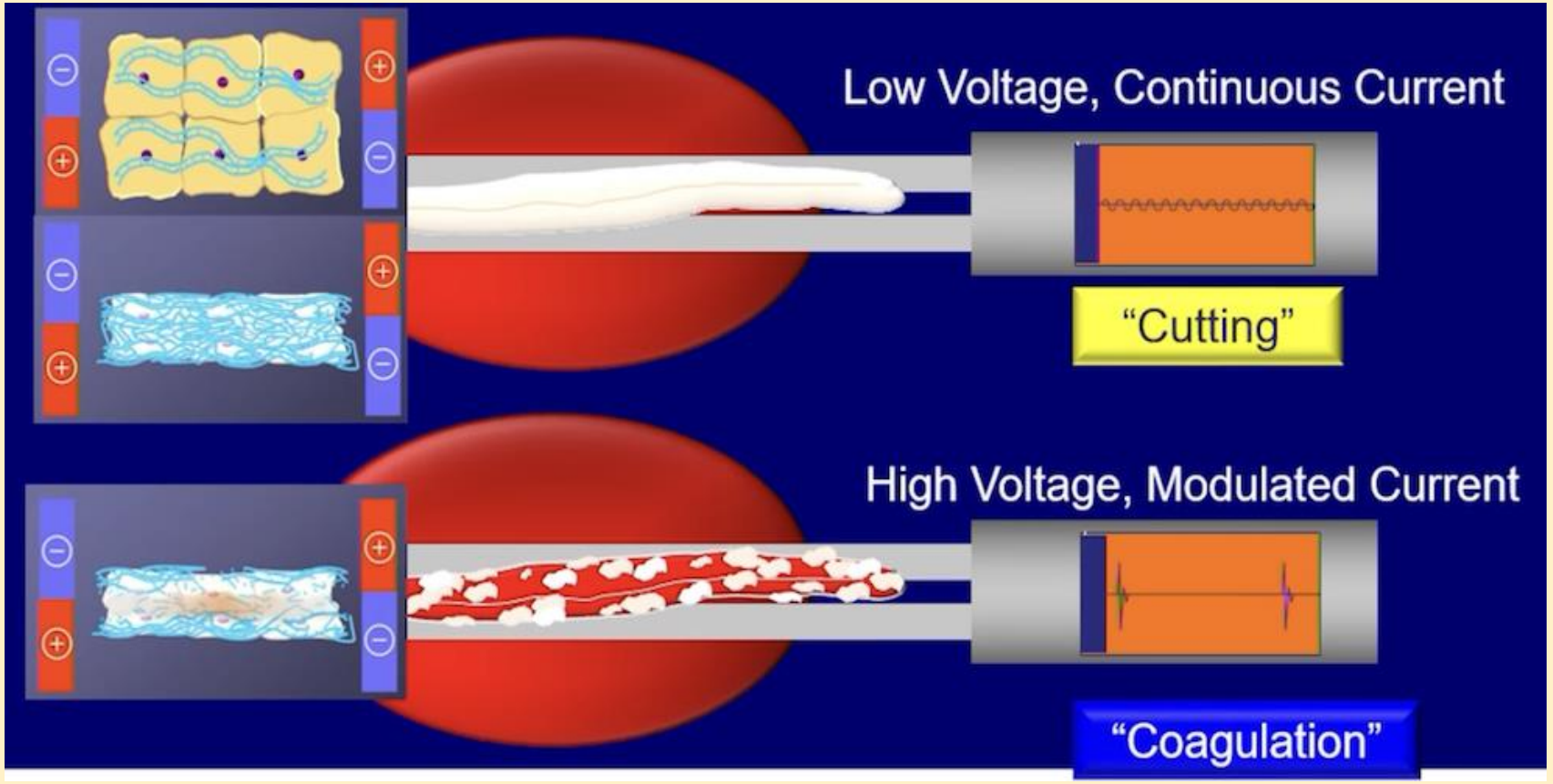
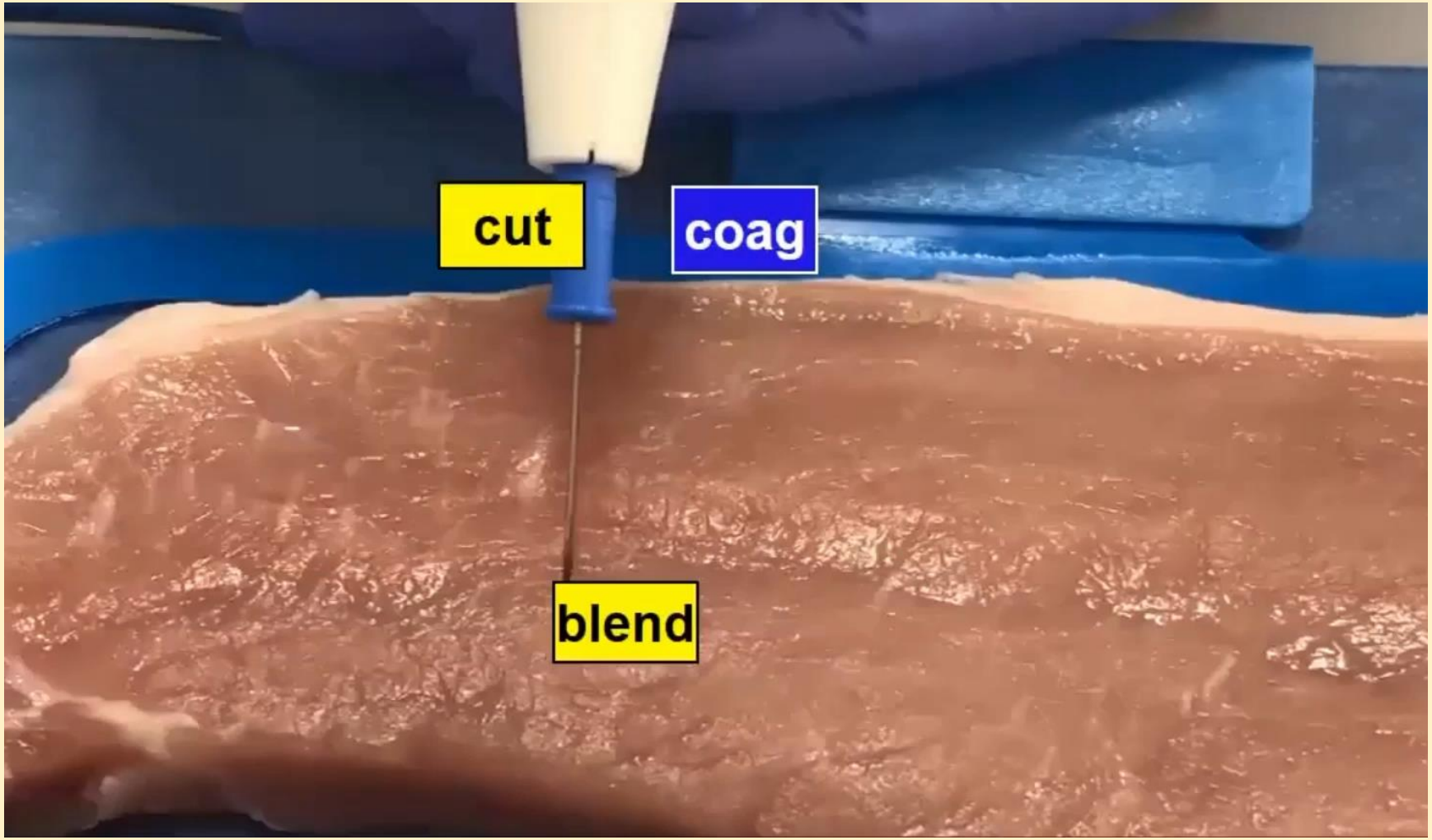
Principles of Electrosurgery

Effect of Voltage & Modulation on Seal Quality



Soderstrom et al. Obstet Gynecol 1989;74:60-3 (RCT Class 1).

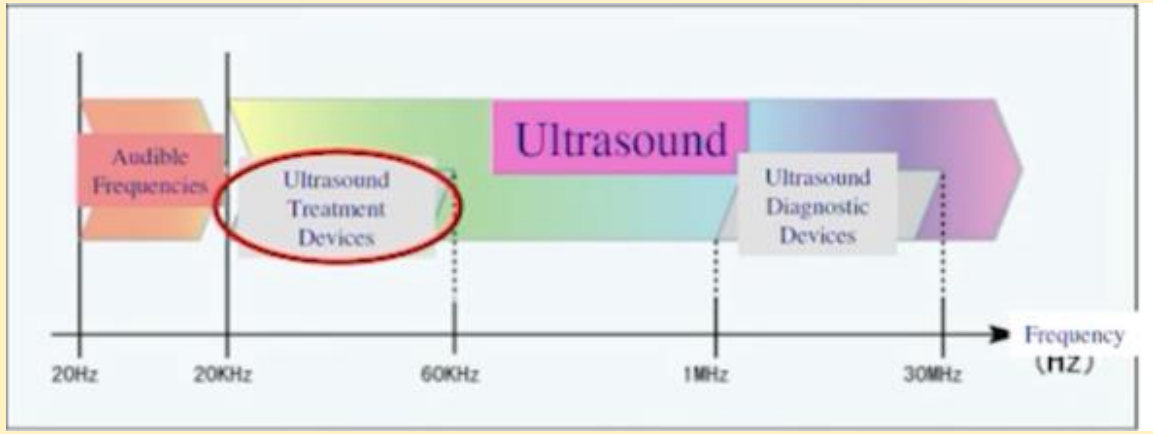
Principles of Electrosurgery



Ultrasonic Energy Systems

Definition:

Energy transported through a material via motion or disturbance of the material (i.e. vibrations!)



Classification:

- ✓ **<20 Hz** — **Subsonic (can be felt)**
- ✓ **20 Hz - 20 000 Hz** — **Sound (can be heard)**
- ✓ **>20 000 Hz** — **Ultrasound (dogs and bats can hear)**

Ultrasonic shears: **23,500 Hz (Olympus) - 55,500 HZ (Ethicon, Covidien, Olympus)**

The SAGES manual on the fundamental use of surgical energy (FUSE)

Ultrasonic Energy Systems

Ultrasound Energy: Why?

- ✓ **No electrical circuit needed**
- ✓ **Advantages**
  - ➢ ***No need for "dispersive electrode"***
  - ➢ ***No electricity in shaft of instrument***
  - ➢ ***No risk of stray electrical injury***
  - ➢ ***No electrical interference to monitors, etc.***

But

You still need to be careful of thermal Injury!

Ultrasonic Energy Systems

Ultrasound Energy: How Does it Work?

Mechanism: friction & shock waves

1. Friction between jaws:

- ✓ *Heat coagulates vessels*
- ✓ *Mechanical disruption*

2. Shock waves:

- ✓ *cavitation (low pressure vaporizes fluid -spray)*
- ✓ *Cuts tissue*

Ultrasonic Energy Systems

Path of Energy: Electrical to Mechanical

Controller Box or Battery: *Electricity (alternating current)*

→

Handpiece: *Converts Electricity to Mechanical Energy (U/S)*

→

Shaft & Tip of Instrument: *Mechanical Energy Only*

Ultrasonic Energy Systems

Ultrasound Generator: A Voltage Converter

Working Principle

The generator sends an electrical signal of 23.5 or 47 kHz to the transducer

Ultrasonic Energy Systems

How to Generate Ultrasound Energy

Working Principle

The transducer converts the electrical signal into an ultrasonic stationary wave

Electrical Wave
23000-47000 Hz
1000 V

→

Mechanical Wave
23000-47000 Hz
0.08-0.2 mm

Ultrasonic Energy Systems

Ultrasound Power Settings

- ✓ **Usually 2 settings: Max & Min**
- ✓ **Essentially a "volume control" - amplitude of vibrations**
- ✓ **Max setting - higher amplitude waves**
  - ✓ ***Cuts quickly (possible more bleeding)***
  - ✓ ***Less time for thermal coagulation***
- ✓ **Min setting - lower amplitude waves**
  - ✓ ***Can be "fine-tuned" by user from 1-5***
  - ✓ ***Cuts slower, so more time for vessel sealing by thermal energy***
  - ✓ ***Also, more time for thermal spread, collateral injury***

Ultrasonic Energy Systems

Cutting vs Coagulation

Cutting is enhanced by

- ✓ *Squeezing blades together (this may be limited by your handle)*
- ✓ *Lifting up so more pressure on metal blade*
- ✓ *"Turning up the volume" (use Max, not Min)*

Ultrasonic Energy Systems

How Does It Seal Vessels?

- ✓ **Vessel walls must be compressed together (requires closure of jaw)**
- ✓ **Protein in vessel wall denatures and forms sticky coagulum**
- ✓ **Vessels walls adhere together after energy source is removed**

Ultrasonic Energy Systems

Heat Production and Thermal Spread

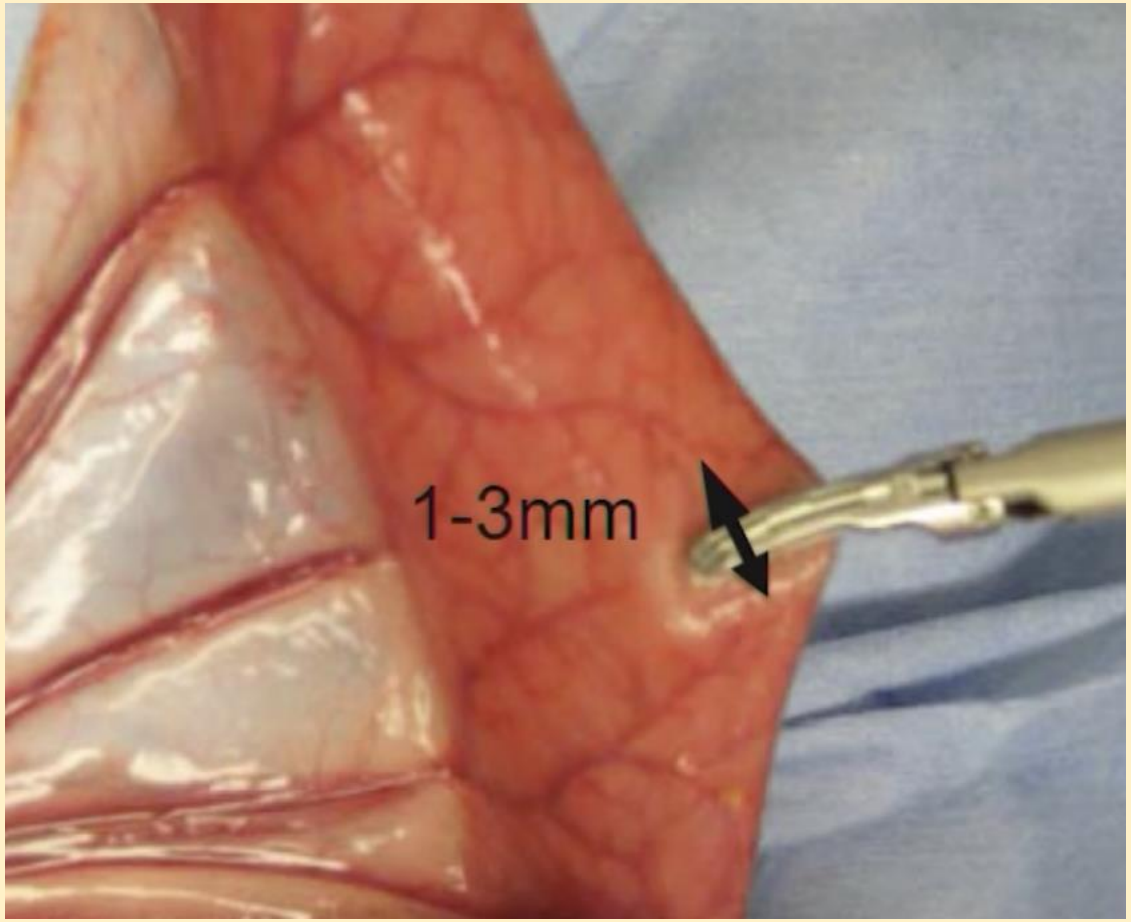
	Mean Peak Active Blade Temperature (°C ± SD)[10]	Mean Active Blade Cool Down Time to 60°C (sec ± SD)[10]	Mean Thermal Spread (mm ± SD)[8]	Mean Seal Time (sec ± SD)[9]
Sonicision™	263.1 ± 18.8	37.6 ± 4.4	1.44 ± 0.5	8.40 ± 3.60
ACE+™*	266.3 ± 20.2	37.4 ± 5.8	1.25 ± 0.2	8.12 ± 3.74
P-Value	P = 0.771	P = 0.704	P = 0.100	P = 0.62

*Covidien pre-clinical comparative testing between the Sonicision ™M device and the Harmonic ACETM**

- ✓ **Heat production of more than 200 °C**
- ✓ **Lateral thermal spread of 1.5 - 3 mm**

Ultrasonic Energy Systems

Lateral Thermal Spread: During Activation



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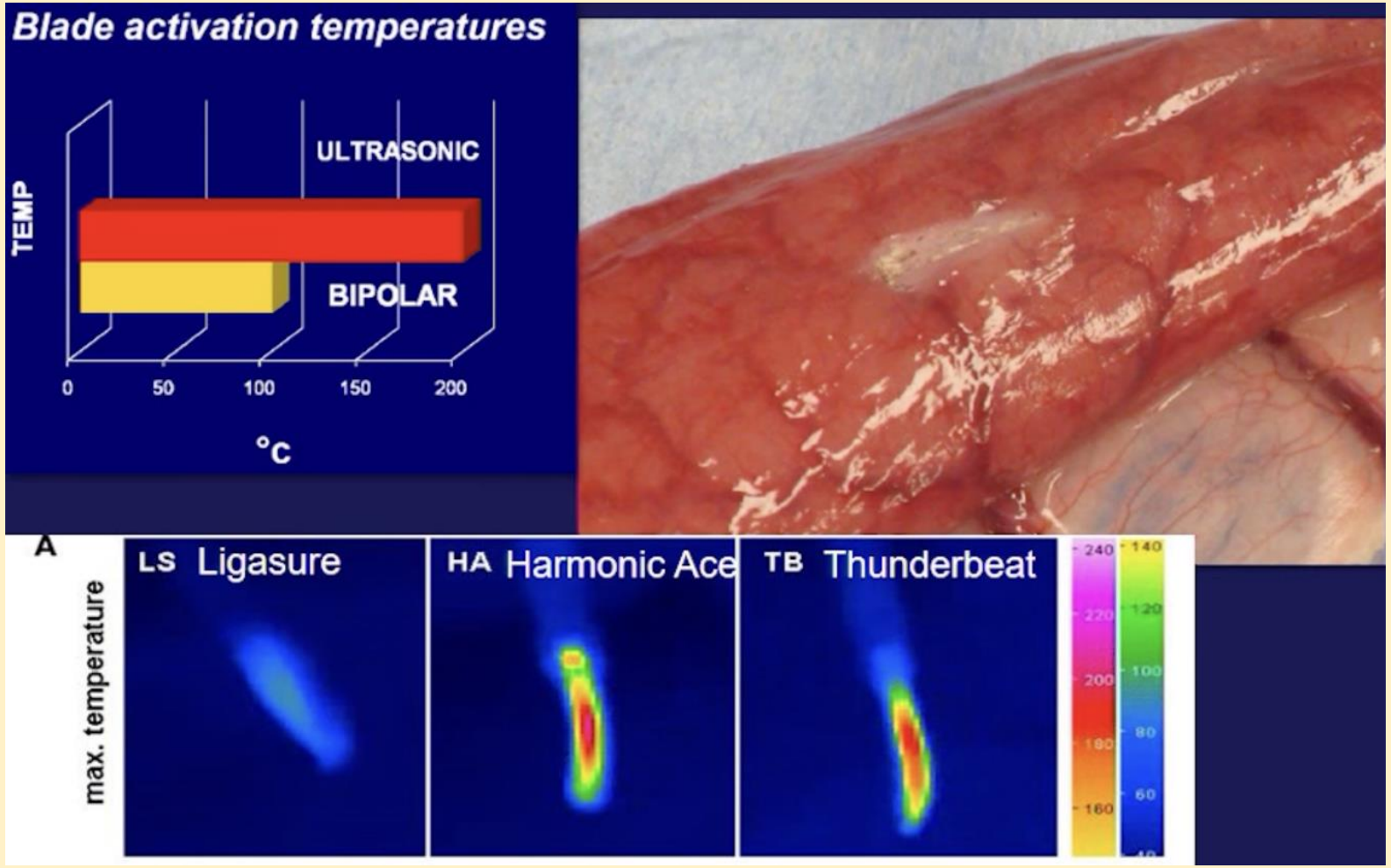
Ultrasonic Energy Systems

Residual Heat Injury: After Activation



Sehofer D. et al. Surg Endosc. 2012 Sep; 26(9): 2541-2549. Published online 2012 Mar 24.

Ultrasonic Energy Systems

Evidence

Evaluation of Surgical Energy Devices for Vessel Sealing and Peripheral Energy Spread in a Porcine Model

Gregory W. Hruby, Franzo C. Marruffo, Evren Durak, Sean M. Collins, Phillip Pierorazio, Peter A. Humphrey, Mahesh M. Mansukhani and Jaime Landman*,†

From the Departments of Urology (GWH, FCM, ED, SMC, PP, JL) and Pathology (MMM), Columbia University Medical Center, New York, New York, and Department of Pathology, Washington University (PAH), St. Louis, Missouri

Bipolar

- ✓ *Artery: 536 mm Hg, Vein 386 mm Hg*
- ✓ *Up to 7 mm vessels*

Ultrasonic shears burst pressure

- ✓ *Artery 436 mm Hg, Vein 160 mm Hg*
- ✓ *Most Up to 5 mm vessels, although some available for 7mm vessels*

*Hruby GW et al. J Urol 2007:178:2689-93.

Ultrasonic Energy Systems

Industry Sponsored Testing

Median burst pressures* in sealed small and large vessels

Ex vivo porcine carotid arteries

VESSEL DIAMETER	LIGASURE™ 5MM BLUNT TIP (LF1537) DEFAULT POWER LEVEL	HARMONIC ACE®+7 ADVANCED HEMOSTASIS MODE	*P*-VALUE
3-5 mm	836 mmHg	**1,314 mmHg**	0.001
5-7 mm	591 mmHg	**1,419 mmHg**	<0.001

(Mann-Whitney test) Note: LigaSure (Covidien, Mansfield, MA, USA)

Ultrasonic Energy Systems

Take-Home Points: Ultrasonic Devices

Advantages

- ✓ *Versatile device*
- ✓ *No electricity in patient*
- ✓ *No dispersive electrode*
- ✓ *Vessels are sealed, 5-7mm*
- ✓ *Minimal spread of energy*
- ✓ *No char, so no smoke*

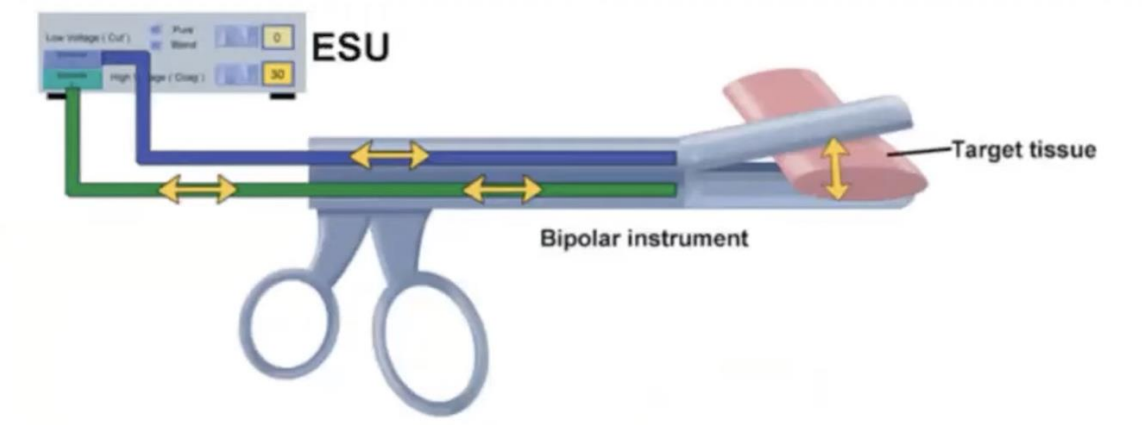
Disadvantages

- ✓ *Creates spray*
- ✓ *Heat retained in shaft of instrument*
- ✓ *Vascular sealing affected by technique (Min, max and lifting)*
- ✓ *Not as good at vessel sealing as advanced bipolar (that ability is evolving)*
- ✓ *Can be more expensive*

The SAGES manual on the fundamental use of surgical energy (FUSE)

Bipolar Energy Systems

THE RIGHT TOOL FOR THE RIGHT JOB: *WHAT IS THE EVIDENCE?*



Ultrasonic	Adv Bipolar
Harmonic	Ligasure
Sonicision	Enseal
	Voyant
Thunderbeat	

Ultrasonic Energy Systems

THE RIGHT TOOL FOR THE RIGHT JOB: *WHAT IS THE EVIDENCE?*

Ultrasonic Instruments		Bipolar Vessel Sealer
	I. Burst Pressure	
Equal	Vessels ≤ 5 mm	Equal
Inferior	Vessels 6-7 mm	Superior
Superior	II. Thermal Damage	Inferior
Inferior	III. Residual Heat	Superior
Superior	IV. Dissection	Inferior
Equal	V. Cost	Equal

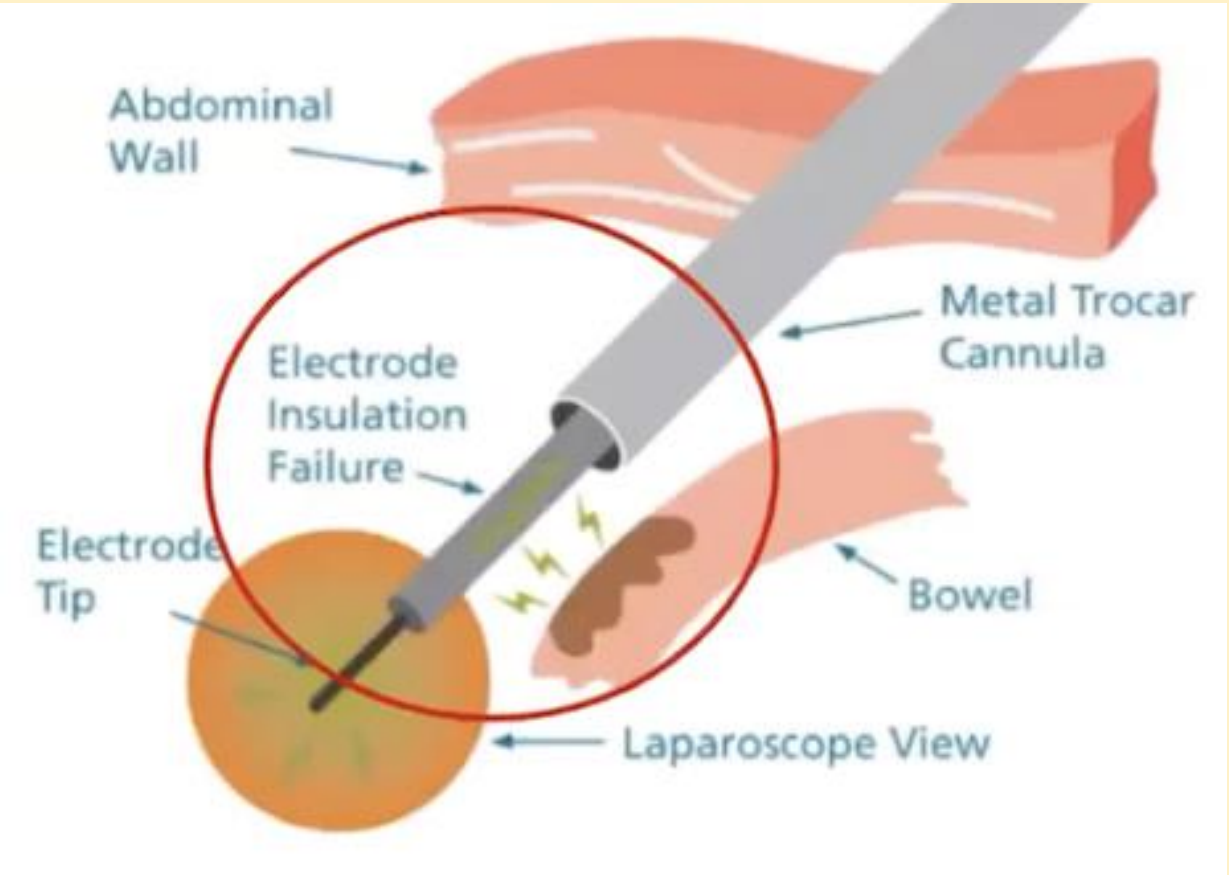
Lamberton GR, Hsi RS et al. J Endourol (2008) 22: 2307.
Person B, Vivas DA et al. Surg Endosc (2008) 22: 534
Govekar HG, Robinson 11V et al. Surg Endosc (2011) 25: 3499
Kim FJ, Chammas MF et al. Surg Endosc (2008) 22: 1464
Govekar HG, Robinson TN et al. Surg Endosc (2011) 25: 3499.
Noble EJ, Smart HJ et al. Br J Surg (2011) 98: 797
Hruby GW, Marruffo FC et al. J Urol (2007) 178: 2689.

Current Diversion

- Insulation fallure
- Direct coupling
- Capacitive coupling
- Alternate site injuries

Current Diversion

Insulation fallure



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Current Diversion

Direct coupling

Occurs when one conductive element of the circuit touches or arcs to an instrument outside the intended circuit.

- ✓ **Often utilized intentionally (e.g. coagulation)**
- ✓ **Potential risk when**
  - ✓ *current directed towards non-target tissues*
  - ✓ *instruments not completely/ always in view (e.g. laparoscopy)*

✓ **Metal-to-metal arcing**

- ✓ **Direct coupling between the active electrode and any metal (instrument, clip, etc)**

✓ **Beware of staple lines**

The SAGES manual on the fundamental use of surgical energy (FUSE)

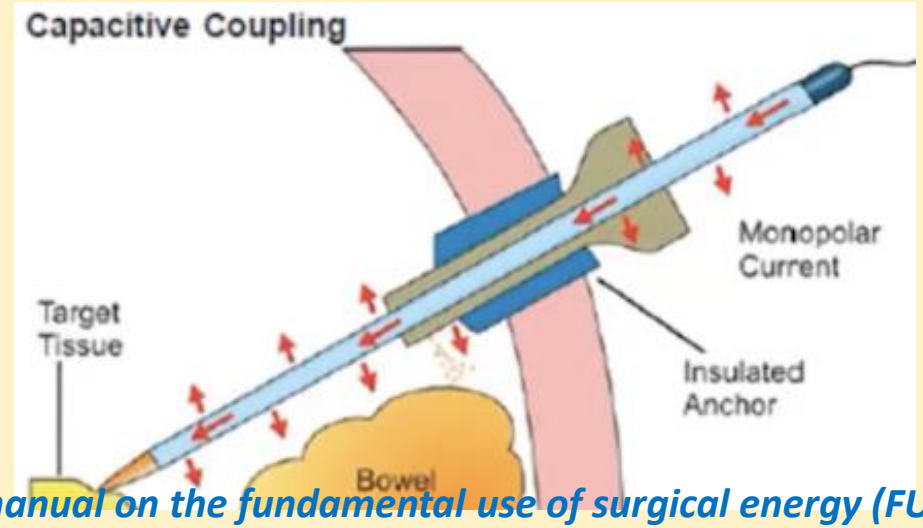
Current Diversion

Capacitive coupling

Capacitor: two conductors separated by an insulator or dielectric

Capacitive coupling: the stored electrical charge within the capacitor

- ✓ ↑*voltage,*↑*power setting*
- ✓ *"open" activation*
- ✓ *Activation over previously desiccated tissue (*↑*impedance)*



The SAGES manual on the fundamental use of surgical energy (FUSE)

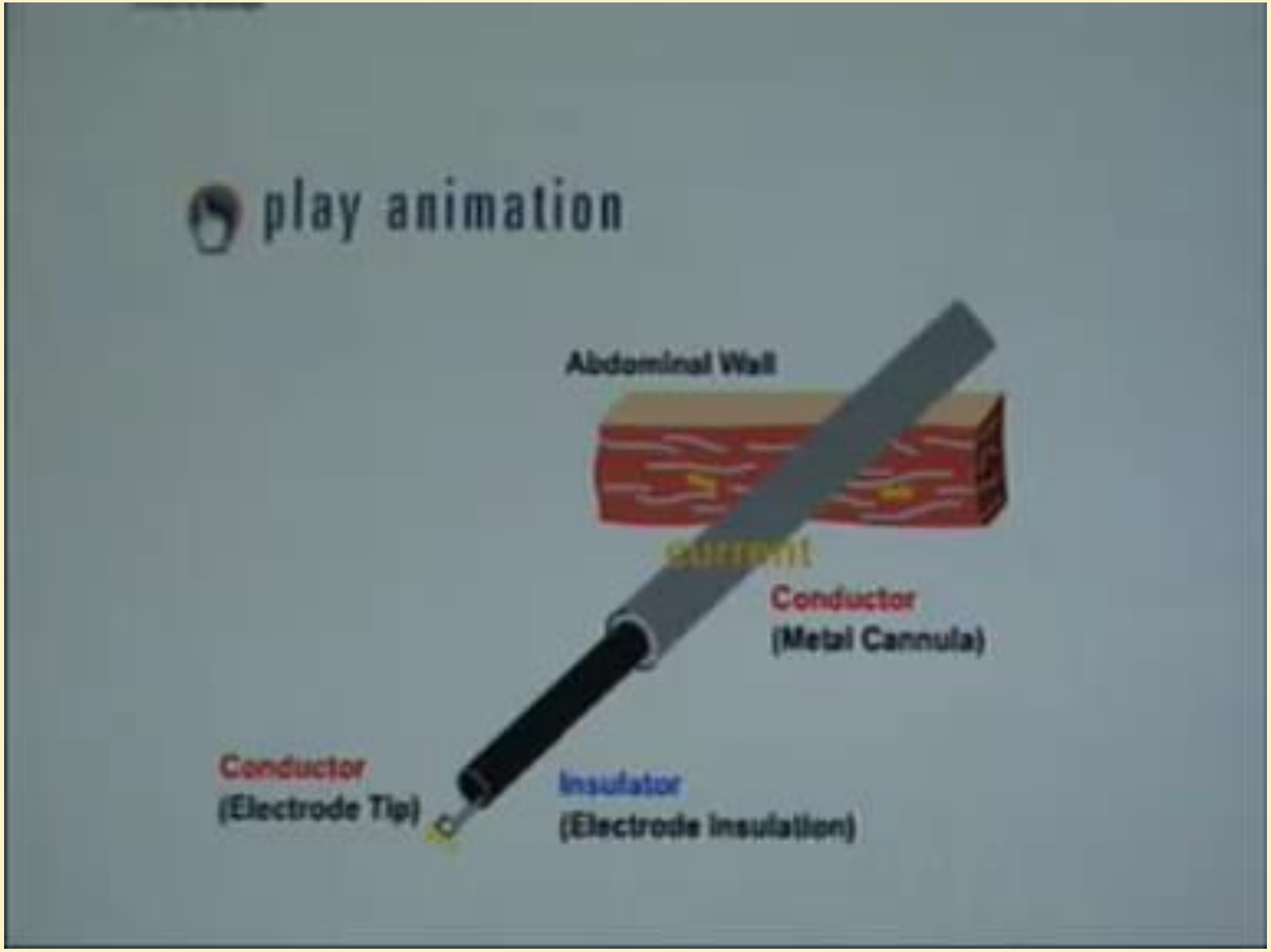
Current Diversion

Alternate site injuries

- ✓ Beware of patient in contact with metal objects
- ✓ Risk of skin burns

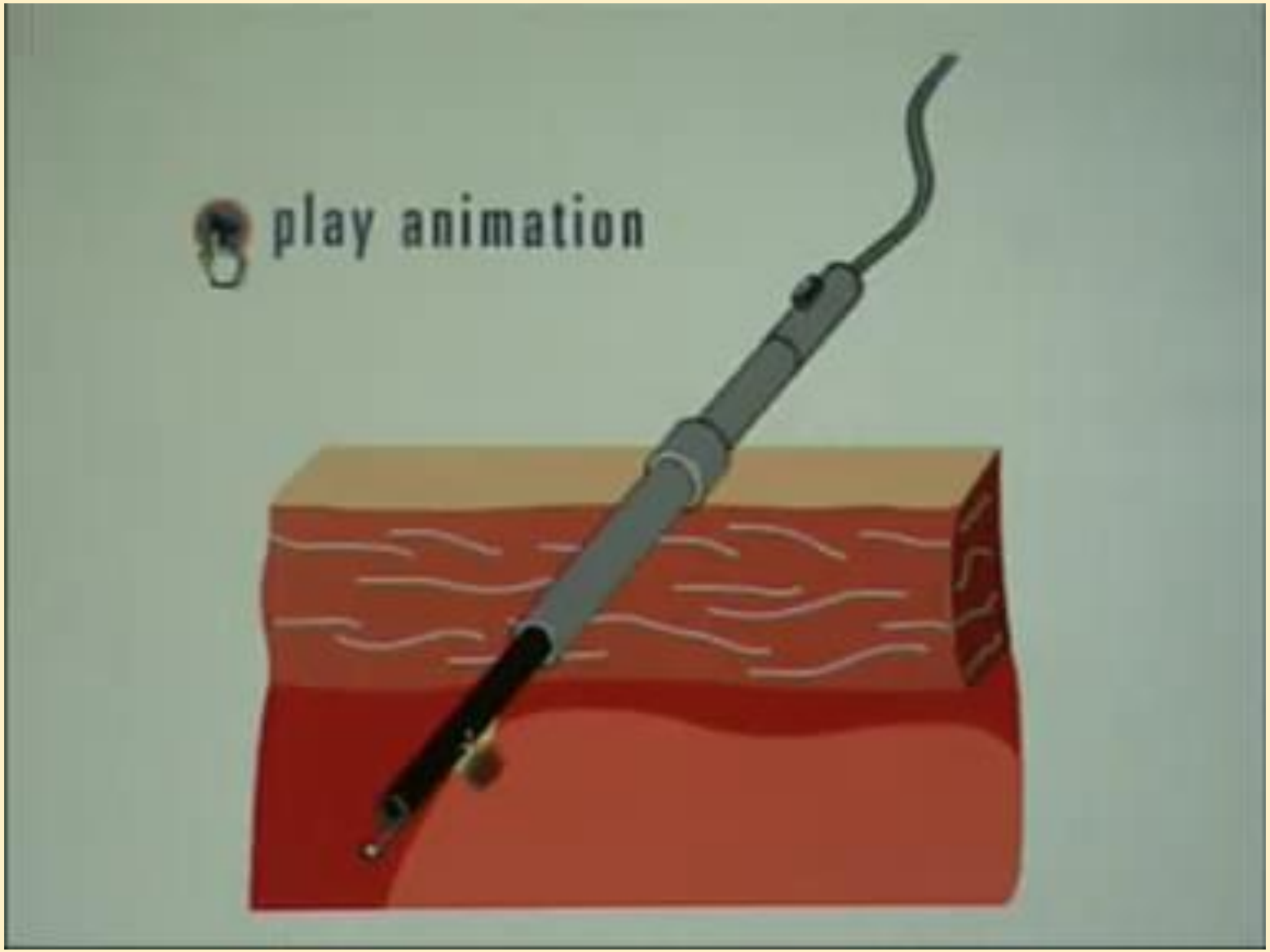
The SAGES manual on the fundamental use of surgical energy (FUSE)

Injuries

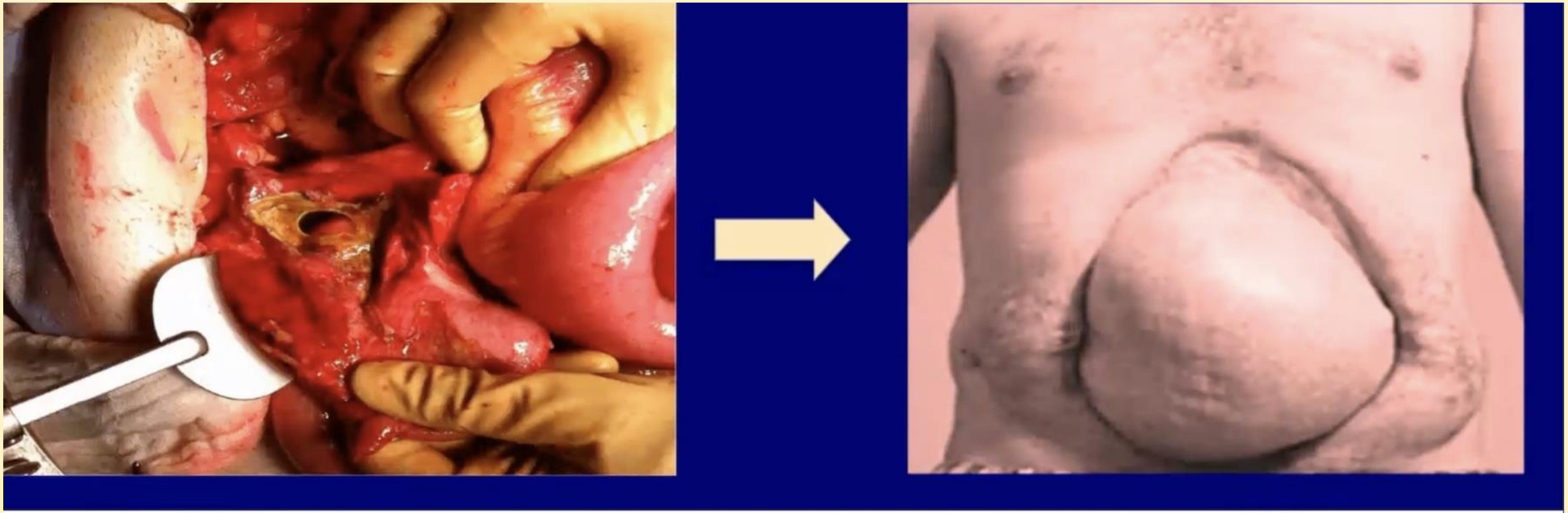

play animation
Abdominal Wall
Conductor
(Metal Cannula)
Conductor
(Electrode Tip)
Insulator
(Electrode Insulation)

Injuries

Injuries



Injuries

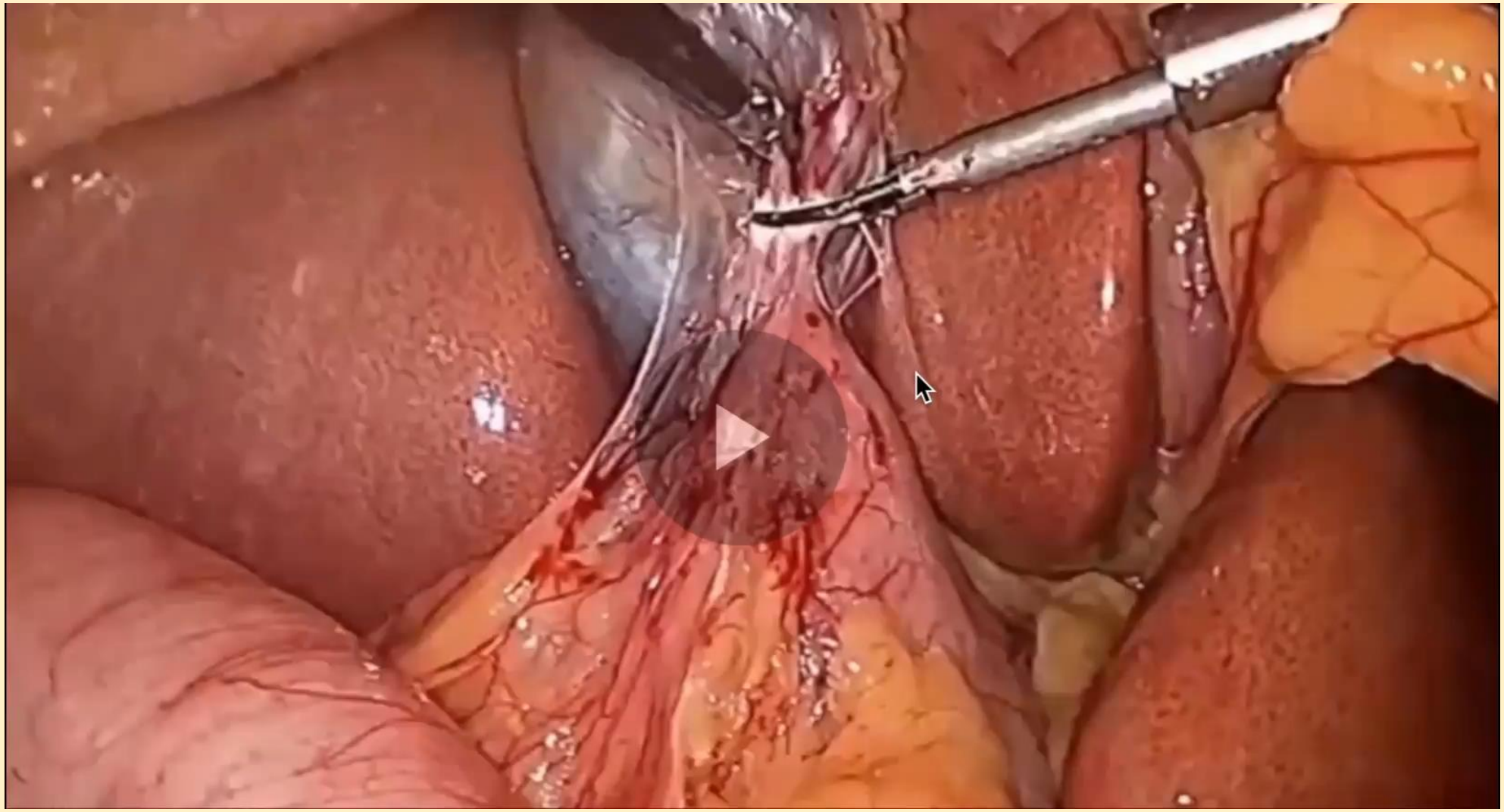


1. Nduka CC et al. Cause and prevention of electrosurgical injuries in laparoscopy. 1994 J Am Coll Surg 179:161-170
2. Market engineering research for the U. S. market for general surgery laparoscopy access and closure instruments. Medical and Healthcare Marketplace Guide. 1999. Frost and Sullivan, London, UK

Injuries

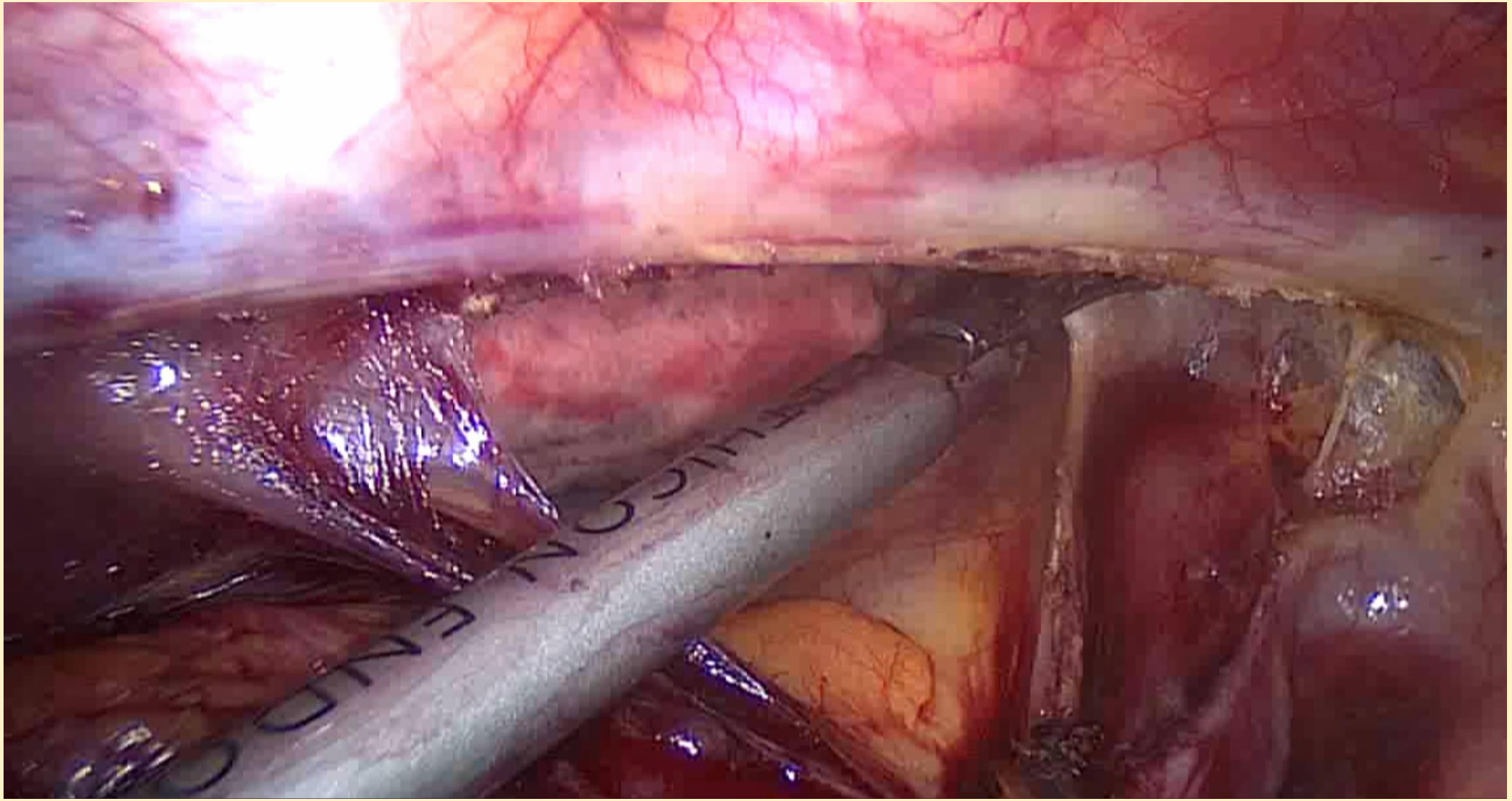

Lauren Wargo
May 23, 2010
Cleveland Plain Dealer
NBC Today Show: Nov 2011

Injuries



Injuries

Ultrasonic Energy Systems



MCQ

Which of the following is most likely to lead to a complication when using radiofrequency ablation on a liver lesion:

A. Injury of the operator due to capacitive coupling

B. Injury to the skin due to direct coupling

C. Injury due to malignant hyperthermia

D. Injury to adjacent structures due to heat

The SAGES manual on the fundamental use of surgical energy (FUSE)

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MCQ

The "coagulation" mode on the electrosurgical unit:

A. Uses an interrupted high voltage waveform

B. Uses a continuous low voltage waveform

C. Uses an interrupted low voltage waveform

D. Uses a continuous high voltage waveform

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All of the following conditions are desirable during bipolar electrical surgery, except:

A. Development of proximal thrombus

B. Elimination of the tissue cooling via obstruction of continued blood flow

C. Electrical bypass via tissue compression

D. Localized cellular and tissue heating

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If a bipolar device becomes adherent to the target tissue, the operator should:

A. Increase the power output of the ESU unit in order to evaporate the adhered layer of tissue

B. Turn off the ESU and peel the jaws of the bipolar device from the adhered tissue

C. Repeatedly open and close the bipolar device jaws until the tissue is dislodged

D. Reactivate the bipolar device under irrigation to create steam bubbles

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The SAGES manual on the fundamental use of surgical energy (FUSE)

MCQ

Which of the following are true:

A. Bipolar electrosurgery is radiofrequency

B. Monopolar electrosurgery is radiofrequency

C. Both

D. Neither

The SAGES manual on the fundamental use of surgical energy (FUSE)

MCQ

Which of the following are true:

A. Bipolar electrosurgery is radiofrequency

B. Monopolar electrosurgery is radiofrequency

C. Both

D. Neither

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Ευχαριστώ!