Clear Answers to Common Electrosurgical Questions

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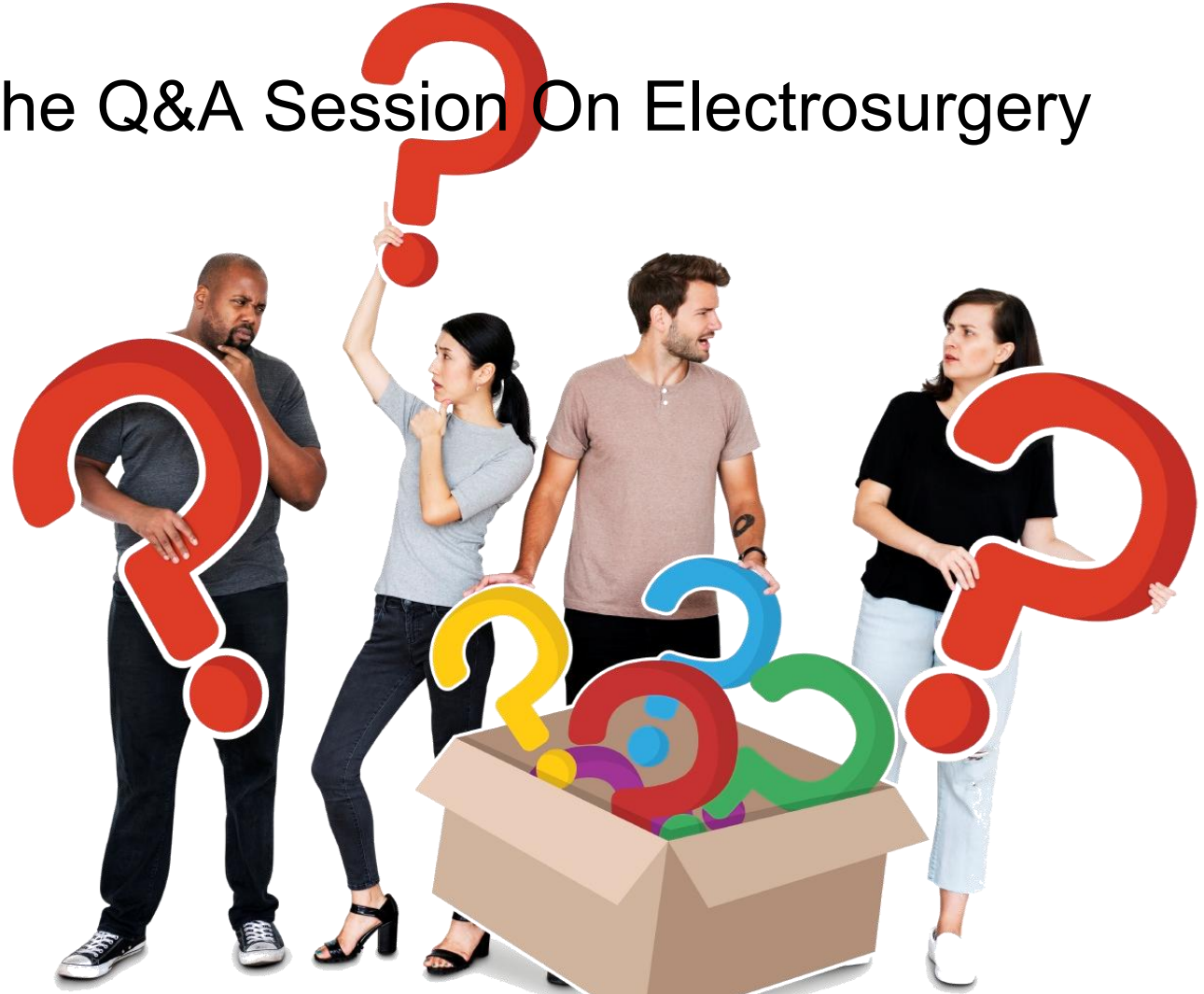
GE HealthCare

HTM MIXER Milwaukee

Welcome to the Q&A Session On Electrosurgery



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What Is Electrosurgery Anyway?

- Electrosurgery is the use of high-frequency electrical current to cut tissue or stop bleeding during surgery.
- Electrosurgery isn’t a niche technology—it’s a core tool used in more than 85% of all surgeries.

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Question 1.

I can move my shoulders up and down with a 9-volt battery in a TENS unit, but the same effect is not produced when using thousands of volts from an electrosurgical generator. Why?

Transcutaneous Electrical Nerve Stimulation (TENS)

TENS Unit vs. Electrosurgical Unit

9V TENS Unit
Nerve stimulation

2000V - 9000 V Electrosurgical Generator
NO muscle or nerve stimulation

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Electricity Runs the Body

Electricity in the body isn’t just running the show—it *is* the show. Without it, your body would be as lifeless as a flashlight without batteries. Consider what it controls…

- Heart rhythm
- Brain waves
- Body animation
- Nerve impulses

Before Going Forward, Let's Go Back to the Mid 1770s…

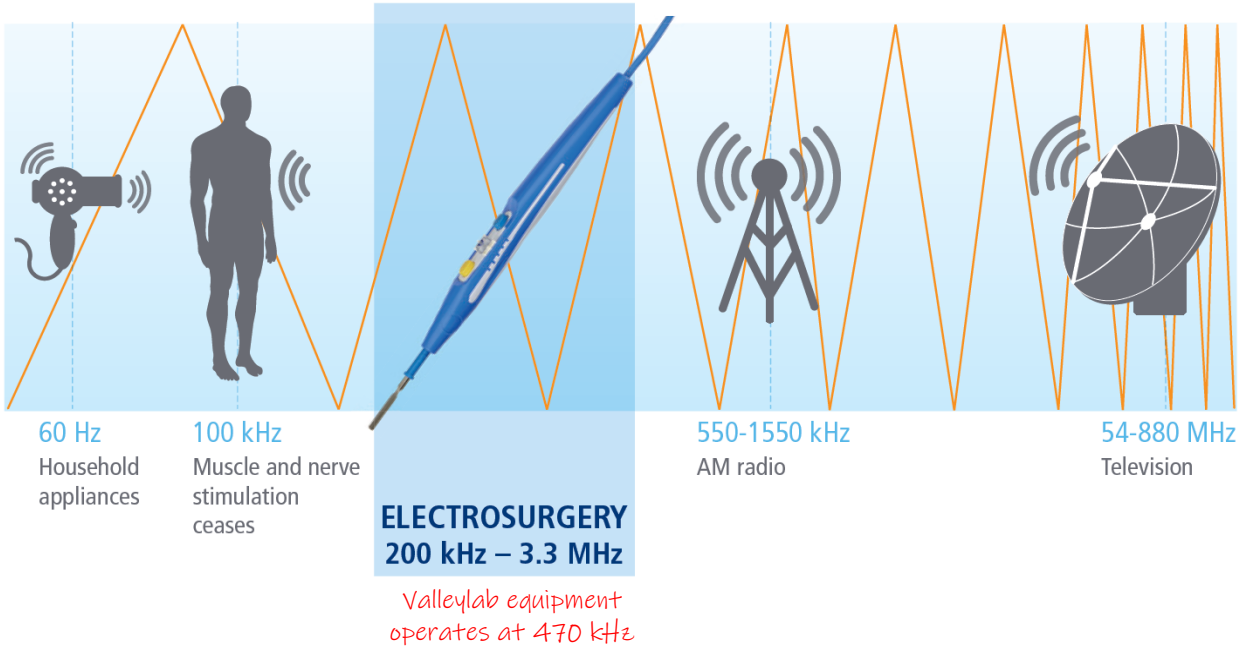
Luigi Galvani – Discovery of Bioelectricity

- Italian physician and physicist (1737-1798)
- He lived during the era of many discoveries in electricity.
- In 1786, Galvani conducted experiments with static electricity.
- He discovered the relationship between electricity and animation.

Hippocrates	460 BC – 377 BC	
Albucasis	936 - 1013	
600 years later…		
Benjamin Franklin	1706-1790	
Charles Augustin Coulomb	1736 - 1806	
Luigi Aloisio Galvani	1737 - 1798	
Alessandro Giuseppe Volta	1745 - 1827	
[illegible]	1775 - 1836	
Carl Friedrich Gauss	1777 - 1855	
Hans Oersted	1777 - 1851	
Georg Ohm	1789 - 1854	
Michael Faraday	1791 - 1867	
William T. G. Morton	1819 - 1868	
James Maxwell	1831 - 1879	
William J. Morton	1840 - 1920	
Thomas Edison	1847 - 1931	
Jacques-Arsène d'Arsonval	1851 - 1940	
Nikola Tesla	1856 - 1943	
Harvey Cushing	1869 - 1939	
Lee De Forest	1873 - 1961	
Guglielmo Marconi	1874 - 1937	
William Bovie	1881 - 1958	

It's Not About the Voltage But the Frequency

In 1881, William J. Morton discovered that muscle and nerve stimulation ceased at about 100 kHz.



Valleylab equipment operates at 470 kHz

The Human Body Reacts to Lower Frequencies

120V *60 Hz – Involuntary Muscle Contraction*

Preset Programs

#	Description	Pulse Rate (Hz)	Pulse Width (µs)	Timer	Conditions
1	**Conventional TENS** Ideal for first application of TENS for both acute & long term pain	80	180	Continuous	Neck Pain, Shoulder Pain, Elbow Pain, Rheumatic Pain, Lumbago, Menstrual Pain, Hip Pain, Osteoarthritic Pain in the Knee
2	**Burst TENS** Most effective for radiating pain in arms, legs and deep muscular pain	2	180	Continuous	Osteoarthritic Pain in the Knee, Sciatica Central Pain
3	**Modulated TENS** Pain relief with a massage effect	80	70 - 180	Continuous	Neck pain, shoulder pain, elbow pain, rheumatic pain, lumbago, menstrual pain, hip pain, osteoarthritic knee pain
4	**Mixed Frequency TENS** Alternates between 2 low rates	15/2	180	Continuous	Osteoarthritic knee pain, neck pain, shoulder pain, central pain, lumbago
5	**Mixed Frequency TENS** Effective program for long term use with a reduced accommodation factor, alternates between high rate and low rate	80/2	180	Continuous	Osteoarthritic knee pain, neck pain, shoulder pain, menstrual pain, central pain, lumbago Nausea, motion sickness
6	**Nausea** Specifically for the treatment of nausea, treatment most successful placing electrode over acupuncture point C6	10	180	Continuous	Nausea
7	**Migrane/Headaches** Reduced pulse width ideal for treating nerve rich areas	80	60	Continuous	Tension Type Headache, Neck Pain, Postherpetic Neuralgia
8	**Low Frequency Modulation** 70% rate modulation over 10 seconds	10	200	Continuous	Neck Pain, Shoulder Pain, Elbow Pain, Rheumatic Pain, Lumbago, Menstrual Pain, Hip Pain, Osteoarthritic Pain in the Knee
9	**Frequency & Width Modulation** 90% rate & width modulation over 10 seconds	50	250	Continuous	Neck Pain, Shoulder Pain, Elbow Pain, Rheumatic Pain, Lumbago, Menstrual Pain, Hip Pain, Osteoarthritic Pain in the Knee
10	**Frequency Sweep Mode** Sequential modulation of frequency to prevent stimulus accommodation	5-125	120	Continuous	For all types of pain conditions
11	**Frequency & Width Modulation** Modulation Rate & Width over 6 seconds	2-100	150 - 260	Continuous	Neck Pain, Shoulder Pain, Elbow Pain, Rheumatic Pain, Lumbago, Menstrual Pain, Hip Pain, Osteoarthritic Pain in the Knee
12	**Frequency Modulation** Modulation Rate over 6 seconds	7-80	260	Continuous	Neck Pain, Shoulder Pain, Elbow Pain, Rheumatic Pain, Lumbago, Menstrual Pain, Hip Pain, Osteoarthritic Pain in the Knee

9V *1-150 Hz – Nerve Stimulation*

The Frequencies of Thought: Brainwaves That Define Us

In His Image: What the Human Body Reveals About God

Delta (0.5 - 4 Hz) is the body's repair mode — slow, deep pulses during sleep.

Theta (4 - 8 Hz) taps imagination, meditation, and creative reflection.

Alpha (8 - 13 Hz) brings peace, like the quiet after prayer or a sunset walk.

Beta (13 - 30 Hz) is sharp focus and critical thinking.

Gamma (30 - 100 Hz) is peak performance, memory, and heightened awareness.

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Why ***Doesn't*** the Body React to Higher Frequencies

The ability of electrical current to stimulate nerves and muscles depends not on the voltage, but on the **frequency**. As frequency increases, our tissues simply can't keep up. At high frequencies—like those used in ESUs—the body experiences only heat, not nerve stimulation.

Traffic Light Analogy

TENS signals are like traffic lights you can react to… stop, go, stop.

ESU signals change so fast, it's like they all blur together — you don't know what to do, and you just stay put.

Device Frequency and Tissue Effect

Humans: 1 Hz to 10,000 Hz

Device	Frequency Range	Effect on Tissue
TENS	1 Hz – 150 Hz (9 volts)	Nerve & muscle stimulation, contraction
Household AC	60 Hz (120 volts)	Involuntary muscle contraction
Defibrillator (older models)	~60 Hz (damped) (200 and 1000 volts)	Direct muscle/heart depolarization*
Electrosurgical Unit (ESU)	300 kHz – 4 MHz 2000 – 9000 volts	No nerve/muscle stimulation; heats tissue
Microwave Ablation	~900 MHz – 2.45 GHz	Internal water heating (thermal destruction)

* **Depolarization – Orchestra Analogy**
  Think of the heart as an orchestra. A defibrillator's shock is like a conductor stopping all the musicians with one big gesture, so they can start again together in sync. An ESU's high-frequency current is like a metronome ticking so fast no one can follow — the orchestra stays in chaos, and no music comes out.

Question 2.

I’m confused by all the terms that are used: electrocautery, electrosurgery, diathermy, hyfrecation, and ablation? Can you help me out?

Seven Tools, Three Purposes: Burn, Heal, and Block

Modality	Primary Purpose	One-Liner Analogy
TENS	Block pain	Static jam to block pain signals
NMES	Strengthen muscle	Invisible trainer forcing workouts
Ultrasound	Heal tissue	Massage without the hands
Diathermy	Heal tissue	Microwave for muscles
Electrocautery	Burn tissue	Branding iron — tool gets hot
Electrosurgery	Burn tissue	Lightning scalpel — cuts from inside
Hyfrecation	Burn minor lesions	Low-power microwave zapping small spots

Seven Tools, Three Purposes: Burn, Heal, and Block

TENS:
A TENS unit (Transcutaneous Electrical Nerve Stimulation) is a small, battery-powered device that delivers low-voltage electrical pulses through the skin to stimulate nerves and help relieve pain.

Analogy: *The TENS units keeps your nerves so busy that the "pain message" gets lost in the chatter.*

Six Tools, Three Purposes: Burn, Heal, and Block

NMES:
NMES (Neuromuscular Electrical Stimulation) is a device that sends controlled electrical pulses through the skin to cause muscles to contract. It's used to build strength, prevent muscle atrophy, or help retrain muscles after injury or surgery.

Whereas a TENS Unit stimulates nerves to **reduce pain**, NMES stimulates muscles to **make them move**.

Analogy: *NMES is like a robot coach making your muscles do jumping jacks, even if you're just laying down.*

Six Tools, Three Purposes: Burn, Heal, and Block

Ultrasound:

When tissue is exposed to ultrasound, the sound waves cause a micro-vibration within the tissue. This vibration creates heat energy that increases blood flow to the area. This increased blood flow causes an increase in oxygen and chemicals that are essential for healing of the damaged tissue.

SAM – *Sustained Acoustic Medicine*

Analogy: *It's like a gentle shaker; it vibrates stuff deep inside without anyone pushing on it.*

Six Tools, Three Purposes: Burn, Heal, and Block

Diathermy:
Diathermy is a therapeutic treatment that uses high-frequency electromagnetic energy to generate heat deep inside body tissues. It helps relax muscles, improve blood flow, and speed up healing.

Diathermy is like a heat lamp that reaches under the skin. You don't feel it burning on the surface — instead, it warms the muscles and joints from the inside out.

Analogy: *It's like turning on an invisible heater inside your muscles — you don't see it, but your body feels warmer and looser.*

Six Tools, Three Purposes: Burn, Heal, and Block

Electrocautery:
Electrocautery is like a tiny branding iron for surgeons — it gets red-hot at the tip and is used to seal blood vessels or burn off tissue, but it never sends electricity into the patient's body.

Analogy: *It's like poking something with an orange-hot marshmallow stick from the fire. The stick burns whatever it touches.*

Six Tools, Three Purposes: Burn, Heal, and Block

Electrosurgery:
Electrosurgery is a surgical technique that uses **high-frequency** electrical current to cut through tissue or stop bleeding by generating heat inside the body.

Electrosurgery is like a smart electric scalpel — instead of slicing with a blade, it uses focused electricity to vaporize or seal tissue, all while reducing bleeding.

Analogy: *It's like magic scissors that cut by sending sparks inside the tissue — it doesn't look hot, but it works like lightning.*

Six Tools, Three Purposes: Burn, Heal, and Block

Hyfrecation:
Hyfrecation is a medical procedure that uses low-power, high-frequency electrical current to destroy small tissue growths, such as warts, skin tags, or superficial lesions. It's a form of monopolar electrosurgery, but much gentler and used on the skin, not deep internal tissue.

Hyfrecation is like a tiny spot welder for your skin — delivering small, controlled bursts of heat to zap unwanted tissue without cutting.

Analogy: *It's like zapping a bug with a tiny electric spark. It's a tiny power burst, just enough to sizzle it.*

Question 3.

What is the difference between cut (dissection), coagulation (hemostasis), and blend modes? And what is the difference between the fulgurate and spray coag sub types?

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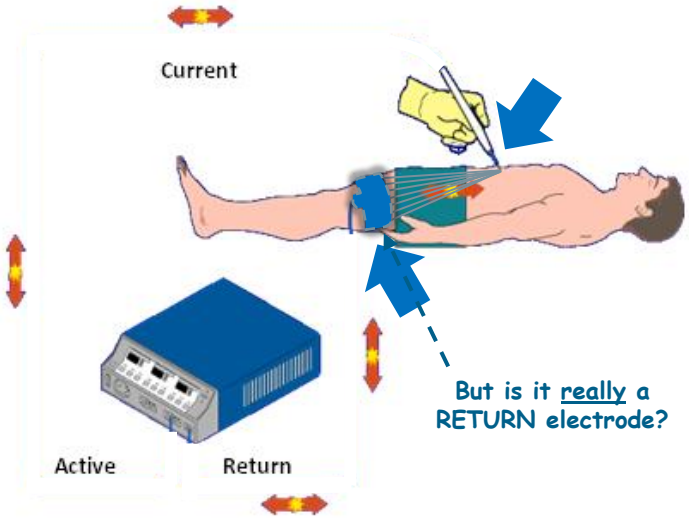
Monopolar Electrosurgery

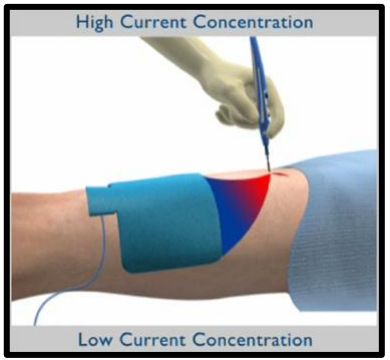
How are the electrodes the same and how are they different?

Active electrode at surgical site

Return (dispersive) electrode at another site

Current flows through the body between the electrodes and returns to the generator.





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Three Basic Electrosurgical Procedures

Small area = high concentration

- Cutting (vaporization)
- Coagulate (Latin for “to curdle”)
  - Fulguration (Latin for *lightning*) – arching (“spraying”) between electrode and tissue to stop heavy bleeding
  - Desiccation (Latin *to dry up*) – touching the tissue to achieve hemostasis (aka coagulation) in individual vessels
  - Ablation (Latin *to carry away*) – heats and coagulates large volumes of tissue (e.g., liver or tumor)
- Blend (cut and coagulate)

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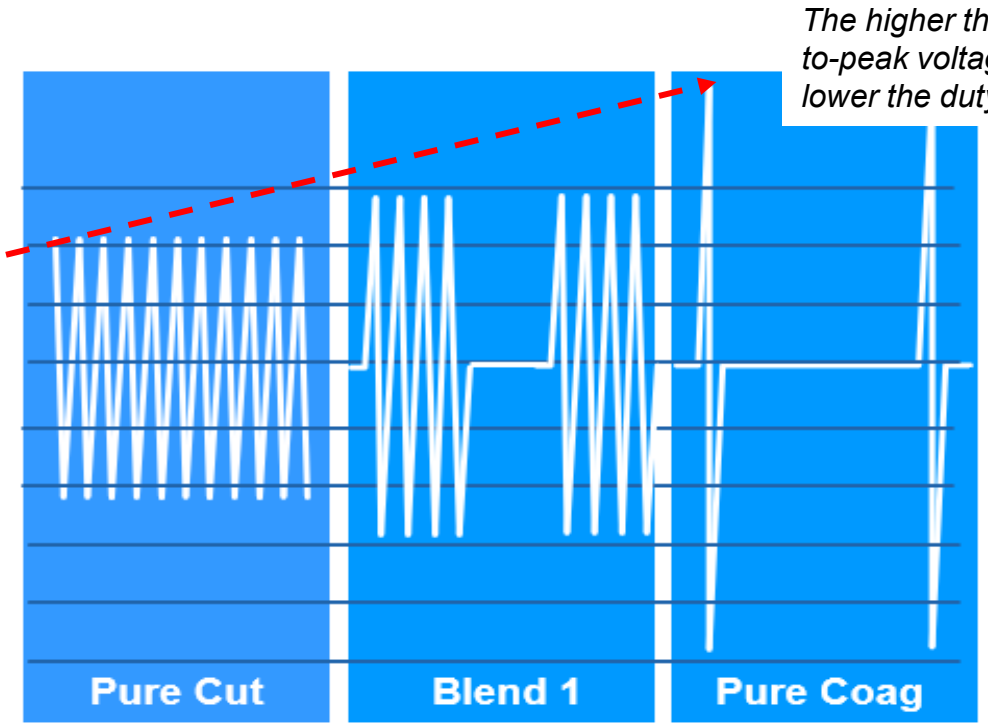
Waveforms



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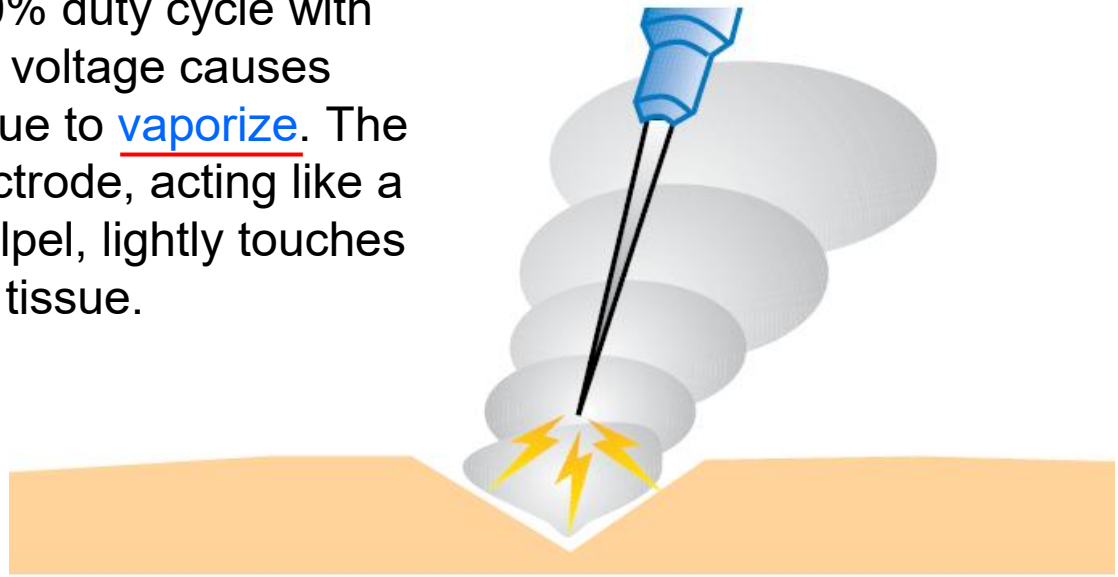
Cut Mode

100% duty cycle with low voltage causes tissue to vaporize. The electrode, acting like a scalpel, lightly touches the tissue.



Vaporization

One Advantage of Using Electrosurgery

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Three Basic Electrosurgical Procedures

Fulgurate – direct and deeper

Spray – diffused and superficial

Why spray coagulation is used in liver resection:

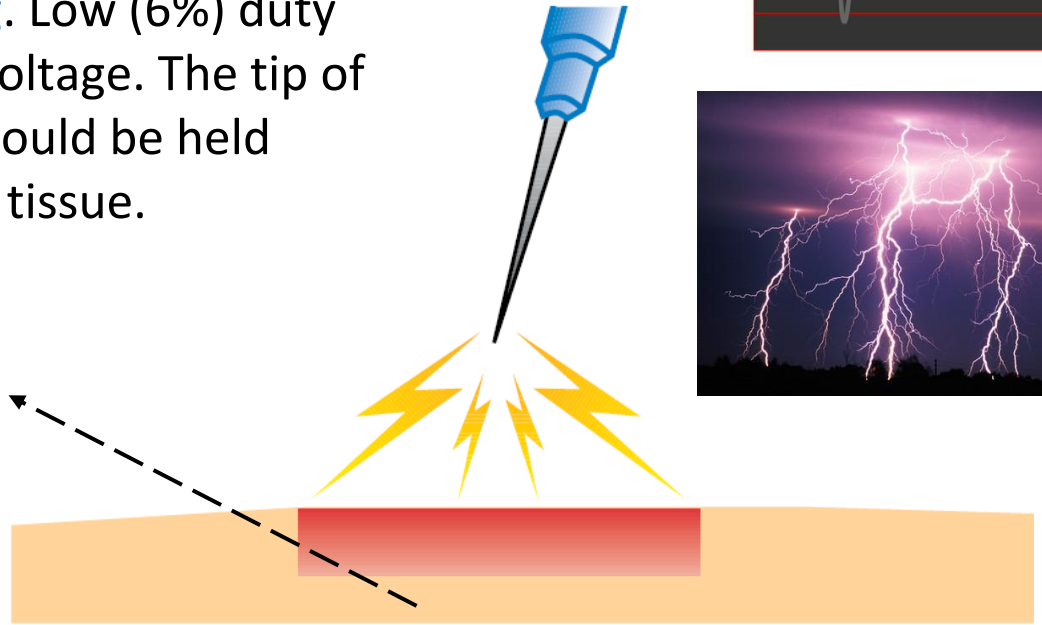
Because the liver is extremely vascular, it bleeds easily. When a surgeon cuts through liver tissue, hundreds of small vessels can ooze simultaneously. ***Spray coagulation*** *provides a broad, superficial hemostatic field that seals many of those bleeders quickly without deep charring.*

Coag Mode

Fulguration (lightning) is used to control bleeding. Low (6%) duty cycle, but high voltage. The tip of the electrode should be held slightly over the tissue.

For example, the ForceTriad™ energy platform Coag duty cycles are:

- Fulgurate – 6.5%
- Spray – 4.6%



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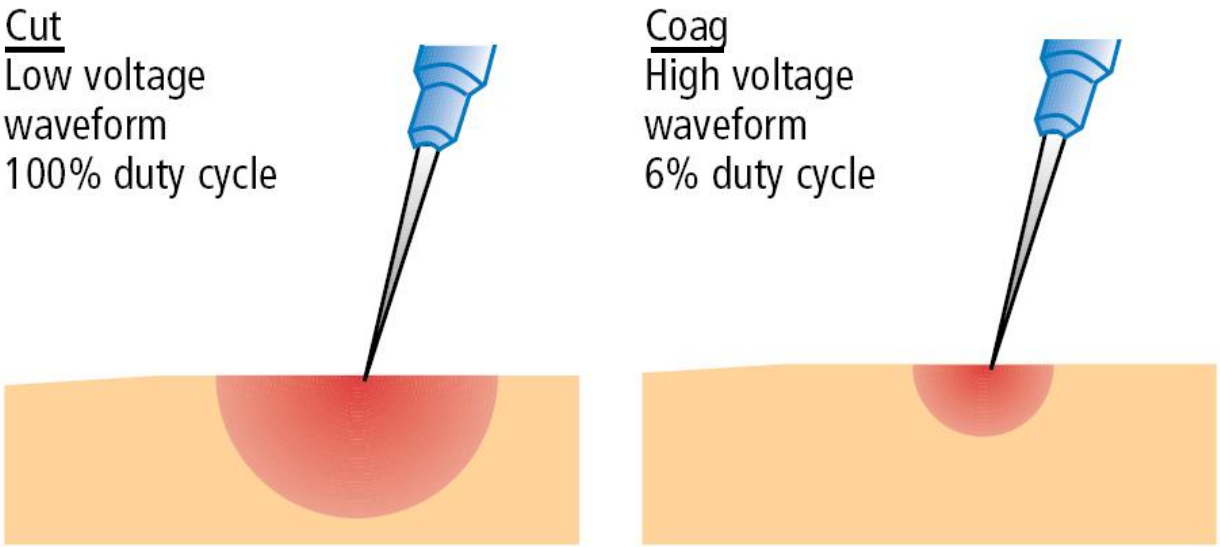
Desiccation: The Process Of Extreme Drying

Desiccation can be achieved using the Cut or Coag mode to create a deeper-reaching coagulation to directly seal individual bleeding vessels.



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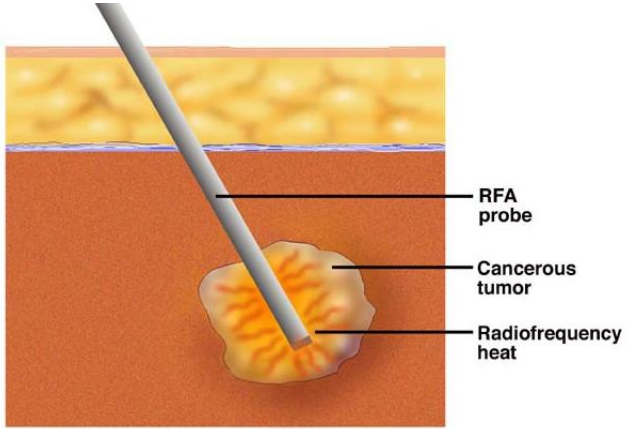
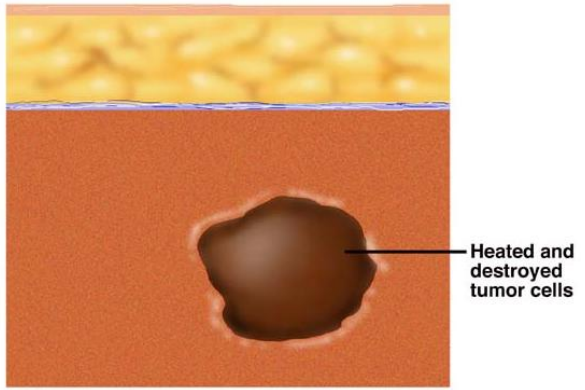
Ablation

- Heat is generated locally by a high frequency current that flows from the electrodes.
- A probe is inserted into the center of the tumor for about 10-15 minutes.
- The local heat melts (coagulates) the tissue that is adjacent to the probe.
- The whole procedure is monitored visually by ultrasound scanning.





RF and Microwave Ablation Units

RF - CoolTip™

µW – VT Gen™

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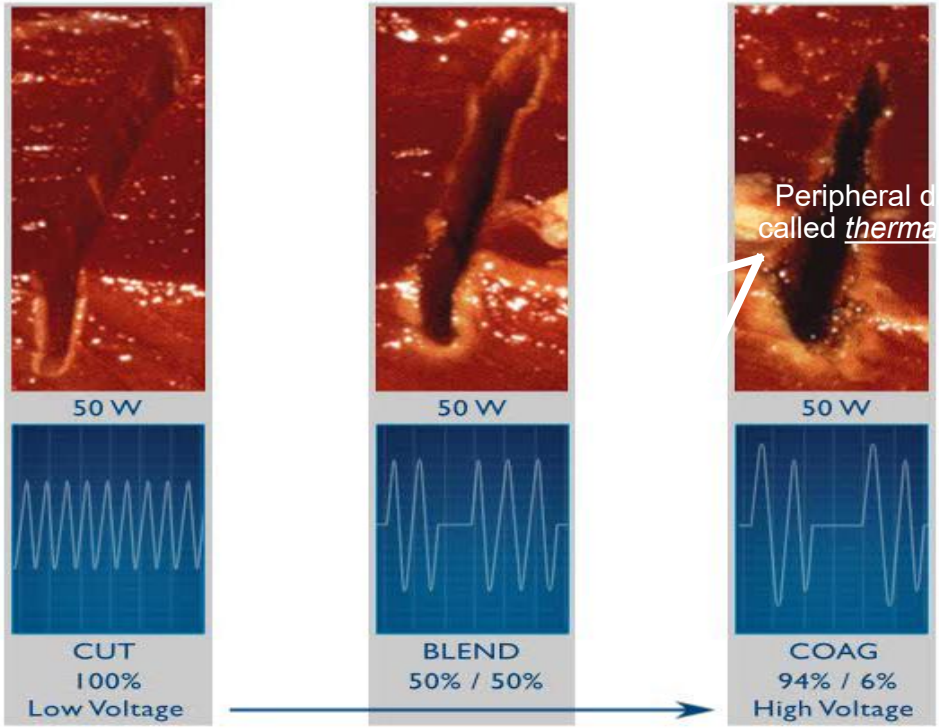
Comparison of Waveform Effects



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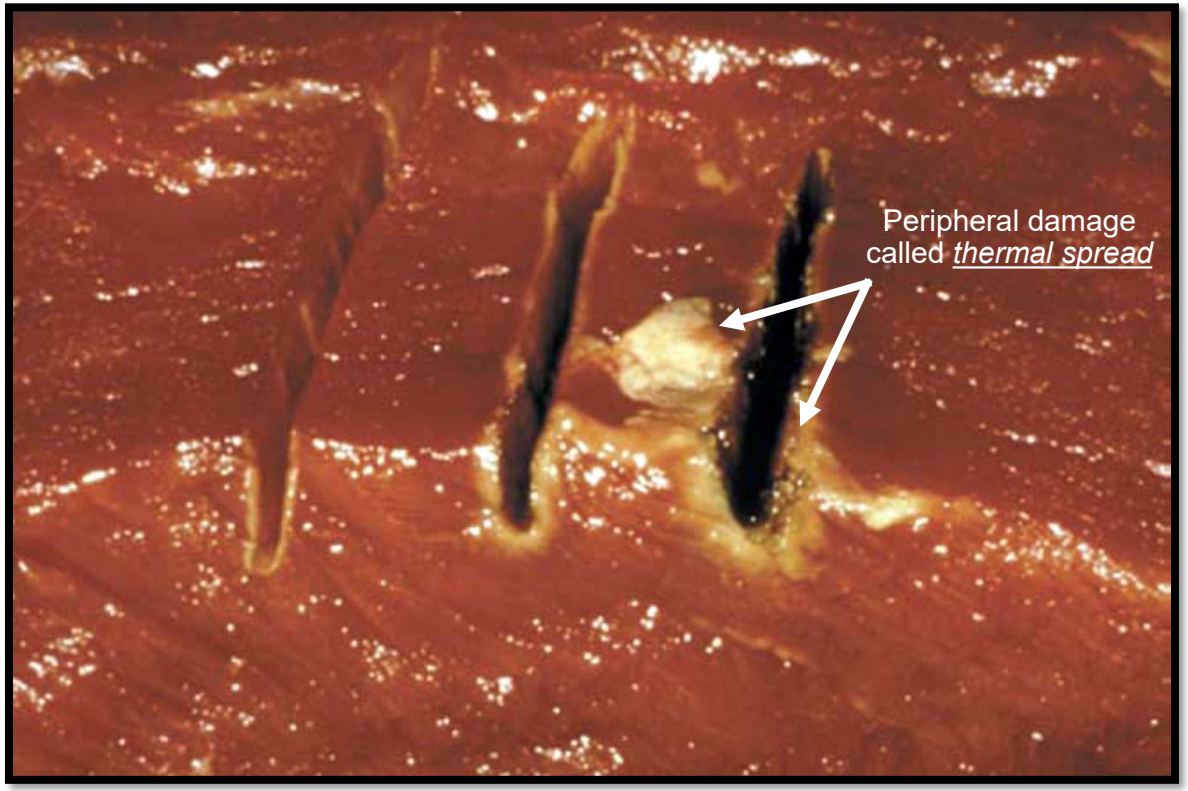

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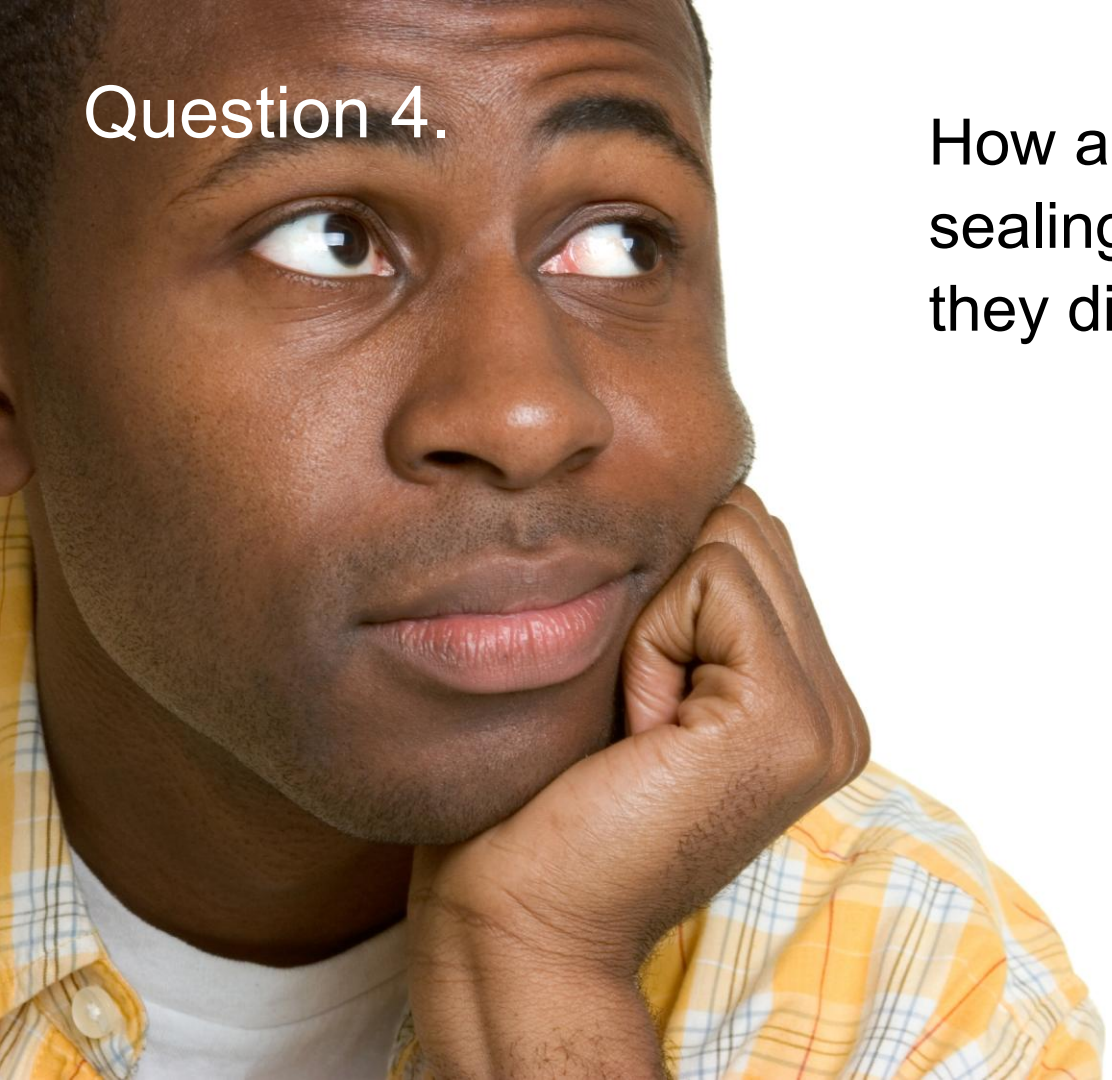
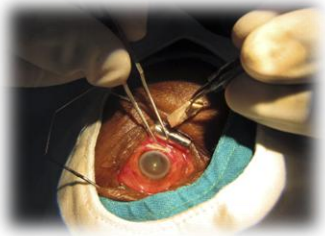


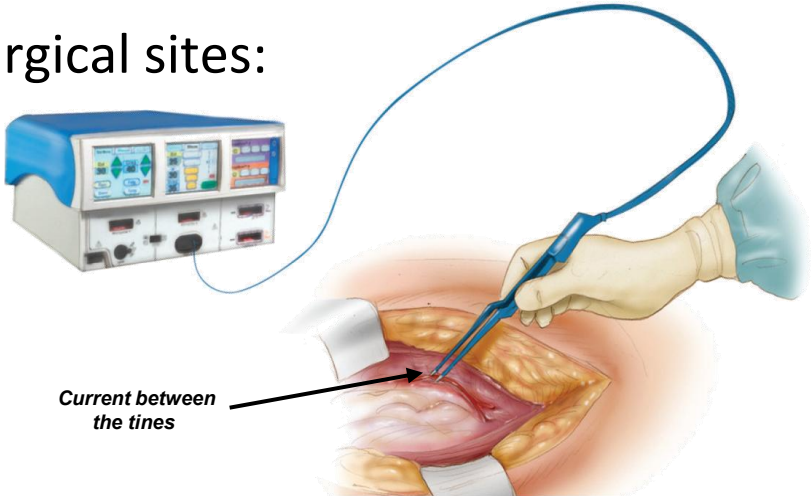
Question 4.

How are bipolar and vessel sealing the same and how are they different?

Bipolar Electrosurgery

- Active and return electrodes are within the instrument; no patient return electrode (pad) required
- Current flow is confined to tissue between the two tines (electrodes)
- Relatively low voltage (300V – 1200V)
- Used for delicate tissue and confined surgical sites:
  - Laparoscopy
  - Spinal
  - Neurosurgery
  - Ophthalmology





Typical Bipolar Forceps

Semkin

Bayonet

Angled

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Ligature or LigaSure?

16th century witnessed a decline in cautery due to advantages of ligature (thread or wire) in treating battlefield wounds.

LigaSure™

Surgeon's Knot

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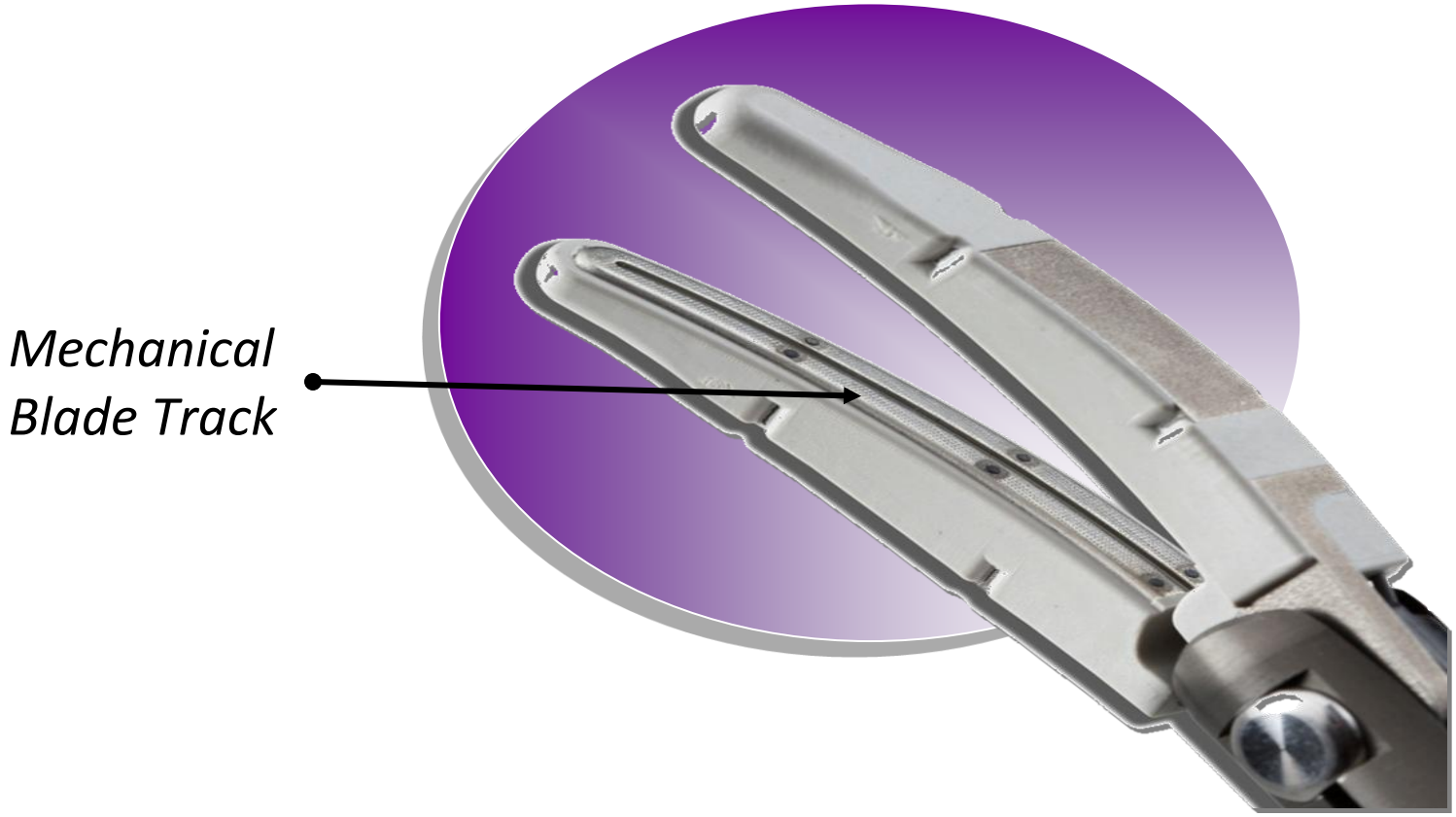
LigaSure™ Jaw



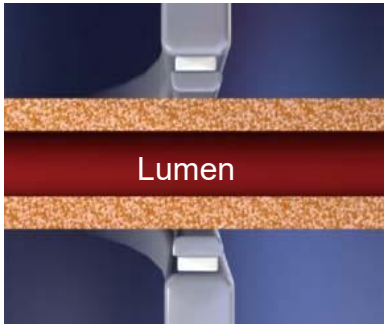
Laparoscopic LigaSure Instruments

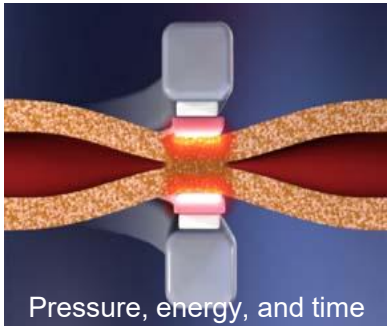
Tissue fusion

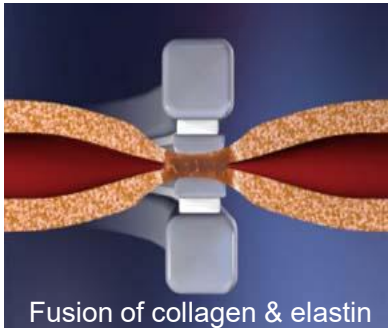
Tissue fusion
sealer/divider

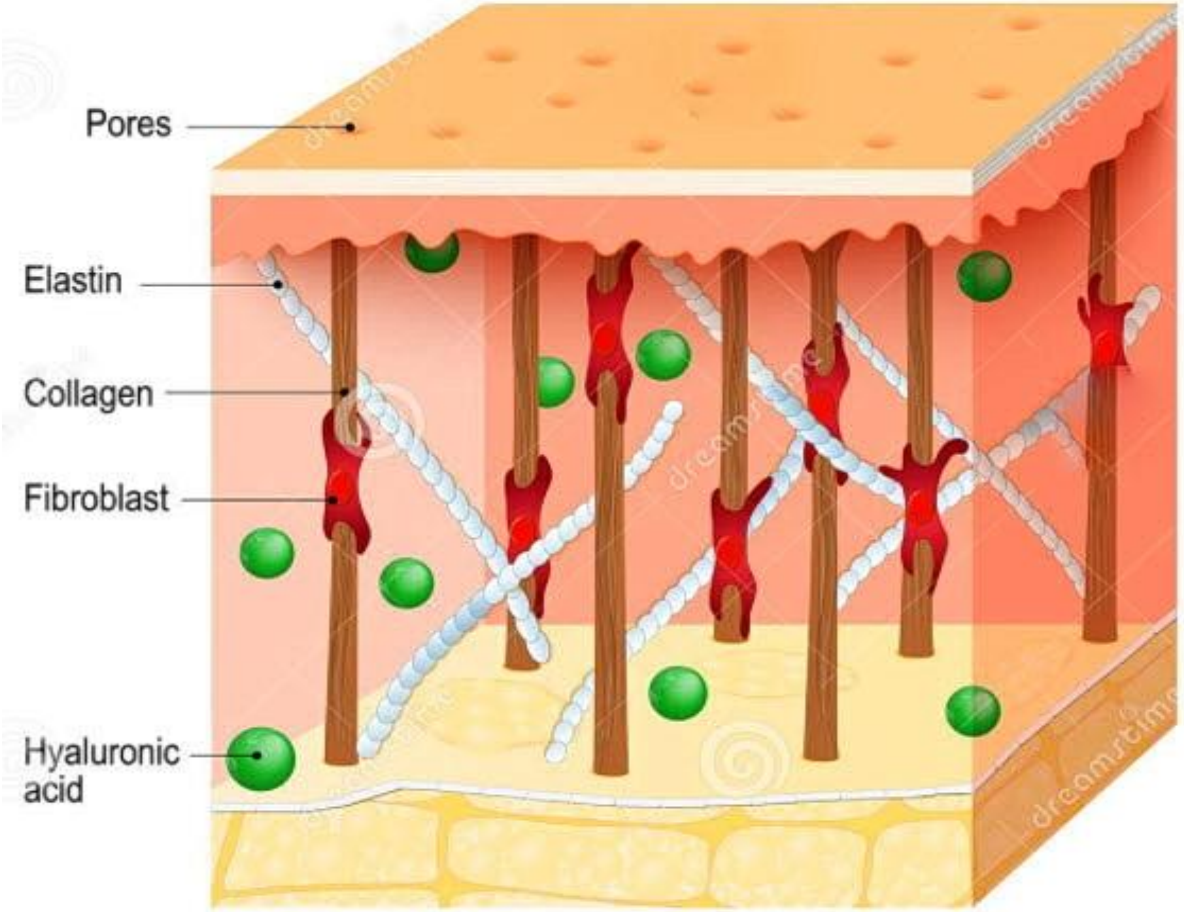
Vessel Sealing Graphic

- Applies optimal pressure to vessel/tissue bundle
- Energy delivery cycle:
  - Measures initial resistance of tissue and chooses appropriate energy settings
  - Delivers pulsed energy with continuous feedback control
  - Senses that tissue response is complete and stops the cycle








Pores
Elastin
Collagen
Fibroblast
Hyaluronic acid

How Are Bipolar and Vessel Sealing the Same?

1. Two-Electrode System - Both use two active poles.
2. Localized Energy Delivery - Energy is confined to the tissue between the jaws.
3. No Patient Return Electrode Needed - Since current doesn't travel through the rest of the body, no grounding pad is required.
4. Hemostasis by Coaptive* Coagulation - Both techniques achieve hemostasis by compressing tissue and denaturing proteins, causing the walls of the vessel to fuse closed.

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* *Coaptive - something that fits together or is joined together closely.*

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Summary: Comparing Bipolar With Vessel Sealing

Feature	**Bipolar Electrosurgery**	**Vessel Sealing Systems**
Control	Basic ON/OFF control	Computer-controlled energy delivery
Energy Modulation	Fixed or surgeon-controlled	Real-time impedance monitoring
Vessel Size Limit	Typically, up to **2–3 mm**	Effective up to **7 mm**, sometimes larger
Consistency	Highly **operator dependent**	**Algorithmic precision** = reproducible results
Feedback Mechanism	None	Continuous tissue feedback loop
Outcome	Coagulation (may crush or char)	**True fusion** of collagen and elastin fibers
Burst Pressure	Lower and less predictable	Higher, safer vessel sealing strength
Instruments	Simple bipolar forceps	Sophisticated instruments (e.g., LigaSure, ENSEAL)

Question 5.

What are cross-coupling checks and why are they important when doing a PM on an ESU?

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Verifying Cross Coupling – Mono 1 Current

The current should not exceed 150 mA. Values on training generator were as follows:

- Bipolar Resection CUT 0.00 mA
- Bipolar High 0.0 mA
- Mono 2 COAG Spray 42.7 mA
- Mono 2 CUT Pure 42.8 mA

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Why Is It Important?

Cross-coupling checks are essential because:

- Patient injuries from unintended burns are serious.
- Surgical precision depends on clean, isolated energy delivery.
- ESU behavior must match surgeon expectations with no electrical "surprises."

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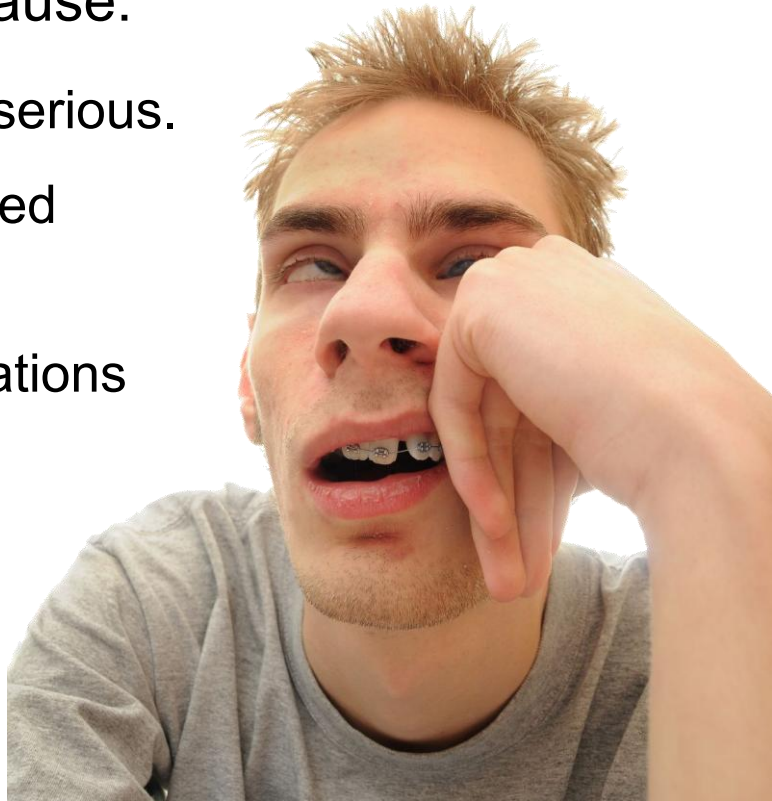

Question 6.

What does “buzzing the hemostat” mean?

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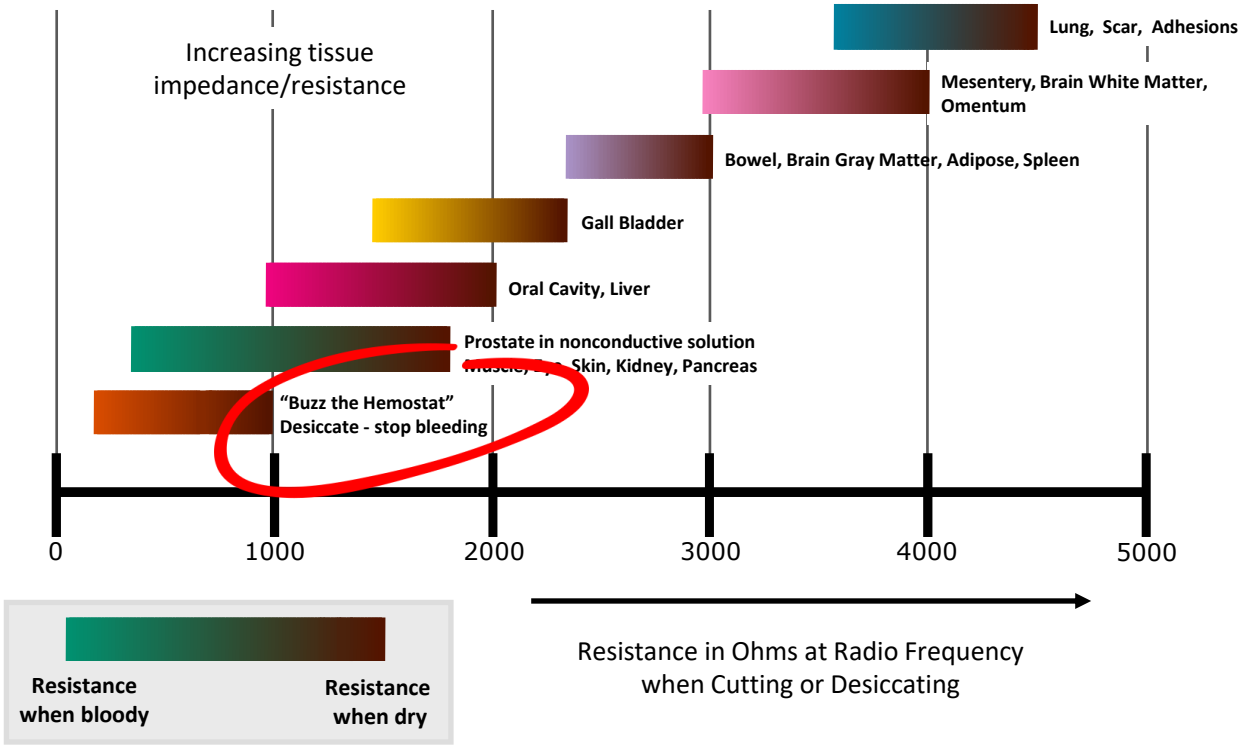
“Buzzing the Hemostat”



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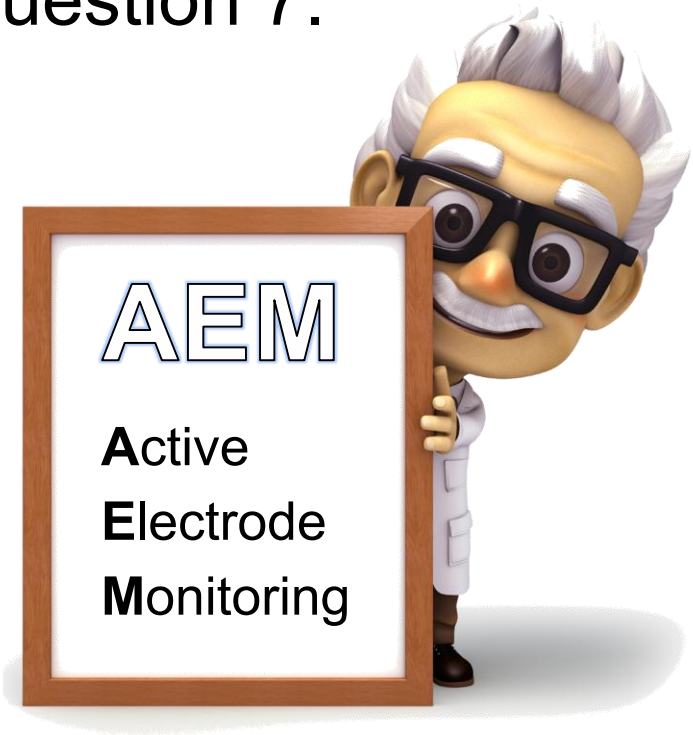
Question 7.



I keep hearing about “AEM” as it applies to electrosurgery. Can you explain what AEM is?

Electrosurgery is powerful—maybe even dangerous—but only if we remove the guardrails. Each safety feature plays a role, and AEM is just one of the sentinels keeping the patient safe.

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Debunking the AEM “Magic Box” Myth

Some students say: *The hospital bought a device that monitors the ESU output for safety.*

Reality: There is NO standalone safety box for this.

The truth is: AEM is a built-in safety technology—embedded inside the generator (like the FT10) and AEM-compatible instruments.

- The generator has internal monitoring circuitry.
- The instruments have a conductive shield and RFID chip.
- Together, they shut down power if stray current is detected.

If either part is missing, AEM protection is inactive.

No Shield, No Chip, No Protection.

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Question .

Why are there so many names for Patient Return Electrodes?

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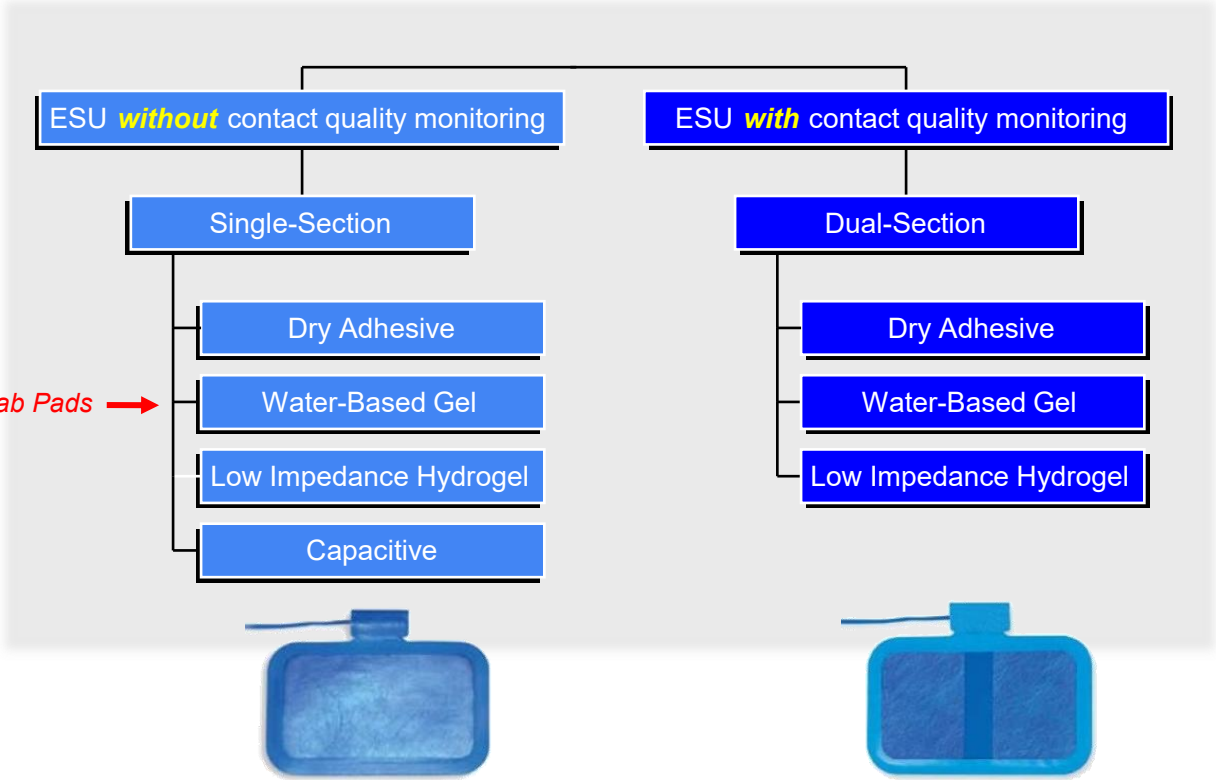
Patient Return Electrodes (PREs)



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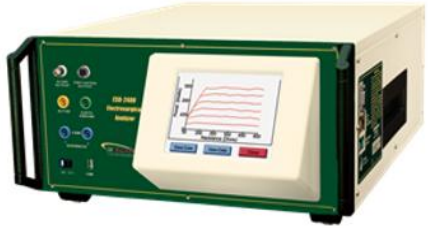
Patient Return Electrodes (PREs)

Manufacturer	Return Electrode Name	Monitoring Technology Name	Notes
Bovie / Apyx	*Split Pad*	Not branded; uses impedance-based monitoring	Often referred to generically as a "split pad" without a proprietary name
ConMed	*Dual Return Electrode*	**ARM™** (Automatic Return Monitor)	ARM monitors pad contact and stops output if loss of contact is detected
ERBE	*Split Neutral Electrode*	**NESSY®** (Neutral Electrode Safety System)	NESSY is ERBE's proprietary pad contact quality monitoring system
Megadyne (Ethicon)	*Mega Soft® or Mega 2000*	**CQM™** (Contact Quality Monitoring)	Formerly independent, now part of Ethicon (Johnson & Johnson)
Medtronic (Valleylab)	*Valleylab Return Electrode*	**REM™** (Return Electrode Monitoring)	REM was one of the first contact quality systems
Olympus / Celon	*Split Return Electrode*	**CQM** or similar tech (branded under generator line)	Olympus sometimes uses OEM'd generators or private-labeled systems

Question 9.



I would like to know if my ESU analyzer is acceptable for testing. Can you help me?

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Required Loads for Valleylab PMs and Calibration

	5 Ω	10 Ω	30 Ω	50 Ω	100 Ω	200 Ω	300 Ω	400 Ω	1 KΩ	2 KΩ	3 KΩ	5 KΩ
Force FX™-C Electrosurgical Generator												
Calibration		×	×		×	×		×	×			
Output Testing					×	×	×	×				
ForceTriad™ Energy Platform												
Calibration									×			×
Output Testing				×	×	×	×	×				
FT10™ Energy Platform												
Calibration	×											×
Output Testing				×	×	×	×	×				
Force EZ™-C Electrosurgical Generator												
Calibration[1]		×	×	×	×	×		×		×	×	
Output Testing[1]		×	×		×	×		×		×	×	

[1] A 750 Ω load is also required, but this value can be attained by connecting the 500 Ω, 200 Ω and 50 Ω resistors in series.

Question 10.

OEMs aren’t willing to sell us parts or give us passwords, so why should we spend money to go to an ESU course?

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Your turn...
What's your why?