Ohio State University Medical Center

Energy Device Options – Strategies to Prevent Injury

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FUSE
Fundamental Use Safe Energy

Program Content

- Basics of Electricity
- Principles of Electrosurgery
- Clinical Applications
- Electrosurgical Technologies
- Associated Risks
- Recommendations for Safe Practices

Electrosurgical Injuries

- AORN estimates c. 40,000 patients burned by faulty ES devices per year
- Up to 70% of ES burns in laparoscopic surgery may be undetected at the time of injury
- ACS survey: 18% of surgeons had experienced insulation failure or capacitive coupling injury, 54% knew a colleague who had a stray electrical burn
- In 1999, nearly $600 million paid in claims re ES injuries

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Source: Outpatient Surgery Feb 2002

Two Types of Energy Used in Surgery

Electromagnetic Energy

- Electrosurgery
  - Monopolar Electrosurgery
  - Bipolar Electrosurgery
- Laser

Mechanical Energy

- Suturing
- Stapling
- Ultrasonic (Ultrasound)

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Basic Principles of Electricity

Electricity always . . .

– Seeks ground (its source)

– Seeks the path of least resistance

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Properties of Electricity

Current Flow of electrons during a period of time, measured in amperes

Circuit Pathway for the uninterrupted flow of electrons (must be complete/ closed to flow)

Impedance Obstacle to the flow of current measured in ohms

Voltage Force pushing current through the resistance, measured in volts

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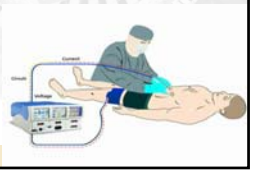
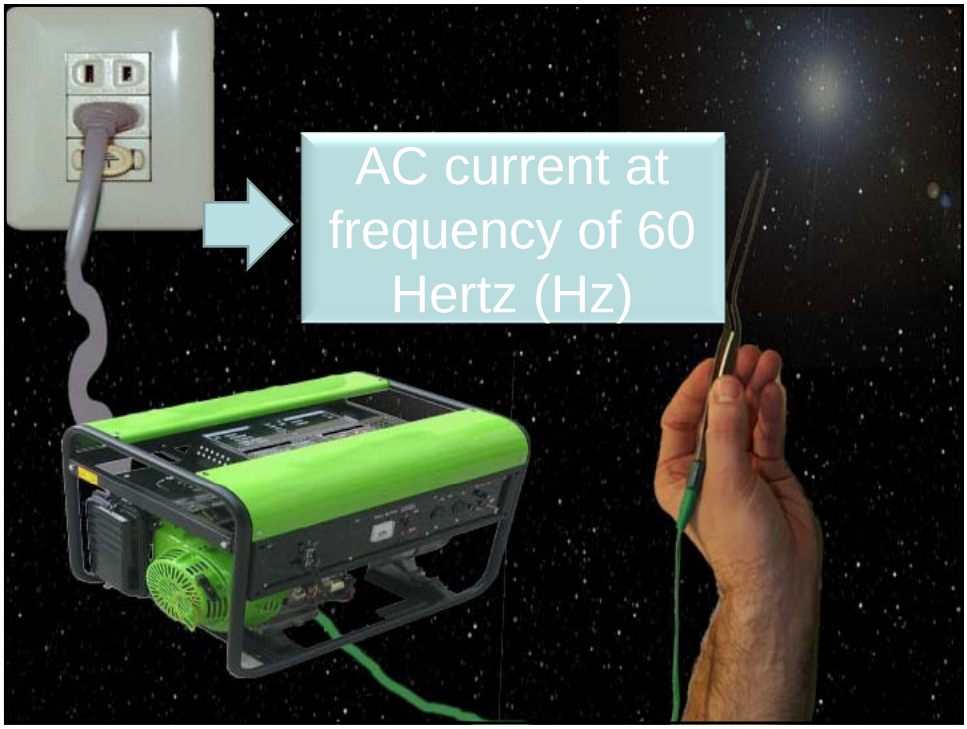
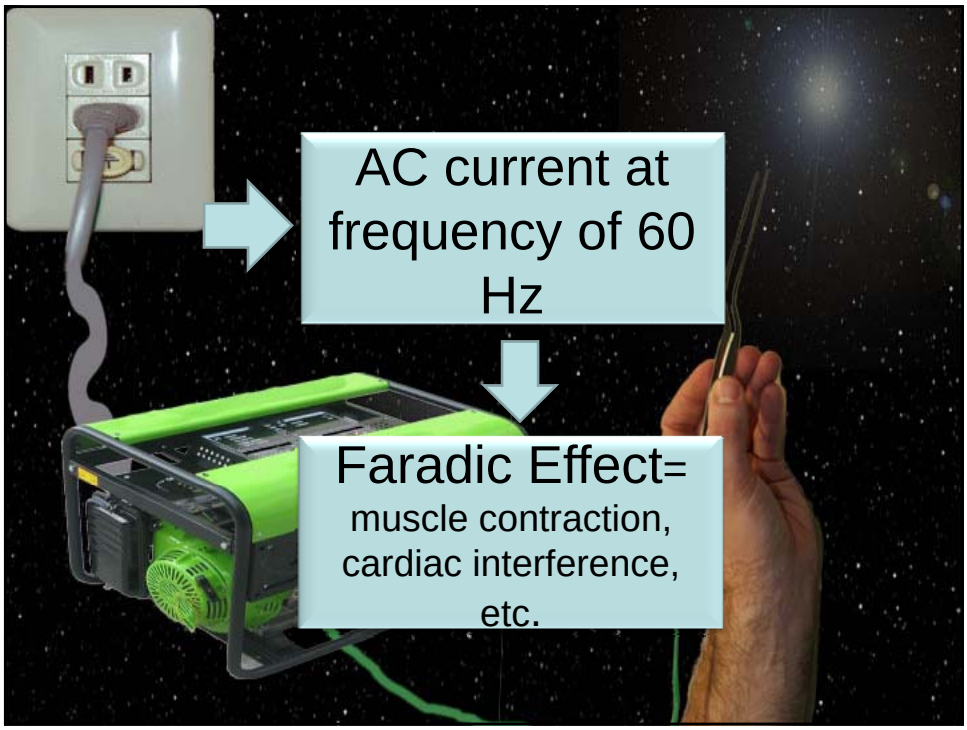
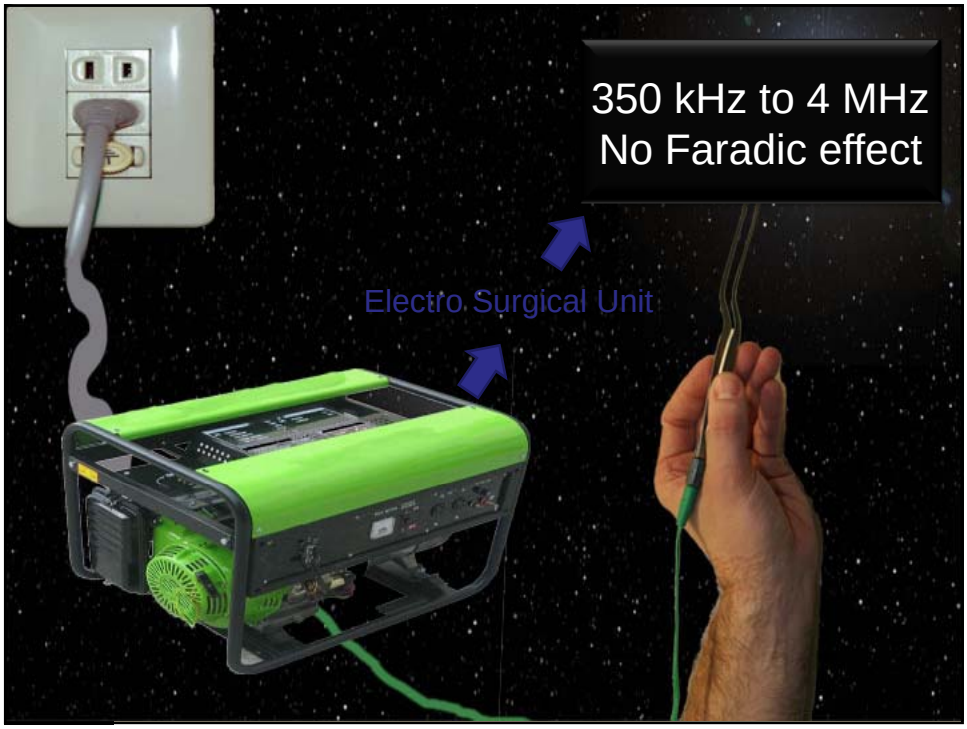
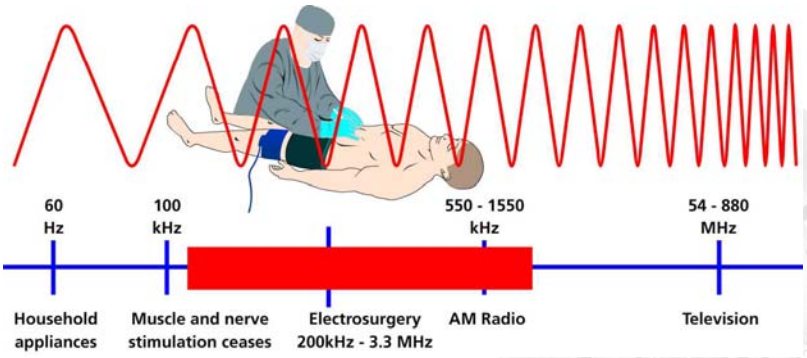



AC current at frequency of 60 Hertz (Hz)


AC current at frequency of 60 Hz
Faradic Effect=
muscle contraction, cardiac interference, etc.



Frequency Spectrum



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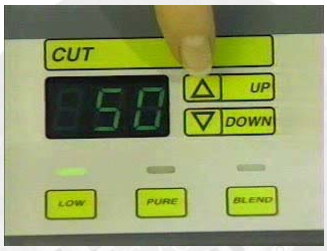
Electrosurgical Unit: Patient Protection Measures

- Inspect for any damage
- No fluids on top of unit
- Do not use in presence of flammable material (e.g. alcohol, nitrous oxide)
- Patient not in contact with any metal objects

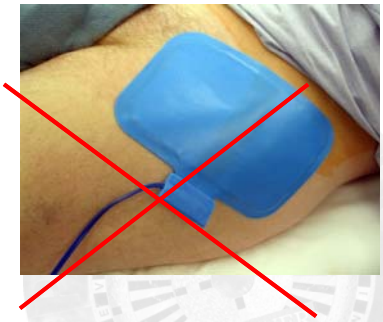
Generator (ESU) Power Settings

- **Use the lowest possible setting to achieve the desired surgical effect**
- The setting will depend upon conditions such as:
  - Patient size
  - Generator power capabilities
  - Target tissue type
  - Electrode configuration
  - Surgeon Technique
  - Location of patient return electrode



Dispersive Electrode Guidelines

- Contact with patient must be uniform over large surface area
- Avoid the following:
  - Bony prominences
  - Metal implants or prosthesis
  - Scar tissue
  - Hairy areas
  - Adjacent to leads/electrodes
  - Pressure areas/points
- Never cut to size



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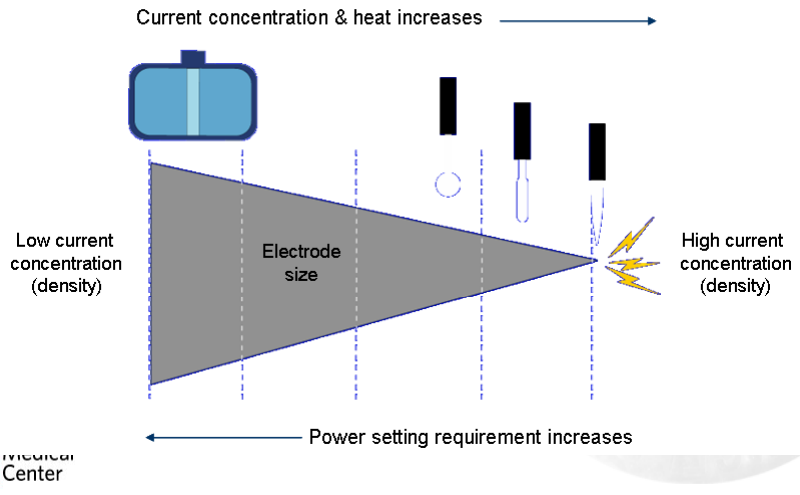
Electrode Size and Effect on Power Settings



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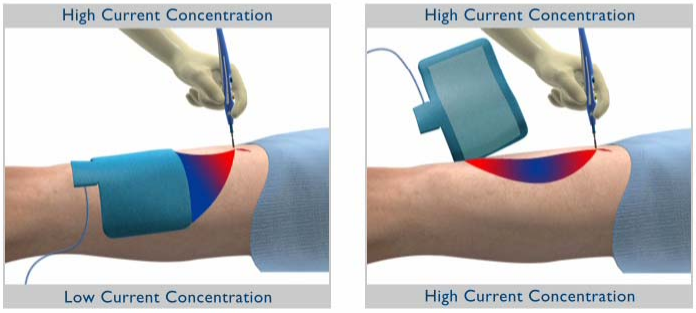
Current Concentration/Dispersal



The more concentrated the current, the greater the potential for a burn.

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Patient Burns

Pad site burn

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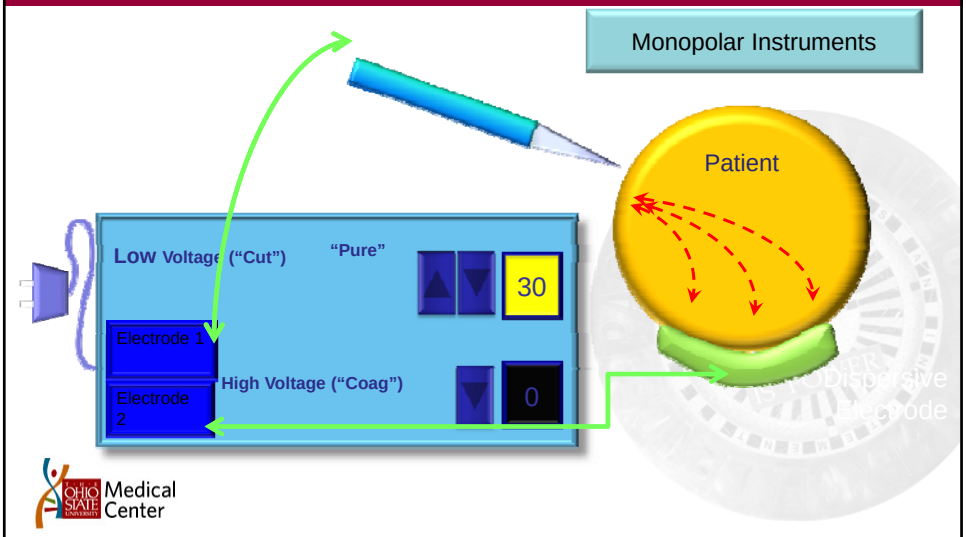
MonoPolar



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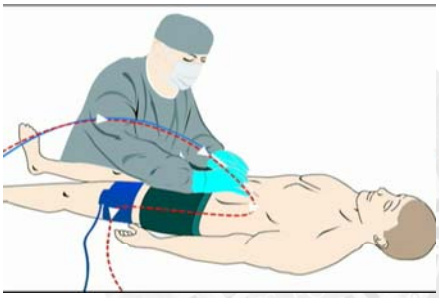
Monopolar

- Active electrode at surgical site
- Return electrode at another site
- Current flows through the body between the electrodes
- High voltage
  - Coag – 3000 – 9000 V
  - Cut – 1350 – 4000 V



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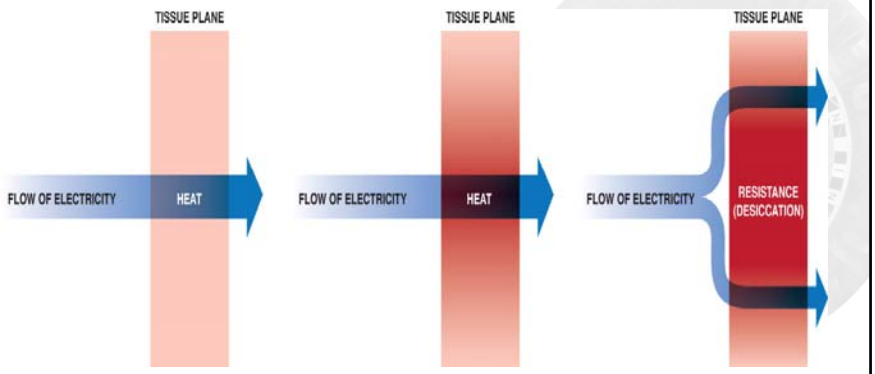
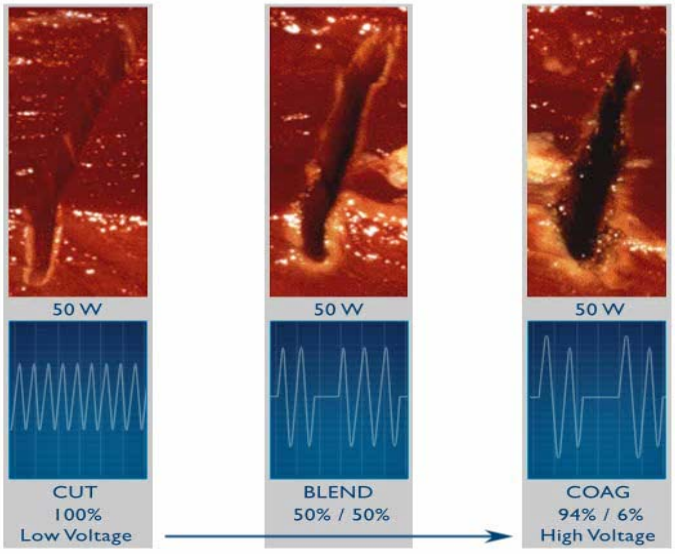
Mushroom Effect

As the tissue desiccates
Impedance Increases



Waveforms

(Blend is a CUT mode)



Direct Coupling

- Occurs when one conductive source touches or arcs to another

  1. Current may be directed toward non-target tissue

  2. Instrument in contact with active electrode may not be completely in view (laparoscopic case) and/or contacting other tissue (bowel or abdominal wall)

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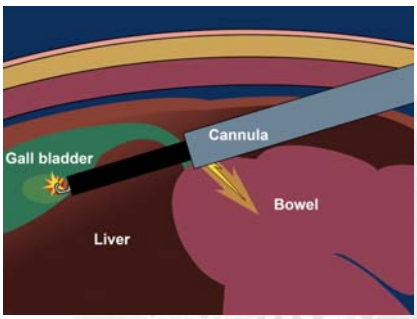
Capacitive Coupling

- Capacitance: defined as stored electrical charge when two conductors separated by an insulator
- Capacitive coupling current occurs when the circuit is completed through the dielectric (e.g. insulator)
- Charge stored in capacitor until either generator is deactivated or pathway to complete circuit is achieved



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Alternate Site Injuries

- Current delivered must return to generator
- Much less common today with isolated generators (will not deliver more current to electrode if not enough current returns to generator, i.e. leaves via an alternate site)
- Precautions: patient should not be in contact with any objects with high conductivity

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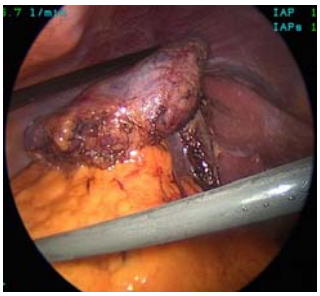
Inadvertent Activation



- Beware of creating an injury out of field of view (blind instrument insertion or inadvertent electrode application)

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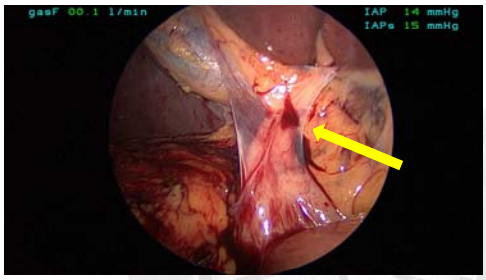
Direct Thermal Extension

- Duodenum often adherent to or in close proximity to gallbladder
- Use short activations of electrode (2-3 sec)
- Beware the adhesion with narrow attachment to duodenum



Adhesions between GB and duodenum

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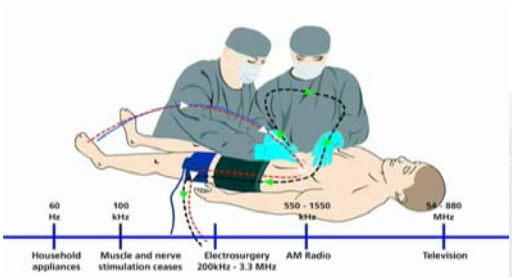
Surgeon Burns/Surgical Glove Injuries

- Holes are present in 15% of new surgical gloves and in ½ after use in surgery
- Capacitive coupling from sweating skin inside surgical glove



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Surgeon Burns/Surgical Glove Injuries: Mechanisms of Injury

1. High voltages across glove (dielectric) break insulating capacity of glove
2. Decreased glove resistance (with time and exposure to saline (sweating)
3. Capacitive coupling – risk inversely proportional to glove thickness and increases with higher voltage and longer contact time (active electrode and touching hemostat)

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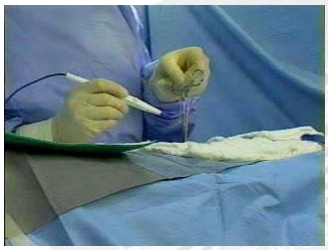
Helpful Hints to Avoid Hemostat Burns

- **Use lowest power setting possible**
- **Activate low voltage (cut) waveform**
- **Avoid touching the patient**
- **Hold hemostat with full grip**
- **Do not activate in open circuit (avoid metal to metal arcing)**



Note: Surgical gloves do not insulate against RF current

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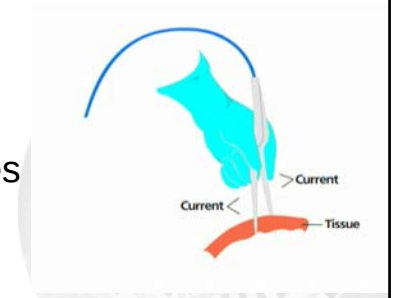
Bipolar

- Active and return electrodes in the instrument
- Current flow confined to tissue between electrodes
- Low Voltage
  - 320 - 1200 volts



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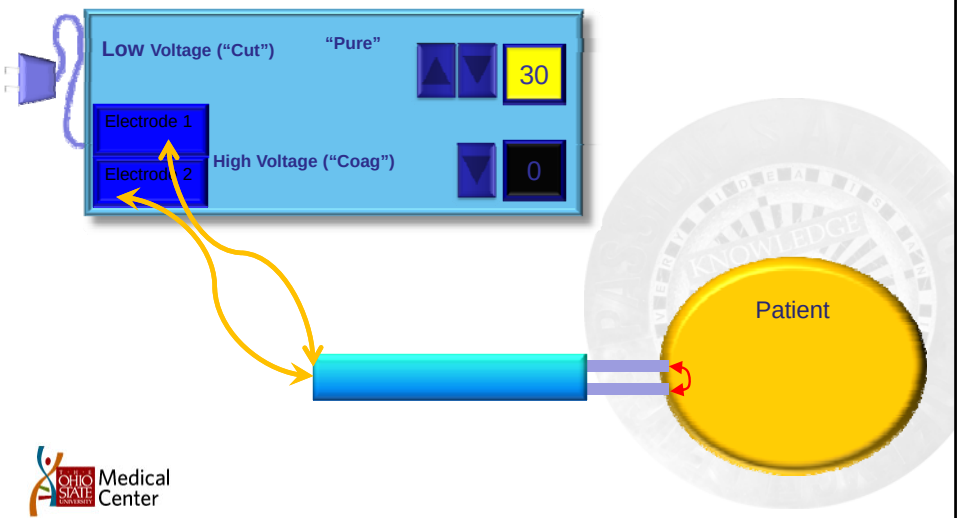
Bipolar



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Bipolar

- Benefits:
- Doesn't Require Dispersive Electrode
- Energy Primarily stays between the Jaws
- Requires less Voltage and Current ("cut" waveform)

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Limitations of Traditional (simple) Bipolar

- Continuous, uninterrupted delivery of energy
- Surgeon controls the delivery of energy visually
- No feedback mechanism to determine impedance (thermal Spread, carbonization)
  - Promotes excessive thermal damage
- Devices coapt tissue poorly

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Modern Advance Bipolar Technology

- Smart Generator Technology
  - Near real-time Impedance feedback from delivery device
  - Pulsing (rapid on/off) energy delivery
    - Allows for interval tissue cooling
  - Audible signal indicates adequate coagulation
  - Vessel up to 7 mm vessels

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Best Practices

- No tension
  - Let the instrument do its job
- Keep Jaws Clean:
  - Never activate with coagulum build-up on the inside of the jaws.
- Vessels up to 7 mm
  - Be careful of calcified vessels.

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Best Practices

OVERLAPPING SEALS:

- Consider overlapping seals in areas of anatomical tension.
- When overlapping seals, do so by 30-50%.

• Knife blade damage

- Do not attempt to fuse or cut over clips, staples or sutures
- Do not use the knife for cutting suture

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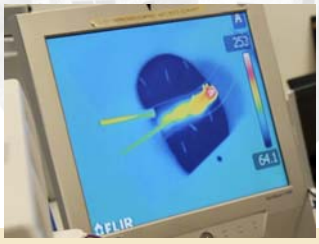
Thermal Spread with Bipolar

• With Modern Bipolar Instrument

- Seen with all electrosurgical instruments
- Tissue damage occurs at 60 degrees Celsius
- Range 1-4 mm
- Be aware of residual heat.



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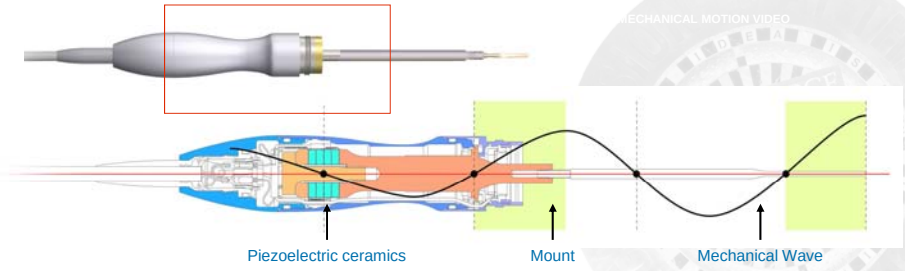
Ultrasonic Technology: The Hand Piece

Electrical energy from the generator is converted to mechanical motion in the hand piece



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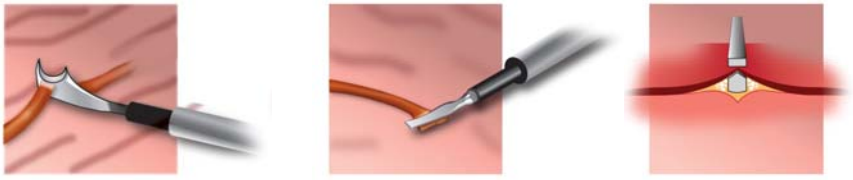
Actions of Ultrasound on Tissue



Cutting | Coagulation | Cavitation

All surfaces of the ultrasonic blade are active.

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Factors affecting cutting and coagulation

1. Blade pressure
2. Tissue tension
3. Power level
4. Blade sharpness

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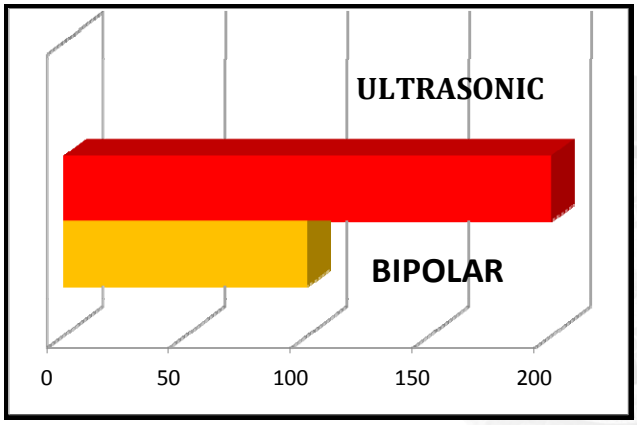
Blade activation temperatures



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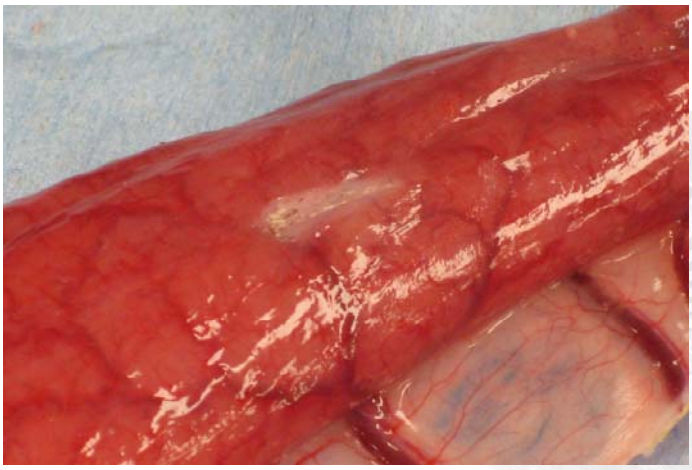
Thermal Spread

Blade activation temperatures



Benefits and Risks of Ultrasonic Coagulation

- Vessels are sealed or welded together
- Minimal spread of energy, ***but the blade is HOT***
- Coagulum does not stick to blade
- Minimal smoke generation more water vapor
- No neuromuscular stimulation
- Uniformly coagulates 5mm vessels

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Current Leakage

- Active electrode cords should not be wrapped around metal instruments
- Active electrode and other electrical device cords should not be bundled together

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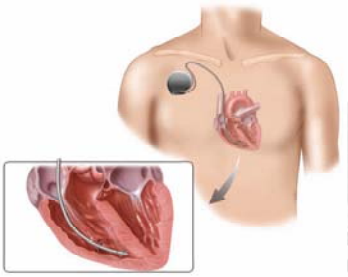
Pacemakers

- Consult pacemaker manufacture
- Use electrosurgery with care
- Use ultrasonic technology
- Use low power setting (bipolar)
- Avoid current flow through heart and pacemaker
- Keep cords away from pacemaker and leads



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AORN Recommended Practices 2009

Automatic Implantable Cardioverter Defibrillators

- Use of Electrosurgery on a patient with an activated AICD may trigger an electrical shock to the patient
- The AICD device should be deactivated before the ESU is activated

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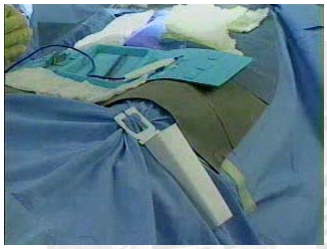
AORN Recommended Practices 2009

Active Electrodes

- When not in use, always place active electrodes in a non-conductive holster
- Active electrode tips should be securely seated into the hand piece (increase risk of sparking or burn to targeted tissue)



AORN Recommended Practices, 2009

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Smoke/By-products

- Types of products from electrosurgery
  - Toxic vapors and gases (e.g. benzene, hydrogen cyanide, formaldehyde)
  - Chemicals and irritants (potentially mutagenic or carcinogenic)
  - Bioaerosols including blood fragments
  - Viruses
  - Methemoglobin and carboxyhemoglobin in laparoscopic surgery
- Surgical masks filter size = 5 microns, 77% of surgical smoke contents are 1.1 microns or smaller

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Effects of Smoke/By-products

- High concentrations of smoke cause ocular and upper respiratory irritation in health care personnel.
  - Note: No documentation of cancer cases from OR smoke exposure.
- OSHA recommendation: smoke evacuation systems should be used to reduce acute and chronic risks to patients and health care personnel

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Source: AORN 2005;81:616-642
DHHS Pub 96-128 (OSHA), Sept 1996

Fire Hazard

- Do not activate ignition sources in the presence of flammable agents
- Avoid pooling of prep
- Drape patient after vapors from flammable agents have dissipated

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OR Fires

- Rare but potentially devastating
- ECRI estimate: 550-650 cases/yr (similar to # wrong site surgery cases)
- 95% are minor and result in no injury
- 20-30 serious with disfiguring or disabling injuries

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ECRI Institute is an independent, nonprofit organization that researches the best approaches to improving the safety, quality, and cost-effectiveness of patient care.

Why is it important?

Surgical Fire Jury Award $30 million

Links;

http://www.wenatcheeworld.com/news/2013/dec/06/botched-surgery-will-cost-hospital/

THE WENATCHEE WORLD

Botched surgery will cost hospital

by K.C. Mehaffey | Dec. 6, 2013, 10:37 a.m. | Comment

23 Send to Kindle

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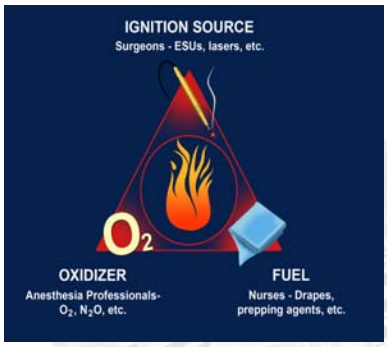
OR Fires: Fire Triangle

- Fire triangle:
  - Heat source (ESU, lasers)
  - Fuel (drapes, prep)
  - Oxidizer (O2, N2O)
- 21% occur in the airway, 44% head, neck, face or upper chest
- Ignition sources:
  - ES equipment - 70%
  - Lasers - 10%



Modified from Health Devices Oct 2009

Explosions

- Significant risk in ether/cyclopropane era (even from static discharges)
- Electrosurgery risk with unprepped bowel
  - Hydrogen-air mixtures btn 4-7% and methane btn 5-15% potentially explosive
  - Avoid mannitol for bowel prep (promotes production of methane)

Prevention: When Using Electrosurgery

- Minimize use of open O2 (via mask or cannula) for head and neck procedures
- Be aware of O2 enrichment under drapes (esp head and neck procedures)
- Tracheostomy: Use cold instruments to tracheal rings and enter the airway
- Do not apply drapes until flammable preps have fully dried; soak up spilled or pooled age
- Connect fiberoptic light cable before activating source; standby source before disconnecting

From Health Devices Oct 2009

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What to Do if OR Fire Occurs

1. Stop flow of all airway gases to patient (disconnect breathing circuit)
   - For airway fires, disconnect breathing circuit from tube and remove ET tube
2. Immediately remove burning and burned materials from patient (whether *on* or *in* the patient).
3. Extinguish the fire on burning materials (CO2 fire extinguisher rarely necessary)
4. Care for the patient
   - Restore breathing (use room air, never O2), manage pt injuries

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Conclusion

- Understanding the fundamentals of surgical energy (FUSE) in Operating room is everyone's responsibility
- SAGE's has initiated the FUSE program which is modeled after FLS and FES.

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