KALS Kandy Academy of Laparoscopic Surgery

Energy Sources In Laparoscopy

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Introduction

- Energy devices are the work-horse of minimally invasive surgery, providing cutting, coagulation and reliable hemostasis

- Safe energy use prevents thermal injury, stray-current burns and delayed bowel perforation

Basic Principles of Surgical Energy

Surgical energy utilizes the conversion of electrical, mechanical, or laser energy into heat for tissue modification

Main types include

- electrical (monopolar, bipolar)
- mechanical/ultrasonic,
- laser/thermal

Electrosurgery Fundamentals

- 3 main components of electrosurgery are electrosurgical generator, active and passive electrodes
- When the circuit is complete, electrical energy is converted into heat which brings the electrosurgical effects in the target tissue
- Heat = $Current^2$ x voltage x Time

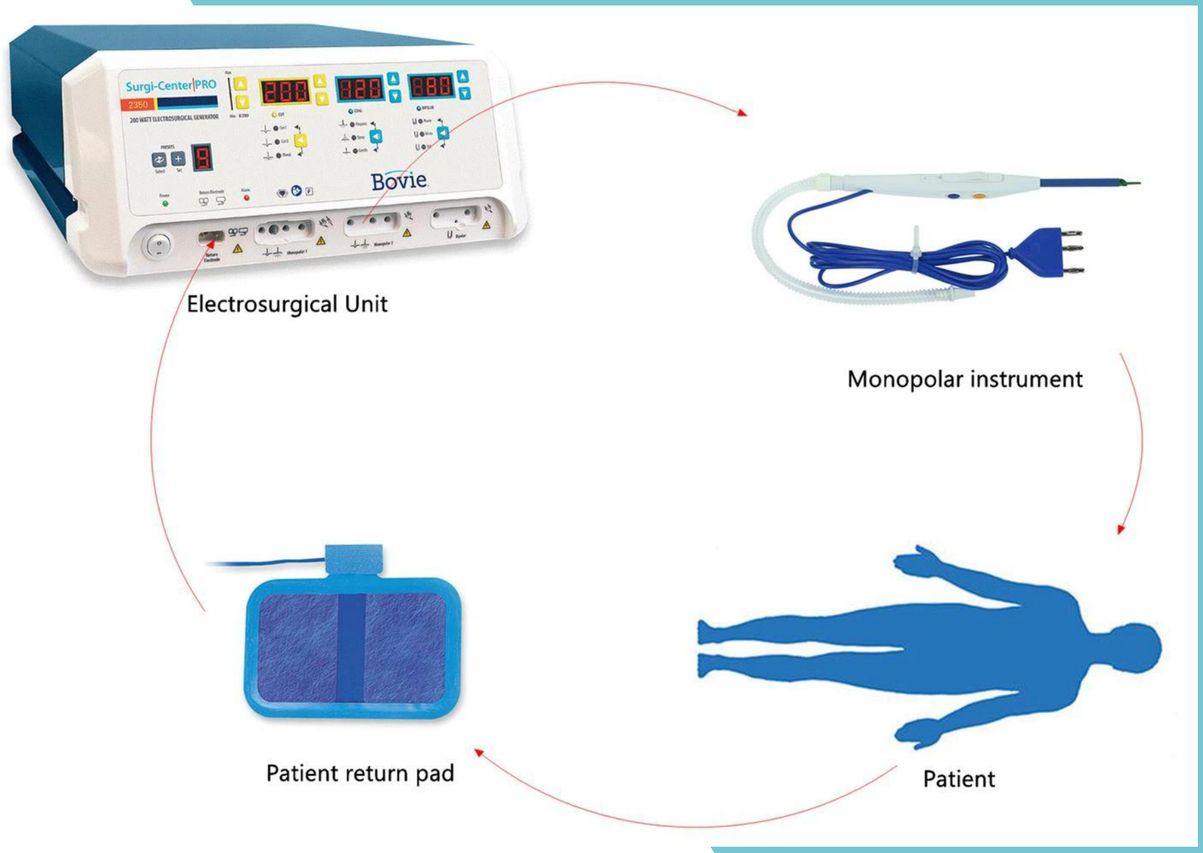
Tissue effects of electrosurgery

- Vaporization = tissue destruction and cutting
- Fulguration = tissue destruction and small vessel haemostasias
- Desiccation = cell wall rupture and cytoplasm boiling
- Coaptation = vessel sealing owing to denaturation and renaturation of proteins

Energy source	Tissue effects
Monopolar	Vaporization, fulguration, desiccation, coaptation
Conventional Bipolar	Desiccation, Coaptation
Advanced Bipolar	Desiccation, coaptation, blade tissue transection
Ultrasonic technology	Desiccation, coaptation, mechanical tissue transection

Monopolar Electrosurgery

- Active tip delivers current. Return pad completes circuit
- The electrical current flows through the patient
- Instruments: scissors, hook, blade
- Advantages
  - low cost
  - Versatile functions
- Limitations
  - stray current injuries (rare)
  - higher lateral thermal spread
  - Smoke generation

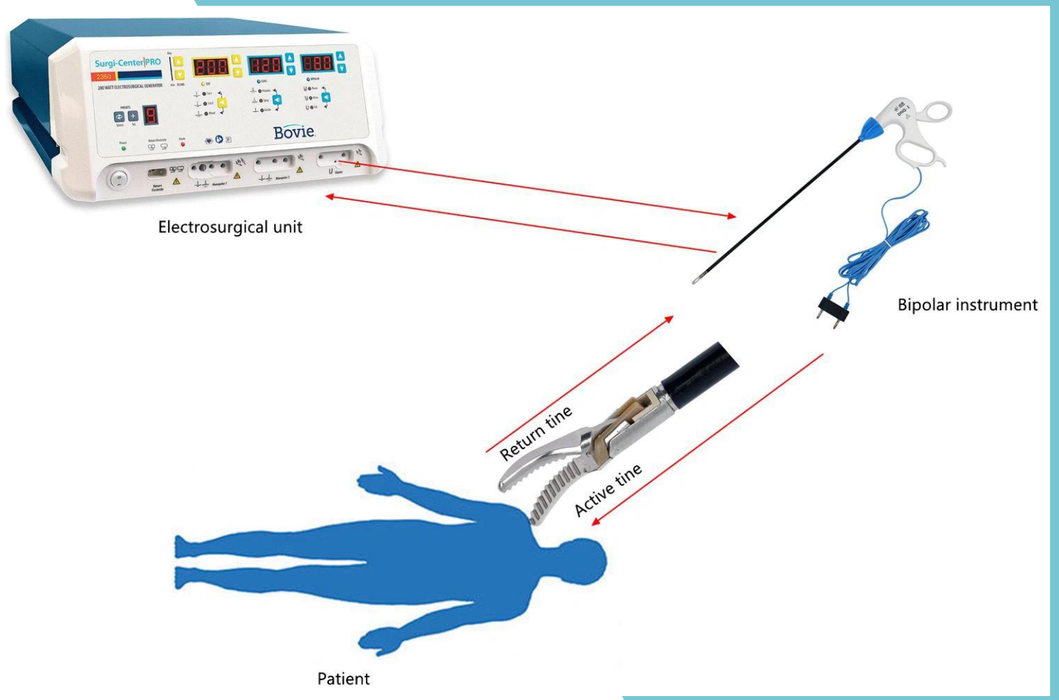


Mechanism of Stray Cut Injuries

- Capacitance Coupling
  - High-frequency current passes through intact insulation to a nearby conductor
  - Up to 62% of delivered current may transfer
  - Higher risk with plastic laparoscopic ports (poor current dispersal)
  - Can cause unseen visceral burns
- Insulation Failure
  - Micro-fractures in thin insulation layer
  - Seen in 19–39% reusable and ~3% disposable instruments
  - Often microscopic and invisible
  - Causes high-density current leakage leading to full-thickness bowel injury
- Direct Coupling
  - Active electrode contacts another metal instrument
  - Energy transfers directly to adjacent tissue
  - Laparoscope commonly involved

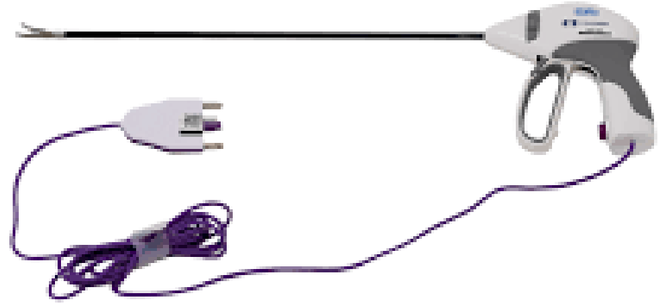
Bipolar Electrosurgery

- Electric current confined to tissue between jaws
- Seals vessels ≤5 mm, no stray current
- Drawbacks
  - lateral thermal spread until deactivation
  - no audio feedback
  - needs a separate cutter



Advanced Bipolar Devices

- LigaSure®, EnSeal®, PlasmaKinetic System (PKS)
- Uses controlled tissue feedback response systems that senses tissue impedance to continuously adjust the voltage and current generated by the unit
- Uses audio signals to inform the surgeon that vessel sealing has been achieved , minimizing the lateral thermal spread associated with prolonged device activation
- Can seal vessels up to 7mm
- Benefits
    - reduced power
    - minimized thermal spread
    - consistent sealing
- Higher purchase cost is a disadvantage



Ligasure

EnSeal

Ultrasonic Energy Devices

- Convert electrical energy into vibrations in the handpiece of the device at frequencies more than 20 000 Hz
- These vibrations oscillate the non-articulating jaw of the instrument.
- Tissue is compressed between an articulating jaw and the non-articulating jaw to impart the tissue effects derived from combination of thermal and mechanical energy.
- Advantages
  - less instrument traffic, owing to the combination of vessel-sealing and tissue cutting
  - less smoke generation
- Disadvantages
  - lateral thermal spread
  - higher and more prolonged instrument tip temperatures than other energy sources
  - requires training and experience
  - Relatively expensive

Hybrid Devices

- Laparoscopic devices that combine several energy source technologies.
- These include LigaSure Advance (monopolar and bipolar electrosurgery), Thunderbeat (ultrasonic and bipolar technologies) etc.
- Aim: to reduce instrument traffic, enhance precision

Advantages and Limitations

Source	Precision	Speed	Cost	Safety	Learning Curve
Monopolar	Moderate	Fast	Low	Moderate (risk)	Low
Bipolar	Good	Moderate	Low-moderate	Better (no stray)	Low
Advanced Bipolar	High	Fast	High	Best (feedback)	Moderate
Ultrasonic	High	Moderate	Moderate-high	Low thermal spread	Moderate
Hybrid	Very high	Fast	High	Potentially best	Higher

Complications and Safe Use

- Complications
  - Thermal injury
  - Insulation failure
  - Capacitive coupling
  - Delayed bowel perforation
- Safe practices
  - Use lowest effective power
  - Brief activations
  - Visual tip control
  - Routine instrument inspection

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