Use of Electrosurgery and Argon Plasma Coagulation: Therapeutic Tools in GI Endoscopy

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Objectives

• Define the basics of Electrosurgery and how it is adapted for clinical use.
• Describe how to effectively use Electrosurgery and APC in GI Endoscopy.
• Describe the nursing considerations for safe use of Electrosurgery and APC.
History of Electrosurgery
In 1978, Dr. Glover published an article on the use of thermal knives in comparison to other modalities and stated, “There is no group of instruments in the surgical armamentarium that is used as frequently and understood as poorly as Electrosurgery units.”
Electrocautery vs. Electrosurgery

Electrocautery:
- Uses direct current
- Often used inaccurately to describe “Electrosurgery”
- Current does not enter the patient’s body – only the heated wire tip comes in contact with tissue

Electrosurgery:
- Uses High-Frequency Alternating Current (AC)
- AC Circuit must be completed: includes the electrosurgical generator, active electrode, the patient and return electrode
We are educated…but…

> Formalized Education on Electrosurgery

Survey of 400 Surgeons
This Happened to *Experts*?
The Electrical FREQUENCY Spectrum
(Why patients do not feel electrosurgery...)

- 60 Hz: Household
- 100,000 Hz: Neuromuscular stimulation
- 350,000 Hz: ESU's
- 54-880 MHz: TV
- 550-1550 kHz: AM Radio
The Clinical Circuit

- **Circuit** - flow of current from the ESU to the active electrode, to the patient, to the pad, and back to the ESU.

- **Current** – flow of electrons through the electrical circuit.

- **Voltage** - electrical force pushing current around the circuit, through varying degrees of tissue resistance.

- **Resistance** (Impedance) - literally the tissue being treated, which has varying characteristics.
GI Endoscopy Pad Placement

- Well vascularized area
- Shortest circuit possible
- Optimum – on flank
- Alternatives – Thigh or Arm
- Avoid Buttock placement
- Remove pads carefully to prevent shearing of skin
Two Basic Principles of Electricity

- Always seeks ground.
- Always seeks the path of least resistance.
Variables Impacting Tissue Effect

- Type of Generator: Constant voltage vs. constant power
- Waveform: Cut vs. Coag, Preconditioning
- Type (size) of Electrode, current density
- Physician technique
- Pad placement
- Patient variables: age, body type, hydration, tissue, IED’s etc.
- Length of activation
- Anatomical location
- Physician technique
- Pad placement
- Patient variables: age, body type, hydration, tissue, IED’s etc.
- Length of activation
- Anatomical location
## ESU Thermal Effects on Cells

<table>
<thead>
<tr>
<th>Temp</th>
<th>Tissue Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>104°F:</td>
<td>Reversible cellular trauma</td>
</tr>
<tr>
<td>120°F:</td>
<td>Irreversible cellular trauma</td>
</tr>
<tr>
<td>158°F:</td>
<td>Coagulation (Desiccation)</td>
</tr>
<tr>
<td>212°F:</td>
<td>Cutting</td>
</tr>
<tr>
<td>392°F:</td>
<td>Carbonization</td>
</tr>
</tbody>
</table>
Types of Electrical Waveforms

CUT: Sinusoidal (continuous)

- Voltage quickly raises water temperature in the cell to boiling point
- Cell water turns to steam
- Cell explodes, separating from adjoining cells
- Cleavage plane is created = clinical “CUT”
Types of Electrical Waveforms
CUT Waveform – ENDO CUT

Specialized proprietary waveform that involves a fractionated cutting mode characterized by controlled alternating cutting and coagulation cycles developed especially for GI endoscopy – polypectomy and sphincterotomy.
Types of Electrical Waveforms

COAGULATION: Modulated (with resting points)

- Current waveform with spikes of high voltage followed by rest periods
- This allows the cellular proteins to slowly denature
- Coagulation occurs
All watts are not created equal!

Voltage

<table>
<thead>
<tr>
<th>60W</th>
<th>60W</th>
<th>60W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinusoidal</td>
<td>Modulated Blend Cut/Coag</td>
<td>Fulguration</td>
</tr>
</tbody>
</table>

< 200Vp | ~1000Vp | ~4000-5000Vp
Electrosurgical Applications in GI Endoscopy

- Polypectomy
- Sphincterotomy
- Monopolar hemostasis
- Bipolar hemostasis
- Devitalization of tissue
Accessories for Polypectomy
Influencing Variables
Endoscopic Resection (Polypectomy)

- Type of Polyp
- Size of Polyp
- Anatomical Location
- Using Cut vs. Coag
- Method – Approach
- Electrode – Current Density
- Submucosal Injection
- Use of Clips, Endoloop, etc.
Types of Polyps

- **Pedunculated**
  - Stalk is present
  - Varying thickness
  - May contain vessel supply

- **Sessile**
  - No stalk is present
  - Varying sizes
  - Flat
  - Carpet
  - Laterally spreading tumor (LST)
Types of Polyps

- Hyperplastic
  - Most common type
  - Non-neoplastic
  - Inflammatory
  - Lower risk of malignancy

- Adenoma
  - Pre-malignant
  - Neoplastic
  - Dysplastic
  - Greater risk of malignancy
### Types of Adenomas

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubular</td>
<td>Tube-like</td>
</tr>
<tr>
<td></td>
<td>Most common</td>
</tr>
<tr>
<td>Villous</td>
<td>Ruffled</td>
</tr>
<tr>
<td></td>
<td>Least common</td>
</tr>
<tr>
<td>Tubulovillous</td>
<td>Mixed tubular / villous tissue</td>
</tr>
</tbody>
</table>

*Images show examples of each type.*
### Layers of the GI Tract Wall

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mucosa</strong></td>
<td>epithelium + lamina propria + muscularis mucosae capillaries, tight connective tissue</td>
<td>250 μm</td>
</tr>
<tr>
<td><strong>Submucosa</strong></td>
<td>loose connective tissue larger blood vessels easily expanded by fluid</td>
<td>500-1000 μm</td>
</tr>
<tr>
<td><strong>Muscularis propria</strong></td>
<td>smooth muscle largest blood vessels nerve plexuses</td>
<td>2000-2500 μm</td>
</tr>
</tbody>
</table>
GI Tract Wall

Diameter of the esophagus ≈ 24 mm = diameter of a quarter

Esophageal wall thickness ≈ 4 mm = width of three pennies

Cecal wall thickness ≈ 2 mm
Submucosal Injection

Submucosal injection provides an additional cushion to protect the muscularis and also aids in dispersing electrosurgical current during electrosurgical procedures, such as saline assisted polypectomy, as well as APC procedures.

Polypectomy Techniques

- Cold Biopsy
- Hot Biopsy
- Cold Snare
- Hot Snare
- Saline Assisted Polypectomy
- Piecemeal Resection
- En bloc Resection
Endoscopic Mucosal Resection - EMR

Most lesions are less than 2cm

Developed for removal of sessile lesions confined to superficial layers of GI tract.

Studies suggest most common techniques:
- Injection-assisted EMR
- Cap-assisted EMR
- Ligation-assisted EMR

Resection by:
- Piecemeal
- En bloc
Endoscopic Submucosal Dissection (ESD)

- **Technically challenging and complex - greater risks**
- **En bloc resection - less invasive than surgery**
- **Allows intact specimens – optimal pathological assessment**
- **Attempt curability**
- **Inadequate reimbursement**
Potential Polypectomy Complications

- Bleeding
- Perforation
Residual Tissue Ablation Post Polypectomy

Long term clinical study results show 50% reduction in adenomatous polyp re-growth with APC use of residual tissue.

### Sphincterotomy Techniques

- Pure or blended waveform controlled by ‘pedal tapping’.

- Software controlled, fractionated cut /coag cycle with ‘pedal down’. Some pulse on/off; others contain spark recognition.

- A pre-cut may be performed when difficult cannulation is experienced.

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Argon Plasma Coagulation

APC is a non-contact monopolar application
Properties of Argon Gas

Properties:

- Non-flammable
- Non-toxic
- Colorless, odorless, tasteless
- Ionizes easily
- Relatively inexpensive
- Noble gas – very stable
- 99.99% pure
APC is a monopolar application in which HF electrical energy is transferred to the target tissue using ionized (conductive) argon gas (plasma), without the electrode coming in contact with the target tissue.
Argon Plasma Coagulation

**Advantages:**

- Non-contact application
- As target tissue becomes coagulated, current automatically seeks new conductive tissue, resulting in a more uniform hemostasis
- Smoke is reduced
- Thinner eschar, more flexible
- Limited penetration depth of approximately 3mm
Argon Plasma Coagulation offers particular advantages for endoscopic applications as it allows APC to be applied en face or tangentially, enabling less accessible areas to be easily treated.
Argon Plasma Coagulation

Application techniques:

**Static:**
- The probe is focused in one single area, thermal penetration will increase over time.
- If applied for long periods of time in the same area, carbonization and vaporization can occur.
- For superficial treatment, short activation times of 1 to 2 seconds are used.

**Dynamic:**
- The probe is moved with paintbrush-like strokes over the target area while observing the target tissue effect.
Argon Plasma Coagulation

Three items needed for Argon Plasma Use:

- Sufficient voltage to jump the air gap.
- Proximity to tissue: 1-5 mm.
- Conductive tissue – moist surface, feeder vessels.
Argon Plasma Coagulation

Scope Technique:

- Purge probe at least twice before placing in the scope.
- Advance the tip of the probe until the first black line is visible on the monitor.
- Leave the probe stationary – move the SCOPE.
- Activate only when the tissue being treated is within the field of view.

*APC probe tip must always remain in the clinicians field of vision during activation.*
Argon Plasma Coagulation

The extent of the thermal effect of APC on tissue depends on several factors:
Argon Plasma Coagulation

Another important factor involving thermal effect is the mode chosen.

APC has evolved through specialized modes with more controllable thermal effect:

- Pulsed 1 APC: pulses one time per second, used for focused coagulation
- Pulsed 2 APC: pulses 16 times per second, used for wide spread coagulation
- Forced APC: Constant beam, often used for devitilization of tissue
- Precise APC: Creates a more superficial coagulation effect using a low-energy output, suitable for temperature sensitive, thin-walled areas.
# GI Thermal Tissue Sensitivity

<table>
<thead>
<tr>
<th>Thermal Tissue Sensitivity</th>
<th>Less Sensitive</th>
<th>More Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stomach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Rectum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Esophagus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Colon (Not including Duodenum or Cecum)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Duodenum / Small Intestine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Right Colon / Cecum</td>
<td></td>
<td></td>
</tr>
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Argon Plasma Coagulation

Gastroenterology Uses found in Clinical Literature

- Radiation Induced Proctopathy
- Watermelon Stomach (GAVE)
- Treatment of Residual Adenomatous Tissue
- Stent Shortening (e.g. migrated stents) - *off label use*
- Strictures
- Exophytic Benign or Malignant Tumors
- Oozing from Vascular Lesions (e.g. Angiodysplasias, Arteriovenous Malformations (AVMs), Telangiectasias)
Nursing Considerations for Clinical Safety
Electrosurgical Clinical Safety
Argon Plasma Coagulation

Minimizing risks of Emphysemas, Embolisms and Perforations:

- **ALWAYS** verbally confirm settings prior to activation and document confirmation.
- Avoid probe contact with the tissue.
- Keep 1-5 mm distance between probe and tissue during activations.
- Activation in static applications should be short (1-2 sec).
- Output settings, mode, and application durations should be based on clinical indications, anatomical location and wall thickness.
Minimizing risks of Emphysemas, Embolisms and Perforations:

- Use the lowest possible settings and gas flow rates.
- Avoid activating an APC probe near a metal clip or metal stent.
- Avoid over-distention of the GI Tract through brief and repeated aspiration of gas.
- Avoid aiming the probe directly at large, open vessels.
Electrosurgical Clinical Safety
Bowel Preps

*Patients should be fully prepped any time electrosurgery is used*

- Incomplete Preps or enema-only preps for Flexible Sigmoidoscopy increases the risk for bowel explosions due to the presence of combustible gases.

- Three things are needed for a bowel explosion to occur:
  - Presence of combustible gases - Hydrogen and/or Methane gas.
  - Presence of Oxygen.
  - Spark created by application of monopolar electrosurgery (Snare Polypectomy, Hot Biopsy, APC, etc.).
Electrosurgical Clinical Safety
Clinical Benefits of Carbon Dioxide (CO₂) Insufflation

- CO₂ does not support combustion during electrosurgical procedures.
- Absorbed 150 times faster than room air – less distention, less intra and post operative pain.
- Due to the rapid absorption, diminished distention/pain post procedure occurs, allowing the physician to quickly rule out insufflation pain, in the event of possible complications, i.e. pancreatitis or perforation.

Note: Caution should be used with patients with severe cardiopulmonary disease, i.e. COPD or compromised absorption, i.e. Sickle Cell Anemia.

Preventative measures to avoid combustion in oxygen enriched environments:

**Maintain oxygen concentration at a safe level**

- **Conscious Sedation Patient**
  Supplemental nasal cannula
  O\(^2\) at 3 L/M or LOWER
  Mask delivery is considered high risk

- **Intubated Vent Patient**
  Supplemental O\(^2\) Concentration should be reduced to 40% or less

- **Activation**
  Activate during the patient’s exhalation phase, or during apnea

*Combustion requires heat source, fuel, and oxygen*
Electrosurgical Clinical Safety

Dispersive Electrodes

The Dispersive Electrode Should NOT Be Placed Over:

- Boney prominences
- Scar tissue – including Tattoos
- Skin/Scars over an implanted metal prosthesis
- Hairy surfaces – clip if necessary
- Lotions or oils on skin
Electrosurgical Clinical Safety
Dispersive Electrodes

**MONO Foil or Single pad:**
- *Perform only completion of the electrical circuit.*
- The current density of the pad edges is not measured.
- The correct orientation of the pad is not measured.

*Mono Pads bypass the pad safety systems of generators...*

**DUAL Foil or Split Pad:**
- Completes the electrical circuit.
- Disperses the current density.
- Engages the safety system of the unit to monitor for high current density (and correct orientation with NESSY).
**Electrosurgical Clinical Safety**
**Dispersive Electrodes**

**FDA Data Update: MAUDE**

(Manufacturer And User Facility Device Experience)

- *Hospital Reports of Burns, accessory damage causing injury, staff injuries, fires, and jewelry injury.*

*Accounts of PREVENTABLE accidents.*

http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/search.cfm
Electrosurgical Clinical Safety
Alternate Site Burns

*Electricity Always Seeks Ground*…

- Observe skin touching conductive objects - IV poles, metal bed rail parts.
- Watch for fingers, toes, ankles, and elbows touching metal.
- Check for arms over bedrails and hands grasping handrails.
- Separate all wires, including heart monitor wires from active cords and dispersive electrode cords.
Electrosurgical Clinical Safety

Jewelry

Jewelry Removal:

- ESU Manufacturers and clinical guidelines recommend removing ALL pierced and non-pierced jewelry if within the circuit.

- Additional risks are posed due to:
  - Patient positioning
  - Patient transfers
  - Electrosurgery use and pad placement

Navel and genital jewelry can be in the circuit, increasing risk of burns.

Tongue studs can damage scopes and impede intubation in an emergency.
Electrosurgical Clinical Safety
Pacemakers, ICDs, IEDs

Advance Preparation:

- Physician offices and/or Pre-Admission phone calls MUST collect information
- Patient Pacemaker ID card
- Pacemaker, ICD, IED policy and decision tree
Electrosurgical Clinical Safety
Pacemakers, ICDs, IEDs

Basic Safety:

- Use Bipolar when possible
- Keep 15 cm between the active electrode and any EKG electrode
- Have resuscitation equipment at the ready – DOCUMENT
- Have the device clinical support line available
- Contact the IED manufacturer for specific deactivation recommendations
Electrosurgical Clinical Safety
Pacemakers, ICDs, IEDs

If the physician must use Monopolar current:

- Place pad on opposite lower extremity.
- Use the lowest setting possible.
- Use the shortest activations possible.
- If the ICD is deactivated, re-establish integrity of the device post-procedure*.

* IMPORTANT FOR RISK MANAGEMENT
Unintentional electrical stimulation of the patient’s nerves and muscles caused by demodulation of the electrical current.

- Loose wires
- Broken wire bundles
- Defective/broken adapters
- Active cords should be routinely inspected for breaks
Summary

• Electrosurgery and APC are useful therapeutic tools in GI endoscopy.

• It is important the clinician understands the basic principles and properties of electricity, electrosurgery and APC and how it is adapted for clinical use.

• To insure optimal patient outcomes, nurses should adhere to the accepted current standards and recommended practices for clinical safety e.g. SGNA and AORN.