

CLINICAL PRACTICE UPDATES

AGA Clinical Practice Update on the Use of Electrosurgery in Therapeutic Endoscopy: Expert Review



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DESCRIPTION: This American Gastroenterological Association (AGA) Institute Clinical Practice Update aims to review the available evidence and provide expert advice regarding the use of electrosurgery in gastrointestinal endoscopy.

METHODS: This Clinical Practice Update was commissioned and approved by the AGA Institute Clinical Practice Updates Committee and the AGA Governing Board to provide timely guidance on a topic of high clinical importance to the AGA membership and underwent internal peer review by the Clinical Practice Updates Committee and external peer review through standard procedures of *Clinical Gastroenterology and Hepatology*. This manuscript is framed around best practice advice points agreed upon by the authors, based on the current available evidence and expert opinion in this field. Because systematic reviews were not performed, these best practice advice statements do not carry formal ratings regarding the quality of evidence or strength of the presented considerations.

BEST PRACTICE ADVICE STATEMENTS:

**BEST PRACTICE
ADVICE 1:** Endoscopists should have a thorough understanding of fundamental electrosurgical principles.

**BEST PRACTICE
ADVICE 2:** Endoscopists should have knowledge of the specific electrosurgical unit that they are using and the related electrosurgical settings.

**BEST PRACTICE
ADVICE 3:** Endoscopists should understand the concept of current density and that multiple factors influence tissue effect besides electrosurgical unit settings, and therefore, changing the electrosurgical unit settings alone may not achieve the optimal desired tissue effect.

**BEST PRACTICE
ADVICE 4:** The endoscopist should adopt best safety practices when utilizing electrosurgery, which includes incorporating a pre-procedure timeout to review electrosurgery safety, optimal positioning of the electrosurgical unit in the room for both visibility and operation, and the use of closed-loop communication among team members prior to electrosurgical unit activation and troubleshooting.

**BEST PRACTICE
ADVICE 5:** Either a cut- or coagulation-predominant electrosurgical current can be considered for the resection of colorectal polyps without clear differences in the risk of serious adverse events, complete resection rate, or polyp recurrence.

**BEST PRACTICE
ADVICE 6:** Hot instead of cold snare polypectomy should be strongly considered for the removal of large pedunculated polyps as these lesions can often contain thick blood vessels prone to bleeding when transected.

Abbreviations used in this paper: AGA, American Gastroenterological Association; APC, argon plasma coagulation; BPA, Best Practice Advice; EMR, endoscopic mucosal resection; ESD, endoscopic submucosal dissection; ESU, electrosurgical unit; GI, gastrointestinal; STSC, snare tip soft coagulation.

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BEST PRACTICE ADVICE 7:	Following piecemeal endoscopic mucosal resection of colorectal polyps, thermal ablation of the resection margins should be considered to reduce the risk of recurrence.
BEST PRACTICE ADVICE 8:	Endoscopists should recognize that the operational environment (gas vs fluid) affects the tissue effect.
BEST PRACTICE ADVICE 9:	Endoscopists should be aware that, although the application of soft coagulation current is an effective hemostatic and ablative technique, it can also cause deep tissue injury and the potential for delayed perforation.
BEST PRACTICE ADVICE 10:	Hot forceps avulsion using a cutting current can be an effective adjunct technique for removing focal areas of gastrointestinal lesions complicated by non-lifting fibrosis.
BEST PRACTICE ADVICE 11:	The endoscopist should understand the principles of argon plasma coagulation as a non-contact method of delivering electrosurgical energy and how gas flow and power parameters can be adjusted to achieve the desired tissue effect.
BEST PRACTICE ADVICE 12:	Endoscopists should understand how to optimally deliver electrosurgical energy to achieve the desired sphincterotomy at the time of endoscopic retrograde cholangiopancreatography while minimizing the risk of immediate/delayed bleeding and pancreatitis.
BEST PRACTICE ADVICE 13:	Endoscopists performing third-space endoscopy should have in-depth understanding of how to optimize the desired tissue effects while minimizing any off-target tissue damage.

Keywords: Electrocautery; Electrosurgery; Therapeutic Endoscopy.

Electrosurgery is extensively used in endoscopic therapeutic procedures. An understanding of the principles of electrosurgery is fundamental for its safe and effective use across the various applications of this technology in gastrointestinal (GI) endoscopy. The intent of this document is to provide an expert review on several key concepts for electrosurgery and offer practical guidance on how to optimize patient outcomes and prevent adverse events in endoscopy.

Basic Principles on the Safe and Effective Use of Electrosurgery

Best Practice Advice 1: Endoscopists should have a thorough understanding of fundamental electrosurgical principles.

Electrosurgery is based on the principle of converting high frequency alternating current generated by an

electrosurgical unit (ESU) into thermal energy, with the resulting effect at the target tissue. The thermal effect is dictated by the basic principles of electrosurgery (eg, current, resistance, impedance, voltage, and power) outlined in [Table 1](#). In general, electrosurgery can be performed using either a monopolar or bipolar device. With monopolar energy, current flows from electrode (eg, device) to the target tissue, through the patient to the return electrode (dispersive pad) and back to the generator. As opposed to monopolar energy, with bipolar electrosurgery, the current path is confined to the tissue between the 2 active electrodes located on the endoscopic instrument; hence, there is no need for a dispersive pad.

The rapidity, amplitude, and depth of the heat generated determines the tissue effect. For instance, with instantaneous heating to a high temperature (>100°C), intracellular fluid quickly vaporizes, leading to rupture of cellular membranes, clinically resulting in a

Table 1. Terminology and Basic Principles of Electrosurgery

Term	Definition
Current (I)	Defined as the flow of electrons through a circuit. Measured in amperes (A).
Resistance (R)	Describes the ease by which electrons flow through the tissue. Measured in ohms (Ω).
Voltage (V)	Defined as the force that pushes current through the circuit. Measured in volts.
Power (P)	Defined as the energy transferred in a circuit per unit of time. Measured in watts (W). Power = V × I or V ² /R
Ohm’s law	Current is directly proportional to voltage and inversely proportional to resistance (I = V/R).

cutting effect. Conversely, at lower temperatures ($<100^{\circ}\text{C}$), proteins are denatured leading to tissue desiccation with the specific effect of coagulation. Knowledge of the electrosurgical concepts of duty cycle and crest factor is needed to understand the continuum of cutting and coagulation current waveforms. Duty cycle refers to the amount of time that energy is being actively delivered in each waveform. In general, higher percentage duty cycle waveforms produce more cutting and less coagulation tissue effect. Crest factor refers to the peak voltage relative to the average voltage of a waveform. With waveforms with higher voltage spikes, current can force current despite high impedance, resulting in deeper tissue effect. Although each ESU manufacturer has different settings, the concepts that govern them are the same, with most settings having different duty cycle and crest factor parameters to achieve the desired tissue effect^{1,2} (Figure 1).

Best Practice Advice 2: Endoscopists should have knowledge of the specific ESU that they are using and the related electrosurgical settings.

Understanding the functions of the ESU is key in determining how to optimize current density and tissue effect. In therapeutic endoscopy, considerations for which waveform to use depends on the desired tissue effect. The ESU is often controlled by 2 separate pedals: the yellow left pedal activates the “cut” function, whereas the blue right pedal activates the “coagulation” mode. In general, when the aim is to cut tissue, high current density is desired. Conversely, when coagulation

is desired, a lower current density should be delivered. ESU manufacturers have created “blended” currents, through which the modulation of duty cycle and crest factor results in waveforms that provide different degrees of cutting and coagulation effect. Some commonly suggested ESU settings for various indications are listed in Table 2.

A key concept in the use of electrosurgery in endoscopy is that circuit resistance is not constant. Tissue resistance depends largely on the degree of vascularization and water content. For one, tissue resistance varies at baseline throughout the GI tract (eg, lower in the esophagus vs higher in the colon) and between the layers of the GI tract wall (eg, from least to highest: submucosa, mucosa, and muscularis propria). In addition to these variables, resistance will change (often increase) throughout the procedure, due to alterations in tissue characteristics during the application of electrosurgical current. For instance, resistance increases during snare polypectomy with current application due to progressive tissue desiccation. As governed by Ohm’s law, as this tissue resistance increases, the current will decrease unless the voltage is increased. Previously, most ESUs were analog, in which the selected power output remains constant, regardless of changes in the target tissue properties throughout the procedure. This, in turn, resulted in higher risk for collateral thermal injury due to fluctuations in voltage and variable tissue effects. Newer-generation ESUs contain microprocessors in which the power output is adjusted according to

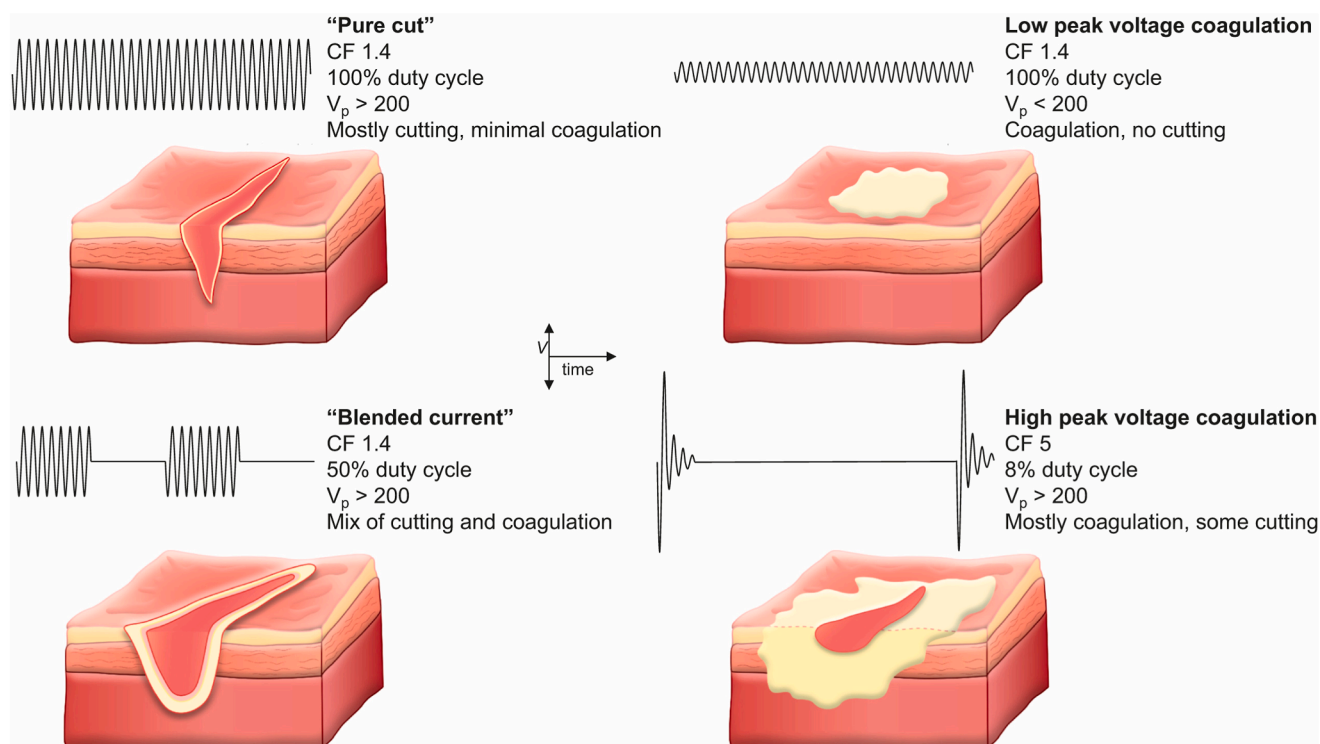


Figure 1. The degree of cutting vs coagulation tissue effect is determined by duty cycle, CF, and voltage characteristics of each respective waveform. CF, crest factor.

Table 2. Commonly Used ESU Settings for Various Endoscopic Procedures Based on Manufacturer^a

Indication	Olympus ESG 300	ConMed Beamer CE200	ERBE VIO 300D and VIO3
EMR	Pulse cut slow power 120 W effect 2	Polyp pulse cut II G2 Pure coagulation 20–30 W	EndoCut Q, Effect 2–3, Duration 2–3, Interval 2–3 Forced coagulation effect 2–3, 30–40 W
Hemostasis	Soft coagulation 30–40 W	Gentle coagulation 50 W	Soft coagulation effect 5, 60–80 W Forced coagulation effect 1, 10 W
Sphincterotomy	Pulse cut fast 120 W effect 2	Papilla pulse cut 1 G2	Endocut I, Effect 2–3, Duration 2–3, Interval 2–3
Mucosal incision	Pulse cut fast 120 W	ESD G2-G5	Endocut I, Effect 2–3, Duration 2–3, Interval 2–3
Submucosal dissection	Forced coagulation/power coagulation, Effect 2–3, 40–50 W Pulse cut fast effect 3, 80–120 W	Hot biopsy 35–37 W	Forced coagulation 30–50 W Dry cut 30–40 W Swift coagulation 30–50 W EndoCut I Effect 2–3, Duration 2–3, Interval 2–3 Precise Sect (VIO3) 40–60 W

ESD, endoscopic submucosal dissection; ESU, electrosurgical unit; W, watts.

^aESU settings will vary depending on the device being used with the ESU (eg, size of coagulation grasper, diameter of knife/snare wire) and other factors, including but not limited to endoscopist's technique and patient and tissue characteristics. These settings are meant as reference, and the operator should contact the manufacturer for guidance on a case-by-case basis.

changes in tissue impedance, thereby maintaining a constant voltage and a more consistent and precise tissue effect. It should be emphasized that many other factors (eg, device, user technique, patient and tissue characteristics) beyond generator settings may have an equal if not more important role in determining tissue effect; hence, ESU settings should be individualized and adjusted in real-time to achieve the desired tissue effect. An in-depth discussion of the principles of electrosurgery is outside the scope of this document, but additional reviews are currently available and are great resources for the practicing endoscopist.^{3,4}

Best Practice Advice 3: Endoscopists should understand the concept of current density and that multiple factors influence tissue effect besides ESU settings, and therefore, changing the ESU settings alone may not achieve the optimal desired tissue effect.

Current density is defined by the amount of current per unit area of cross-section ($D = \text{intensity [amperes]}/\text{area [cm}^2\text{]}$). Although modifying ESU setting (ie, current intensity) can impact current density, the practicing endoscopist should be aware of how other additional factors (ie, device properties, user technique, tissue characteristics) interact and influence current density (Table 3). A key concept to remember is that current density is inversely proportional to the surface area of contact. This concept has important practical implications. The smaller surface area to contact the tissue (eg, thin monofilament snare as opposed to a thick braided snare) will often result in higher current density, which translates into improved cutting with less heating of the immediate surrounding tissue. Conversely, increasing surface area contact results in lower current density and slower heating of tissue. For instance, during hemostasis, the use of electrodes with

larger surface area (eg, coagulation forceps, larger diameter cautery probes) results in lower current density and helps coapt vessels during delivery of energy, which, in turn, decreases blood flow through the target, preventing heat sink effect and improving coagulation. Because heat generated in the tissue is directly proportional to the power dissipated by the tissue, the larger surface contact area also translates into higher risk of thermal injury to adjacent tissue. Therefore, even when coagulation is the desired effect, a small surface contact area (eg, selectively grasping a vessel with the coagulation grasper and tenting away from other structures) may help reduce collateral thermal injury.

Best Practice Advice 4: The endoscopist should adopt best safety practices when utilizing electrosurgery, which includes incorporating a pre-procedure timeout to review electrosurgery safety, optimal positioning of the ESU in the room for both visibility and operation, and the use of closed-loop communication among team members prior to ESU activation and troubleshooting.

ESU-related complications or malfunction are uncommon. Most adverse events associated with the ESU are operator- or device-related.² We strongly advise incorporating a pre-procedure timeout to review electrosurgery safety. The endoscopy team, which includes the endoscopist, room nurse, technician, and anesthesia team should routinely adhere to best practices when operating the ESU (Figure 2). Two safety measures deserve additional discussion:

Placement of dispersive electrode (Pad)

When using a monopolar device, the dispersive electrode/pad is necessary to complete the electric

Table 3. Factors Influencing Current Density and Tissue Effect

Variable	Comments
ESU settings and waveforms	Work with the manufacturer of the ESU to determine appropriate settings because preset choices may not be appropriate in all circumstances.
Duration of ESU activation	Aim for the shortest possible activation time to accomplish the desired tissue effect.
Amount of pressure/tension applied by the electrode on the tissue	More pressure results in decrease in current density (less cutting, more coagulation).
Speed of movement of the electrode	Slower movement (eg, slow snare closure) results in more coagulation/less cutting.
Material and structure of the electrode	Monofilament electrode (eg, monofilament snare) will promote more cutting and braided electrode more coagulation.
Surface area of the electrode	Thin electrode (eg, thin snare) will promote more cutting and thicker electrode more coagulation.
Coagulum/eschars on the electrode	Eschars will increase resistance resulting in lower current density and less precision. Sparking, and potentially flaming of the eschar can occur.
Patient variables	Age, body weight, degree of hydration (ie, increasing age, body weight, decreased hydration increase tissue impedance).
Distance of the electrode from the return electrode (in monopolar mode)	The goal is to have the return electrode as close to the active electrode as possible which for GI applications is the patient's flank.

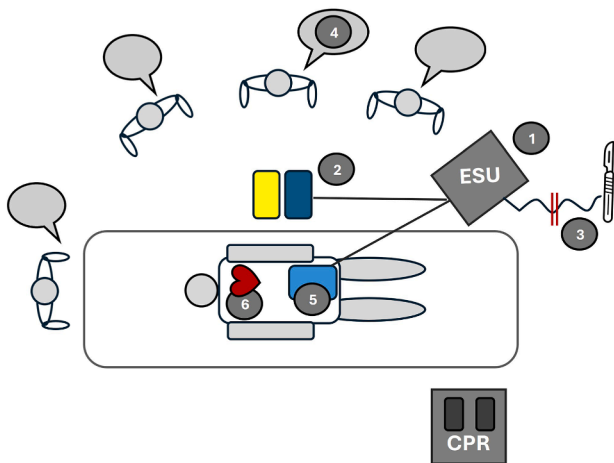
ESU, electrosurgical unit; GI, gastrointestinal.

circuit. Proper placement includes placing the pad as closely as possible to the treatment site, as this allows the shortest electrical circuit. Notably, the pad should be placed over muscular areas with good blood supply (eg, thigh, flank, upper arm) and away from areas with poor current skin dispersion (scars, bony protuberances, excessive hair, tattoos, implants). The appropriate dispersive pad size depends primarily on the patient's size and weight and should be adequately selected to safely disperse the electrical current. For larger patients or when high-power settings are required, a dual-pad

system can be placed strategically to maximize the surface area for current dispersal.

Implantable devices

Implanted cardiac devices, including pacemakers and cardioverter defibrillators, may potentially react to electrical signals from the ESU, resulting in adverse events including pacing inhibition, mode switching, device inactivation, and even delivery of inappropriate



BEST SAFETY PRACTICES FOR ESU OPERATION

- 1 ESU generator should be positioned so that the display monitor featuring the power settings is clearly visible and within reach of operation.
- 2 ESU activation pedals and other foot-equipment should be routinely aligned in the same manner to reduce the risk of inadvertently stepping on the wrong pedal during the procedure
- 3 ESU should remain on "standby" mode and all devices insulated and disconnected from the active cord when not in use or between applications to prevent unintentional activation
- 4 Closed loop communication should be used when operating the ESU:
 - Allows team members to acknowledge each step of the process via verbal confirmation, seeking clarification when necessary, and followed by verification that the task in hand has been correctly interpreted to close the loop prior to its execution
- 5 Endoscopy team should be knowledgeable on best practices for the placement and management of dispersive pads:
 - The pad should be placed over areas with good blood supply and avoid skin irregularities (e.g. scars, hair, implants, areas of moisture, sweat) that may be prone to failure and hinder current conduction). Body hair should be shaven at the chosen site to ensure uniform pad contact
 - The size of the dispersive pad should be appropriate to the patient's age and weight
 - Dual-pads can be considered for select cases (e.g. larger patients)
- 6 Endoscopy team should be familiar and follow the protocols regarding the operation of cardiac (e.g. defibrillators, pacemakers) and other implantable devices (e.g. neurostimulators) [5]:
 - Standard practice should include obtaining detailed information of all implantable devices and consultation with cardiology and/or manufacturer when indicated
 - Cardiac devices should be continuously monitored during the procedure
 - If feasible, bipolar device should be considered as an alternative among patients with implantable defibrillators
 - Cardiac resuscitation equipment should be readily available

Figure 2. Endoscopy layout and best safety practices for the ESU operation. CPR, cardiopulmonary resuscitation.

shocks.⁵ Mandatory preoperative assessment should include determining the manufacturer and model of the implantable device, location of the device, and whether the patient is device-dependent.⁵ Although there are no GI societal consensus in the management of cardiac and non-cardiac implantable devices during electrosurgery, general recommendations include placing the dispersive pad in a location to avoid current flow through or near the device or leads and to preferentially use multipolar electrocautery when feasible.

Electrosurgery Applications During Endoscopy

Best Practice Advice 5: Either a cut- or coagulation-predominant electrosurgical current can be considered for the resection of colorectal polyps without clear differences in the risk of serious adverse events, complete resection rate, or polyp recurrence.

Two retrospective studies had previously suggested that a cut-predominant current was linked to a greater risk of immediate bleeding, whereas a coagulation current was more likely to be associated with a risk for delayed bleeding.^{6,7} A subsequent randomized trial demonstrated no significant differences in complete resection rates or in the incidence of recurrence following endoscopic mucosal resection with a cut- vs coagulation-predominant current.⁸ For this study, patients were either randomized to a blended cutting current (EndoCut Q, effect 2, duration 1, interval 4; ERBE) or coagulation current (forced coagulation, effect 2, 25 W, ERBE). Intraprocedural bleeding was more common with cut vs coagulation (17% vs 11%; $P = .006$), but there was no difference in the rate of severe adverse events between the 2 groups (7.2% vs 7.9%; $P = .76$) or that of delayed bleeding (5.0% vs 5.7%; $P = .84$). Several aspects should be taken into consideration when interpreting these results. For one, the study was performed using a newer generation ESU that delivers microprocessor-controlled current that adjusts for tissue resistance changes. Hence, these results may not be applicable to other older ESUs. Furthermore, as previously alluded, non-generator associated factors, including endoscopists' technique and tissue characteristics, will also influence treatment outcomes and should be taken into consideration when determining the most appropriate ESU setting.

Best Practice Advice 6: Hot instead of cold snare polypectomy should be strongly considered for the removal of large pedunculated polyps, as these lesions can often contain thick blood vessels prone to bleeding when transected.

Pedunculated polyps contain a feeding blood vessel within the stalk, and using electrosurgery as compared with cold snare resection is advisable to decrease the risk of immediate bleeding. Mechanical transection of polyp stalks can be difficult, and the use of current may

facilitate resection without compromising margins and histopathology. For these lesions, a coagulation-predominant waveform may be preferable,⁹ as it may facilitate the sealing of vessels across the thick stalk prior to transection. The snare should be positioned across the mid-stalk and not too close to the base as to avoid transmitting excessive thermal injury to the colonic wall. Additional best practice advice on appropriate and tailored polypectomy was recently published by the American Gastroenterological Association (AGA).⁹

Best Practice Advice 7: Following piecemeal endoscopic mucosal resection of colorectal polyps, thermal ablation of the resection margins should be considered to reduce the risk of recurrence.

Endoscopic mucosal resection (EMR) is the first-line treatment of large non-pedunculated colorectal polyps with low probability of malignancy; however, local recurrence of neoplasia remains a well-recognized limitation.¹⁰ In the past 5 years, high-quality trials have supported the efficacy of thermal ablation of the normal-appearing post-EMR margin in reducing the rate of recurrence to less than 5% at first follow-up.^{11,12} Thermal treatment, by systematically applying current to the entire resection margin using snare tip soft coagulation (STSC) has been shown to be effective and safe. STSC and argon plasma coagulation (APC) have been shown in randomized trial to be equally effective, but STSC may be more cost-effective in most practice environments.^{10,11} Thermal ablation with STSC or APC should only be performed on the normal appearing mucosal resection defect margins. The application of STSC should be performed with caution, avoiding any thermal injury to the muscularis propria as soft coagulation can penetrate deeply (see Best Practice Advice [BPA] 9). Any visible residual neoplasia should be resected either by additional cold snaring or other adjunct techniques.¹³ Although the role of thermal ablation of resection margins has not been well-established in other GI sites (eg, upper GI tract), preliminary studies suggest that this technique may be safe and reduce the frequency of neoplasia recurrence.¹⁴

Best Practice Advice 8: Endoscopists should recognize that the operational environment (gas vs fluid) affects the tissue effect.

The electrosurgical environment has a substantial impact on energy delivery, cutting efficiency, and procedural safety. When the electrode is immersed in a conductive fluid, "underwater" conditions, the contact impedance is significantly reduced, resulting in energy dissipation.¹⁵ This profound drop in peak voltage accounts for the predominant coagulation effect, as relatively high-voltage is needed to generate the spark formation for cutting in under water/saline conditions. Designated ESU settings are typically needed (usually adjusting for higher power output) to achieve the desired cutting and/or coagulation effect. Consulting the ESU manufacturer for details and specific settings is advised.

Although “underwater” is commonly used interchangeably when referring to immersion EMR or endoscopic submucosal dissection (ESD) techniques, it should be noted that saline is preferred over water to mitigate the risk of water intoxication syndrome, a rare but serious complication secondary to dilutional hyponatremia, which can occur during prolonged procedures or large resection. In all, with the increasing application of immersion techniques in therapeutic endoscopy, studies are needed to further enhance our understanding of how these environments impact electrosurgical performance.¹⁶

Best Practice Advice 9: Endoscopists should be aware that, although the application of soft coagulation current is an effective hemostatic and ablative technique, it can also cause deep tissue injury and the potential for delayed perforation.

Soft coagulation mode delivers a continuous, low-voltage (<200 Vp) sinusoidal waveform that does not produce sparks, making it suitable for the coagulation of large vessels with reduced risk of inadvertent tissue cutting. Because energy delivery occurs via direct contact between the electrode and tissue, the effect is localized and relatively superficial at first. However, the presence of a coagulum and rising impedance during tissue desiccation can lead to uneven current distribution, prompting the ESU to compensate by maintaining or increasing power over time. If the application is prolonged or excessive tissue is grasped, deep thermal injury can ensue, despite the low-voltage setting with this coagulation mode. To minimize the risk of immediate or delayed perforation, the electrosurgical device should be applied with precision. Only the target vessel or bleeding point should be treated with coaptation, to enhance current density and enhance hemostatic efficiency and limiting collateral thermal injury. Once the target tissue has been grasped with the forceps, gentle traction away from the underlying layers may help reduce thermal transmission to the deeper tissue and risk for delayed perforation¹⁷ ([Supplementary Video 1](#)). When soft coagulation is used to ablate tissue (eg, STSC), the snare tip should be placed only on the mucosal surface, avoiding contact with the muscularis propria, and energy applied until the mucosal surface has been ablated.

Best Practice Advice 10: Hot forceps avulsion using a cutting current can be an effective adjunct technique for removing focal areas of gastrointestinal lesions complicated by non-lifting fibrosis.

Non-lifting submucosal fibrosis, whether due to prior biopsy, incomplete resection, or tattoo placement, can significantly hinder complete removal with standard snare-based resection techniques. Hot forceps avulsion is an effective alternative strategy for the management of focal areas of visible neoplasia complicated by fibrosis.^{18,19} This technique refers to the grasping of the target tissue with the hot forceps while applying a predominant cutting current (eg, EndoCut I, effect 3,

duration 1, interval 3 setting; ERBE) to mechanically pull the tissue off. A few technical issues should be taken into consideration to ensure the safety of the procedure. Fibrotic tissue is characterized by poor conductivity and high tissue impedance. Hence, to maximize cutting effect, a small surface area should be targeted to ensure high current density. The target tissue is then mechanically pulled away from the GI wall with simultaneous short bursts of current (ie, tapping the pedal) to facilitate shearing of the adherent tissue. Prolonged continuous activation should be avoided as the cutting current can be associated with deep tissue injury, increasing the risk of bleeding, post-coagulation syndrome, and delayed perforation. The efficacy and safety of hot forceps avulsion in other GI sites besides the colon remains to be determined.

Best Practice Advice 11: The endoscopist should understand the principles of APC as a non-contact method of delivering electrosurgical energy and how gas flow and power parameters can be adjusted to achieve the desired tissue effect.

APC utilizes argon gas that is delivered to the tip of a specially designed catheter where argon gas becomes electrically charged (ionized) by a high-voltage waveform. Ionized argon gas, or plasma, is then able to conduct current without mechanical contact from the tip of the catheter in the path of least resistance to the nearest tissue. The current is conducted through the body in a monopolar circuit configuration, exiting through the dispersive electrode. Settings for APC vary by manufacturer; however, the principles for each setting are similar. The user can set the power and an argon gas flow rate. The power determines the amount of current that is conducted through the ionized argon plasma into the tissue, with higher power and duration usually translating into deeper tissue ablation. The argon gas flow rate determines the volume of argon plasma that is available for current to be conducted through to reach the targeted tissue. The flow rate must be sufficient to provide enough argon plasma to reach the target tissue. However, if the flow rate is too high, the volume of argon plasma will disperse the current, resulting in low current density at the target tissue. The physician must also be aware of the total volume of argon gas that is utilized during the procedure, as argon gas is not absorbed and can cause undesirable luminal distension and risk for bowel perforation. Typically, a flow rate of 0.8 to 1.0 L/min is sufficient for most clinical settings. When using APC, poor bowel preparation can lead to a colon with higher concentrations of hydrogen and methane gas, which, coupled with oxygen and a heat source, can pose a risk for the rare yet fatal complication of colonic explosion. Hence, although no consensus exists on what the threshold should be, a thorough complete bowel preparation (oral as opposed to local colonic) is highly advised when APC is expected to be delivered.

Best Practice Advice 12: Endoscopists should understand how to optimally deliver electrosurgical energy

to achieve the desired sphincterotomy at the time of endoscopic retrograde cholangiopancreatography while minimizing the risk of immediate/delayed bleeding and pancreatitis.

During sphincterotomy, the endoscopist should aim at minimizing sphincterotome wire contact with the mucosa and sphincter to achieve high current density. The wire should not be “buried” into the sphincter, but rather gently applied to the surface with minimal tension, which, in turn, translates into high current density when energy is delivered while minimizing risk of collateral thermal injury. During sphincterotomy, a “pure cut” current theoretically provides the most efficient cut with the least amount of thermal injury and edema to the adjacent tissue, thereby minimizing the risk of pancreatitis, which was suggested in an older study comparing “pure cut” with a blended cut/coagulation current.²⁰ Nonetheless, more recent studies with newer energy setting with blended currents have not shown an increased risk in pancreatitis and may be associated with a reduced risk of post-sphincterotomy bleeding.^{21–23} Hence, the risk of pancreatitis from sphincterotomy may be primarily associated with technique (eg, small area of tissue contact of the cutting wire contact with minimal tension) rather than energy setting.

Best Practice Advice 13: Endoscopists performing third-space endoscopy should have in-depth understanding of how to optimize the desired tissue effects while minimizing any off-target tissue damage.

When performing endoscopic surgical procedures, considerations for which current to employ depend on the desired tissue effect (eg, cutting, coagulation, or both), tissue site and risk of thermal injury to adjacent tissue, the device used, user technique, and other factors that may affect current density (Table 3). In the following section, we discuss specific considerations pertaining to third-space endoscopy (eg, endoscopic submucosal dissection, per-oral endoscopic myotomy), focusing primarily on the performance of monopolar electrosurgery.

When dealing with fibrotic tissue (low in water content), a cut current should be used in the setting of the higher tissue resistance, thereby reducing the risk of excessive thermal injury to adjacent tissue from coagulation current with high peak voltages. Submucosal dissection can be adequately achieved using either a cutting or coagulation current, and the choice often depends on multiple factors, including endoscopist’s preference and location in the GI tract, as well as tissue characteristics. Preemptive hemostasis of smaller caliber blood vessels during submucosal dissection can often be adequately achieved with the shaft of the ESD knife using a low-power setting (ie, 10 W forced coagulation mode), which reduces current density and risk of inadvertently cutting through the vessel. When doing so, the vessel should be initially “skeletonized” (isolated from surrounding tissue to improve contact with knife). Gentle pressure should then

be applied to the vessel with the widest portion of the knife (ie, shaft) to promote vessel-sealing and reduction of blood flow to avoid heat sink effect (Supplementary Video 2). For larger vessels (ie, wider than the widest portion of the ESD knife), and especially for arteries, the use of coagulation forceps is preferred.

For “underwater” applications, higher cutting settings must be used to perform any dissection, and a higher power coagulation setting is needed for preemptive hemostasis of blood vessels due to the dispersion of current underwater resulting in lower current density compared with air or CO₂. Studies to determine the optimal ESU settings and their safety for diverse endoscopic procedures are currently underway.

Conclusion

An understanding of the basic principles of electrosurgery is important in endoscopy to achieve the desired tissue effect. A working knowledge of key concepts, including current density and tissue resistance, are fundamental in the safe and effective operation of modern ESUs and its various settings. The endoscopist must be aware of how multiple factors, including ESU parameters, technique, and device and tissue characteristics, interact and dictate tissue effect.

Supplementary Material

Note: To access the supplementary material and/or video(s) accompanying this article, visit the online version of *Clinical Gastroenterology and Hepatology* at www.cghjournal.org, and at <https://doi.org/10.1016/j.cgh.2026.02.007>.

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Conflicts of interest

These authors disclose the following: Dennis Yang serves as a consultant for Boston Scientific, Olympus, Fujifilm, Microtech, Medtronic, 3D-Matrix, ERBE, and Neptune Medical. Peter V. Draganov is a consultant for Boston Scientific, Olympus, Lumendi, Cook Medical, Medtronic, 3D-Matrix, and Microtech. Joo Ha Hwang is a consultant for Boston Scientific, Olympus, FujiFilm, Medtronic, Microtech, Neptune, ERBE, Endorobotics, and Lumendi. The remaining author discloses no conflicts.