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Different behavior of electrosurgical currents between air and saline immersion therapeutic endoscopy

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Impedance and voltage of monopolar currents are directly related. By replacing air with saline solution, a change in behavior of these currents are achieved in endoscopy, resulting in a desired coagulation effect. However, the underlying electrophysical mechanisms of this effect remain poorly explained. This investigation assessed the relationship between the electrical parameters and the surrounding environment for three high-voltage monopolar coagulation currents commonly used for therapeutic endoscopy. Six consecutive applications per setting and per environment were performed with dissection knife on porcine kidney. When transitioning from air to saline immersion, a 99% decrease in impedance was observed for all current settings tested (Air_{Range}: 4400–8150 Ω, $Saline_{Range}$: 64–71 Ω; $p < 0.01$ for all settings). This resulted in a 52-78% reduction in peak voltage (Air_{Range}: 920–1165 V, $Saline_{Range}$: 257–499 V; $p < 0.01$ for all settings), and a 237-2030% increase in power delivered (Air_{Range}: 3–19 W, $Saline_{Range}$: 50–117 W; $p < 0.01$ for all settings). The dramatic decrease in impedance results in a sharp reduction of voltage, explaining the coagulation effect observed when passing from air to saline-immersion therapeutic endoscopy.

Keywords Endoscopy, Electrosurgery unit, Third-space endoscopy, Endoscopic mucosal resection, Polypectomy, Underwater endoscopy, Vessel, Coagulation, Cutting, Pre-seal, Therapeutic endoscopy

All electrosurgical currents are affected by the device itself and environmental conditions. The basic physical principles of electricity are led by both Ohm's law and the equation of electric power according to the relationship between impedance and voltage – i.e., ***Impedance*** = ***Voltage***^{2}/***Power*** – which in turn is associated with the cutting effect of monopolar high-voltage currents.

In the currently expanding area of therapeutic endoscopy, the unintentional transection of larger blood vessels using conventional high-voltage electrosurgical modes emerges as a predominant cause of intra-procedural bleeding. To mitigate this risk, lower voltage or blended currents/settings are generally used in order to maximize the coagulation effect, while minimizing the cutting effect[1]. However, the effectiveness of these coagulation modes is limited by their shallow energy penetration. As a result, it becomes necessary to use tools with large surface electrodes, like hemostatic forceps (also known as coagulation graspers). These tools are designed to spread the current over a broader area, which helps achieve deeper coagulation. Nevertheless, using these instruments can be time-consuming due to the need for switching tools during procedures, and it also introduces additional costs due to the requirement for extra equipment[2].

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Recent research has highlighted a desired coagulation effect when transitioning high-voltage currents from air to saline immersed environment, using the same endoscopic tools and electrical settings[3,4]. By minimizing the cutting effect, this saline-immersion approach has been shown to efficiently pre-seal (i.e. coagulation without cutting effect) large blood vessels in a third-space endoscopy study, reducing intra-procedural bleeding and device-exchange by 28% and 21%, respectively[3]. However, the electrophysical mechanisms when passing from air to saline-immersion therapeutic endoscopy have not been explored.

To better understand this phenomenon and explore potential uses of this technique, this study aimed to examine how electrical current behaves in two different settings: atmospheric air and saline immersion. Using a porcine model, this pre-clinical research sought to uncover how these environments affect the performance and therapeutic outcomes of currents usually adopted in GI endoscopy.

Methods

We assessed the behaviour of three different high-voltage monopolar coagulation currents usually used in third-space endoscopy (preciseSECT, swiftCOAG and forcedCOAG), both in atmospheric air and in a 0.9% saline solution, using porcine kidneys. Main current parameters, i.e. impedance (Ohm, Ω), peak voltage (Volt, V), and power (Watt, W), were continuously recorded during the procedures. These parameters are related according to the following formula:

Voltage = √(Impedance x Power).

The peak voltage of the current is considered responsible for the spark creation that is associated with the cutting effect of the current. Thus, the lower the peak voltage of the current, the lower its cutting effect. The extent of tissue coagulation effect, defined as lateral thermal width, was qualitatively and quantitatively evaluated.

Animal model

We employed an ex-vivo porcine model for all experiments. Kidneys were obtained from a domestic pig at a local slaughterhouse, then frozen and stored. Before the experiments, each kidney was thawed in a water bath at 25 °C for 30 min to ensure even thawing and to prevent any change on the biochemical and biomechanical properties of the material. The kidneys were maintained at room temperature (22 °C) throughout the experiments. To facilitate consistent application on the homogeneous renal cortex, each kidney was precisely cut with a sharp knife. This preparation allowed us to directly compare the effects of the two different environments under each experimental setting, using one kidney for each comparison.

Knife, electrosurgical unit, and settings

This study utilized the Erbe VIO®3 electrosurgical generator (REF. 10160-000, Erbe Elektromedizin GmbH,

Tübingen, Germany), with the settings configured to preciseSECT E6.5, swiftCOAG E4.0, and forcedCOAG E3.0 (further details in **Suppl. Figure 1**). These specific settings were selected to replicate the dissection and coagulation currents typically used in therapeutic endoscopy. Of note, the electrosurgical generator has been programmed to limit the power delivered according to cutoffs specific for each current (limit preciseSECT: 65 W; limit swiftCOAG 120 W; limit forcedCOAG 50 W) for safety reasons. The HybridKnife® I-Type (REF. 20150-061, Erbe Elektromedizin GmbH, Tübingen, Germany) was employed in an ex-vivo laboratory setting to conduct the experiments.

Recording of current parameters

We used a proprietary tool, the Erbe VIO-docu (Erbe Elektromedizin GmbH, Tübingen, Germany), specifically designed to capture and analyze electrical data from the VIO®3. Although not available for commercial use, this tool works in a fashion similar to a standard oscilloscope but facilitates the real-time acquisition of a broad range of electrical data, including peak voltage (V), impedance (Ω), and power (W) directly from the VIO®3 device. For this study, data from the VIO-docu were systematically collected across all modes and environments.

Ex-vivo test procedure (supp. Figure 2)

To investigate the effects of alternating high-voltage current in air and saline immersion environments, one specimen of a porcine kidney was fully submerged in a standard saline solution (0.9% NaCl), while the other specimen was exposed to air. For each setting, six applications were performed at a constant speed (1 mm/s) and electrode depth (1 mm). A custom-built test stand was employed for this purpose, comprising a stepper motor that was controlled and regulated by a custom-built software package. The stepper motor was capable of motion at various speeds and ranges (Fig. 1). Changes in impedance, peak voltage, and power were measured for each application using the Erbe VIO-docu tool.

Qualitative and quantitative assessment of tissue coagulation/lateral thermal spread

Following the experiments, the coloration of the tissue specimens presented as coagulation margin around the treatment area was qualitatively evaluated by a blinded technician under magnification of an incident light microscope. Specifically, the predominant dark color, resulting from tissue carbonization, indicates a clean cutting effect, whereas the surrounding whitish halo reflects a lateral coagulation effect (whitish appearance, indicative for protein denaturation due to the heating causes coagulation). For the purpose of quantitative assessment, a blinded technician conducted a measurement of the thermal spread on each separate application area.

Statistical analysis

We expressed all electrical parameters as medians with interquartile range (IQR – 25th to 75th percentile). We compared the median values of electrical parameters across the different environments under identical electrical

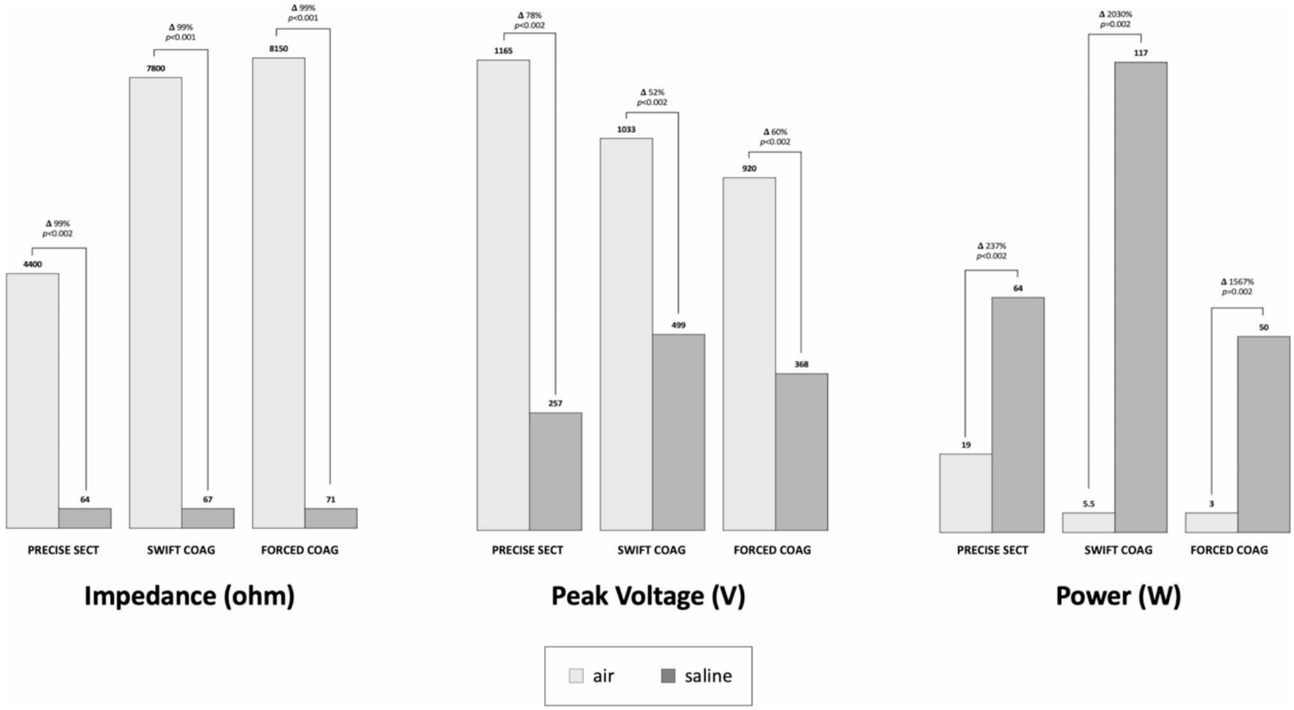

Fig. 1. This graph shows the parameter variations when passing from air to saline solution with each of the three currents tested in the ex-vivo model. In detail, peak voltage (Voltage), Power (Watts) and Impedance (Ohms) are reported.

	preciseSECT E6.5			**swiftCOAG E4.0**			**forcedCOAG E3.0**		
Setting	**Peak Voltage *(IQR)***	**Power *(IQR)***	**Impedance *(IQR)***	**Peak Voltage *(IQR)***	**Power *(IQR)***	**Impedance *(IQR)***	**Peak Voltage *(IQR)***	**Power *(IQR)***	**Impedance *(IQR)***
Air	1165 V (1160–1173)	19 W (15–24)	4400 ohm (3200–6600)	1033 V (1011–1052)	5.5 W (3–7)	7800 ohm (5925–8825)	920 V (898–944)	3 W (2–4)	8150 ohm (7275–8650)
Saline	257 V (252–264)	64 W (63–66)	64 ohm (62–65)	499 V (488–505)	117 W (114–119)	67 ohm (66–69)	368 V (365–372)	50 W (50–50)	71 ohm (69–72)
Difference	− 78%	+ 237%	− 99%	− 52%	+ 2030%	− 99%	− 60%	+ 1567%	− 99%
p-value	$p < 0.002$	$p = 0.002$	$p < 0.002$	$p < 0.002$	$p = 0.002$	$p < 0.001$	$p < 0.002$	$p = 0.002$	$p < 0.001$

Table 1. Median values for measurements of voltage, power, and impedance with interquartile range (25th to 75th percentile) in both environments and for all three evaluated modes. *IQR* – interquartile range; *V* – volts, W- watts.

settings by employing a non-parametric Mann-Whitney test (since the sample size per mode and environment was 6). The values of the lateral thermal spread were expressed also as the median with IQR. The Mann-Whitney test was also employed here to facilitate comparisons between different environments. Data were compiled into an Excel spreadsheet (Microsoft Excel 2010; Microsoft Corporation, Redmond, Washington, USA). Statistical analyses were conducted using Prism 9 (GraphPad Software, LLC, version 9.5.1).

Results

Impedance

When comparing the parameters recorded during the 18 applications of current to the animal model (6 for each type of current) with those applied to the same model with the same currents in a saline-immersion setting, a 99% decrease in impedance was consistently observed with all the three currents. In details, the maximum decrease was observed for forcedCOAG (8150 $\Omega_{air,}$ 95% CI 7275–8650 vs. 71 $\Omega_{saline,}$ 95% CI 69–72; Δ: −8079 Ω; $p < 0.01$), followed by swiftCOAG (7800 $\Omega_{air,}$ 95% CI 5925–8825 vs. 67 $\Omega_{saline,}$ 95% CI 66–69; Δ: −7733 Ω; $p < 0.01$), and preciseSECT (4400 $\Omega_{air,}$ 95% CI 3200–6600 vs. 64 $\Omega_{saline,}$ 95% CI 62–65; Δ: −4336 Ω; $p < 0.01$; Table 1; **Supp.**Table 1; Fig. 1).

Peak voltage

When passing from air to saline solution, a 52–78% decrease of the peak voltage was recorded according to the setting used. In details, the maximum reduction (−78%) was reported for preciseSECT (1165 $Vp_{air,}$ 95%

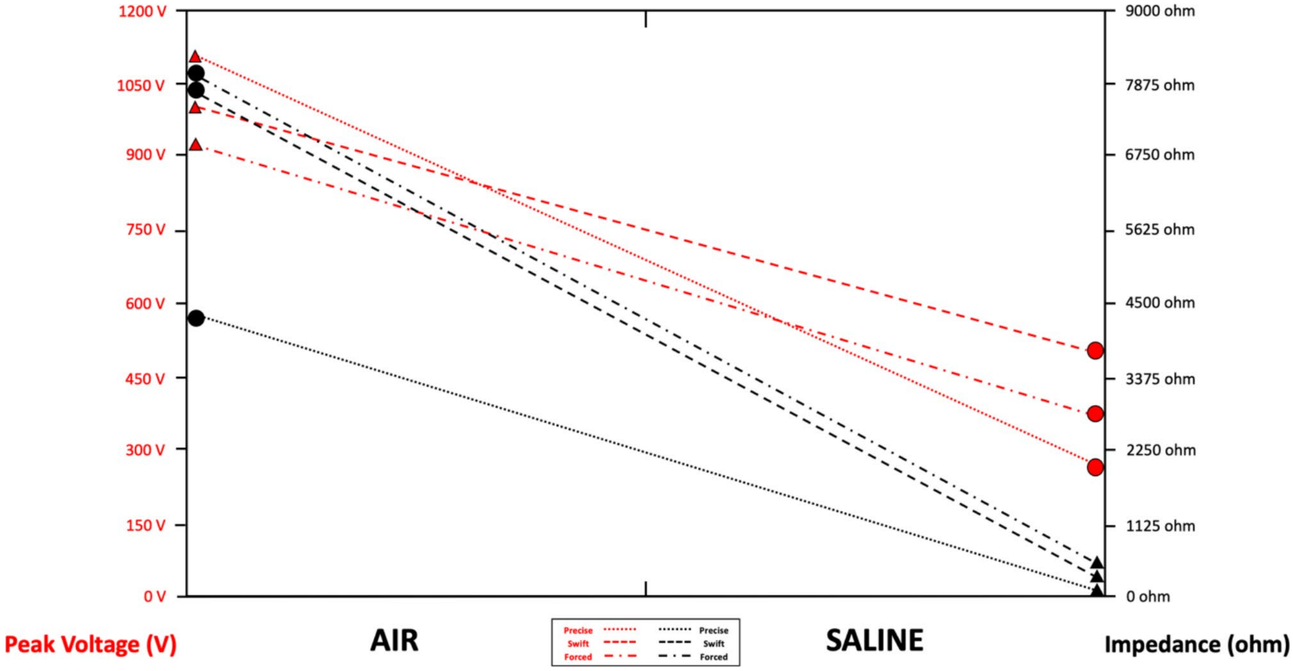

Fig. 2. Relationship between voltage and impedance in air and saline immersion setting. According to Ohm law, the decrease in impedance results in exponential drop of voltage with each of the three currents tested in an ex-vivo animal model. Impedance: Ohm; Peak Voltage: Voltage.

Setting	preciseSECT E6.5	swiftCOAG E4.0	forcedCOAG E3.0
Air (mm; IQR)	0.55 mm (0.40–0.65)	0.53 mm (0.35–0.68)	0.36 mm (0.25–0.40)
Saline (mm; IQR)	0.58 mm (0.55–0.74)	1.33 mm (1.22–1.59)	1.06 mm (0.88–1.24)
Relative difference	+ 4.5%	+ 152%	+ 189%
p-value	0.275; NS	0.002	0.002

Table 2. Median values of thermal spread with interquartile range (25th to 75th percentile) in both environments and for all three evaluated modes. *IQR* – interquartile range; *NS* – not significant.

CI 1160–1173 vs. 257 $Vp_{saline,}$ 95% CI 252–264; $p < 0.01$), followed by forcedCOAG (–60%; 920 $Vp_{air,}$ 95% CI 898–944 vs. 368 $Vp_{saline,}$ 95% CI 365–372; $p < 0.01$), and swiftCOAG(– 52%; 1033 Vp_{air}, 95% CI 1011–1052 vs. 499 $Vp_{saline,}$ 95% CI 488–505; $p < 0.01$; Table 1; **Supp.**Table 1, Fig. 1). The relationship between impedance and voltage is reported in Fig. 2.

Power

The amount of energy delivered to the tissue increased when passing from air to saline solution by 237–2030% with all three currents. In details, the maximum difference (+ 2030%) was recorded for swiftCOAG (5.5 $W_{air,}$ 95% CI 3–7 vs. 117 W_{saline}, 95% CI 114–119; $p < 0.01$), followed by forcedCOAG (+ 1567%; 3 $W_{air,}$ 95% CI 2–4 vs. 50 $W_{saline,}$ 95% CI 50–50; $p < 0.01$), and preciseSECT (+ 237%; 19 $W_{air,}$ 95% CI 15–24 vs. 64 $W_{saline,}$ 95% CI 63–66; $p < 0.01$; Table 1; **Supp.**Table 1; Fig. 1). The internal programing of the preciseSECT mode also adopted to the demand for additional power by increasing the number of power cycles (**Supp.** Figure 3).

Width of lateral thermal damage

The thermal lateral spread increased when passing from air to saline solution with all the three currents tested by 4.5–189%. In details, the maximum difference was reported for forcedCOAG (+ 189%; 0.36 $mm_{air,}$ 95% CI 0.25–0.40 mm vs. 1.06 mm_{saline}, 95% CI 0.88–1.24 mm; $p < 0.01$) followed by swiftCOAG (+ 152%; 0.53 $mm_{air,}$ 95% CI 0.35–0.68 mm vs. 1.32 mm_{saline}, 95% CI 1.22–1.59 mm; $p < 0.01$). No significant difference was observed for preciseSECT (0.55 $mm_{air,}$ 95% CI 0.40–0.65 mm vs. 0.58 mm_{saline}, 95% CI 0.55–0.74 mm; $p = 0.27$; Table 2; **Supp.**Table 2).

Figure 3 shows the qualitative effect of each current when passing from air to saline solution. The latter setting was consistently associated with a predominant coagulation effect as indicated by its primarily whitish

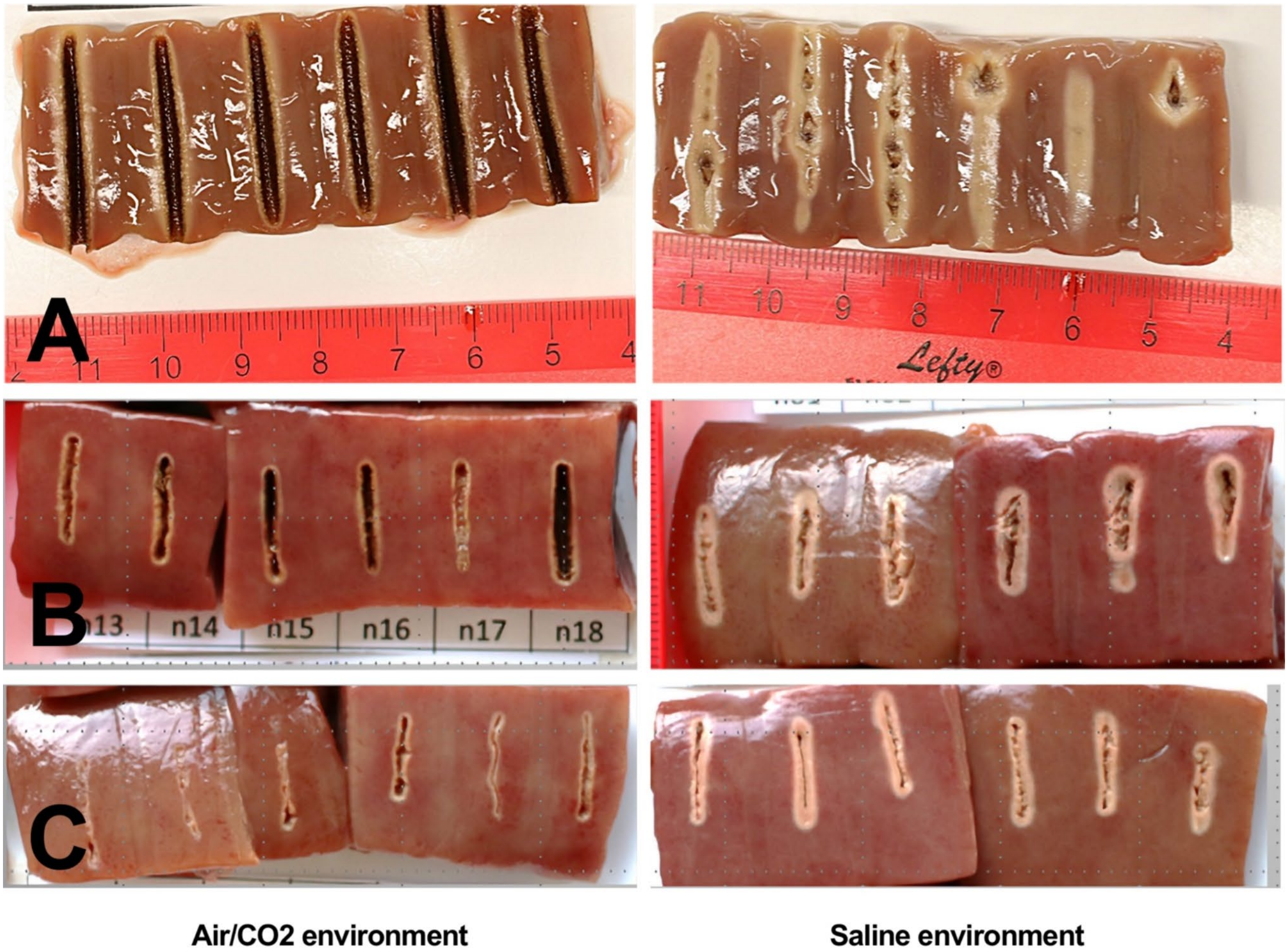

Fig. 3. Tissue effect on porcine kidney in air/CO2 (left) and saline environment (right). In (**A**) preciseSECT E6.5, (**B**) swiftCOAG E4.0; (**C**) forcedCOAG E3.0. Cutting was performed with a HybridKnife® I-Type (Erbe REF. 20150-061) with constant speed (1 mm/s) and cutting depth (1 mm) at room temperature. Whitish color: coagulation effect; Brownish color: cutting effect.

coloration, indicative of protein denaturation, with a central brownish halo, suggesting a localized area of cutting effect amidst the broader coagulation margin.

Discussion

According to our study, the transition from air to saline immersion profoundly affected the behavior of high-voltage currents, resulting in a 99% drop in the impedance. This results in a consequent 52–78% drop of voltage that prevents the cutting effect. In an animal model, this change in behaviour resulted in a marked increase of the coagulation effect, irrespectively of the monopolar current used, and consequent minimization of the cutting effect. This explains the clinical evidence of a substantial increase of the coagulation effect when passing from air to saline solution in therapeutic endoscopy[3,4].

The relevance of our findings is related with the fact that this change of behavior appears to be a universal law of any current when transitioning from air to saline solution. Consistently, all the three currents tested showed a 99% drop of the impedance when moving from air to saline solution. This dramatic drop in impedance resulted in a consequent decrease in peak voltage according to the relationship between voltage and impedance. In turn, the drop in peak voltage explains the predominant coagulation effect as a relatively high-voltage is required for spark formation that is necessary for the cutting effect. Thus, the markedly reduced cutting effect observed in saline immersion in the animal model is to be referred to the decrease in the peak voltage. As internal programming of electrosurgical modes is designed to deliver a specified amount of energy to the tissue, this drop in voltage is compensated by the increase in power, up to the fixed safety limit in power of the mode, in order to avoid tissue damage. With the already decreased voltage, this increased power is converted to heat and ultimately, an even more pronounced coagulation effect.

Additionally, a deeper and wider coagulation effect (whitish coloration around the application), instead of cutting, can also be attributed to a greater dispersion of electrical charges due to the medium used (saline solution) and not only to the reduction in the total impedance of the medium through which the current is conducted. When transitioning from air to saline solution, two currents were associated with a 10- to 23-fold increase in power, while only 2.5-fold increase was observed in the remaining current. The minimal lateral extension of the thermal effect observed with PreciseSECT mode is likely due to its intelligent energy modulation system, which adjusts energy delivery based on tissue impedance feedback. This regulation results in localized energy deposition and minimized thermal spread. Consequently, two currents resulted in a ≥ 1 mm extension of the lateral thermal effect, while no extension was found for the third setting. This is likely to be clinically relevant as the wider thermal effect permits a complete coagulation of the whole vessel wall, explaining the pre-sealing of large vessels observed in clinical practice. Conversely, a less lateral spreading effect could be useful to minimize deep thermal injury, especially when the deep layer is too close to the knife.

Regarding the benefit, the findings of our study may be applied to any endoscopic technique where a pronounced coagulation effect is needed. Of note, we already showed the benefit of the air-saline immersion transition for coagulating large vessels in third-space endoscopy and after endoscopic mucosal resection as both prophylaxis and treatment intervention. However, cap-assisted procedures allow for easier switching from air to saline solution within the distal attachment, irrespective of the gravity effect, even when the entire procedure is not completely under saline immersion. In addition, we cannot exclude beneficial application of this technique in other areas outside gastrointestinal endoscopy, such as urology, interventional radiology and gynecology.

In terms of safety, we cannot exclude that the exponential power increase of the current may result in adverse events in clinical practices. However, this is likely to be prevented by the caution when trying unexplored and untested modes under saline, especially with higher power settings, and also by the electrosurgical algorithm that limits the maximum power delivered. This is in line with our observation of no major adverse events when applying this approach in clinical practice also due to the lasting cushion of water in submucosa.

When considering our data in a broader context, the possible benefits of a saline immersion setting are not limited to the change in behavior of the current used. Firstly, the saline-immersion water reduces the electrocautery-related injury to the muscle layer decreasing the delayed perforation rate due to the heat-sink effect[5]. Second, it allows easier scope handling and, thus, a better stability. Third, it eliminates any gas/fluid interface within the distal cap improving greatly the endoscopic view of the submucosal space[6]. Four, a better exposure of the submucosal layer is provided by the saline-immersion setting and, hence, a more precise submucosal dissection can be performed[7]. Five, it also simplifies the detection of the bleeding point, which is of critical importance during the creation of the submucosal tunnel. Six, the replacement of gas with saline solution avoids gas-related adverse events, such as subcutaneous emphysema and tension capno-peritoneum.

Some limitations are present in this study. In this study, we utilized fixed settings to provide a controlled comparison across the three modes in air and saline environments. These settings were chosen based on their relevance in clinical practice, aiming to establish a baseline understanding of their electrophysical properties. We recognize that the applicability of our findings could be enhanced by exploring a broader range of settings and exploring a broader range of parameters, as different clinical scenarios may require adjustments. All the settings used are monopolar so that our results cannot be expanded to the bipolar currents generally used in surgery. Third, we employed ex vivo porcine kidney tissue due to its homogeneous parenchymal structure, which allows for the better visualization of tissue effects and provides consistent electrical parameters (impedance, voltage, and power). The moderate conductivity of kidney tissue supports effective energy transfer during electrosurgery, making it suitable for assessment of both cutting and coagulation effects. Moreover, the kidney cortex shares similarities with the liver, another parenchymatous organ widely utilized for studying tissue-electrosurgical interactions. We acknowledge that this model does not perfectly replicate the layered GI tract structure. However, we believe it acceptably represents the higher cell-density vessel wall than the submucosal tissue. Fourth, the current model did not include the blood flow as well as intraprocedural bleeding that could have affected the variables we measured. These factors, particularly the heat sink effect in saline, could most likely reduce lateral thermal spread. Our controlled setup allowed us to isolate and assess the basic electrophysical properties, and to assess the corresponding tissue effect, but in vivo studies would be better to validate these findings. Hence, we propose that an understanding of the fundamental behavior of currents in different environments should be integrated with existing clinical observations in order to form a comprehensive understanding of the phenomenon.

In the future, it would be ideal to have electrosurgical setting created for saline immersion environments possibly utilizing intelligent algorithm that adapt the current for the blend coagulation and cutting effect required.

In summary, the transition from air to saline immersion setting modulates the voltage and power of the applied monopolar currents as a result of a profound decrease in impedance in the saline environment, thereby amplifying the coagulation effect while attenuating the cutting effect. This explains the desired coagulation effect previously observed in this setting.

Data availability

The data that support the findings of this study are available from ERBE but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of ERBE.

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References

1. Tanaka, S., Toyonaga, T. & Morita, Y. Endoscopic vessel sealing: a novel endoscopic precoagulation technique for blood vessels during endoscopic submucosal dissection. Vol. 25, Digestive endoscopy: official journal of the Japan Gastroenterological Endoscopy Society. Australia; pp. 341–2. (2013).
2. Venkat, M. & Visrodia, K. Management of Adverse Events of Submucosal Endoscopy. Gastrointest Endosc Clin N Am [Internet]. Jan 1 [cited 2024 Apr 30];33(1):183–96. (2023). https://pubmed.ncbi.nlm.nih.gov/36375882/
3. Capogreco, A. et al. Prophylactic underwater vessel coagulation for submucosal endoscopy. *Gut* ;1–3. (2024).
4. Capogreco, A. et al. Underwater coagulation using hybrid knife in peroral endoscopic myotomy for achalasia. *Endoscopy* **56** (S 01), E197–E198 (2024).
5. Tseng, C. W., Hsieh, Y. H., Lin, C. C., Koo, M. & Leung, F. W. Heat sink effect of underwater polypectomy in a porcine colon model. BMC Gastroenterol [Internet]. ;21(1):1–6. (2021). https://doi.org/10.1186/s12876-021-01985-1
6. Spadaccini, M. et al. Underwater EMR for colorectal lesions: a systematic review with meta-analysis (with video). Gastrointest Endosc [Internet]. 2019 Jun 1 [cited 2024 Apr 30];89(6):1109–1116.e4. https://pubmed.ncbi.nlm.nih.gov/30862352/
7. Despott, E. J. et al. Saline immersion therapeutic endoscopy facilitated pocket-creation method for endoscopic submucosal dissection (with video). Gastrointest Endosc [Internet]. 2019 Mar 1 [cited 2024 Apr 30];89(3):652–3. https://pubmed.ncbi.nlm.nih.gov/30784510/

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Author contributions

A.C., C.H., R.M., M.E. and A.R. designed the study. A.C., A.R., C.H., R.DS., N.S. and S.K. wrote the manuscript. N.S. and S.K. performed statistical analysis. All authors participated in the data collection. All the Authors revised and approved the final manuscript.

Declarations

Competing interests

AC is a consultant for ERBERM is a consultant for ERBE, Fujifilm, 3DMatrix and Boston ScientificCH is a consultant for Alpha-Sigma, Fujifilm, Medtronic, Norgine, Olympus and PentaxAR is a consultant for Medtronic, ERBE, Fujifilm and Olympus Others authors nothing to declares.

Additional information

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