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Argon plasma coagulation and radiofrequency ablation in nonvariceal upper gastrointestinal bleeding

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ABSTRACT

Upper gastrointestinal bleeding (UGIB) is one of the most common causes of emergency department visits worldwide and represents a significant public health problem in many countries. Endoscopy plays a major role in the diagnosis and treatment of UGIB. Endoscopic hemostasis of peptic ulcer bleeding is preferably achieved by the combination of injection with contact thermal methods or mechanical methods. Argon plasma coagulation (APC) is a noncontact thermal method of hemostasis that has been employed to treat bleeding angioectasia. The use of APC in this situation presents satisfactory results with a low adverse event rate. APC presents the possibility to treat large bleeding areas in a single session. There is also a limited experience with the use of APC for peptic ulcer bleeding and bleeding from gastrointestinal neoplasia. More recently, radiofrequency ablation has been employed for the treatment of diffuse UGIB caused by angioectasias with promising results.

1. Introduction

Upper gastrointestinal bleeding (UGIB) is one of the most common causes of emergency department visits and represents a significant public health problem in many countries. Endoscopy plays a major role in the diagnosis and treatment of UGIB. Endoscopic hemostasis of peptic ulcer bleeding is preferably achieved by the combination of injection with contact thermal methods or mechanical methods. Argon plasma coagulation (APC) is a noncontact thermal method of hemostasis that has been initially employed to ablate Barrett mucosa and to treat angioectasias in the small bowel and colon but also proved to be useful to achieve endoscopic hemostasis of UGIB. Radiofrequency ablation (RFA) has also been employed for Barrett mucosa ablation. More recently, the use of RFA has been described for the treatment of diffuse UGIB caused by angioectasias. In this article, we will discuss the principles, the indications, the technique, and the results of APC and RFA for the treatment of nonvariceal UGIB.

2. Principles of APC

APC is an electrosurgical procedure that combines a monopolar current with the argon gas to achieve coagulation. Argon (Ar) is a colorless, odorless and tasteless, noble, nontoxic, and a chemically inert gas that has the property of conducting electrical energy. This energy is transferred to the target tissue without contact between the electrode and the tissue (Figure 1). The plasma beam follows the path of the least electrical resistance, which permits the argon plasma to be applied both *en face* and tangentially, allowing treatment of regions that are normally difficult to access. Endogenous heating of the target tissue creates the tissue effect of APC during application of electrical current voltage. Temperature rise can be a determinant of thermal insult that can vary among hyperthermia, devitalization, coagulation, desiccation, carbonization, and vaporization (Figure 2). Because of desiccation, the tissue surface loses its electrical conductivity and the plasma beam changes its direction to adjacent non-desiccated, conductive tissue. This results in a limited depth of the injury. Nevertheless, a study demonstrated that in comparison with bipolar coagulation, which maintains the electric current restricted between the 2 poles of the probe, the argon plasma leads to deeper tissue damage [1]. This tissue damage and the coagulation effect depends especially on the power setting of the electrosurgical generator, but also on the duration of the application and the distance from the probe tip and the tissue.

When the distance is not close enough, there is no ignition of the gas, as the resistance to electrical current flow is too high, and the activation of the pedal results only in flow of inert argon gas. In general, the optimal distance between the probe and tissue ranges from 2-8 mm (Figure 3) [2].

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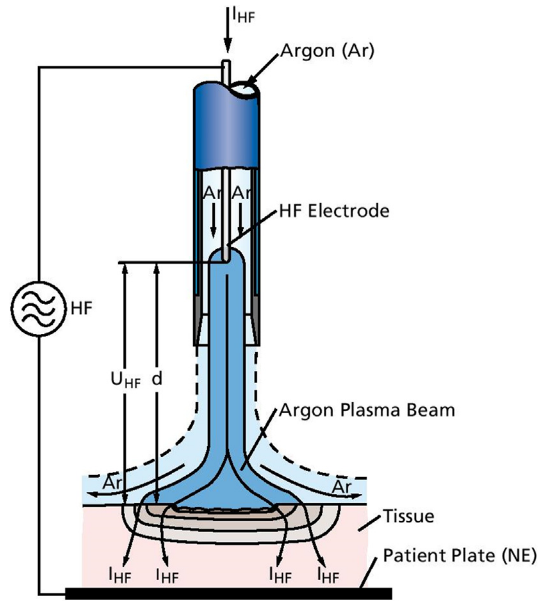

Fig. 1. Transfer of energy from APC probe to the tissue. Abbreviations: HF, electrosurgical unit; I_{HF}, high frequency or electrosurgical current; U_{HF}, high frequency voltage; d, distance between electrode and target tissue; Ar, argon; NE, patient plate (*Courtesy*: Anderson Bellangero, E. Tamussino & Cia Ltda—Sao Paulo, Brazil). (Color version of figure is available online.)

3. APC instruments

The APC systems comprises a specialized electrosurgical generator capable of high-frequency monopolar current, with an activation foot pedal, an argon gas flow meter attached to the gas cylinder, flexible, single-use delivery probes, and disposable grounding pads.

The generators are in fact multipurpose electrosurgical units that can deliver different levels of power output and different types of currents, with the possibility to be driven by different monopolar or bipolar endoscopic accessory. In Figure 4, we demonstrate an example of this generator (VIO ESU/APC System, ERBE USA).

The APC probes are flexible instruments that are capable of delivering the argon gas and the electrical current at the same time, with the activation of a single pedal. These probes differ according to their diameter, length, and tip design [3]. The diameter and the length are important for the appropriate use according to the endoscope length and size of the working channel, and do not influence the operation of the system. There are probes that can be used with bronchoscopes, cholangioscopes, gastroscopes, colonoscopes, and enteroscopes. On the contrary, the distal tip design will determine the direction of the argon gas flow and, usually, the plasma direction (Figure 5A) that will create various plasma and tissue effects (Figure 5B).

4. Principles of RFA

RFA with the HALO ablation system (Covidien, GI Solutions, Sunnyvale, CA) is an endoscopic ablation technique used initially for treatment of Barrett esophagus. The RFA controller delivers a preset amount of energy (Joules per centimeter^2 of electrode [J/cm^2]) at up to 350 W to the bipolar RFA electrode for the ablation of the mucosa. The controlled transmission of energy guarantees the limitation of tissue injury to the superficial layers, that is, epithelium and lamina propria. Initially designed for the treatment of Barrett mucosa, it is also Food and Drug Administration approved for the coagulation of bleeding sites in the

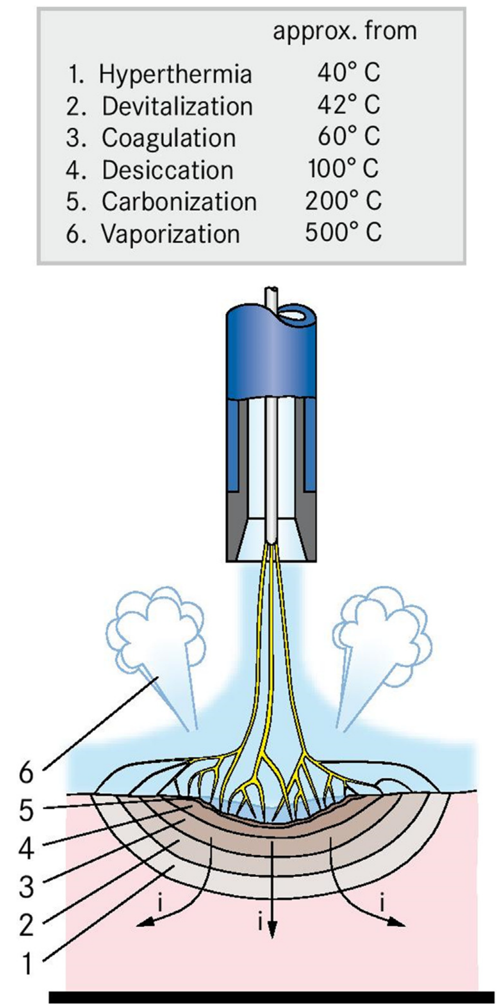

Fig. 2. Temperature-dependent tissue effects. The arrows marked as "i" indicate the flow of current (*Courtesy*: Anderson Bellangero, E. Tamussino & Cia Ltda—Sao Paulo, Brazil). (Color version of figure is available online.)

gastrointestinal tract. Indications include esophageal ulcers, arteriovenous malformations, angiodysplasia, Mallory-Weiss, Dieulafoy lesions, and gastric antral vascular ectasia (GAVE) [4].

5. RFA instruments

The RFA system includes an ablation device and a power generator. The ablation device used in gastrointestinal bleeding is a single-use disposable flexible strap that slides over the tip of an endoscope (compatible with diameters ranging from 8.6-12.8 mm) without disturbing the endoscope vision or mobility. There is also a smaller model that is used through the scope, thus not requiring withdrawal of the endoscope to clean the accessory. In Table 1, the different models of the RFA catheters and their respective dimensions are described. In Figures 6 and 7, the available RFA catheters and the thermal injury "footprints" are illustrated.

The endoscope is deflected upward and adjusted against the gastrointestinal mucosa so that the electrode is in full contact with the affected tissue, and the articulated platform allows the electrode to conform to the tissue surface. The device is connected to a bipolar radiofrequency energy generator that provides precise control of the thermal injury depth and guarantees the uniformity of tissue ablation. The ability to provide a controlled amount of