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HYBRID ARGON PLASMA COAGULATION IN THE TREATMENT OF BARRETT'S ESOPHAGUS: AN EXPERIMENT

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Background. Barrett's esophagus (BE) is a precancerous condition marked by the transformation of squamous epithelium into columnar epithelium. Traditionally, radiofrequency ablation (RFA) has been the standard treatment, but newer methods like hybrid argon plasma coagulation (APC) and cryotherapy are emerging as alternatives.

Aim. To compare the effects of various lifting fluids on the efficiency of performing hybrid APC in the treatment of BE.

Methods. The experiment was conducted on pig esophagi. Various lifting fluids (0.9% sodium chloride, 4% gelatin, and 6% hydroxyethyl starch) were used. A gastroscope, an electrosurgical unit with an APC2 module, and endoscopic needles were employed. Pathological analyses were performed to assess the efficacy of the lifting fluids and compare hybrid APC to standard APC. Nine procedures were conducted, including classic APC and hybrid APC using different fluids and power settings.

Results. Classic APC at 30 watts showed limited mucosal coagulation, while at 60 watts, full coagulation with significant submucosal damage was observed. Hybrid APC with colloid solutions provided longer lifting duration, reducing the need for reinjections. At 30 and 60 watts, hybrid APC preserved the submucosal and muscular layers, with complete mucosal coagulation at higher wattages.

Conclusions. Hybrid APC offers an effective alternative to traditional methods for treating Barrett's esophagus, with fewer complications and increasing global adoption.

Keywords: Barrett's esophagus, hiatal hernia, argon plasma coagulation, argon plasma ablation, Esophageal metaplasia.

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ГІБРИДНА АРГОНОПЛАЗМОВА КОАГУЛЯЦІЯ В ЛІКУВАННІ СТРАВОХОДУ БАРРЕТТА: ЕКСПЕРИМЕНТ

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Актуальність. На сьогодні з'явились нові види лікування стравоходу Барретта (СБ), включаючи гібридну аргоноплазмову коагуляцію (АПК) і кріотерапію.

Мета роботи. Порівняння впливу різних рідин для ліфтингу на ефективність виконання гібридної аргоноплазмової коагуляції при лікування СБ.

Матеріали і методи. В експерименті використовувались стравоходи від великих білих свиней. Було проведено 8 досліджень: класична АПК з напругою 30 та 60 Вт, гібрида АПК з використанням 0,9% розчину NaCl, 4% розчину желатину, 6% розчину гідроксиетиленкрохмалю та напругою 30 і 60 Вт.

Результати. При виконанні класичної АПК при напрузі 30 Вт відмічались коагуляційні зміни в слизовому шарі до м'язової пластинки та незначні ділянки пошкодження підслизового шару. При використанні класичної АПК при напрузі 60 Вт спостерігалась повна коагуляція слизового шару, значні коагуляційні зміни підслизового шару та власної м'язової пластинки. Під час виконання гібридної АПК при напрузі 30 Вт спостерігалась коагуляція слизового шару, при цьому підслизовий шар був інтактним. При напрузі 60 Вт відмічалась повна коагуляція слизового шару, підслизовий та м'язовий шари залишались інтактними.

Ключові слова: стравохід Барретта, грижа стравохідного отвору діафрагми, аргоноплазмова абляція, аргоноплазмова коагуляція, метаплазія стравоходу.

Background. Barrett's esophagus (BE) is a precancerous condition characterized by the metaplastic transformation of the stratified squamous epithelium into the columnar epithelium. Patients with BE have an increased risk of developing esophageal adenocarcinoma. The epithelial transformation follows a specific progression: first to metaplasia, then to low-grade dysplasia, high-grade dysplasia, and eventually to adenocarcinoma [1, 2].

Until recently, radiofrequency ablation (RFA) was considered the gold standard for treating BE. However, in the last few years, new treatment methods have emerged, including hybrid argon plasma coagulation (APC) and cryotherapy, challenging RFA as the first-line treatment method [3, 4]. The main limitations of modern ablation technologies include stricture formation, hidden glands under the non-squamous epithelium, the need for multiple sessions to achieve remission, the risk of disease recurrence, and techni-

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cal difficulties in patients with tortuous esophageal anatomy. Hybrid APC combines fluid injection into the submucosal layer using special high-pressure instruments to create a protective cushion before ablation, allowing safer treatment at greater tissue depths than standard APC. The advantages of hybrid APC include the ability to treat larger areas in a single session, perform deeper treatments, and reduce the frequency of stricture formation and other side effects [5, 6]. We conducted our experiment to assess the impact of lifting fluids used during hybrid APC for treating BE.

Methods. The experiment used esophagi from large white pigs. The esophagi were purchased at our own expense on a local farm. For lifting, the following substances were used: 0.9% sodium chloride solution, 4% gelatin solution, and 6% hydroxyethyl starch solution. For chromoendoscopy, a 4% indigo carmine solution was used. The experiment involved the use of a diagnostic gastroscope (GIF-EZ1500; Olympus), an electrosurgical unit with an APC2 module (VIO 200 D) and the ERBEJET2 system, and a 21G endoscopic needle. The esophageal samples were sent to the pathohistological laboratory at the Shalimov National Scientific Center of Surgery and Transplantology, where the effectiveness of the lifting fluid and the power used during hybrid APC were compared with conventional APC. Eight studies were conducted: conventional APC at 30 and 60 watts, hybrid APC using 0.9% NaCl solution at 30 and 60 watts, hybrid APC with 4% gelatin solution at 30, 60 watts, and hybrid APC with 6% hydroxyethyl starch solution at 30 and 60 watts (Figure 1).

The study on animals was conducted in compliance with international and national ethical standards, in accordance with the principles of the Helsinki Declaration and the recommendations of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes.

Fig. 1. Stages of conducting an experiment

Results. During conventional APC at 30 watts, coagulation changes were observed in the mucosal layer down to the muscularis mucosae, with minor submucosal damage, and there were also isolated areas of mucosa that did not undergo coagulation (Figure 2). When using conventional APC at 60 watts, complete coagulation of the mucosal layer was observed, with significant changes in the submucosal layer and the muscularis mucosae (Figure 3). During hybrid APC, the experiment proceeded as follows: thermal marking of the outer boundaries of the target area was performed using APC, followed by the injection of the lifting solution, stained with methylene blue. The amount of fluid used was adjusted to create a sufficient cushion under the mucosa.

During hybrid APC, the experiment was conducted as follows: thermal marking of the outer boundaries of the target area was performed using APC. Next, a lifting solution, stained with methylene blue, was injected. The amount of fluid was adjusted to create a sufficient cushion under the mucosa. Coagulation was then performed either in longitudinal stripes or a circular pattern until a visible coagulation effect was achieved.

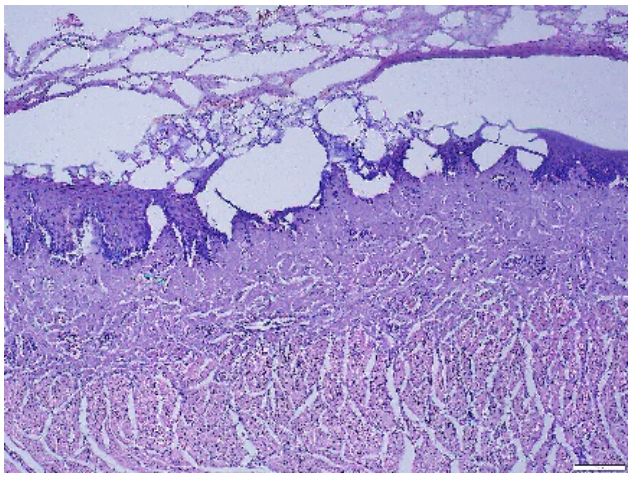

Fig. 2. Histological picture of tissues after APC 30 watts

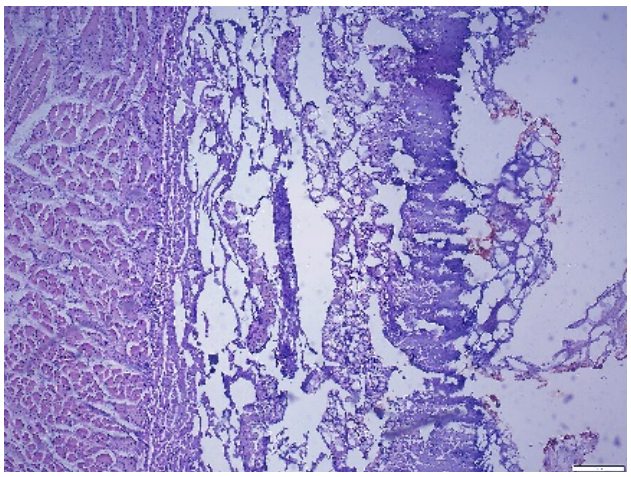

Fig. 3. Histological picture of tissues after APC 60 watts

When comparing the lifting solutions, no significant difference was found for the experiment. However, it is worth noting that colloid solutions (gelatin and hydroxyethyl starch) provided a longer-lasting lifting effect, allowing the surgeon to work longer without needing to reinject. During hybrid APC at 30 watts, coagulation of the mucosal layer was observed, though some areas remained unaffected, while the submucosal layer remained intact (Figure 4). At 60 watts, full coagulation of the mucosal layer was achieved, with the submucosal and muscular layers remaining intact (Figure 5, 6).

The results of the studies from the pathohistological laboratory are presented in the table (Table 1). In summary, the mucosal layer showed consistent coagulation at all wattages, with increasing depth of effect as the wattage increased. Coagulation of the submucosal layer was observed at 60 watts, but not at lower settings. The muscularis layer was only affected at 60 watts during standard APC.

Table 1

Determining the depth of coagulation of the layers of the esophagus

Esophageal layer \ Voltage and Lifting Solution		APC 30 W	APC 60 W	APC with 0,9% NaCl 30 W	APC with 0,9% NaCl 60 W	APC with 4%Gel 30 W	APC with 4%Gel 60 W	APC with 6% HES 30 W	APC with 6% HES 60 W
Mucosa	1000 μm	+	+	+	+	+	+	+	+
	2000 μm	+/-	+	+/-	+	+/-	+	+/-	+
	3000 μm	+/-	+	+/-	+	+/-	+	+/-	+
Submucosa		+/-	+						
Muscularis			+						

Legend: "+" indicates complete coagulation; "+/-" indicates partial coagulation; blank spaces indicate no significant changes observed.

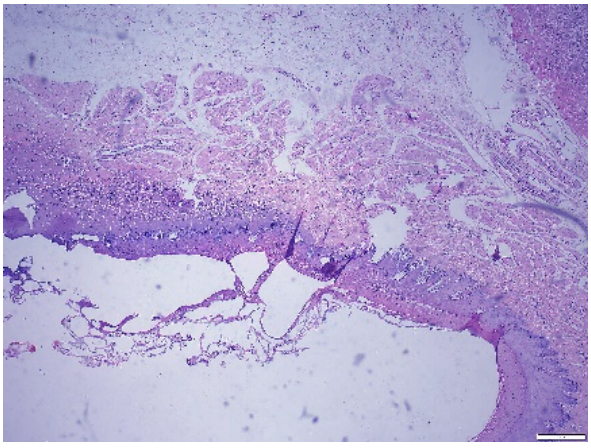

Fig. 4. Histological picture of tissues after HAPC 30 watts with gelatine solution

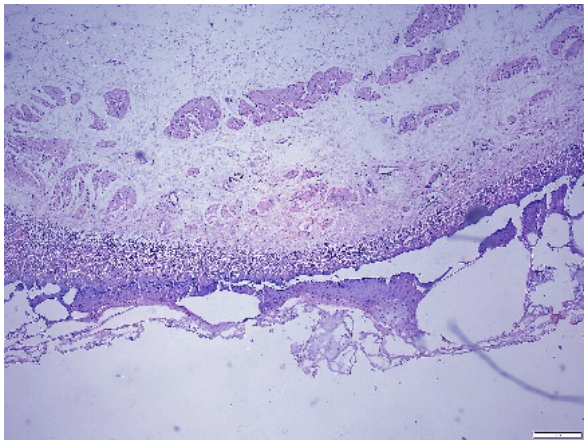

Fig. 5. Histological picture of tissues after HAPC 60 watts with gelatine solution

Discussion. Given the increasing incidence of Barrett's esophagus (BE), improving treatment strategies is of utmost importance. Endoscopic treatment remains the leading approach for managing this condition.

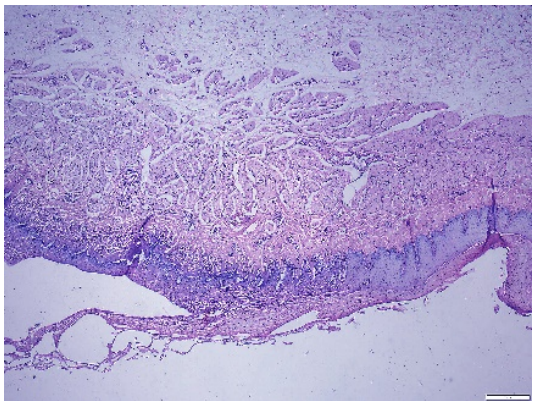

Fig. 6. Histological picture of tissues after HAPC 60 watts with 0.9 % NaCl solution

Although APC was one of the first methods used to treat BE, its application has been limited due to the risks of perforations and strictures. These risks could be mitigated by reducing power settings, but this resulted in decreased efficacy of the ablation treatment. Previous ex-vivo experiments demonstrated that creating a "cushion" before APC reduces the depth of coagulation by half compared to standard APC at the same power levels and decreases the incidence of submucosal coagulation [7]. According to studies, the risk of strictures after hybrid APC is lower than after RFA [8, 9].

This experiment demonstrated that hybrid APC offers a significant advantage in treatment compared to standard APC. Hybrid APC is safer, more effective, and associated with fewer complications. Additionally, it was found that no significant difference in the lifting effect was observed between different solutions used, but it should be noted that colloid solutions (gelatin and hydroxyethyl starch) provided a longer-lasting lifting effect, allowing the surgeon to work longer without the need for reinjection.

Conclusions. With the advancement of new technologies, the role of endoscopic therapy in the treatment of Barrett's esophagus continues to expand. Hybrid APC is a new alternative treatment strategy for Barrett's esophagus, which has proven to be effective, with a lower risk of postoperative complications, and is increasingly used by surgeons worldwide.

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