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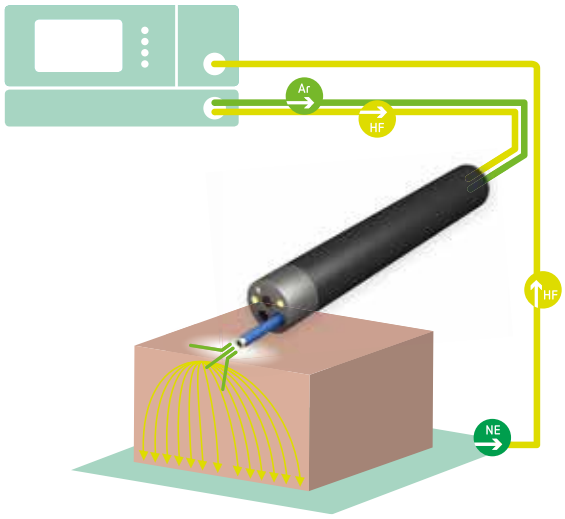
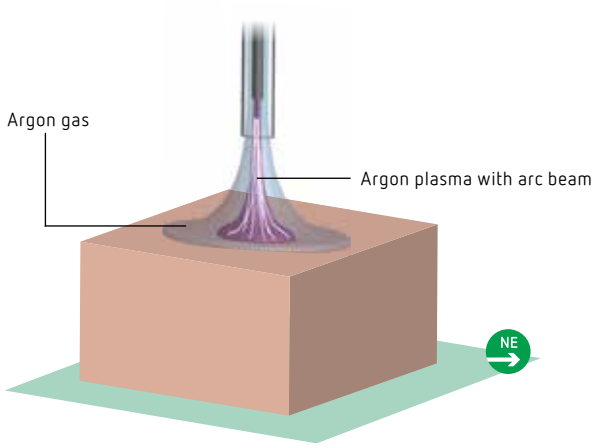
Basic knowledge in plasma surgery
Argon plasma coagulation

Principles of plasma surgery



Schematic illustration of monopolar argon plasma coagulation



The argon gas is ignited at the electrode of the APC probe, the ionized argon plasma transfers the energy to the target tissue

ARGON PLASMA COAGULATION

Argon plasma coagulation (APC) is an electrosurgical procedure. Here, high frequency alternating current is transferred to the target tissue from the tip of the probe via the ionized argon gas. This procedure reliably arrests bleeding with an effective and metered surface coagulation and devitalizes tissue. The APC is contact-free so that the distal end of the instrument cannot adhere to the coagulated tissue and tear open the scab that has formed. A further advantage is the limited penetration depth of the APC which minimizes the risk of perforations.[1]

Due to its numerous application advantages, the procedure is employed in endoscopy and open surgery.

PHYSICAL PRINCIPLES[2-4]

In APC, the energy is transferred to the tissue via ionized, electrically conductive argon plasma using an APC probe with monopolar technology. The thermal effects are coagulation, dessication or devitalization of the target tissue.

In contrast to lasers, the energy between the electrode and the target tissue is transferred via an electrical field in APC and not optically. The argon plasma beam follows the path of least electrical resistance.

1 Kähler, G F et al. Investigation of the thermal tissue effects of the argon plasma coagulation modes pulsed and precise on the porcine esophagus, ex vivo and in vivo; Gastrointest. Endosc., 2009

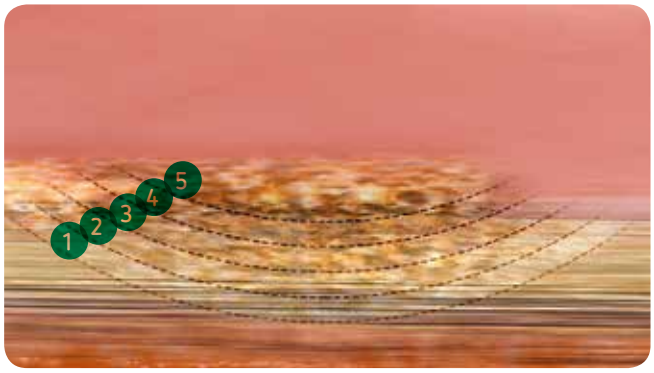
2 Eickhoff A, Repici A, Manner H, Enderle, MD. Electrosurgical Pocket Guide for GI Interventions; Erbe Elektromedizin GmbH

3 Eickhoff, A et al.: Prospective nonrandomized comparison of two modes of argon beamer (APC) tumor desobstruction: effectiveness of new pulsed APC versus forced APC; Endoscopy 2007

4 Zenker, M. Argon plasma Coagulation; GMS Krankenhhyg Interdiszip. 2008

Tissue effects

The tissue effect of the APC is provided by the current which flows through the tissue and the resulting endogenous heating. One distinguishes between various thermal effect zones in the tissue, depending on the achieved target temperature.
1. Hyperthermia, 2. Ablation 3. Coagulation/Dessication, 4. Carbonization and 5. Vaporization.



	above approx.
1 *Hyperthermia*	*40° C*
2 *Ablation*	*60° C*
3 *Coagulation/Desiccation*	*100° C*
4 *Carbonization*	*150° C*
5 *Vaporization*	*300° C*

The tissue effect spreads radially in depth.[4]

FACTORS INFLUENCING THE TISSUE EFFECT[1,4]

The degree of the thermal effect of the APC on the tissue depends on several factors. The most important factors on coagulation depth in order of priority:

1. Application duration (especially for static application)
2. Power setting or effect stage
3. Probe distance (working distance)
4. Other factors: type of tissue, static/dynamic application

1 Kähler, G F et al. Investigation of the thermal tissue effects of the argon plasma coagulation modes pulsed and precise on the porcine esophagus, ex vivo and in vivo; Gastrointest. Endosc., 2009
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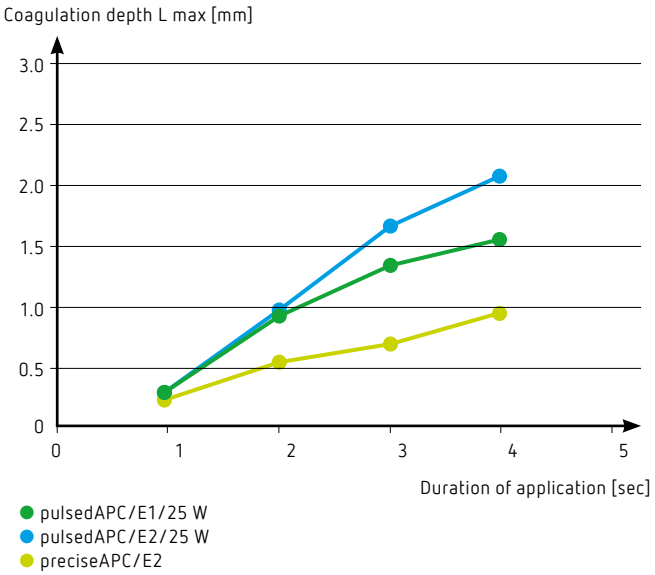
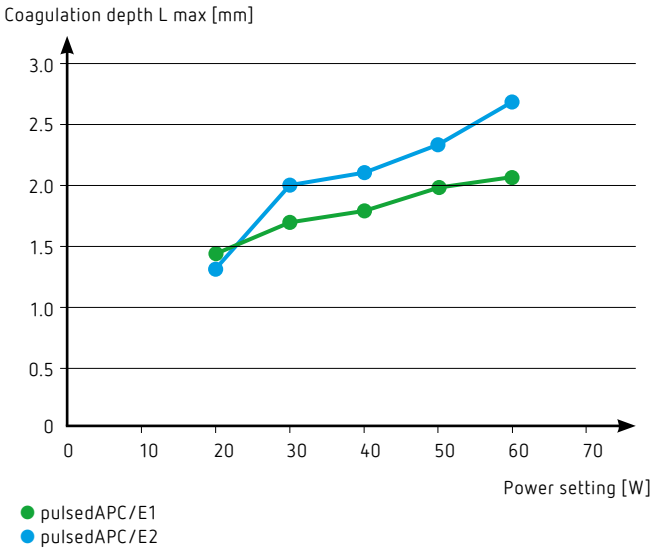
Tissue effects

Duration of application



Power



APPLICATION TIME – THE MOST IMPORTANT FACTOR[2-7]

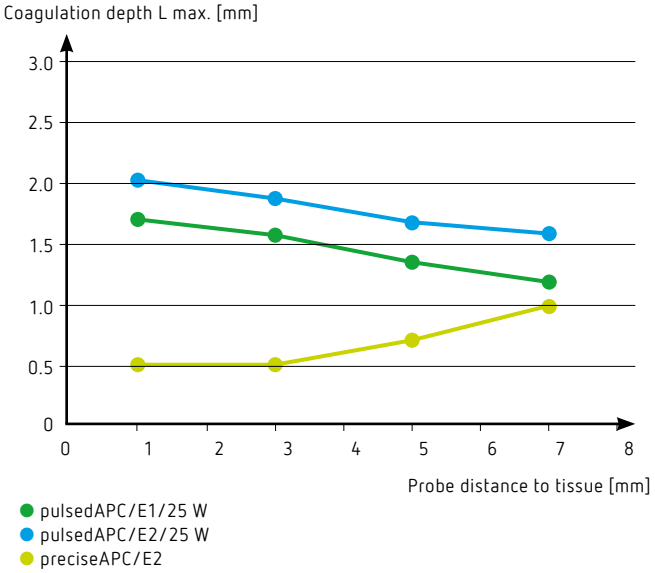
The longer the APC is activated, the deeper the effect on the target tissue. For this reason, we recommend starting with short activation times and to increase the duration step by step up until the desired effect is achieved. In case of longer APC application at a single point, the depth effect increases strongly and if the application duration is too long, the tissue may be carbonized and perforated.

In dynamic application, the APC probe should be moved under visual control in slow, controlled movements (brushstrokes) over the target tissue.

POWER SETTING[2-7]

The coagulation depth is dependent on the power setting and should be set according to the localization and indication.

Probe distance



PROBE DISTANCE[2-7]

The greater the probe distance, the lower the penetration depth. If the probe distance increases, a point can be reached where ignition is no longer possible.

FURTHER FACTORS: TYPE OF TISSUE[2-7]

The structures of biological tissue differ in their sensitivity, which has to be considered with electrosurgery and particularly with APC in the power setting and application duration.

2 Eickhoff A, Repici A, Manner H, Enderle, MD. Electrosurgical Pocket Guide for GI Interventions; Erbe Elektromedizin GmbH

3 Eickhoff, A et al. Prospective nonrandomized comparison of two modes of argon beamer (APC) tumor desobstruction: effectiveness of new pulsed APC versus forced APC; Endoscopy 2007

4 Zenker, M. Argon plasma Coagulation. GMS Krankenhhyg Interdiszip. 2008

5 Taghavi SA, Soleimani SM, Hosseini-Asl SM et al. Adrenaline injection plus argon plasma coagulation versus adrenaline injection plus hemoclips for treating high-risk bleeding peptic ulcers: a prospective, randomized trial. Can J Gastroenterol 2009; 23(10): 699 – 704.

6 Wang HM, Hsu PI, Lo GH et al. Comparison of hemostatic efficacy for argon plasma coagulation and distilled water injection in treating high-risk bleeding ulcers. J Clin Gastroenterol 2009; 43(10): 941 – 945.

7 Herrera S, Bordas JM, Llach J et al. The beneficial effects of argon plasma coagulation in the management of different types of gastric vascular ectasia lesions in patients admitted for GI hemorrhage. Gastrointest Endosc 2008; 68(3): 440 – 446.

APC modes

The constant voltage control of the plasma modes enables consistent quality and reproducibility of the tissue effects.[22]

forcedAPC

Effective devitalization with forcedAPC

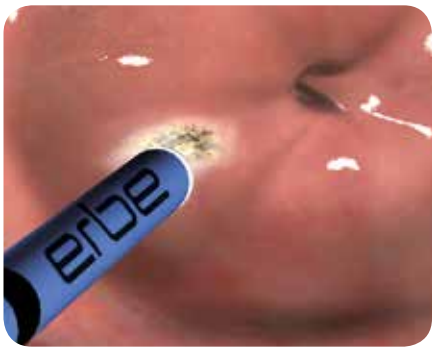
This mode offers effective coagulation and devitalization. The HF power is voltage-controlled up to 120 Watt and is applied as a continuous energy transfer.

preciseAPC®

The preciseAPC® mode used in thin-walled structures

Unlike forcedAPC, preciseAPC® operates in the lower energy range. This allows uniform coagulation effects to be precisely adjusted in the target tissue, which enables a homogenous tissue effect particularly in thin-walled structures or peristaltic movement.

pulsedAPC®



The pulsedAPC® mode used for tissue ablation and coagulation

This mode is based on pulsed activation (on–off). pulsedAPC® is variable in use, for ablating or coagulating tissue. pulsedAPC® is easy to meter and offers homogenous tissue effects as a result. In pulsedAPC®, powers of 1 to 120 Watt may be set. 2 different pulse frequencies can be set.

22 Instructions for use APC 3

Applications

Applications in flexible endoscopy, gastroenterology and pneumology

- ☑ **Chronic bleeding[5-8] (Fig. 1)**
  → GAVE syndrome (watermelon stomach)
  → Radioproctitis
  → Angiodysplasia
- ☑ **Coagulation of bleeding in the resection base following EMR[9]**
- ☑ **Devitalization of tumor residues following EMR[10]**
- ☑ **Immediate recanalization of exophytic stenoses[15-18]**
- ☑ **Coagulation of diffuse and acute bleeding in the entire gastrointestinal and bronchial tract[8,19]**
- ☑ **Devitalization of stent ingrowth or overgrowth[20]**
- ☑ **Trimming of stents in the gastrointestinal or bronchial tract[21]**

Coagulation of a telangiectasia with APC

5 Taghavi SA, Soleimani SM, Hosseini-Asl SM et al. Adrenaline injection plus argon plasma coagulation versus adrenaline injection plus hemoclips for tre-ating high-risk bleeding peptic ulcers: a prospective, randomized trial. Can J Gastroenterol 2009; 23(10): 699 – 704.

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8 Manner H, Enderle MD, Pech O et al. Second-generation argon plasma co-agulation: two-center experience with 600 patients. J Gastroenterol Hepatol 2008; 23(6): 872 – 878.

9 Katsinelos P, Gkagkalis S, Paroutoglou G, Chatzimavroudis G, Fasoulas K, Zavos C, Varitimiadis K, Lazaraki G, Kotronis G, Kountouras J. A prospective comparative study of blended and pure coagulation current in endoscopic mucosal resection of large sessile colorectal polyps. Surg Laparosc Endosc Percutan Tech. 2014 Jun; 24(3): 226 – 31.

10 Manner H, Rabenstein T, Pech O, Braun K, May A, Pohl J, Angelika Behrens A, Vieth M, Ell C: Ablation of residual Barrett's epithelium after endoscopic resection: a randomized long-term follow-up study of argon plasma coagulation vs. surveillance (APE study), Endoscopy 2014; 46(01): 6–12

15 Wang H, Tao M, Zhang N, Luo L, Li D, Zou H, Zhou Y, Liang S. Bronchoscopic interventions combined with percutaneous modalities for the treatment of thyroid cancers with airway invasion. Eur Arch Otorhinolaryngol. 2015 Feb; 272(2): 445 – 51.

16 Wang JW, Huang M, Zha WJ, Zhou LF, Qi X, Wang H. Flexible bronchoscopic intervention for endobronchial hamartoma. Zhonghua Jie He He Hu Xi Za Zhi. 2013 Dec; 36(12): 963 – 7. Chinese

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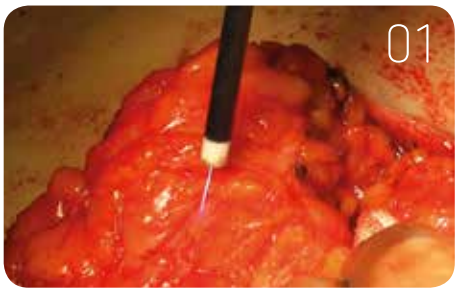
18 Sim DW, Oh IJ, Kim KS, Choi YD, Kwon YS. Pleomorphic adenoma of the trachea. J Broncholology Interv Pulmonol. 2014 Jul; 21(3): 230 – 3.

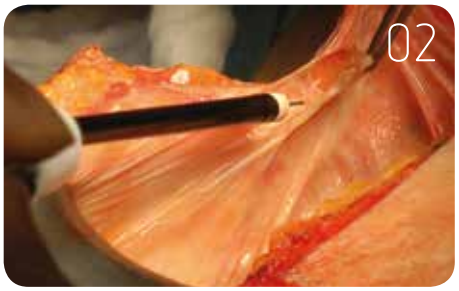
19 Reichle G. Die Argonplasma-Koagulation zur bronchoskopischen Rekanalisation und Blutstillung. Atemw- Lungenkrkh 2003; Jahrgang 29: 258 – 269.

20 Reichle G, Freitag L, Kullmann HJ, Prenzel R, Macha HN, Farin G. Argon plasma coagulation in bronchology: a new method – alternative or complementary?. Pneumologie 2000; 54: 508 – 516.

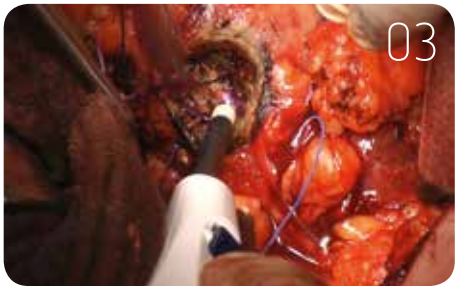
21 Chen YK, Jakribettuu V, Springer EW, Shah RJ, Penberthy J, Nash SR. Safety and efficacy of argon plasma coagulation trimming of malpositioned and migrated biliary metal stents: a controlled study in the porcine model. Am J Gastroenterol 2006; 101: 2025 – 2030



Extensive homogenous coagulation with APC



Low smoke formation in argon-assisted cutting



Diffuse surface coagulation with APC

Extensive homogenous coagulation with APC

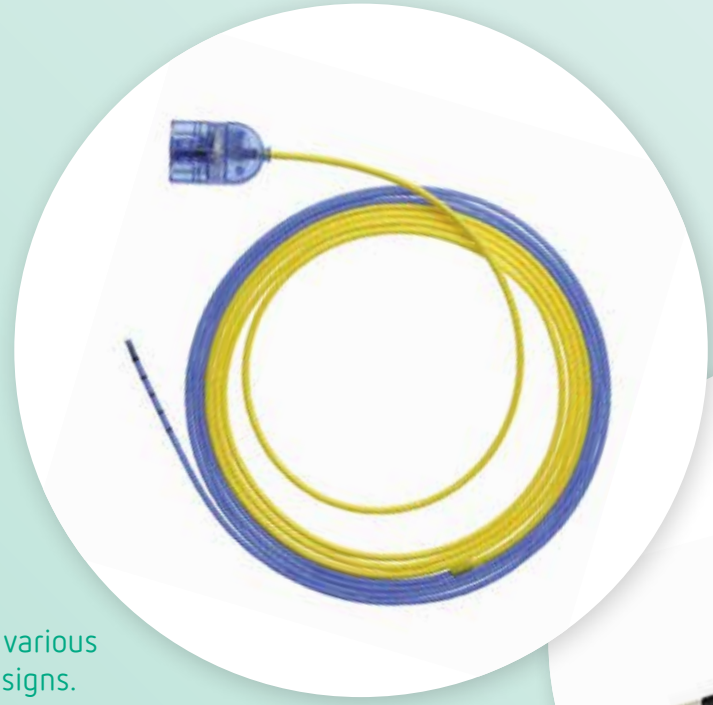
Good view of the operative site with argon-assisted incision

Applications in gynecology, urology and general surgery

- ☑ Coagulation of extensive bleeding in breast surgery (Fig. 1)
- ☑ Argon-assisted resection of mammary layers and mammary gland tissue (Fig. 2)
- ☑ Coagulation of a resection base in partial nephrectomy (Fig. 3)
- ☑ Coagulation of the liver bed base with the APC function of the APCapplicator (Fig. 4)
- ☑ The liver capsule is opened with an argon-assisted incision. (Fig. 5)

Erbe products* for plasma surgery

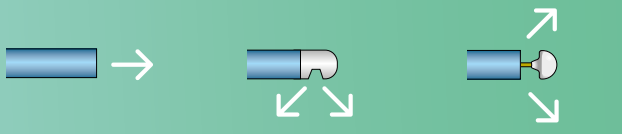
The Erbe equipment for plasma surgery consists of the workstation with VIO® 3 and APC 3 as well as open surgical, laparoscopic and endoscopic probes and applicators. The workstation supports the instruments and applications with the forcedAPC, preciseAPC® and pulsedAPC® modes. Virtually all indications can be treated with these modes, ranging from selective flat coagulation of minor bleeding to the devitalization of extensive lesions.



FiAPC®probes in various lengths and designs.

The APCapplicator and its functions covers numerous procedures in the surgical specialties. The instrument is available in open surgical and laparoscopic design.

Beam forms



Axial Beam A

Side Fire Conical Beam SC

Circumferential Beam C

The FiAPC® probes have axial, lateral and circular beam forms

** Current patents: www.erbe-med.com/ip*

The electrosurgery workstation
with the electrosurgery unit VIO® 3 and APC 3
on a Cart. The APC 3 is operated
via the display of the VIO® 3.

THE DIRECT LINK TO THE WEBCAST
"THE FUNDAMENTALS OF ELECTROSURGERY IN ENDOSCOPY"
BY PD DR. AXEL EICKHOFF

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