Endoscopic hemostatic devices

The American Society for Gastrointestinal Endoscopy (ASGE) Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methodology is used, with a MEDLINE literature search to identify pertinent clinical studies on the topic and a MAUDE (US Food and Drug Administration Center for Devices and Radiological Health) database search to identify the reported complications of a given technology. Both are supplemented by accessing the "related articles" feature of PubMed and by scrutinizing pertinent references cited by the identified studies. Controlled clinical trials are emphasized, but, in many cases, data from randomized, controlled trials are lacking. In such cases, large case series, preliminary clinical studies, and expert opinions are used. Technical data are gathered from traditional and Web-based publications, proprietary publications, and informal communications with pertinent vendors.

Technology Status Evaluation Reports are drafted by 1 or 2 members of the ASGE Technology Committee, reviewed and edited by the committee as a whole, and approved by the Governing Board of the ASGE. When financial guidance is indicated, the most recent coding data and list prices at the time of publication are provided. For this review, the MEDLINE database was searched through September 2008 for articles related to endoscopic hemostatic devices by using the keywords "multipolar electrocautery," "bipolar electrocautery," "heater probe," "hemostatic grasper," "argon plasma coagulator," "injection needle," "endoloop," "clip," paired with "complication," "perforation," "peptic ulcer disease," "gastric antral vascular ectasia," "Dieulafoy lesion," "Mallory-Weiss tear," "radiation induced angioectasias," "diverticular bleeding," "angiodysplasia," and "postpolypectomy bleeding."

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BACKGROUND

Endoscopic hemostatic therapy has been shown to improve outcomes in upper GI bleeding.[1-3] Hemostatic devices used for upper GI bleeding have also been applied to the colon.[4,5] Therapeutic modalities include contact thermal devices (eg, heater probe [HP], multipolar electrocautery [MPEC] probes, and hemostatic graspers), noncontact thermal devices (eg, argon plasma coagulator [APC]), injection needles, and mechanical devices (eg, band ligators, clips, and loops). Band ligators are the subject of a separate recent Status Evaluation Report.[6] This report describes all other commonly used hemostatic devices currently available in the United States.

TECHNOLOGY UNDER REVIEW

Thermal hemostatic devices

Thermal devices generate heat either directly (eg, HP) or indirectly by passage of electrical current through tissue (eg, MPEC probe, APC, hemostatic grasper). Heating leads to edema, coagulation of tissue protein, and contraction of vessels and indirect activation of the coagulation cascade, resulting in a hemostatic bond.[7] Tissue coagulation requires a temperature of approximately 70°C. Contact thermal devices also allow coaptation of vessels, which may contribute to hemostasis.[8]

Multipolar/bipolar electrocautery: MPEC probes deliver thermal energy by completion of an electrical circuit between 2 electrodes on the tip of a probe as current flows through nondesiccated tissue. In contrast to monopolar electrocautery, the circuit is completed locally; therefore, no grounding pad is required. As the targeted tissue desiccates, there is a decrease in electrical conductivity, limiting the maximum temperature (100°C) and depth and breadth of tissue injury.[9] A port at the tip delivers water for irrigation, which can help to improve visualization of the target tissue. A foot pedal controls delivery of energy. Power output is in watts (W). Maximum power settings are dependent on the generator used, but usually do not exceed 50 W. A standard setting is 20 W. Irrigation can be controlled by a foot pedal connected to a pump or by

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TABLE 1. Contact thermal devices

Manufacturer	Device name	Sheath diameter (French)	Sheath length (cm)	List price	Special features
Multipolar electrocautery probes					
Boston Scientific (Natick, Mass)	Gold Probe	7, 10	300, 350	$285 each	
	Injector Gold Probe	7, 10	210	$335 each	Integrated 25-gauge injection needle
ConMed Endoscopic Technologies (Chelmsford, Mass)	Bicap Superconductor, multielectrode bipolar probe	5, 7, 10	200, 300, 350	$310 each	
	Palladium tip bipolar hemostasis probe	7, 10	300	$240 each	
Cook Medical (Winston-Salem, NC)	Quicksilver bipolar probe	7, 10	350	$271 each	
Olympus America (Center Valley, Pa)	SolarProbe	7, 10	350	$235 each	
US Endoscopy (Mentor, Ohio)	Bipolar hemostasis probe	7, 10	350	$230 each	
Heater probes					
Olympus America	HeatProbe	7, 10	230, 300	$530 each	Reusable
Hemostatic grasper					
Olympus America	Coagrasper	7	165	$200 each	Rotatable

simply flushing the irrigation port with a syringe. Pressure is often applied to the target tissue during coagulation to ensure coaptation. Catheters come in several lengths and diameters that must be coordinated with the length and size of the working channel of the endoscope (Table 1).

HP: The HP consists of a Teflon-coated hollow aluminum cylinder with an inner heating coil. A thermocoupling device at the tip of the probe maintains a constant temperature. In contrast to MPEC, the mechanism of tissue coagulation is direct heat transfer. Pressure is usually applied with HP therapy, and there is an irrigation port. A foot pedal controls heat activation and irrigation. HP activation delivers energy to the diode in the probe tip. Once the pulse has been initiated, the duration of activation is predetermined and cannot be stopped until the entire amount of preselected joules is delivered.[10]

Hemostatic grasper: The hemostatic grasper is a recently developed device similar to monopolar hot biopsy forceps currently used for polypectomy.[11] The grasper operates much like a biopsy forceps, although, unlike biopsy forceps, the jaws are flat instead of cupped and the device is rotatable. The jaws are closed around the target tissue, and then monopolar electrocautery is used to desiccate the tissue. Clinical experience with this device is limited, with one study reporting the use of the hemostatic grasper during a natural orifice transluminal endoscopic surgery cholecystectomy.[12]

APC: An APC is a noncontact electrocoagulation device that uses high-frequency monopolar alternating current conducted to target tissues through ionized argon gas (argon plasma). Electrons flow through a stream of electrically activated ionized argon gas from the probe electrode to the targeted tissue, causing tissue desiccation at the interface. As the tissue surface loses its electrical conductivity as a result of desiccation, the plasma stream shifts to adjacent nondesiccated (conductive) tissue, which limits the depth of injury. If the catheter is not near target tissue (ie, the resistance to electrical current flow is too great), there is no ignition of the gas, and depression of the foot pedal results only in flow of inert argon gas. Coagulation depth is dependent on the generator power setting, duration of application, and distance from the probe tip to the target tissue.[13] The optimal distance between the probe and tissue ranges from 2 to 8 mm.[14] The available APC systems (ERBE USA, Marietta, Ga; ConMed Electrosurgery, Centennial, Colo; Canady Technology, Pittsburgh, Pa) include a specialized electrosurgical generator capable of high-frequency monopolar current, an activation foot pedal, an argon gas cylinder, disposable grounding pads, and flexible, single-use delivery probes. A gas flow meter adjusts to allow argon flow rates of 0.5 to 7 L/min. These generators can also serve as multipurpose electrosurgical units capable of varying levels of power output with any monopolar or bipolar

TABLE 2. Noncontact thermal devices

Manufacturer	Device name	Sheath diameter (French)	Sheath length (cm)	Fire direction	List price	Special features
Canady (Hampton, Va)	Canady plasma GI probe	5, 7	230, 340	Straight, side	$1550/box of 10	
ConMed Endoscopic Technologies (Chelmsford, Mass)	Beamer argon probe	5, 7, 10	160, 230, 320	Straight fire	$2550/box of 10	
	Beamer argon snare probe	7	160, 230	Straight fire	$1750/box of 5	Combination APC probe and snare
ERBE (Marietta, Ga)	APC probe	5, 7, 10	150, 220, 300	Straight, side, circumferential	$1995-2305/box of 10*	
	FiAPC probe	5, 7, 10	150, 220, 300	Straight, side, circumferential	$2077-2387/box of 10†	Integrated filter

APC, Argon plasma coagulation.
*All probes $1995/box of 10 except the side-fire probes ($2050/box of 10) and the 300-cm probes ($2305/box of 10).
†All probes $2077/box of 10 except circumferential and side-fire probes ($2132/box of 10) and 300-cm probes ($2387/box of 10).

endoscopic accessory. Probes are composed of Teflon (DuPont, Wilmington, Del) with a ceramic tip encasing the tungsten electrode. They are available in a variety of lengths and widths (Table 2). Probes are available with forward, side, or circumferential ports allowing forward, tangential, or circumferential applications, respectively.

Injection needles

Injection needles consist of an outer sheath (plastic, Teflon, or stainless steel) and an inner hollow-core needle (19-25 gauge) (Table 3). Using a handle on the end of the needle sheath, the operator can retract the needle into the sheath for safe passage through the working channel of the endoscope. When the catheter is placed near the target tissue, the needle can be extended out of the end of the sheath to a preset distance, and a syringe attached to the handle is used to inject liquid agents into the target tissue. Injection of various solutions achieves hemostasis by both mechanical tamponade and cytochemical mechanisms.[15]

Mechanical hemostatic devices

Endoscopic clipping devices: All endoscopic clipping devices have 3 main components: a metal double- or triple-pronged preloaded clip, a delivery catheter, and a handle used to operate and deploy the clip. Clips are available in a variety of jaw lengths (Table 4). The delivery catheter consists of a metal cable within a metal coil sheath enclosed within a Teflon catheter. The tip of the metal cable has a hook onto which the clip is attached. The handle consists of 2 sliding components. The first allows advancement of the metal cable holding the clip out of the protective sheath. The second is the plunger that controls opening, closing, and deployment of the clip. After insertion of the catheter through the working channel of the endoscope, the clip is extended out of the sheath. The clip is then positioned over the target and opened with the plunger handle. A rotation mechanism on the handle of some clips allows a change in orientation of the clip jaws. The jaws of the clip are applied with pressure and closed onto the target tissue by using the device handle.[16] Some clips may be reopened and repositioned, whereas others are permanently deployed and released on closure. Similarly, some clips are automatically released on deployment, and others require repositioning of the plunger handle to release the deployed clip from the catheter. Hemostasis is achieved by mechanical compression.

Detachable loop ligating devices: Detachable loop ligating devices consist of a circular- or elliptical-shaped nylon loop preloaded onto a delivery system that includes a hook wire (to which the loop is attached) within a Teflon sheath and an operating handle. Some older devices required preloading of the loop onto the hook wire. The loop is advanced out of the sheath and placed around the target tissue, usually the stalk of a large pedunculated polyp. The loop is tightened with advancement of a silicon rubber stopper by using the handle. When the loop is closed to the desired extent, as evidenced by tissue cyanosis or hemostasis, it is then released from the hook wire. There is a separate loop-cutting device that can be used to cut and release the nylon loop if it is malpositioned or fails to release from the catheter.

EASE OF USE

Thermal hemostatic devices are relatively easy to use because they require only direct or indirect (eg, APC) contact with the target tissue. Use of argon plasma coagulation requires an endoscopist to have fine control of the

TABLE 3. Injection needles

Manufacturer	Device name	Sheath diameter (French)	Sheath length (cm)	Needle gauge	Needle length (mm)	List price	Special features
Boston Scientific (Natick, Mass))	Interject sclerotherapy needle	7	200, 240	23, 25	4, 6	$37 each	
ConMed Endoscopic Technologies (Chelmsford, Mass)	Click-Tip injection needle	7	180, 230	19, 22, 25	4, 6	$580/box of 10	
	FlexiTip disposable sclerotherapy needle	7	160, 230	25	4, 5, 6	$255/box of 5	
	Sure Shot injection needle	7	230	25	5	$315/box of 5	
Cook Medical (Winston-Salem, NC)	AcuJet variable injection needle	7	220	23, 25	Variable	$42 each	
	Disposable varices injector	7	200-320	23, 25	Variable	$48 each	
	Injectaflow variable injection needle	7	220	23, 25	Variable	$61 each	Flush port
Kimberly-Clark (Roswell, Ga)	Injection needle catheter	7	160, 200, 240	23, 25	4, 6	$260/box of 10	
Olympus America (Center Valley, Pa)	Injector Force injection needle	7	165-230	21, 23, 25	4, 5, 6, 8	$276/box of 6	
TeleMed Systems (Hudson, Mass)	Sure-Stop sclerotherapy needle	5, 7	160-240	21, 23, 25	4, 5	$130/box of 5	
US Endoscopy (Mentor, Ohio)	Articulator injection needle	7	160, 230, 350	25	4, 5	$250/box of 5	
	Carr-Locke injection needle	7	230	25	5	$275/box of 5	
	iSnare	10	230	23, 25	5	$625/box of 5	2.5 × 4-cm integrated snare
	Vari-Safe injection needle	7	230	23	4, 5, 7	$50 each	

endoscope because the optimal distance of 2 to 8 mm from the device to the tissue target must be maintained during energy delivery. Power generators for contact thermal probes and APCs are portable and use a standard 110-V outlet. Ten-French probes require an endoscope with a working channel larger than 3.4 mm. Repeated application of thermal energy can result in the buildup of coagulum at the catheter tip, which can impede conductivity, necessitating removal of the probe and cleaning of the tip.

For mechanical methods of hemostasis, injection needles require only an understanding of how the handle works to extend the needle from the sheath. Both clips and detachable loops have more complex delivery mechanisms and handles that require a high degree of coordination between the endoscopist and endoscopy assistant. Use of an angulated endoscope or a side-viewing endoscope may make deployment of clips and advancement of injection needles difficult. If the position of some targeted lesions limits visualization or results in tangential orientation, clips may be difficult to place. Additionally, if there is a vessel within an ulcer with a large fibrotic base, there may not be adequate tissue to anchor a clip device. Optimal positioning of a clip and loop device before deployment generally requires more experience relative to standard diagnostic endoscopic methods.

EFFICACY AND COMPARATIVE ANALYSIS

Peptic ulcer disease

Several meta-analyses including more than 1000 patients have shown that thermal hemostatic devices, injection therapy, and clips either in combination or alone are all highly successful in achieving initial hemostasis in

TABLE 4. Mechanical hemostatic devices

Manufacturer	Device name	Sheath diameter (French)	Sheath length (cm)	Jaw opening width (mm)	List price	Special features
Endoscopic clipping devices						
Boston Scientific (Natick, Mass)	Resolution clip	7	155, 235	11	$145 each	2-prong clip
Cook Medical (Bloomington, Ind)	Triclip	7, 8	207	12	$316 (box of 3)	3-prong clip, 8-French model has flush port
Olympus America (Center Valley, Pa)	QuickClip2	7	165, 230	9	$95 each (box of 5 or 20)	2-prong clip, rotatable
	QuickClip2 long	7	165, 230	11	$95 each (box of 5 or 20)	2-prong clip, rotatable
Detachable loop-ligating devices						
Olympus America	Endo-Loop	7	195, 230	30*	$330/box of 10 loops, $570 each for catheter	Nonsterile, reusable catheter
	Poly-Loop	7	230	30*	$525/box of 5	Sterile, single-use loop and catheter

*Loop diameter.

bleeding peptic ulcer disease. Clips and thermal therapy, either alone or paired with injection therapy, are superior to injection therapy alone in preventing rebleeding and the need for surgery. There is no significant difference between clips and thermal therapy in rebleeding rates, the need for surgery, and mortality.[1-3,17]

Numerous prospective, randomized studies have compared thermal therapies with no treatment, thermal therapies with injection, thermal therapies with each other, and thermal therapies combined with injection. In several studies, the use of an MPEC probe and an HP have been compared with no treatment or sham procedures and show immediate hemostasis rates of 78% to 100%, significantly lower rebleeding rates (0%-18% vs 20%-41%), and a decreased need for surgery, shorter length of hospitalization, and less need for transfusion.[10,18-21] Comparisons among different thermal modalities show that they are all similar in rebleeding rates, need for surgery, and transfusion requirements.[14,22,23] Early studies demonstrated that the use of an APC, MPEC probe, and HP have similar efficacy in initial hemostasis and decreasing rebleeding rates compared with injection therapy of epinephrine alone, sclerosant alone, or combined sclerosant and epinephrine.[24-28] Injection therapy with saline solution alone is significantly less effective than MPEC in treating bleeding ulcers, with rebleeding rates of 29% versus 12% with MPEC.[29] MPEC paired with epinephrine injection prevents rebleeding and decreases transfusion requirements compared with epinephrine injection alone, with rebleeding rates of 6.7% versus 30%, respectively.[30] The use of an HP or APC paired with epinephrine injection is equally efficacious in treating high-risk peptic ulcers.[31] Epinephrine injection followed by MPEC also has a higher rate of initial hemostasis than epinephrine injection alone.[32]

Clips have been compared with thermal therapy, injection therapy alone, and thermal therapy combined with injection in many randomized trials. Clips and APCs have similar efficacy in initial hemostasis, recurrent bleeding, 30-day mortality, and the need for emergency surgery.[14] One study showed that the rate of recurrent bleeding is higher with an HP than clips (21% vs 1.8%, $P < .05$).[33] Another study demonstrated that initial hemostasis was higher with an HP compared with clips (100% vs 85%, $P = .01$), although no significant difference was seen in rebleeding, transfusion requirements, or 30-day mortality.[34] Clips have been compared with an HP paired with epinephrine injection with similar clinical outcomes.[35] One study showed a higher rebleeding rate in a group with epinephrine injection followed by the use of an HP (33%) relative to clips alone (5%).[36] Clips have also been compared with injection therapy as well as the combination therapy of clips and injection therapy. Clinical outcomes were similar between the groups.[31,37-39] One study found that the rebleeding rate was higher in the epinephrine injection alone group than in the combination therapy group with clips paired with epinephrine injection (21% vs 3.8%, $P = .008$).[40]

Gastric antral vascular ectasia

APC is the most commonly reported modality for the ablation of gastric antral vascular ectasia (GAVE). Multiple sessions are usually required, but transfusion requirements can be eliminated in more than 70% of patients.[41-43] MPEC and HP have also been described for the ablation of GAVE.[44,45] Long-term sequelae of ablation include antral scarring and hyperplastic polyps.[46] A recent retrospective study of thermal therapy (APC or MPEC probe) compared with band ligation found that band ligation required fewer sessions for cessation of bleeding.[47] Newer mucosal ablation techniques[48] such as radiofrequency ablation and cryotherapy have also been used to ablate GAVE in small pilot studies. A study of 26 patients with a variety of bleeding lesions (eg, GAVE, arteriovenous malformations, radiation proctitis, radiation gastritis) were treated with cryotherapy with a mean of 3.6 sessions.[49] These patients had previously undergone treatment with MPEC and HP but continued to have bleeding. Cryotherapy with nitrous oxide was efficacious in causing hemostasis in 77% overall, with follow-up of 6 months. In another recent report of 12 patients, including 8 patients in whom the use of an APC failed, cryotherapy resulted in a decrease in transfusion requirement and an increase in hemoglobin.[50] A pilot study of 6 patients with GAVE treated with the HALO90 device (Barrx Medical, Sunnyvale, Calif) showed improved hemoglobin concentrations in all patients after 1 to 3 treatments. Five of 6 patients were no longer transfusion dependent.[51]

Angiodysplasia

MPEC probes, HPs, and APCs have all been described in treating angiodysplasia encountered in the GI tract during upper endoscopy, enteroscopy, and colonoscopy.[52-54] One series of 16 patients showed that thermal ablation of angiodysplasia decreased transfusion requirements in 76% of patients and that only 1 to 2 sessions were needed for ablation compared with a mean of 6 sessions needed to ablate GAVE.[43] In contrast to treating bleeding peptic ulcers, lower power settings and lower appositional forces are used with MPEC and HP treatment of angiodysplasia.

Dieulafoy lesions

Injections of epinephrine, ethanol, or histoacryl have been described as successful in stopping bleeding from Dieulafoy lesions. Epinephrine injection followed by thermal therapy (eg, MPEC, HP) or clip placement has also been effective in small case series.[55-58] A prospective, randomized trial of 24 patients compared mechanical devices (clips or band ligation) and injection of hypertonic saline solution for Dieulafoy lesions.[59] The rate of rebleeding was significantly lower in the mechanical group (8%) than in the injection group (33%).

Mallory-Weiss tears

Studies of endoscopic therapy for Mallory-Weiss tears have focused on actively bleeding lesions. A randomized, controlled trial of 44 patients undergoing MPEC versus sham MPEC in active upper GI bleeding revealed that in a subgroup of 17 patients with Mallory-Weiss tears, there was a significant improvement in the MPEC group with regard to initial hemostasis (100% vs 13%) and emergency surgery or other intervention and a trend toward less need for transfusions.[19] A prospective, randomized study of 41 patients with actively bleeding Mallory-Weiss tears randomized to clips or band ligation showed that all patients had immediate hemostasis, and only 1 patient rebled in the clip group and 2 in the banding group.[60] A study of 35 patients with actively bleeding or oozing Mallory-Weiss tears were prospectively randomized to either clip application or epinephrine injection.[61] There was no difference in immediate hemostasis or rebleeding.

Radiation-induced angioectasias

The use of MPEC, HP, and APC has been described in small case series as successful treatments for bleeding from radiation-induced angioectasias, usually in the rectum. Multiple sessions were typically required for complete ablation.[62-65] Other mucosal ablation therapies such as cryotherapy and radiofrequency ablation have also been used for radiation-induced angioectasias.[49,51]

Diverticular bleeding

Epinephrine injection with or without MPEC has been described in observational studies as an effective measure to obtain initial hemostasis in diverticular bleeding.[4,5] Case reports also describe the use of clips in diverticular bleeding.[66-68]

Postpolypectomy bleeding

Various combinations of epinephrine injection, MPEC, and HP application to postpolypectomy bleeding sites have been described.[69] Clips have also been used to stop postpolypectomy bleeding.[66,70] Detachable loops were developed for the prevention of postpolypectomy bleeding. Small case series have described the feasibility of placing loops before polypectomy.[71,72] Several prospective, randomized studies evaluated the role of detachable loops, clips, and injection therapy in the prevention of postpolypectomy bleeding after removal of large polyps. A study of 159 patients showed that the application of a detachable loop with epinephrine injection resulted in a significant decrease in immediate bleeding compared with epinephrine injection alone (1% vs 9%), although there was no difference in delayed bleeding.[73] A study comparing loop placement, epinephrine injection, and no therapy showed that there is a significant increase in postpolypectomy bleeding with the removal of large polyps (>2 cm) when no therapy is used (2.7% vs 2.9% vs 15.1%,

TABLE 5. CPT codes for endoscopic hemostasis

CPT code description	Esophagoscopy	EGD	Enteroscopy	Stoma	Flex sig	Colonoscopy
Control of bleeding, any method*	43227	43255	44366	44391	45334	45382
Injection sclerosis	43204	43243				
Removal by ablation technique	43228	43258	44369	44393	45339	45383

Flex sig, Flexible sigmoidoscopy.

*Any method may include, but is not limited to, the following hemostasis techniques: injection, bipolar cautery, unipolar cautery, laser, heater probe, clip, or argon plasma coagulator.

respectively).[74] One study in patients undergoing saline solution lift polypectomy showed that the addition of epinephrine had no effect on the rate of postpolypectomy bleeding.[75] Another study demonstrated no decrease in postpolypectomy bleeding with prophylactic clip placement.[76] The data to date, therefore, reveal no clear benefit of routine prophylactic therapy with the possible exception of the use of detachable loops and epinephrine injection in large pedunculated polyps.

SAFETY

Thermal hemostatic devices

Rare perforations of peptic ulcers treated with MPEC and precipitation of bleeding (the majority stopped with further application of MPEC) in as many as 18% of patients have been reported.[20] Colonic perforation after treatment of angiodysplasia, particularly in the right colon, has been reported in as many as 2.5% of cases.[77]

The rate of perforation after treatment of GI bleeding with HP has been reported to be as high as 1.8% to 3%, and precipitation of bleeding has been reported in as many as 5% of patients.[1,78,79] Colonic perforation with application of an HP to angiodysplasia in the cecum has also been reported.[80]

Complications from an APC are rare and include distention of the GI tract with argon gas, submucosal emphysema, pneumomediastinum, and pneumoperitoneum.[14,81,82] Perforation has been described after the use of an APC in the duodenum and colon.[80] These complications may be related to the power setting, duration of application, and distance of the probe tip to the target tissue.[13] Cases of intracolonic gas explosion caused by ignition of accumulated oxygen, hydrogen, and methane have also been described. These explosions occurred in patients with incomplete or inadequate colonic cleansing or when malabsorbed carbohydrates were used as a bowel preparation.[83,84] Therefore, complete colonic cleansing with a polyethylene glycol- or saline solution-based laxative should be used before using APC in the colon.

Injection needles

Complications of injection therapy are usually related to the substance injected rather than the needle itself. However, there are reports of needles failing to extend from their sheaths and of needles separating from the catheter in the patient and requiring retrieval. No direct patient harm has been reported from either of these device failures.[80] Cardiac arrhythmias and hypertension have been reported after epinephrine injection.[85] Most complications occurring from injection therapy are complications related to esophageal variceal sclerotherapy.[86] Sclerotherapy complications may occur in as many as 50% of patients and can be separated into local complications including retrosternal pain, dysphagia, odynophagia, ulcerations, strictures, bleeding, perforation, and systemic complications including fever, bacteremia, sepsis, pleural effusions, pneumonia, and adult respiratory distress syndrome.[87-89]

Mechanical hemostatic devices

There are numerous reports of handle malfunction, the inability to separate the clip from the catheter after deployment, and premature deployment of the clip. There is one report of inadvertent colon perforation while attempting to deploy a clip for a postpolypectomy bleed. Interestingly, this small perforation was closed with another clip. One reported incident of a clip failing to detach from the catheter led to additional bleeding that was successfully treated with another clip.[80] Clips are complex mechanical devices, and whether these reports represent device failure or operator inexperience with the device is not discernible. Although most clips detach and pass without incident within days, there have been reports of clips retained at the site of deployment for prolonged periods.[16,90] The clinical significance of clip retention is unknown, but there have been no adverse consequences reported. None of the clips described in this review are magnetic resonance imaging safe.

Detachable loop ligating devices have been associated with loop entanglement with snare complicating polypectomy, slippage of the loop resulting in delayed bleeding, and inadvertent transection of the polyp stalk leading to immediate bleeding.[91]

FINANCIAL CONSIDERATIONS

Commonly used CPT* (Current Procedural Terminology) codes for endoscopic hemostasis are shown in the Table 5, and the detailed instructions for use of these numerous individual codes are provided elsewhere.[92] Tables 1 through 4 contain the list price of frequently used hemostatic devices available in the United States. The costs vary greatly among the different devices. Thermal probes are the most expensive devices, costing typically several hundred dollars each. The HP is more expensive but is reusable, whereas MPEC probes and APC catheters are single use. Clips and loops are approximately \$100 each, although a mean use of 3 clips per patient for peptic ulcer bleeding has been reported.[66] Injection needles are the least expensive devices, costing approximately \$50 each, although they are commonly used in conjunction with thermal probes or clips. All prices were obtained from the vendors as of September 1, 2008. Two cost identification studies have shown that in patients with bleeding peptic ulcers, the mean cost of hospitalization in patients treated with endoscopic therapy is less than half of the cost for patients treated with medical-surgical therapy.[19,93]

AREAS FOR FUTURE RESEARCH

The optimal device for ablation of GAVE and angiodysplasia remains unclear. New technologies using radiofrequency ablation and cryotherapy may also hold promise in ablating GAVE,[49-51] but require further study. The role of endoscopic therapy in diverticular bleeding remains unclear, as does the optimal modality for hemostasis. The patient group most likely to benefit from the use of mechanical hemostatic devices such as clips and loops in the prevention of immediate or delayed postpolypectomy bleeding requires further study.

SUMMARY

Endoscopic therapy improves clinical outcomes for many causes of GI bleeding. There are many safe and effective devices available for endoscopic hemostatic therapy. Although there are few compelling data favoring a particular device for treatment of various etiologies of GI bleeding, patients with peptic ulcer disease requiring intervention will benefit from the combination of thermal therapy or clips and injection therapy compared with injection therapy alone. Selection of the optimal hemostatic device depends on characteristics of the lesion, local expertise, equipment availability, and cost.

Abbreviations: APC, argon plasma coagulator; ASGE, American Society for Gastrointestinal Endoscopy; GAVE, gastric antral vascular ecstasia; HP, heater probe; MPEC, multipolar electrocautery.

*CPT (Current Procedural Terminology) is a registered trademark of the American Medical Association.

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Prepared by:
ASGE TECHNOLOGY COMMITTEE
Jason D. Conway, MD, MPH
Douglas G. Adler, MD
David L. Diehl, MD
Francis A. Farraye, MD, MSc
Sergey V. Kantsevoy, MD, PhD
Vivek Kaul, MD
Sripathi R. Kethu, MD
Richard S. Kwon, MD
Petar Mamula, MD, NASPGHAN representative
Sarah A. Rodriguez, MD
William M. Tierney, MD, Committee Chair

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