Colonoscopic Polypectomy: Current Techniques and Controversies

4

Fabio Monica and Giulia Maria Pecoraro

4.1 Introduction

Colonoscopic polypectomy is a well-recognized method for the prevention of colorectal cancer (CRC), reducing its incidence [1] and mortality [2].

The first polypectomy was performed in 1969 by Dr. Hiromi Shinya, a general surgeon working at Beth Israel Hospital in New York, using an electrosurgical polypectomy snare that he designed. The results were published a few years later in the *New England Journal of Medicine* and this article became known as one of the twentieth century's landmark articles in the field [3].

Despite their proven effectiveness, polyp resection techniques are based on expert opinion and uncontrolled observational studies and are limited by a lack of evidence [4–6]. Moreover, there is no standardized polypectomy method, so that most endoscopists perform polypectomy as they have learned during their endoscopic training or advanced fellowship. In 2004 a survey conducted among American gastroenterologists showed substantial variation in polypectomy practices even for lesions less than 10 mm [7–9]. Proper removal of polyps needs not only the skills of an experienced endoscopist but also a complete knowledge of the characteristics of endoscopic instruments and accessories, according to their suitability for the morphology and size of the colorectal polyp, in order to avoid complications and to reduce the occurrence of incomplete polypectomy, which is one of the major causes of interval colon cancer [10, 11].

In the CRC screening era, detection and resection of all polypoid lesions are the main goals of quality colonoscopy, and submitting all resected polyps to histological examination is still the standard of care [12, 13].

F. Monica (✉) • G.M. Pecoraro
Division of Gastroenterology and Digestive Endoscopy, Azienda Sanitaria Universitaria Integrata di Trieste, Academic Hospital Cattinara, Trieste, Italy
e-mail: monifabio@gmail.com

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Before performing a polypectomy it is necessary to determine whether the patient is receiving anticoagulant/antiplatelet therapy to assess for bleeding risk, as shown in the American Society for Gastrointestinal Endoscopy guidelines (2016) [14]. (For this topic please refer to Chap. 9.)

4.2 Polypectomy Techniques

A successful polypectomy has to be effective in achieving complete resection, efficient in the retrieval of all lesions, and safe in minimizing the risk of complications such as perforation or bleeding. Furthermore, the resection must provide an accurate histological diagnosis, with evaluation of the margins and investigation for possible neoplastic invasion of the underlying layers.

Several techniques are used to remove polyps; they are classified according to the accessories used, with or without the use of electrosurgery. The choice of technique depends on the morphology, size, and location of the polyps and the experience of the endoscopist [15, 16].

Classification of colorectal polyps is critical to facilitate a standardized approach to therapy [13, 17, 18]. At present, superficial neoplastic lesions of the gastrointestinal tract are stratified into three categories according to the Paris endoscopic classification: protruded (type 0-I), superficial (type 0–II), and excavated (type 0–III). Protruded lesions are subdivided into pedunculated (0-Ip), if the polyps have a head connected with a stalk; sessile (0-Is), if the polyps are broad-based without a connecting stalk; and semipedunculated (0-Isp) if the polyps have short stalk [19–21]. Based on size it is possible to identify three types of polyps: diminutive, ≤5 mm; intermediate, between 6 and 9 mm; and large, >10 mm.

The endoscopic techniques for polypectomy are:

1. Cold forceps biopsy (CFB)
2. Hot forceps biopsy (HFB)
3. Snare excision: cold snare polypectomy (CSP) and hot snare polypectomy (with monopolar cautery [HSP])
4. Simple fulguration with argon plasma coagulation (APC) and advanced techniques such as endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD), which are discussed in the next chapter.

The optimal method for polypectomy is the removal of the polyp in one piece (en-bloc resection), but if the size of the polyp is larger than 2 cm, it may be necessary to remove it in multiple pieces (piecemeal resection).

4.2.1 Cold Forceps Biopsy

The cold forceps technique is easy to use, and has a high retrieval rate and a low complication rate [22]. The distance between cups determines the size of the

Fig. 4.1 Jumbo forceps

forceps (5–8 mm). The diameter of the forceps cup is about 3 mm. In jumbo forceps the cup size is greater than 3 mm (Fig. 4.1).

The cold forceps technique is used most often for diminutive lesions (≤5 mm) and consists of grasping the polyp and removing it with a firm pull. This allows safe retrieval. Nevertheless, one-bite forceps polypectomy is not always adequate because it may leave residual polyp (also, the exact margins of the polyp may be obscured by blood), so two bites can be done with standard forceps, or, for the complete removal of 4- to 5-mm polyps, jumbo forceps can be used [13, 23, 24]. In two-bite cold forceps polypectomy, the first bite should include a normal mucosal margin to reduce remnant tissue.

A recent prospective study showed that forceps ensured complete resection in 96% of cases for polyps between 1 and 3 mm and in 76% of cases for polyps between 4 and 5 mm [25]. Another study demonstrated that residual adenoma was present in 29% of diminutive polyp sites [26]. Even jumbo forceps seem to be associated with a high rate of residual adenoma [27].

However, another study has shown that complete resection was achieved in 90% of diminutive polyps and 100% of polyps <3 mm in size when performed with chromoendoscopy and washing and post-resection examination [28]. In any case, the endoscopist should always examine the biopsy site to ensure complete removal.

Fig. 4.2 Hot biopsy

4.2.2 Hot Forceps Biopsy

HFB (Fig. 4.2) consists of the thermal ablation of polyps with a coagulation current through an electrosurgical unit, so it is similar to CFB except for its use of electrocautery to remove polyp tissue. When the polyp is grasped in the forceps, electrocautery is applied to destroy the polyp base, while the polyp tissue is preserved inside the forceps as a histological specimen. However, the use of HFB can make histological diagnosis difficult and it has a risk of delayed bleeding or hypercoagulation syndrome [12, 29, 30]. A prospective randomized clinical trial [31] compared the efficacy and safety of CSP and HFB for diminutive colorectal polyps in 287 patients, evaluating endoscopic en-bloc resection and complete histological resection rates (primary outcome), and complication and polyp retrieval rates (secondary outcomes). The authors concluded that CSP is more effective and safer than HFB for diminutive polyps. For these reasons HFB is not recommended as a standard method.

4.2.3 Snare Excision

Snare excision is commonly used for polyps ≥6 mm [7, 32]. Different types of wire loop snares are available, differing according to shape (round, oval, hexagonal, asymmetrical) (Fig. 4.3), according to filament (monofilament or double-stranded) (Fig. 4.4), and according to size (10, 13, 15, 20, 22, 27, and 30 mm) (Fig. 4.5). All of

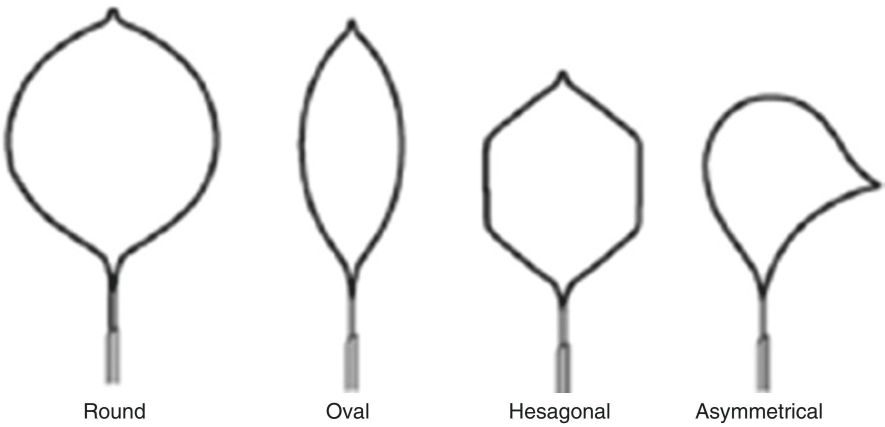

Fig. 4.3 Various shapes of snares

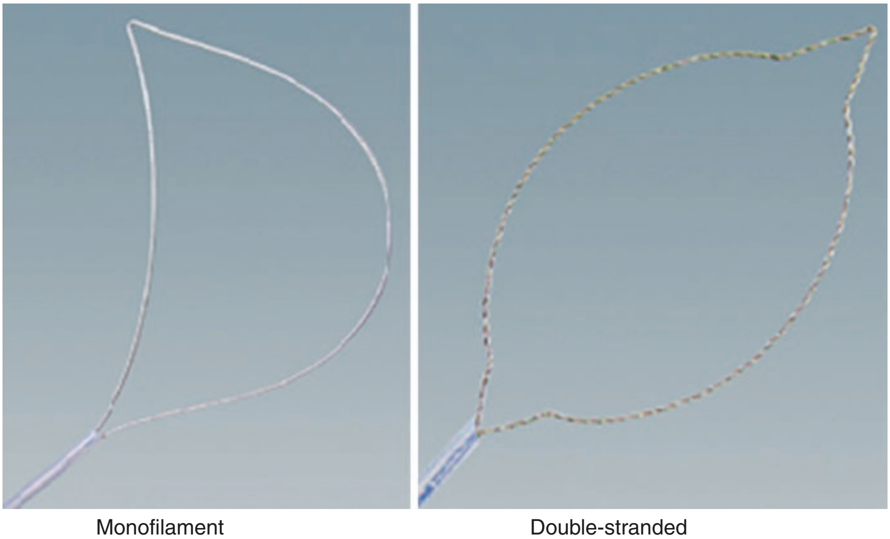

Fig. 4.4 Various types of filament

these snares can be either soft or stiff. Other specific snare types have also been developed, such as barbed snares (oval snares with spikes or spiral snares) to ensure a firm grasp or prevent slippage of flat or sessile polyps, spiral snares with an incorporated retrieval device, and rotatable snares [33]. The choice of snare is usually made according to the endoscopist's preference as there are no controlled trials demonstrating the superiority of any one device over another.

There are two ways to use the snare: cold snare and standard snare excision with electrocautery.

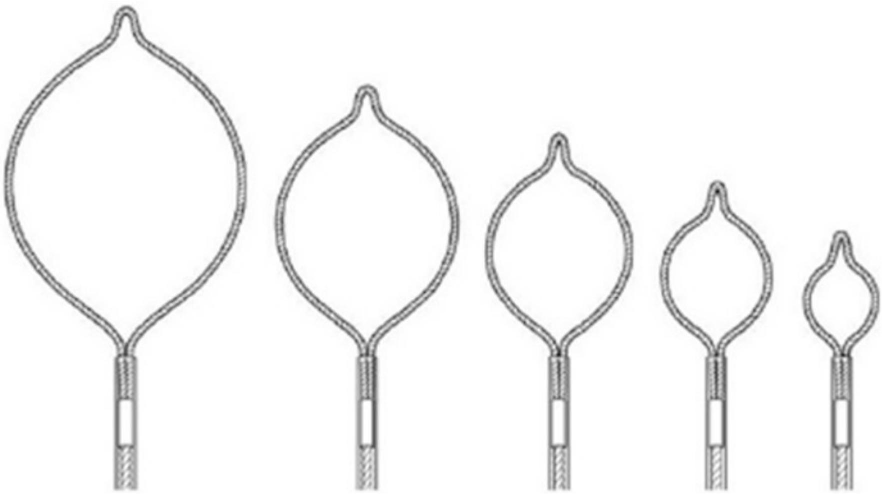

Fig. 4.5 Various sizes of snares

The first method is when the endoscopist decides to cut the polyp with only the mechanical strength of the snare, which is closed in a single, continuous, and controlled movement to guillotine the tissue, also capturing 1–2 mm of normal tissue around the polyp. Suction can help the snare to capture the polyp and surrounding tissue. The polyp can be readily suctioned in the working channel of the endoscope and retrieved in a suitable trap [34]. If there is minimal bleeding, successful hemostasis is always achieved by the technique of positioning the endoscope 'en face' and close to the post-polypectomy base or creating pressure with the power of a water jet [35].

CSP is preferred for lesions less than 10 mm (4–9 mm). Moreover, it also seems better for polyps ≤5 mm, as shown in a recent study, in which it was found to be adequate for complete and safe polyp removal, as well as shortening the withdrawal time of the colonoscopy procedure [36]. CSP allows efficient resection of polyp tissue in a single piece, with a lower rate of incomplete resection than biopsy [26] and it is almost without risk [34], except for insignificant bleeding that usually stops within a few seconds [36]. Repici et al., in an observational study, demonstrated the safety of the cold snare for polyps less than 10 mm, with a low rate of bleeding (1.8%) and no delayed bleeding or perforation [37]. If there is some bleeding, especially in patients taking anticoagulants, it is immediately displayed and can be treated endoscopically.

In view of these findings for CSP, and because of the high rates of incomplete resection with CBF excision, the European Society of Gastrointestinal Endoscopy (ESGE) guidelines now recommend against the use of CBF excision. Only in the case of a polyp sized 1–3 mm where cold snare polypectomy is difficult or not possible, CBF may be used [38].

HSP, i.e., standard snare excision with monopolar cautery, is the most widely used technique for polyps of 10–19 mm and it has been used for about 40 years [39, 40].

Despite this long history, the application of electrocautery in snare polypectomy has not yet been standardized because of the lack of large controlled trials (see Sect. 2.3.4).

4.2.3.1 Saline Lift Technique

To make HSP effective and safe it may be aided by the saline lift technique, which prepares the polyps for resection. With a suitable needle, saline solution (or other agents that are retained for longer periods) can be injected into the submucosa under the polyp, raising the lesion from the underlying muscularis propria.

This has the dual purpose of increasing the distance between the polyp and the submucosa, ensuring complete removal of the polyp and reducing the risk of complications [41]. This method potentially decreases the risk of perforation because the electric current will be conducted within a greater tissue space. Further more, most endoscopists use dilute epinephrine (1:10,000 or 1:20,000) to reduce the risk of bleeding, taking advantage of its vasoconstrictor properties.

Unfortunately, saline solution is rapidly absorbed, so alternative agents have been studied, including hyaluronic acid [42], dextrose solution [43], succinylated gelatin [44], hydroxyethyl starch [45], and recently polidocanol [46]; these are used with or without epinephrine. (For this topic please refer to Chap. 7).

4.2.3.2 Steps for Performing Polypectomy

When performing endoscopic polypectomy with a snare, some steps should be kept in mind.

Correct Position

The polyp should always be placed in the 5- to 7 o'clock position.

Identification of the polyp margins: High-definition/resolution endoscopes with electronic chromoendoscopy (Narrow Banding Imaging (NBI), Olympus Corporation, Tokyo, Japan; Fuji Intelligent Chromo Endoscopy (FICE), Fujifilm Corporation, Tokyo, Japan; Blue Light Imaging (BLI), Fujifilm Corporation, Tokyo, Japan; iSCAN, Pentax Corporation, Tokyo, Japan) help to provide clear visualization of the polyp margins. Adding biologically inert blue dye (methylene blue or indigo carmine) to the saline used to lift the polyp helps in defining the borders of a flat/sessile lesion.

Infiltration of the submucosa (*optional if HSP is used)*: This must always be started in the proximal part (anatomically) of the polyp base, so that the polyp will rise from the side of the vision and will not tip over.

Ensnaring (Trapping)

The tip of the snare should be placed proximal to the fold; the nurse then opens the snare slowly, surrounding the polyp, and then the snare is slowly closed while the catheter tip is simultaneously advanced at the base of the polyp, keeping the tip in position. This allows the trapping of the entire polyp base and prevents the snare from slipping back over the head of the polyp when it is closed. Gentle suction during snare closure facilitates the entrapment of a completely flat lesion, but it must be done carefully to avoid clasping too much tissue or a colonic fold.

Resection

The snare is completely closed to cut the polyp with electrocautery.

When electrocautery is used the endoscopist should minimize the duration of energy delivery to limit damage to the colonic wall. Every part ensnared should be lifted away from the wall: this can be done by tenting the polyp toward the center of the lumen just before the application of the current, to prevent deep perforation. Furthermore, we must be careful that the tip of the snare does not inadvertently touch the wall behind the polyp, because if this happens thermal injury with delayed perforation may occur.

Retrieval

If the pieces are relatively small they can be suctioned through the suction channel [34]; otherwise, an endoscopic net, wire basket, or forceps can be used for the retrieval of a large resected polyp or tissue that will not pass through the channel, especially if the polyp is located in the right colon.

The optimal method of removal for large polyps (>1 cm) varies with the type of polyp, so it is important to identify large pedunculated or sessile polyps and flat lesions.

4.2.3.3 Polypectomy for Different Types of Polyps

Most pedunculated polyps develop large feeding blood vessels in the stalk [47], and the size of these vessels may be greater than the size of the polyp and its stalk.

When removing pedunculated polyps, applying energy early and closing the snare slowly will help to avoid complications such as bleeding. The electrocautery snare should be placed around the stalk at approximately one-half to one-third of the distance between the polyp head and the colon wall, allowing sufficient resection margin in case there is malignancy and leaving a visible residual stump of the stalk after resection that can be grasped in the event of bleeding.

To prevent bleeding, it is useful to place a nylon loop (Endoloop, Olympus Corporation, Tokyo, japan) [48] around the stalk below the resection point (even if the presence of this loop may make the procedure challenging) or to place clips across the polyp stalk.

Bleeding rates increase when the stalk is >5 mm [47]. However, the size threshold for the prophylactic application of mechanical measures to prevent bleeding is not known. The ESGE guidelines recommended that, for a pedunculated polyp with a head ≥20 mm or a stalk ≥10 mm in diameter, it is useful to pretreat the stalk with these mechanical measures for hemostasis and/or to use an injection of dilute epinephrine [38].

No difference in efficacy between clips and a nylon loop for the prophylaxis of bleeding is currently known [49].

Large sessile polyps are difficult to remove and polyps greater than 2 cm are usually removed in a piecemeal manner or by using advanced techniques.

In order to perform the polypectomy in a correct and safe way, the endoscopist must know and apply the electrical current that is the most suitable for the type and size of polyp to be removed.

Table 4.1 Endoscopic techniques according to the feature of polyps

Size and type of polyp	Technique	Instrument	Other accessories
3–4 mm	Cold forceps (one-bite)	Forceps	–
	Hot forceps (not recommended)		
5–6 mm	Cold forceps (two-bite)	Forceps or jumbo forceps	–
7–9 mm	Cold snare	Mini oval snare, barbed snare	–
	Hot snare		Injection needle (optional)
Large pedunculated	Hot snare	Braided-soft	Injection needle, Endoloop, clip
Large sessile	Hot snare	Braided-stiff	Injection needle
Flat lesion	Hot snare	Monofilament	Injection needle

Traditionally, snare polypectomy is performed using a blended, coagulation, or pure cutting electrical current. Table 4.1 summarizes the endoscopic techniques according to the feature of polyps.

4.2.3.4 Electrosurgery Unit (ESU)

The basic principle of the ESU is that heat can be produced without a neuromuscular response when a high-frequency alternating current between 300 kHz and 3 mHz (radiofrequency) passes through tissue. The ESU is a commonly used endoscopic tool for cutting or coagulating tissue. Depending on the wave form chosen, energy applied at the cellular level produces heat because of tissue resistance, resulting in the bursting of cell membranes, with tissue disruption or coagulation being caused by a less intense electrical current, which can desiccate and shrink cells without bursting the cell membrane, while providing hemostasis [12, 13].

Monopolar devices transmit current from an electrode in the instrument tip through the patient's body to a plate (usually placed on the leg or thigh) to complete the circuit; bipolar devices have both active and return electrodes in the instrument tip, thereby foregoing the need for a grounding plate.

Various types of ESU have been developed, depending on the current used; for example, pure coagulation current and pure cutting current. However, these methods involve complications, because coagulation current may be associated with perforation, owing to the deep tissue penetration of heat, whereas the use of cutting current has a risk of immediate post-polypectomy bleeding because the tissues are cut before vessels are coagulated. Therefore, engineers have developed a blended current that modulates the frequency of the electrical current (duty cycle) and adjusts the peak voltage. The result is that the current exerts a cutting effect on the tissue with a coagulating effect at the resected margin [39]. Specific tools have been developed to facilitate controlled tissue cutting during various applications, alternating cutting and coagulation currents.

The blended current can be provided by a conventional electrosurgical generator or by using a generator with a microprocessor that automatically controls currents, fractionates cutting and coagulating phases, and adjusts output based on tissue impedance, with the result being the restriction of deep tissue injury.

Improvements in technology have seen the introduction of more sophisticated electrosurgical generators in which the ENDO CUT mode (Erbe, Elektromedizin GmbH, Tubingen, Germany) has been widely used because of its better results for polypectomy, as it rapidly modifies the current in response to changes in the tissue impedance. Alternating cutting and coagulation cycles allow controlled cutting to be performed with sufficient hemostasis during the entire cutting process, with minimal depth and spread of thermal injury. For more effective cutting or deeper coagulation, the endoscopist can adjust different parameters: the coagulation power, the cut duration, and the interval between the previous and next cut [14].

Some studies have shown that, overall, the ENDO CUT is better than a conventional electrosurgical generator in terms of the quality of the polypectomy specimens and the less extensive tissue damage [50].

However, electrosurgery is responsible for almost all the complications associated with polypectomy [51] and there are no uniform or standard guidelines for electrosurgical settings during polypectomy.

4.2.3.5 New Methods

Recently "underwater" polypectomy has been used during water-aided colonoscopy. This technique for the removal of flat colorectal lesions was described for the first time by Dr. Kenneth Binmoeller and colleagues, in 2012 [52].

The bowel lumen is filled with water rather than air, and a submucosal injection of the lesion is not required. This technique increases the complete resection rate and reduces possible complications: bleeding, transmural burns, and perforation. Both cold and hot snares can be used safely because water does not affect the conductivity of the tissue during polypectomy. However, further studies are needed to validate the technique.

In recent years the use of carbon dioxide insufflation during polypectomy has developed too. This seems to reduce patient discomfort during and after the procedure because CO_2 is absorbed faster than air [53, 54].

4.2.4 Argon Plasma Coagulation

Argon plasma coagulation should be used for the electrocautery of islets of adenomatous tissue between resected pieces or polypectomy margins, but its efficacy is unclear because this method is associated with polyp recurrence [20, 55]. This technology uses a non-flammable and inexpensive gas: ionized argon (plasma). A jet of ionized argon is emitted by 6000-volt peak energy. Thermal energy is conducted by argon and delivered into the tissue with a depth of penetration of roughly 2–3 mm, producing denaturated proteins, with the net effect being tissue destruction and coagulation. The tip of the probe must be oriented less than 1 cm from the target lesion and it is important not to fire too close to the mucosa, because the coagulation effect is similar to that of monopolar electrocautery rather than the effect achieved via ionizing plasma, which causes deeper injury of the tissue.

4.3 Controversies

4.3.1 Incomplete Resection

There are two important issues with polypectomy: incomplete resection and non-retrieval of the polyp. Surveillance intervals are based on complete removal of all adenomas, while in cases of incomplete polypectomy, residual neoplastic tissue can progress to malignancy. It has been estimated that up to 27% of interval cancers may occur owing to incomplete endoscopic resection [10, 56].

The CARE study [57] showed that residual adenoma was common after HSP, and rates of incomplete resection varied according to the type and size of the polyps: there were high rates (over 10%) for non-pedunculated neoplastic polyps, and the rates of incomplete resection were 6.8% for polyps 6–9 mm, 17.8% for polyps 10–20 mm, and 31.0% for sessile serrated polyps. In another study, 17.6% of patients with large sessile polyps had residual adenomatous tissue when reexamined [58].

Of note, the CARE study [57] concluded that the rates of incomplete resection varied significantly among endoscopists (6.5–22.7%), suggesting that the individual operator factor and appropriate training are the most important factors for correct and successful polypectomy [59, 60].

A survey of 189 gastroenterologists showed there was no agreement on a technique for the removal of 4- to 6-mm polyps. For polyps 1–3 mm in size, forceps techniques (cold or hot) were more frequently used and for polyps 7–9 mm in size electrosurgical snare resection was predominant, whereas for polyps measuring 4–6 mm, 19% of the respondents reported using cold biopsy forceps, 21% hot biopsy forceps, 59% a hot snare, and 15% a cold snare. Thus, for polyps 4–6 mm in size no one polypectomy method was used significantly more than any other method [7].

Prospective randomized comparisons are required to assess the efficacy and safety of cold-snare polypectomy versus cold biopsy in lesions 4–6 mm and of cold forceps versus HSP, particularly in lesions 6–9 mm.

4.3.2 Non-retrieval of Polyps

Another issue is the non-retrieval of polyps; this prevents pathological evaluation of the resected polyp, which is one of the criteria for surveillance intervals. Generally, the percentage of polyps lost after resection ranges from 2.1 to 19% [61, 62]. The biopsy techniques provide high polyp retrieval rates (95–100%) [25, 61]. On the other hand, in one retrospective study, about 13% of smaller polyps (1–5 mm) and 19% of polyps overall removed by cold-snare, were not retrieved [63].

The optimal retrieval strategy has not been defined, although some factors were independently associated with non-retrieval: previous colorectal surgery, resection by cold snare, location in the right colon, inadequate bowel preparation, and a polyp size up to 5 mm [63, 64]. In a retrospective study, 4383 removed polyps were analyzed in terms of the polyp features (number, size, and location), removal technique, bowel preparation, and quality of the colonoscopy (duration of examination, insertion, and withdrawal). Multivariate analysis showed that the independent factors for non-retrieval of polyps were small size and cold-snare removal. Other factors correlated with non-retrieval were sessile polyps and location in the proximal colon. In this study the number of polyps per patient, quality of bowel preparation, and duration of the procedure were also correlated with the retrieval rate [63].

The American Society for Gastrointestinal Endoscopy [65] has formulated new paradigms for the colonoscopic management of diminutive (5 mm in size) colorectal polyps that may reduce costs and improve patient safety compared with the current paradigm. The first paradigm ("resect and discard") refers to polyps that are removed and discarded so that the endoscopic assessment of histology is done to establish future surveillance; the second paradigm proposes to leave in situ all diminutive polyps in the rectosigmoid colon when the endoscopist has established a hyperplastic pattern. There are some criticisms in regard to adopting this strategy and it is still under investigation.

Finally, providing education and feedback to endoscopists will improve polyp retrieval rates, especially for clinically relevant, right-sided polyps [66].

4.4 Polyps that are difficult to approach

When we are faced with a polyp that is difficult to approach owing to its location in a tight turn or behind a colonic fold, we can employ some strategies, such as locking the dials on the endoscope or asking an assistant to maintain the scope position (for polyps in tight bends), performing retroflexion of the scope tip (only in the right colon), or using a side-viewing duodenoscope [67, 68] or cap-assisted colonoscope for polyps behind folds. However, no standardized guideline exists for the removal of such polyps, and the choice of method depends on the experience and preference of the operator.

Sometimes polypectomy can be difficult in the presence of submucosal fibrosis caused by previous attempts at resection or even injudicious biopsies. In such cases the submucosal injection of saline solution does not ensure the lifting of the polyp, because the mucosa and submucosa adhere to the underlying muscularis propria, and incomplete removal occurs with snare polypectomy [69]. Thus, for polyps that are difficult to approach, it is mandatory to do a complete resection in one session and never perform biopsies on the polyps. If you are not able to do this, it is preferable to refer the patient to a tertiary center.

4.5 Tattooing

After polypectomy it is necessary to assess whether there is an opportunity to make a tattoo of the lesion site, especially when the polyp was large, if we are not sure that removal was complete, or if other sessions will be needed to remove it, and if there are indicators suspicious of malignancy. The tattooing procedure allows simple and accurate identification of the polypectomy site. However, if the lesion is located in the rectum, in the cecum, or near the ileocecal valve, the site should not be tattooed [38].

Although tattooing is not done routinely at the time of the initial procedure, some endoscopists prefer to tattoo all large polypectomy sites at the time of the initial procedure because of the inherent risk of harboring malignancies [70].

Tattooing consists of the injection of a permanent staining agent into the gut wall to create a mark that will identify the site from either inside or outside the lumen; it is typically done with at least two submucosal injections of dye on contralateral sides of the bowel near the lesion. The tattooing should be done a few centimeters distal to the lesion or at three or four sites circumferentially to avoid the risk of tumor seeding [71].

The needle should ideally enter the mucosa at an oblique angle to permit injection into the submucosa rather than penetrating the colon wall, which can result in inflammation and diffuse staining of the peritoneum, thereby obscuring the surgeon's view during operation [72]. If a submucosal bleb is not immediately developed during the injection, the needle should be pulled back slightly while dye continues to be injected until a bleb is seen [73].

More recently some endoscopists have performed a double injection, with a saline injection into the submucosa to form a bleb, followed by an injection of dye using a second syringe. It seems that this technique can improve the efficacy of tattooing and prevent inflammatory complications [74, 75].

Many types of dye are available for tattooing (including methylene blue, indigo carmine, toluidine blue, and hematoxylin), but only two persist for more than 24 h: indocyanine green and India ink [76].

The latter is widely adopted, but some complications related to India ink solution injection have been described. In addition to intraperitoneal spillage (reported in up to 14% of cases, but rarely with any clinical significance), there have been reports of perforation leading to peritonitis [77], abscess formation [78], fat necrosis [79], phlegmonous gastritis [80], inflammatory pseudotumour [81], accidental marking of the small bowel or inadvertent staining of the entire sigmoid colon [82], and abscess in the rectus muscle [83]. Also, India ink is not a sterile solution.

More recently a dilute suspension of pure carbon particles (SPOT® Gi Supply, Camp Hill, PA USA) has been developed as a sterile and biocompatible suspension. This is the only dye approved by the Food and Drug Administration of the United States and it is efficient and safe. However, cases of peritonitis and submucosal fibrosis have been reported with this suspension [84].

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