Underwater endoscopic colorectal polyp resection: Feasibility in everyday clinical practice

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Abstract

Background: Endoscopic mucosal resection is well-established for resecting flat or sessile benign colon polyps. The novel underwater endoscopic mucosal resection eschews submucosal injection prior to endoscopic mucosal resection. Reports about underwater endoscopic mucosal resection were limited to small series of single and/or tertiary-care referral centers, with single or supervised operators.

Objective: The purpose of this study was to determine feasibility and efficacy of underwater resection of polyps of any morphology (underwater polypectomy, here includes underwater endoscopic mucosal resection) in routine clinical practice.

Methods: This study involved a comparison of colonoscopy records of two community hospitals (January 2015–December 2016) for underwater polypectomy ($n = 195$) and gas insufflation polypectomy ($n = 186$).

Results: Comparable demographics, procedural data, overall distribution, morphology and size of resected lesions, number of en bloc and R0 resections (any polyp morphology and size); exception: overall, underwater polypectomy pedunculated polyps were significantly larger than those in the gas insufflation polypectomy group, $p = 0.030$. Underwater polypectomy (median, min) resection time was significantly shorter than gas insufflation polypectomy: sessile and flat polyps 6–9 mm, 0.8 vs 2.7 ($p = 0.040$); 10–19 mm, 2.0 vs 3.3 ($p = 0.025$), respectively; pedunculated polyps 6–19 mm, 0.8 vs 3.3 ($p < 0.001$). Underwater polypectomy resection of pedunculated polyps 6–19 mm showed significantly less immediate bleeding: 11.1% vs 1.5%, respectively ($p = 0.031$).

Conclusions: Underwater polypectomy can be efficaciously used in routine clinical practice for the complete resection of colon polyps, with several advantages over gas insufflation polypectomy.

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Key summary

1. Underwater endoscopic mucosal resection (UEMR) eschews submucosal injection of fluids prior to EMR. Reports about UEMR were limited to small series of single and/or tertiary-care referral centers, particularly focused on the resection of large, flat lesions.

2. In routine clinical practice at two community hospitals, compared with traditional gas insufflation polypectomy, the underwater resection of polyps (also with pedunculated morphology) achieved comparable proportions of en bloc and R0 resections, shortening resection time (all polyp morphologies with size of 6–19 mm), and with less immediate bleeding episodes for pedunculated polyps of 6–19 mm.

Introduction

Endoscopic mucosal resection (EMR) is a technique commonly used in the gas-insufflated colon for resecting flat or sessile benign polyps, particularly of large size.[1] A fluid is injected in the submucosal space, lifting the lesion away from the muscularis propria[2] to decrease the risk of iatrogenic damage.[3]

Underwater endoscopic mucosal resection (UEMR) is a novel technique: the bowel lumen is filled with water rather than gas eschewing submucosal injection,[4] based on the endoscopic ultrasound (EUS) observation that in the water-filled lumen the mucosa and submucosa float away from the deeper layers.[4,5]

Reports attesting to the feasibility, efficacy and safety of UEMR were limited to small series of single and/or tertiary-care referral centres,[5–11] with limited number of cases[8,9] and with single[5,7,11,12] or supervised operators,[9,10] using caps fitted at the tip of the colonoscope,[5–8,10,11] pediatric instruments[7,11] or EUS evaluation of the polyps prior to resection.[5,9,10] Minimal data exist from community-based practices where most colonoscopies are performed.[12]

We aimed to demonstrate that underwater polypectomy (UWP, in the current article comprising all underwater resections) can be efficaciously used to resect colorectal lesions irrespective of their size and morphology; and to determine if UWP has advantages over gas insufflation polypectomy (GIP).

Materials and methods

UEMR was adopted at our two community hospitals in Italy in late 2014, after reviewing a number of earlier published reports[4,5,7] and associated videos.[4,5]

In January 2015, almost all flat or slightly elevated lesions were resected using EMR with just a few using the recently adopted UEMR. Gradually, UEMR became the technique of choice, replacing EMR. Within one year, both our hospitals transitioned from GIP (using either air or carbon dioxide (CO_2), depending on the endoscopy room) to underwater resections, also for pedunculated polyps. Hence, in 2016 almost all lesions were resected underwater. The current observational retrospective study included two groups of patients that differ only in the endoscopic technique used: subjects >18 years old who underwent colonoscopy from January 2015–December 2016 with polypectomy carried out in a gaseous environment (mostly during 2015) or underwater (mostly during 2016). The treatment strategy and surveillance protocol were equally applied throughout the study period.

Our colonoscopy records reported polyp location, size, morphology (Paris classification)[13] and associated pathology record; colon cleanliness (Boston Bowel Preparation Scale (BBPS)),[14] and adverse events with their management. Resection time was recorded prospectively in cases enrolled in clinical trials unrelated to polyp resection technique and outcomes[15,16] (Italian nationwide observational study about post-colonoscopy outcomes, protocol PG/2016/13127).

Before we adopted UWP, at our hospitals lesions of 6–9 mm were removed using either cold snare or hot snare with submucosal injection, depending on polyp location, endoscopist's experience or preference. We included in the current analysis consecutive sessile, flat and pedunculated polyps judged ≥6 mm in diameter by the endoscopists, removed by hot snare either using GIP and submucosal injection or underwater.

Signed informed consent was obtained from each patient prior to polyp resection. The local Ethical Committee (Azienda Ospedaliera Universitaria di Cagliari) approved the study protocol (PG/2017/5571, 3 April 2017), which conformed to the Declaration of Helsinki, as part of a quality-improvement initiative. Patients received the standard of care and data was anonymized before analysis.

Colonoscopy

Four board-certified endoscopists with adequate levels of expertise in colonoscopy (2000–10,000 cases accrued) and EMR or polyp resection techniques performed the procedures. A split-dose bowel preparation was used to clean the colon. High-definition wide-angle adult video colonoscopes with auxiliary channel (Olympus HD 180–190 series, Olympus Corp, Hamburg, Germany) were used. CO_2 was insufflated using the Olympus UCR unit.
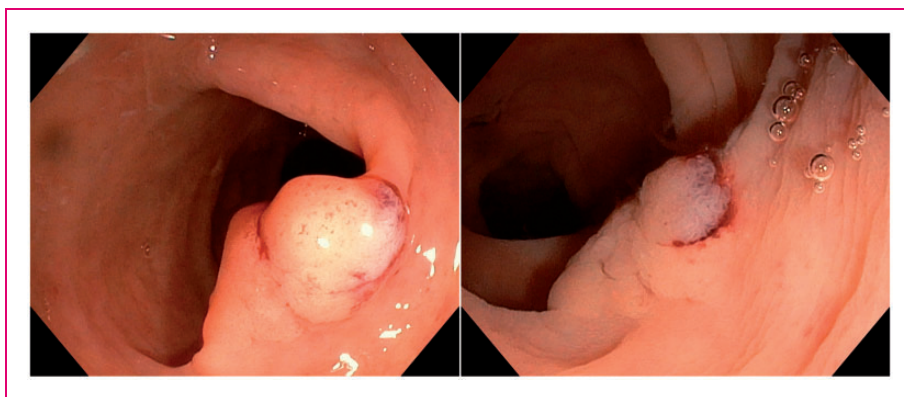
Figure 1. Left: gas insufflation view of a type 0-Is-IIa (Paris classification)[13] polyp. Right: the same lesion seen underwater.
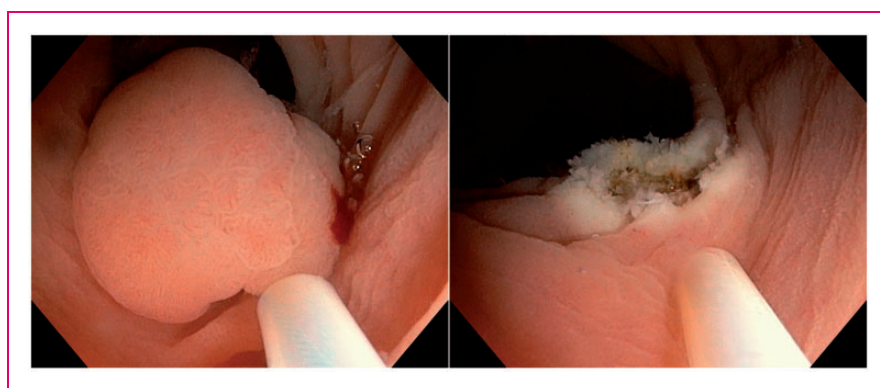

Figure 2. Left: underwater view of the ensnared lesion. Right: underwater view of the resection site.

Polyp location was noted; the polyp size was determined by comparison to the snare tip diameter and crosschecked with pathology reports.

Lesions were assessed by using both white-light and narrow-band imaging (NBI) to determine suitability for resection, defined as follows:[17–19] (a) sessile and flat polyp with 0-Is, IIa or IIb morphology, respectively; (b) pedunculated polyps (0-Ip morphology); (c) benign lesion without Kudo pit pattern V[20] or NICE type 3.[21] For polyps meeting the suitability criteria, EUS was not used prior to resection.[17,18]

Standard polyfilament duckbill or oval snares of different measures (Heyinovo-Wilson, Shanghai, China; Endoflex GmbH, Voerde, Germany) were used for resection. At the discretion of the endoscopists, monofilament snares (Heyinovo-Wilson) were used to resect larger lesions.

Resections were carried out by using ERBE (ERBE Elektromedizin, Tübingen, Germany) electrosurgical units: VIO 200D or ICC200.

En bloc resection was always attempted, otherwise piecemeal resection was performed until resection borders appeared to be constituted only by normal mucosa. The mucosal defect and resection margins were carefully inspected with white light and NBI in order to evaluate the completeness of removal; any residual island of neoplasia was removed by snare or using biopsy forceps and stored in a separate jar. All resected material was retrieved for histologic examination.

At the discretion of the endoscopists, bleeding vessels at first were coagulated using snare-tip soft coagulation, then using argon plasma coagulation (APC) or obliterated using hemoclips.

EMR technique

Traditional EMR was performed as described,[1–3] using the following electrosurgical unit settings: Endocut Q, effect 4, length 1, interval 1; Forced coagulation 25 W, effect 2.

Underwater EMR technique (Figures 1 and 2)

Before starting UEMR, any insufflated gas was replaced with warm-to-touch water to achieve complete filling of the lumen (usually between 100 ml and 300 ml) using a flushing pump (Olympus OFP2). At the discretion of the endoscopists, the margins of lesions >20 mm

were marked within 3–5 mm of their borders using APC or the tip of a snare.

UEMR was performed as described,[4] including normal mucosa outside the margins of the lesion or at the margins identified by the diathermic dots. The opened snare was pushed flush against the bowel wall and torqued to engage a pleat of tissue, maximizing tissue capture.[4] The electrosurgical unit was set to Dry cut, effect 5, 60 W, Forced coagulation 60 W, effect 2 (VIO 200D) or Endocut effect 3, 35 W, Forced coagulation 35 W (ICC200).

Resection of pedunculated polyps

Resections were performed with the snare placed about halfway up the stalk, without prophylactic stalk clipping, ligature, or injection. Before starting underwater resection using the same setting as UEMR, any insufflated gas was substituted with water as described above. In the gas-distended colon, resection was carried out with the same settings as EMR, but with Forced coagulation set at 50 W.

Outcomes of interest

The outcomes of interest, presented as suggested by the European Society of Gastrointestinal Endoscopy (ESGE),[19] were en bloc and R0 resection rates of sessile and flat lesions, resection outcomes of lesions of any morphology, and adverse events. R0 is defined as a complete en bloc resection of a lesion with tumor-free lateral and vertical margins.[18] Our pathologists always report if resection margins are free of neoplastic tissue. Adverse events were identified from hospital files and from Regional Health Service informatics, categorized as immediate bleeding requiring endoscopy therapy after ineffective lavage and snare-tip soft coagulation; delayed bleeding within 30 days after the procedure resulting in an emergency department visit, hospitalization, or re-intervention (endoscopy, angiography, or surgery); post-polypectomy syndrome,[1] and perforation (localized or diffuse release of gas or intestinal fluids into the peritoneum). Resection time is defined as the total time that included submucosal injection (EMR), marking around flat polyps, water infusion (underwater resections) and treatment of immediate complications (e.g. bleeding) with endoscopic therapy. We also evaluated BBPS score at the site of resection, and the use of hemoclips and/or of APC to treat bleeding.

Statistical analysis

Normally distributed variables are presented as means and standard deviations (SDs), and non-normally distributed variables are described with medians and interquartile ranges (IQRs). For categorical variables, p values were obtained using Chi Square test or Fisher's exact test, as appropriate. For continuous variables, p values for comparison of the group means and medians were obtained using t-test and Mann-Whitney U test, respectively. A value of $p < 0.05$ was considered statistically significant.

Table 1. Patients and procedure characteristics.

Variable	Underwater polypectomy $n = 146$ (50.9)	Gas insufflation polypectomy $n = 141$ (49.1)	p Value
Sex, n (%)			0.278
Female	45 (30.8)	52 (36.9)	
Male	101 (69.2)	89 (63.1)	
Age in years, mean (SD)	64.7 (9.0)	65.2 (10.7)	0.717
Indications, n (%)			0.371
Screening	55 (37.7)	46 (32.6)	
Symptoms	91 (62.3)	95 (67.4)	
Sedation, n (%)	32 (21.9)	45 (31.9)	0.056
Quality of colon preparation (Boston Bowel Preparation Scale score at polyp site), median (IQR)	3.0 (2.0–3.0) $n = 126$	3.0 (2.0–3.0) $n = 111$	0.091

IQR: interquartile range; SD: standard deviation.
For categorical variables, p values were obtained using Chi Square test. For continuous variables, p values for comparison of the group means and medians were obtained using t-test and Mann-Whitney U test, respectively.

Results

From January 2015–December 2016, 287 patients underwent either UWP ($n = 146$) or GIP ($n = 141$) (Table 1), for a total of 318 polypectomies (Table 2): 195 UWP and 186 GIP, respectively.

Demographics, indications, use of sedation and colon cleanliness at the site of resection were comparable (Table 1).

Table 2 shows the comparable distribution and morphology (also by size category) of resected lesions. Overall, median sessile and flat polyp size was comparable, pedunculated polyps were significantly larger in the UWP than in the GIP group: 13 mm (IQR 10–20) vs 10.5 mm (IQR 8–15), respectively ($p = 0.030$).

Table 3 reports histology and resection outcomes. Most lesions were adenomas; there were nine carcinomas in situ in the UWP and three in the GIP group, respectively. Two lesions in the UWP group and one in the GIP group, containing infiltrating cancer were referred to surgery.

Resection time was available for 61% and 74.2% of UWP and GIP cases, respectively. Overall, median

Table 2. Characteristics of polyp resected.

Variable	Underwater polypectomy n = 195 (51.2)	Gas insufflation polypectomy n = 186 (48.8)	p Value
Polyp distribution, *n* (%)			0.685
Right colon (cecum and ascending)	38 (19.5)	43 (23.1)	
Transverse colon	29 (14.9)	27 (14.5)	
Distal colon (descending to rectum)	128 (65.6)	116 (62.4)	
Polyp morphology, *n* (%)			
Sessile and flat polyps	108 (55.4)	112 (60.2)	0.340
Pedunculated polyps	87 (44.6)	74 (39.8)	
Sessile and flat polyps, by size category (mm)			0.551
6–9	27 (25.0)	35 (31.3)	
10–19	63 (58.3)	58 (51.8)	
≥20	18 (16.7)	19 (16.9)	
Pedunculated polyps, by size category (mm)			0.103
6–19 mm	65 (74.7)	63 (85.1)	
≥20 mm	22 (25.3)	11 (14.9)	
Polyp size in mm, overall, median (IQR)			
Sessile and flat polyps	10 (9.25–15) *n* = 108	10 (8–15) *n* = 112	0.445
Pedunculated polyps	13 (10–20) *n* = 87	10.5 (8–15) *n* = 74	0.030
Polyps ≥20 mm, overall size in mm, median (IQR)			
Sessile and flat polyps	22.5 (20.0–42.5)	25.0 (20.0–32.0)	0.855
Pedunculated polyps	20.0 (20.0–25.0)	25.0 (20.0–25.0)	0.721

IQR: interquartile range.
Polyp morphology assignment: flat, 0-IIa and 0-IIb; sessile, 0-Is; pedunculated, 0-Ip.[13] For categorical variables, *p* values were obtained using Chi Square test. For continuous variables, *p* values for comparison of the group medians were obtained using Mann-Whitney U test.

UWP resection time (sessile and flat polyps, 2.0 min, IQR 0.8–5.0; pedunculated polyps 1.0 min, IQR 0.7–3.3) was significantly shorter than GIP resection time (3.3 min, IQR 2.5–6.0; 3.5 min, IQR 2.5–5.0, respectively). In detail, median UWP resection time was significantly quicker than GIP for lesions of any morphology in the range of 6–19 mm (*p* from 0.040 to <0.001).

En bloc resections by polyp morphology and size, and the proportion of R0 resections were comparable.

Adverse events

These are reported in Table 4. No post-polypectomy syndrome or perforation cases occurred. UWP showed a lower, but comparable, proportion of adverse events than GIP (8.2% vs 12.3%, respectively; *p* = 0.369), mostly immediate bleeding episodes: 7.2% vs 11.8%. When stratifying by polyp morphology, immediate bleeding episodes for pedunculated lesions were significantly lower in the UWP than in the GIP group: 3.4% vs 13.5%, *p* = 0.019, due to lower occurrence in the cohort of lesions 6–19 mm in size (*p* = 0.031).

Overall, hemoclip use for sessile and flat lesions was comparable, also by polyp size. For pedunculated polyps, hemoclip use was significantly lower in the UWP than in the GIP group (4.6% vs 13.5%, respectively; *p* = 0.045), their use was less frequent for lesions 6–19 mm in size. Use of APC was comparable.

Follow-up surveillance colonoscopies

Forty patients with sessile or flat adenomas resected piecemeal (18 UEMR, 22 EMR) accepted to undergo short-term follow-up (median 14 months, IQR 3.5–21). Of them, 36 (90%; 16 UEMR, 20 EMR) returned to repeat the procedure. Biopsies were taken from post-polypectomy scars to rule out the presence of neoplastic tissue. Only three patients in the GIP group had a recurrent or residual neoplasia.

Table 3. Histology and resection outcomes.

Variable		Underwater polypectomy n = 195 (51.2)	Gas insufflation polypectomy n = 186 (48.8)	p Value
Histology, n (%)				0.195
Adenoma		171 (87.7)	162 (87.1)	
Hyperplastic		11 (5.6)	17 (9.1)	
Carcinoma in situ		9 (4.6)	3 (1.6)	
Invasive cancer		2 (1.0)	1 (0.5)	
Other benign lesion		2 (1.0)	3 (1.6)	
Resection time in minutes, median (IQR)				
Sessile and flat polyps, overall		2.0 (0.8–5.0) n = 64	3.3 (2.5–6.0) n = 75	0.002
6–9 mm		0.8 (0.6–3.5) n = 17	2.7 (2.0–3.4) n = 25	0.040
10–19 mm		2.0 (0.8–4.5) n = 37	3.3 (2.5–5.0) n = 35	0.025
≥20 mm		7.0 (1.4–16.2) n = 10	10.0 (7.0–13.3) n = 15	0.579
Pedunculated polys, overall		1.0 (0.7–3.3) n = 55	3.5 (2.5–5.0) n = 63	<0.001
6–19 mm		0.8 (0.7–2.0) n = 43	3.3 (2.5–5.0) n = 54	<0.001
≥20 mm		4.3 (1.4–7.8) n = 12	5.3 (4.2–8.5) n = 9	0.355
Resection outcomes, n (%)				
Sessile and flat polyps				
En bloc	Size category (mm)			
	6–9	27 (100)	35 (100)	NC
	10–19	51 (81.0)	46 (79.3)	0.821
	≥20	7 (38.9)	5 (26.3)	0.414
Piecemeal	Size category (mm)			
	6–9	0 (0)	0 (0)	NC
	10–19	12 (19.0)	12 (20.7)	0.821
	≥20	11 (61.1)	14 (73.7)	0.414
Pedunculated polyps				
En bloc	Size category (mm)			
	6–19	64 (98.5)	60 (95.2)	0.361
	≥20	22 (100)	11 (100)	NC
Piecemeal	Size category (mm)			
	6–19	1 (1.5)	3 (4.8)	0.361
	≥20	0 (0)	0 (0)	NC
R0[a] resections, n (%)				
Sessile and flat polyps, overall		83 (97.6)	86 (100)	0.246
6–9 mm		27 (100)	35 (100)	NC
10–19 mm		49 (96.1)	46 (100)	0.496
≥20 mm		7 (100)	5 (100)	NC

IQR: interquartile range; NC: not calculated.
Polyp morphology assignment: flat, 0-IIa and 0-IIb; sessile, 0-Is; pedunculated, 0-Ip.[13] For categorical variables, p values were obtained using Chi Square test or Fisher's exact test, as appropriate. For continuous variables, p values for comparison of the group medians were obtained using Mann-Whitney U test.
[a]En block with uninvolved margins.

Table 4. Adverse events.

Adverse events, n (%)	Underwater polypectomies n = 195	Gas insufflation polypectomies n = 186	p Value
Overall			0.369
Immediate bleeding	14 (7.2)	22 (11.8)	
Delayed bleeding[a]	2 (1.0)	1 (0.5)	
Immediate bleeding			
Sessile and flat polyps, overall, n (%)	11 (10.2) n = 108	12 (10.7) n = 112	0.898
6–9 mm	1 (3.7) n = 27	1 (2.9) n = 35	>0.999
10–19 mm	5 (7.9) n = 63	9 (15.5) n = 58	0.193
≥20 mm	5 (27.8) n = 18	2 (10.5) n = 19	0.232
Pedunculated polyps, overall, n (%)	3 (3.4) n = 87	10 (13.5) n = 74	0.019
6–19 mm	1 (1.5) n = 65	7 (11.1) n = 63	0.031
≥20 mm	2 (9.1) n = 22	3 (27.3) n = 11	0.304
Management			
Hemoclip use, overall, n (%)	14 (7.2)	22 (11.8)	0.121
Sessile and flat polyps, overall, n (%)	10 (9.3)	12 (10.7)	0.719
Pedunculated polyps, n (%)	4 (4.6)	10 (13.5)	0.045
6–19 mm	2 (3.1)	7 (11.1)	0.093
≥20 mm	2 (9.1)	3 (27.3)	0.304
Use of argon plasma coagulation,[b] n (%)	4 (21.1)	1 (4.3)	0.158

Polyp morphology assignment: flat, 0-IIa and 0-IIb; sessile, 0-Is; pedunculated, 0-Ip.[13] For categorical variables, p values were obtained using Chi Square test or Fisher's exact test, as appropriate.
[a]Delayed bleeding occurred in two underwater polypectomy resections (one flat and one pedunculated polyp, respectively, each with a diameter of 15 mm) and in one gas insufflation polypectomy resection (pedunculated polyp with a diameter of 10 mm).
[b]All sessile or flat polyps.

Discussion

In October 2014, after adopting UEMR, we further extended the technique to the underwater resection of all polyps. To the best of our knowledge, our is the first study comparing UWP and GIP with data recorded in routine clinical settings at two community hospitals, including pedunculated lesions and with procedures performed by endoscopists with different expertise. In the current study, notwithstanding a relatively short transition time from traditional GIP to UWP, the latter achieved comparable proportions of en bloc and R0 resections with the advantages of the avoidance of submucosal injection (flat lesions), a significantly

shorter resection time (all polyp morphologies with size of 6–19 mm) and less immediate bleeding episodes for pedunculated polyps of 6–19 mm.

During conventional polypectomy, insufflated gas flattens polyps and thins the wall of the colon.[4,5] This lead to the introduction of EMR to decrease the risk of iatrogenic damage to the colon wall.[1] However, submucosal injection under flat lesions increases tissue tension and may paradoxically flatten the polyp relative to the surrounding tissue,[4] making its ensnarement more difficult or impossible.[4,22] Injection may displace the polyp into a less accessible location or constrict the lumen, hampering access to the lesion.[4] Furthermore, there is the risk of dysplastic seeding into deeper wall layers;[23] or the inadvertent injection outside the bowel wall may trigger local peritonitis and infection.[4]

UEMR is a safe and effective technique, relatively easy for experienced endoscopists,[4,8–11] obviating the aforementioned drawbacks of submucosal injection, and the accidental capture of the circular muscular layer of the colon wall with the resecting snare is less probable.[4] Compared with GIP, a heat-sink effect has been described for UEMR.[24] Theoretically this should reduce the risk of a deeper transmural burn.

While transitioning from GIP to UWP, we found the latter easier to capture and resect lesions. We personally observed that infusing water to perform UWP floats the head of pedunculated polyps toward the center of the lumen, allowing for easier and precise snaring mid stalk, particularly helpful when the stalk is kinked. Change of patient position to put the polyp in the best position for ensnaring and resection is needed less frequently than when using GIP. Interestingly, apart from pedunculated polyps of 6–19 mm, polyp distribution, morphology, size, en bloc, and R0 resections were comparable between groups, and yet UWP resections of polyps of 6–19 mm (any morphology) were significantly quicker than in GIP (Table 3). This may have an impact in cases of multiple resections, where more insufflation is used, which can lead to more colon distention and associated discomfort or pain.[25]

Immediate bleeding following polyp resection is not considered an adverse event unless it results in hospitalization, transfusion, or surgery.[5,9,26] For the purposes of our study we counted as adverse events all episodes of immediate bleeding lasting more than 30–60 s after washing the site of resection, and resistant to snare-tip coagulation. Immediate bleeding occurred less frequently in the UWP group, significantly so for pedunculated lesions of 6–19 mm, generally a preferred and easy target since their stalks are cut at some distance from the colon wall, minimizing the risk of perforation.[1] Our observations suggest that UWP can offer a safer approach for the resection of pedunculated

lesions within this size range. However, since UWP and GIP lesions were resected with different electrosurgical generator settings, as also previously reported,[11] the observed differences might be related to the settings themselves, underwater resection, or both.

We speculate that immediate bleeding episodes were less frequent in the UWP group because of the latency between the application of the current and actual cutting. Anecdotally, when performing the procedure underwater a few seconds are required before the snare starts cutting into the ensnared tissue. It is conceivable that during UWP, delayed conduction and heat sink slightly prolongs the resection time, causing more coagulation along the cutting plane.

Within the timeframe of the current study, 108 submucosal injections were avoided to resect sessile and flat lesions using UWP, generating overall savings of about €2,394 (injection needles, €1,944; solution for submucosal injection, €450). The savings generated by UWP regarding only clinically significant lesions ($\geq 10\,mm$, $n = 81$) added up to about €1,796 (injection needles, €1,458; colloidal solution, €338). Moreover, using UWP a cumulative time of 119 min was saved to resect all lesions (UWP = 514 min, GIP = 663 min, respectively).

In the UWP group, hemoclips were used less frequently than in the GIP group to treat bleeding originating from pedunculated lesions, especially those 6–19 mm in size. However, the savings generated by the less frequent use of hemoclips, which application varies widely in clinical practice at different hospitals, were marginal and partially offset by the use of APC. The issue of the economical impact of UWP deserves to be investigated in future studies.

The high proportions of R0 resections are likely due to the predominant number of lesions of small and intermediate size. The sample of polyps $\geq 20\,mm$ is small, and outcomes relative to this subgroup analysis should be interpreted with caution.

We did all resections without using EUS, and yet only two cases (0.9%) of infiltrating cancer occurred in three lateral spreading tumors. This is consistent with the affirmation that EUS may not be routinely required before the resection of colorectal lesions that were adequately evaluated.[17,18]

Our follow-up comprised of a limited number of patients. The observation that the only three cases showing residual or recurrent neoplasia were in the GIP group is consistent with the reported lower proportion of recurrences of UEMR vs EMR, e.g. for the resection of large lesions.[11]

Our study has some strengths. Resection time, when available, was collected prospectively. The follow-up extended up to 22 months. Unlike previous reports of single tertiary-care centers with single endoscopists or performed by experts in this field,[5–10] underwater resection of polyps was done in routine clinical settings at two community hospitals. This should provide reproducibility and generalizability of our results.

Our study also has some limitations. The analysis is retrospective. Resection time was available only for 67.5% of cases. Uncertainty resulting from selection and operator must be taken into account. However, their influence should have been limited, e.g. endoscopists judged UWP pedunculated lesions significantly bigger (Table 2), and yet adopted this technique. Nevertheless, the UWP technique might have changed, and adverse events thereby decreased over time, as the endoscopists gained experience, even if the study spanned a limited amount of time. Our patients' records were accurately updated, and yet some adverse events occurring after discharge might have been missed.

In conclusion, most outcomes between the novel UWP and the time-tested GIP were comparable. Our data suggest that in everyday clinical practice transition to UWP can be implemented for the complete resection of colon lesions, irrespective of their size, with shorter resection time (lesions of 6–19 mm) and lower bleeding episodes (pedunculated polyps 6–19 mm). Based on this evidence, the use of UWP should be encouraged. Further randomized trials are needed to confirm our observations.

Informed consent

Written informed consent was obtained from each patient at enrollment in clinical studies and before polyp resection.

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