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Background and aims

Colonic ESD is particularly challenging and limited to few experts' centers. We recently conducted a pilot study about improvement of colonic ESD thanks to a systematic use of a countertraction device (double-clip traction with rubber band (DCT-ESD).

Materials and methods

French prospective multicenter study between March 2017 and September 2019, including all consecutive cases of naïve colonic ESD. Since the first case of DCT ESD in March 2017, all colonic ESD cases have been performed using DCT-ESD strategy in the 3 centers involved in the study.

Results

Five hundred ninety-nine lesions with a mean size of 53 mm were included in this study, resected by 5 operators in 3 centers. The en-bloc, R0 and curative resection rates were respectively 95.7%, 83.5%, and 81.1%. The adverse event rates were 4.9% for perforation and 4.2% for postprocedure bleeding. Between 2017 and 2019, the rates of R0 and curative resections increased significantly, from 74.7% in 2017 to 88.4% in 2019 ($p = 0.003$) and from 72.6% in 2017 to 86.3% in 2019 ($p = 0.004$), respectively. Procedure duration and speed of resection were 62.4 minutes and 39.4 mm^2/min respectively. No difference was noted between operators.

Conclusion

The DCT-ESD is a safe and reproducible technique, allowing to obtain carcinological results comparable to those of the large Japanese teams with speed of resection twice higher as previous reported studies. The DCT strategy is promising, cheap and seems to be reproducible. Physicians performing colonic ESD should be aware of this promising tool to improve their results in ESD.

BACKGROUND AND AIMS

Endoscopic submucosal dissection (ESD) was developed in Japan in the 2000s, initially for resection of superficial gastric cancers larger than 2 cm in diameter (1–4). A few years later, ESD became the gold standard treatment for large superficial colorectal lesions (5). The en-bloc and R0 resection rates are higher, and the recurrence rate lower, than those of endoscopic mucosal resection (EMR), and use of the technique is not limited by the size of the lesion (6–10). One-piece resection of large lesions via ESD is essential if the submucosal cancer risk is high; piecemeal resection may be noncurative, creating a need for morbid rescue surgery (11–13). ESD has become widely adopted in Europe, and many centers routinely use ESD to treat large rectal lesions. However, ESD of colonic lesions is limited to a few expert centers (5,14–18). The colonic submucosa is thin and frequently fibrotic. Peristaltic movements, the thinness of the muscularis, and difficulty in manoeuvring the scope through the colonic loops render colonic ESD particularly challenging, much more so than rectal, stomach or esophageal treatment. The high cost (19), long operative times, and relatively poor results of ESD in Western countries (unlike in Japan), as well as the good results of piecemeal EMR, have ignited a passionate debate between advocates of fragmented EMR and those of ESD for treatment of large benign lesions (20–23). We recently published a promising and simple strategy that significantly improved the results of colorectal ESD. We placed the lesion under mechanical traction using a rubber band and 2 clips. This improved exposure of the submucosal space, which is key in terms of efficient and safe ESD (24–27). Our pilot study of double clip and rubber band (DCT)-ESD for large, superficial colonic lesions revealed improved R0 resection, a 3-fold decrease in the perforation rate (from 15% to 5%), and a 2-fold increase in the ESD speed (28). We thus performed a large multicenter validation study of DCT-ESD for large, superficial colorectal lesions.

Patients and Methods

Study design

We retrospectively analyzed a prospective consecutive database maintained by 3 French centers IRB approved (87RI20-0021_FECCo; NCT04592003). Since the first DCT-ESD performed (March 2017), all colonic ESDs have used the DCT strategy, implemented by 5 operators in the centers. The Ethics Committee of Limoges University Hospital approved the study, and a “no opposition to data use” form (mandated by French legislation dealing with RIPH3-type studies) was sent to all patients, who then provided written informed consent.

Operators

All procedures were performed by 5 young (mean age 35 years at the beginning of the study) operators (J.R., R.L., T.W., M.P., and J.J.) experienced in ESD. All had extensive animal experience, and all had performed approximately 150 human procedures, including at least 50 rectal ESDs, before study commencement. At that time, 1 operator had no experience with colonic ESD, 3 had experience with less than 30 such procedures, and 1 had experience with approximately 50 colonic ESDs. One operator went to Japan for 12 months of training at a center with colonic dissection expertise.

Inclusion criteria

All naïve colonic lesions treated by ESD were included prospectively and consecutively. In this intention-to-treat study, all patients were included from the time at which ESD was initiated, regardless of whether ESD was discontinued before traction was applied.

Exclusion criteria

Lesions exhibiting significant fibrosis were excluded, as were cases of post-EMR or postsurgical recurrence (29), lesions invading the appendix (24) or diverticula, dysplastic lesions of inflammatory bowel disease, lesions that had previously been tattooed or deeply anchored with clips, lesions invading the ileocecal valve, and submucosal lesions.

DCT-ESD procedure

It was unnecessary to mark the colonic lesion, as lesion demarcation was clear when using the most recent high-definition endoscopes (Fujifilm EC760 and Olympus H190) (Fig. 1, Video 1). First, a hemicircumferential or circumferential mucosal incision was created around the lesion after submucosal injection of a sodium chloride/glycerol mixture or Voluven using the Endocut I current created by the VIO model 3 generator (Erbe Medical, Germany). Initial submucosal dissection (trimming) was then immediately performed using Endocut I current or via swift coagulation all around the lesion. The first clip for the rubber band was inserted through the working channel and positioned on the anal part of the lesion. The second clip grasped the rubber band attached to the lesion and was placed on the opposite wall of the colon (thus in front of the lesion), increasing the submucosal space. Fox rubber band 3D (1/4''), 3-1/2 OZ. (ORMCO^{R}) and repositionable clips were used. (Boston resolution 360 Boston Scientific USA or Quick clip Pro Olympus USA). Submucosal dissection was performed using Endocut I current or swift coagulation. At the end of the procedure, the specimen remained attached to the colonic wall by the second clip and was removed using a 10-mm polypectomy snare with gentle traction. Prophylactic coagulation of the resection bed was performed using coagulation forceps. CO_2 inflation was used during all procedures.

Definitions

R0 resection exhibited tumor-free vertical and lateral margins. Curative resection was R0 resection with no lymphovascular invasion, no undifferentiated tissue, no budding, and no submucosal infiltration deeper than 1,000 μm. The surface area of each specimen was calculated using the following formula: area (mm^2) = (smaller diameter (mm)/2) x (larger diameter (mm)/2) x π. The procedure duration (minutes) was the time between the first submucosal injection and cutting of the last submucosal fiber. The resection speed was (mm^2/min) calculated as the area divided by duration.

Objectives

The primary objective was DCT-ESD efficacy (en-bloc, R0, and curative resection rates). We evaluated the recurrence rate by means of a colonoscopy performed between 6 and 12 months. The secondary objectives were the results according to the operators, according to the experience and identification of factors predicting R0 resection and perforation.

Statistical analysis

Categorical variables are described as frequencies with percentages and quantitative variables as means with standard deviations. The Fisher exact test and the χ^2 test were used to compare categorical variables and the Wilcoxon rank-sum test to compare continuous variables. After assessment of possible collinearity (using the variance inflation factor), 2 logistic regression models were built using the backward stepwise selection method, with R0 resection and perforation as the dependent variables. Independent clinically relevant predictors identified by univariate analyses ($p<0.2$) were entered into the model using the "10 events per variable" rule. All tests were 2-sided, and statistical significance was set at $p=0.05$. All analyses were performed using R open source software ver. 3.4.4 (available online at http://www.R-project.org).

Results

Flow chart

Between March 2017 and September 2019, the 5 operators performed 1,098 colorectal ESDs, of which 599 colonic DCT-ESDs (569 patients) were included after application of the exclusion criteria (Fig. 1). The excluded procedures included 374 rectal ESDs and procedures for 37 lesions involving the appendix, 61 recurrence cases after piecemeal EMR, 8 lesions involving diverticula, 6 lesions with tattoos underneath, 4 dysplastic inflammatory bowel disease lesions, and 3 submucosal lesions.

Patient and lesion characteristics

The study population was 60% male, and the mean age was 68.4 ± 10 years (Table 1). Of all patients, 9% were treated with anticoagulants and 20% with anti-platelet therapies. Most lesions were lateral spreading tumours (LSTs) (85.8%). Over 2/3 (68.4%) of the lesions were located proximal to the splenic flexure, of which 58.9% were in the right colon. The average specimen maximum diameter was 53 ± 22 mm, and 51% of the lesions were larger than 50 mm in diameter.

The procedures

Of all procedures, 90.6% were performed using a dual J knife (Table 2). The injection fluid was glycerol in 81% of the cases. Severe submucosal fibrosis was encountered in 28.5% of cases. The mean procedure duration was 62±52.7 minutes and the mean resection speed 39.1±24.3 mm^2/min. Histologically, 29.4% of lesions were low-grade dysplasia adenomas (Vienna 3), 43.7% high-grade dysplasia adenomas (Vienna 4.1), 15.6% intramucosal adenocarcinomas (Vienna 4.4), 3% superficial submucosal cancers (pT1a), 4.1% deep submucosal cancers (pT1b), 2.7% sessile serrated adenomas, and 0.5% T2 adenocarcinomas. Only 6 specimens were damaged (torn) by the tensile force applied by the clips and rubber band. The adverse events included 29 (4.9%) perforations and 25 (4.2%) cases of post-procedural bleeding.

I.1.1. Primary objective

The rates of en-bloc, R0, and curative resection were 95.7% (573/599), 83.5% (500/599), and 81.1% (486/599), respectively (Table 3). Of the 25 patients in whom en-bloc endoscopic resection failed, 16 were successfully converted to piecemeal EMR during the procedure, and 9 were surgically managed for complete failure of endoscopic resection. The 99 R1 procedures included these lesions and 74 en-bloc resections with positive margins. The 113 noncurative resections featured 99 R1 procedures and 14 procedures for lesions with unfavorable histological results. Thirty-nine (6.6%) patients required post-ESD surgery, most because ESD was noncurative due to pathological poor prognostic factors. Only 4 patients (0.6%) required secondary surgeries because of adverse events (perforations). Of all patients, 173 (29%) were endoscopically controlled during follow-up, and 6 (3.4%) exhibited endoscopic recurrences that were successfully treated during the first endoscopic control. Of these patients, 120 underwent R0 resection, 39 en-bloc R1 resection, and 14 piecemeal EMR after ESD failure. Two (1.7%) recurrences occurred in patients with R0 resection, 2 (14.3%) in patients treated via rescue piecemeal EMR, and 2 (5%) in patients with R1 en-bloc resected lesions.

Secondary objectives

Operators

There were few significant differences between the operators in terms of the lesion characteristics (macroscopic aspects, vascular appearance according to the SANO classification, size, or histological diagnosis) (Table 4). We found significant differences in terms of procedure duration and resection speed, in that 1 operator was significantly faster than the other 4. There were no significant differences in terms of en-bloc or R0 resection or adverse events. All operators had an R0 resection rate > 80%.

Comparison by year

Ninety-five (15.9%) lesions were resected in 2017, 219 (36.6%) in 2018, and 285 (47.5%) in 2019 (Table 5). The lesions were roughly comparable in terms of size and location, but a significant decrease in procedure time (from 95 minutes in 2017 to 50 minutes in 2018; $p<0.0001$) and a major increase in resection speed (from 28 mm^2/min in 2017 to 41.7 mm^2/min in 2019) were evident. The R0 and curative resection rates improved from 74.7% in 2017 to 88.4% in 2019 ($p=0.003$) and from 72.6% in 2017 to 86.3% in 2019 ($p=0.004$), respectively. In contrast, there were no changes in the rate of en-bloc resection, per-procedure perforation, or post-procedure bleeding.

Risk factors for R0 resection

On multivariate analysis, lesions located on the ileocecal valve and poor endoscope manoeuvrability were the only 2 risk factors for non-R0 resection. Nongranular LST subtype was a positive predictor of R0 resection (Table 6).

Risk factors for perforation (Table 7)

On multivariate analysis, the predisposing factors for perforation were severe fibrosis (odds ratio [OR], 3.7; 95% confidence interval [CI], 1.3–10.2; $p=0.012$), and specimen size >50 mm (OR, 3.2; 95% CI, 1.2–8.4; $p=0.021$).

Discussion

This is the largest study of colonic ESD performed in the West. Systematic use of our previously reported DCT strategy affords oncological results similar to those of the best Japanese teams (en-bloc resection success rate 95.7%, R0 rate 83.5%, curative rate 81.1%). These results are significantly better than those of earlier reports. The recent meta-analysis by Fuccio et al (30) reported colorectal ESD en-bloc and R0 resection rates of 81.2% and 71.3% in non-Asian countries; these figures are approximately 93% and 85.6% in Asia. The safety data are also significantly better (4% perforation rate, but only 0.7% of patients required further

surgery). In the above-mentioned meta-analysis, the perforation rate was 8.6% (3.1% requiring surgery) in non-Asian countries, compared with 4.5% and 0.8% in Asian countries. Our lesions were not “simple”; over half were larger than 50 mm, a well-known cut-off in terms of difficulty, and 70% were located above the splenic flexure (31). Moreover, our pilot study recently published suggest 3 times decrease of the perforation rate in our hands using the DCT strategy thanks to a better exposure of the dissection plane (28). We excluded rectal lesions that are easy to treat via ESD, given the perfect endoscope manoeuvrability, possibility of using gastroscope, thicker submucosa and muscularis propria, and assistance of gravity.

Countertraction with a rubber band acts as an additional left hand for the surgeon, considerably simplifying colonic resection and anti-gravity ESD. Gravity is the first point to be considered when performing colonic ESD; it is important to maximise access to the submucosal layer. However, unlike ESD of the rectum, it is not always easy to exploit gravity during colonic surgery, even by changing the patient’s position. Recently, Iacopini et al (14) reported that positional changes did not harness the power of gravity in 22% of colonic ESD cases, compared with only 3% of rectal ESD cases. When using the DCT strategy, we prioritise perfect scope manoeuvrability using unhelpful gravity rather than helpful gravity with poor scope manoeuvrability, which is an important risk factor for non-R0 resection and adverse events.

Other traction strategies have been reported (32), and a recent meta-analysis of randomized controlled trials (33) confirmed the superiority of traction ESD compared with standard ESD in terms of the perforation rate and resection speed but not the R0 resection rate. However, all studies were those of expert Asian teams who had already achieved very high R0 resection rates in their control groups. In an editorial of the journal issue in which (33) appeared (34), Professor Saito concluded that traction ESD is mandatory for Western physicians when treating difficult appendiceal (27) or recurrent lesions (29). However, is procedure duration really of low importance? In our opinion, decreasing the procedure time by improving the resection speed is important. Reimbursement systems and endoscopic unit organizations differ between Western countries and Japan; the long ESD procedure time is one of the most important factors limiting the expansion of colonic ESD to Western countries (20,35,36). In the last year (2019) of our study, 289 colonic ESDs were performed, with a 96% en-bloc resection rate and an 88% R0 resection rate; the mean procedure time was 50 minutes for 50-mm lesions (42 mm^2/min). This is twice the speed of the pocket method of Yamamoto et al. (37,38) Time is money, even in Japan! Procedure duration is not considered important by experts who favour piecemeal EMR over ESD when treating large, benign colorectal lesions. A recent U.S. study (39) on piecemeal EMR, including clip closure of the mucosal scar, reported a procedure duration of 63 minutes for 40-mm colonic lesions, thus longer than our 50-minute time in 2019. Decreasing procedure duration is also better for patient safety in terms of sedation/anesthesia.

However, these data are preliminary data and need to be confirmed by a randomized trial.

DCT is inexpensive. Two hundred rubber bands cost 6 Euros. Compared with other traction systems, our rubber band and clips can pass through the working channel without endoscope removal, and the countertraction adapts to inflation given the elasticity of the rubber band. Only 6 (1%) specimens were damaged by the clips; no adverse event was encountered when removing clips attached to the colonic wall.

The strengths of our study include its multicenter design (5 operators). To date, only 3 colorectal ESD studies in non-Asian countries have been performed by multiple operators (40–42). No significant difference was evident among our 5 operators. Our results suggest a reproducibility of the DCT strategy that enhances efficiency(43). They improved over the course of the study to attain 96% en-bloc and 88% R0 resection rates during the last year of the study (2019, n=289). A learning curve effect could not be eliminated, however at the beginning of the study, the 5 operators were considered experts in France and they had each performed around 150 ESDs.

Also, we retrospectively analysed a consecutive prospective database containing details on all lesions for which ESD was attempted, in an intention-to-treat study. Twelve lesions (2.3%) exhibited endoscopic features of deep invasion, but patients were unfit for surgery. Treating these lesions by ESD lowered the R0 resection rate. The mean lesion size was 53 mm, and over half were larger than 50 mm. In the Asian literature, the mean size is 32 mm (30). Our results would be even better if we considered only the 283 lesions smaller than 50 mm: 96.5% en-bloc and 86% R0 resection rates, 2% perforation and bleeding rates, and a 42-minute procedure duration.

The principal limitation was the nonrandomized design. However, as before, we consider it unethical to randomize patients to standard ESD, as do others.

Finally, which of ESD or piecemeal EMR is optimal for treating large benign lesions of the colon? The efficacy of the DCT strategy in terms of R0 resection, the perforation rate, and the procedure time renders the Japanese approach possible. ESD has a higher intraprocedural cost than that of piecemeal EMR, but this is balanced by the costs of the (several) post-piecemeal EMR control colonoscopies (44). A randomized trial is ongoing, in which the 2 strategies will be compared from a medico-economical viewpoint after 3 years.

Conclusion

In conclusion, systematic DCT countertraction during colonic ESD yields results similar to those of the best Japanese teams. The DCT strategy is promising, cheap and seems to be reproducible. Physicians performing colonic ESD should be aware of this promising tool to improve their results in ESD. A randomized control trial comparing piecemeal EMR and DCT-

ESD is urgently needed to determine whether the Japanese “ESD for all” approach should be mandatory in the West.

Legends :

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Table 2: Procedural characteristics

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Table 6: Univariate and multivariate analyses of predictive factors for R0 resection

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Figure 1: Flow chart of the study

Figure 2: Description of the DCT strategy for colonic ESD. A, Mucosal Incision and trimming. B, Positioning the first clip and the rubber band of the distal part of the lesion. C, Positioning the second clip on the opposite wall of the colon. D, End of the resection. E, Removing the specimen with a 10 mm snare.

Video: Description of the DCT Strategy for colonic ESD

-Large LST-NG of the right colon segment

-Mucosal Incision and trimming

-Positioning the first clip and the rubber band of the distal part of the lesion

-Positioning the second clip on the opposite wall of the colon

-End of the resection

-Removing the specimen with a 10 mm snare

Patients, n=569		
	Sex M:F, n (%)	360 (60):239 (40)
	Age (years)	68.4 (±10)
	Antiplatelet agents, n (%)	123 (20.7)
	Anticoagulant agents, n (%)	54 (9.1)
Lesions, n=599		**n (%)**
	G-LSTs	335 (57.4)
	NG-LSTs	165 (28.3)
	Protruding lesions	75 (12.8)
	Sessile serrated lesions	8 (1.4)
SANO classification		**n (%)**
	SANO I	18 (3.5)
	SANO II	291 (56.1)
	SANO IIIA	198 (38.2)
	SANO IIIB	12 (2.3)
Location		**n (%)**
	Sigmoid	117 (19.6)
	Left colon segment	42 (7)
	Splenic flexure	30 (5)
	Transverse colon	57 (9.6)
	Hepatic flexure	101 (16.9)
	Right colon segment	133 (22.3)
	Ileocecal valve	31 (5.3)
	Cecum	86 (14.4)
Year of resection		**n (%)**
	2017	95 (15.9)
	2018	219 (36.6)
	2019	285 (47.6)
Operator		**n (%)**
	1	109 (18.2)
	2	131 (21.9)
	3	166 (27.7)
	4	116 (19.4)
	5	77 (12.9)

Table 1: Patients characteristics

G-LST: Granular-Laterally spreading tumors, NG-LST: Nongranular-Laterally spreading tumors

Table 2: Procedural characteristics

Lesion size			
		Mean ± SD (mm)	53 (± 22)
		>50 mm, n (%)	304 (51.4)
ESD knife			n (%)
		Dual J knife	538 (90.6)
		Hybrid T knife	48 (8.1)
		Splash M knife	5 (0.8)
		Flush knife	3 (0.5)
> 1 knife		n (%)	
		26 (4.4)	
Submucosal solution			n (%)
		Glycerol	388 (81)
		Hydroxyethyl starch	83 (17.3)
		Orise gel	5 (1)
		NaCl solution	2 (0.4)
		Hyaluronic acid	1 (0.2)
Vascularisation			n (%)
		V1	312 (52.5)
		V2	203 (34.2)
		V3	79 (13.3)
Fibrosis			n (%)
		F0	218 (42.6)
		F1	148 (28.9)
		F2	146 (28.5)
Procedure duration			min
		Mean (± DS)	62.4 (± 52.7)
Resection speed			mm^2/min
		Mean (± DS)	39.1 (± 24.3)
Pathological analysis			n (%)
		Low-grade dysplasia (Vienna 3)	174 (29.4)
		High-grade dysplasia (Vienna 4.1 and 4.2)	258 (43.7)
		Intramucosal carcinoma (Vienna 4.4)	92 (15.6)
		sm ≤1,000 µm (pT1a)	18 (3)
		sm >1,000 µm (pT1b)	24 (4.1)
		T2	3 (0.5)
		Sessile serrated adenoma	16 (2.7)
Complications			n (%)
		Perforation	29 (4.9)
		Postoperative haemorrhage	25 (4.2)
Secondary surgery			n (%)
	39 (6.6)		
		Pathological cause	26 (4.3%)
		Resection failure	9 (1.5%)
		Perforation	4 (0.6%)

Vascularisation V1: low V2: moderate, V3: high

Fibrosis F0: no, F1: moderate, F2: high

Table 3: Carcinological results

En-bloc resection	**n (%)**	
	573 (95.7)	
R0 resection	n (%)	
	500 (83.5)	
Curative resection	n (%)	
	486 (81.1)	
R1 (99)		
En-bloc (74)	Positive lateral margin (55)	• Low-grade dysplasia: 13 • High-grade dysplasia: 41 • Adenocarcinoma: 1
	Positive vertical margin (19)	
Piecemeal (25)		
Noncurative resection (113)		
R1 (99)		
R0 with poor prognostic features (14)	• Emboli: 5 • Budding: 7 • Sm > 1,000: 9 • Poor differentiation: 1	
First control recurrence (n=173)		
	• 6 (3.4%)	• R0: 2/120 (1.7%) • R1: 2/39 (5.1%) • Piecemeal: 2/14 (14.3%)

Table 4: Results by operators

Operator		1	2	3	4	5	*P* value
Number of lesions	n						
		109	131	166	116	77	
Age	(year)						
		69.8	68.1	68.6	68.3	66.1	0.253
Sex							
	Male	60	53	64	60	65	
	Female	40	47	36	40	35	0.353
Type of lesion	%						
	G-LST	61	52	62	53	60	
	NG-LST	21	31	33	27	26	
	Protruding lesion	15	17	5	16	14	
	Sessile serrated lesion	3	0	0	4	0	0.009
SANO classification	%						
	SANO I	0	7	1	1	10	
	SANO II	70	34	50	60	72	
	SANO IIIA	30	57	41	38	18	
	SANO IIIB	0	2	8	1	0	<0.0001
Lesion location	%						
	Sigmoid	16	18	20	26	18	
	Left colon segment	8	9	5	7	7	
	Splenic flexure	5	7	4	4	7	
	Transverse colon	9	13	10	7	6	
	Hepatic flexure	24	17	13	18	14	
	Right colon segment	20	19	26	21	21	
	Ileocecal valve	5	2	7	5	8	
	Cecum	13	15	15	12	19	0.517
Anticoagulants	%						
		6%	13%	12%	9%	1%	0.032
Antiplatelets	%						
		25%	20%	24%	20%	9%	0.067
Mean lesion size	mm						
		60	48	58	52	45	<0.0001

% of lesions >50 mm	%						
		61	40	62	55	27	<0.0001
Procedure duration	min						
		86	54	52	69	55	<0.0001
Resection speed	mm^2/min						
		36	38	52	32	30	<0.0001
Pathological analysis	%						
	Low-grade dysplasia (Vienna 3)	35	24	19	47	26	
	High-grade dysplasia (Vienna 4.1 and 4.2)	38	52	53	26	49	
	Intramucosal carcinoma (Vienna 4.4)	19	10	14	16	22	
	sm ≤1,000 µm (pT1a)	5	2	4	4	0	
	sm >1,000 µm (pT1b)	0	5	8	3	3	
	T2	0	0	1	2	0	
	Sessile serrated adenoma	3	7	1	2	0	<0.0001
Complications	%						
	Perforation	7	6	3	5	3	0.409
	Postprocedure bleeding	7	2	3	5	4	0.339
En-bloc resection	%						
		95.4	96.2	96.4	95.7	93.5	0.883
R0 resection	%						
		80.7	85.5	83.1	83.6	84.4	0.903
Curative resection	%						
		79.8	84	78.9	81	83.1	0.819

Table 5: Results by year

Year		2017	2018	2019	*P* value
Number of lesions	n				
		95	219	285	
Type of lesions	%				
	G-LST-G	67	49	61	
	NG-LST	26	33	26	
	Protruding lesion	7	17	11	
	Sessile serrated lesion	0	1	2	**0.005**
SANO classification	%				
	SANO I	0	2	5	
	SANO II	52	58	55	
	SANO IIIA	45	38	36	
	SANO IIIB	3	2	4	**0.201**
Location of lesions	%				
	Sigmoid	28	20	17	
	Left colon segment	8	9	5	
	Splenic flexure	5	4	6	
	Left transverse	3	6	4	
	Right transverse	0	6	6	
	Hepatic flexure	16	15	19	
	Right colon segment	22	22	22	
	Ileocecal valve	2	4	7	
	Cecum	16	14	14	**0.179**
Anticoagulants	%				
		11	11	7	**0.276**
Antiplatelets	%				
		25	24	17	**0.070**
Mean size	mm				
		57	54	52	**0.058**

Lesion > 50 mm	%				
		60	53	48	**0.108**
Procedure duration	min				
		96	64	51	**<0.0001**
Resection spedd	**mm^2/min**				
		28	40	42	**<0.0001**
Pathological analysis	%				
	Low-grade dysplasia (Vienna 3)	28	28	31	
	High-grade dysplasia (Vienna 4.1 and 4.2)	46	48	42	
	Intramucosal carcinoma (Vienna 4.4)	15	14	17	
	sm ≤1,000 µm (pT1a)	4	3	3	
	sm >1,000 µm (pT1b)	6	4	3	
	T2	1	1	0	
	Sessile serrated adenoma	0	2	4	**0.0009**
Complications	%				
	Perforation	6.3	5.1	4.2	**0.709**
	Postprocedure bleeding	3.2	5.6	3.5	**0.446**
En bloc resection	%				
		94.7	95.4	96.1	**0.827**
R0 resection	**%**				
	Total	74.7	80.8	88.4	**0.003**
	Free horizontal margins	76.8	85.7	92.1	**<0.0001**
	Free vertical margins	93.5	94.5	97.1	**0.207**
Curative resection	**%**				
		72.6	78.1	86.3	**0.004**

Table 6: univariate and multivariate analyses of predictive factors for R0 resection

		Univariate analysis			Multivariate analysis		
		Odds ratio	IC 95%	*P* value	Odds ratio	IC 95%	*P* value
Year							
	2019	2.58	[1.43; 4.65]	0.002			
Lesion characteristics							
	NG-LST	2.54	[1.22; 5.28]	0.013	3.56	[1.16; 10.94]	0.026
	Macronodule	0.51	[0.33; 0.80]	0.003	0.74	[0.37; 1.47]	0.385
	Severe vascularization	0.56	[0.30; 1.03]	0.062			
	Moderate fibrosis (F1)	0.27	[0.13; 0.53]	<0.001			
	Severe fibrosis (F2)	0.20	[0.10; 0.38]	<0.001			
Lesion location							
	Splenic flexure	4.20	[0.94; 18.78]	0.06			
	Right colon segment	1.80	[0.94; 3.44]	0.076	0.96	[0.38; 2.47]	0.939
	Ileocecal valve	0.54	[0.23; 1.28]	0.163	0.30	[0.10; 0.93]	0.037
	Cecum	2.93	[1.26; 6.81]	0.013	2.20	[0.58; 8.34]	0.248
Complication							
	Perforation	0.24	[0.11; 0.53]	<0.001			
Pathological analysis							
	Sm >1,000 µm	0.13	[0.05; 0.33]	<0.001			
	T2	0.02	[0.01; 0.70]	0.03			
Lesion size							
	Diameter	0.99	[0.98; 0.99]	0.03	0.99	[0.98; 1.01]	0.313
Poor manoeuvrability							
		0.26	[0,14; 0,49]	<0.001	0.29	[0.15;]	<0.001

Table 7: univariate and multivariate analyses of risk factors for perforation

		Univariate analysis			Multivariate analysis		
		Odds ratio	IC 95%	*P* value	Odds ratio	IC 95%	*P* value
Type of lesion							
	Protruding	1.11	[0.39; 3.18]	0.843			
	G-LST	0.33	[0.08; 1.39]	0.132			
	NG-LST	0.91	[0.04; 21.7]	0.953			
	Sessile serrated adenoma	5.15	[0.05; 526.2]	0.488			
Lesion location (refer to sigmoïd)							
	Sigmoïd (reference)	X	X	X			
	Left colon segment	0.56	[0.21; 1.46]	0.23			
	Splenic flexure	0.24	[0.05; 1.07]	0.06			
	Left transverse	0.61	[0.19; 1.91]	0.39			
	Right transverse	0.49	[0.16; 1.54]	0.22			
	Hepatic flexure	0.68	[0.34; 1.33]	0.25			
	Right colon segment	0.56	[0.29; 1.06]	0.08			
	Ileocecal valve	1.83	[0.78; 4.30]	0.16			
	Cecum	0.34	[0.15; 0.80]	0.01			
Lesion characteristics							
	Severe vascularization	2.58	[1.03; 6.47]	0.043			
	Severe fibrosis (F2)	3.96	[1.43; 10.94]	0.008	3.69	[1.33; 10.24]	0.012
Macronodule							
		2.51	[1.15; 5.45]	0.021	1.67	[0.72; 3.85]	0.233
Size of lesion							
	>50 mm	3.29	[1.31; 8.34]	0.012	3.16	[1.19; 8.39]	0.021

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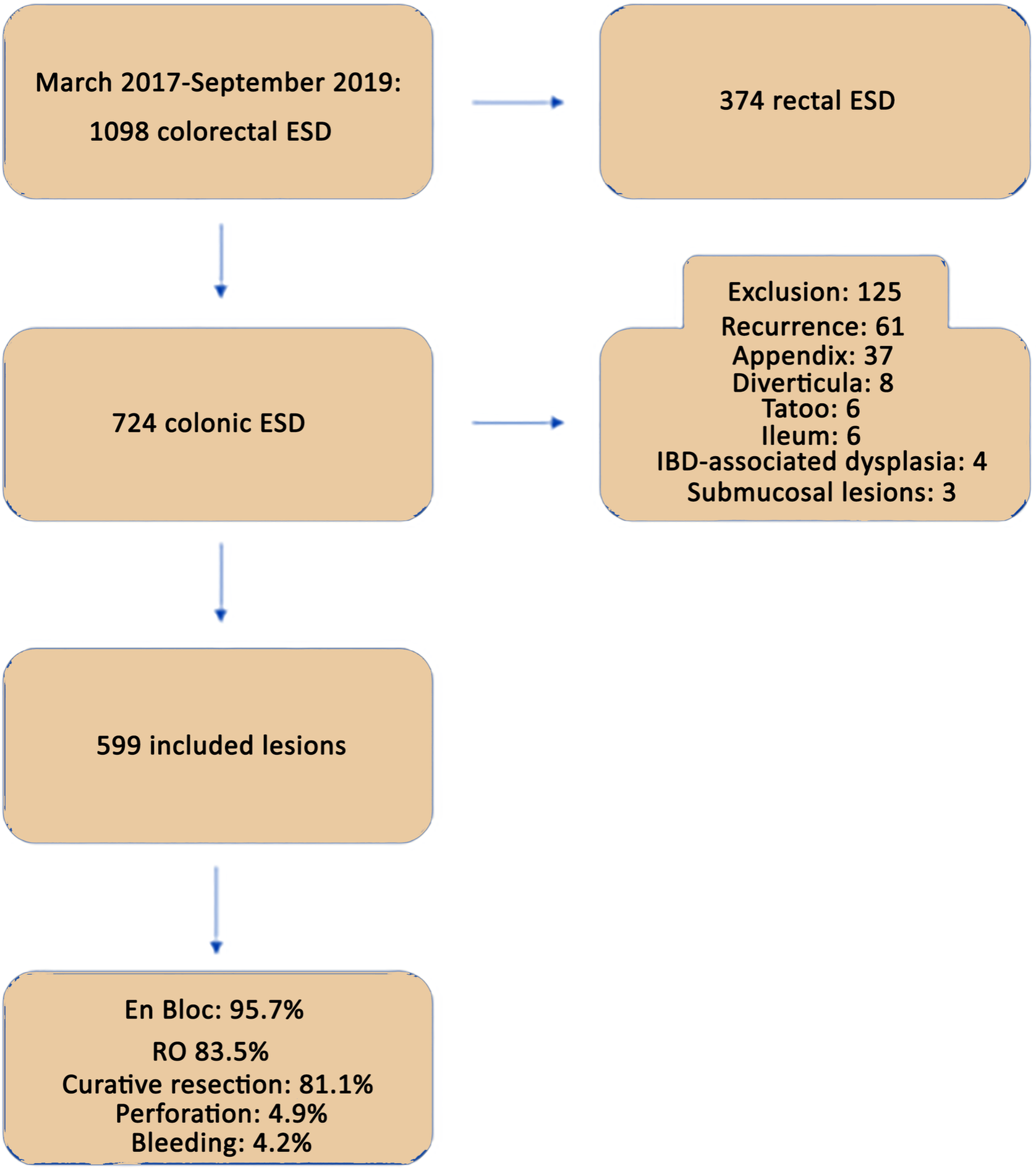
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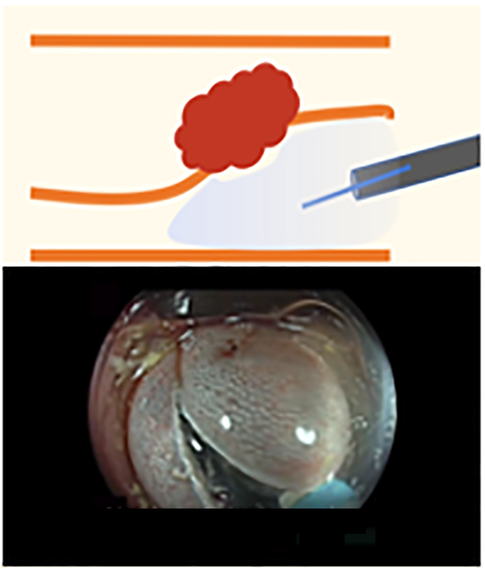
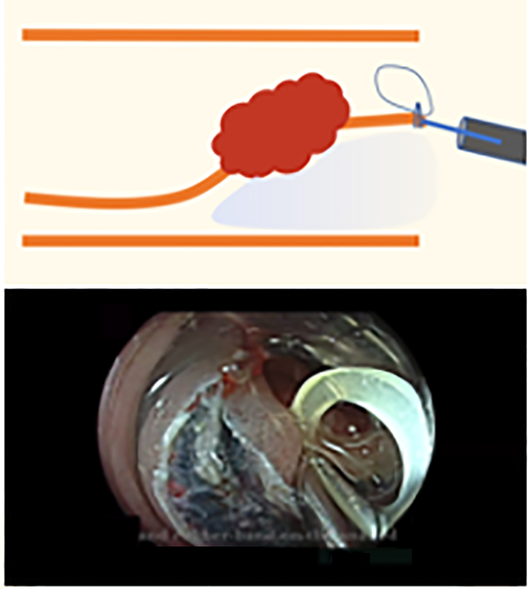
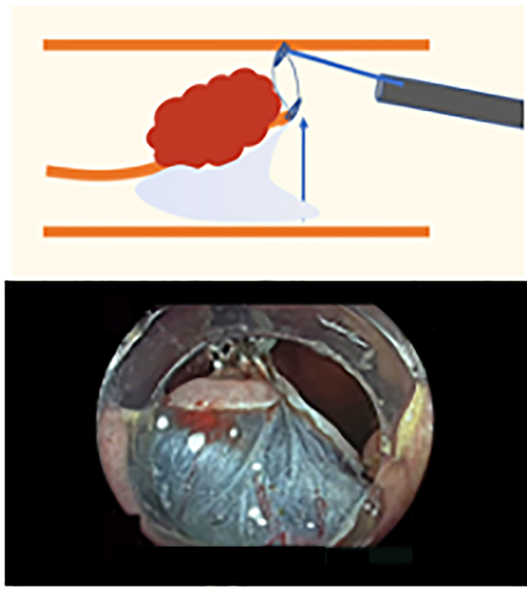
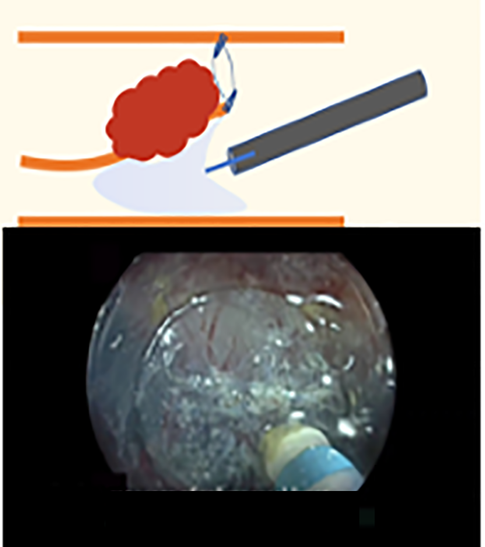
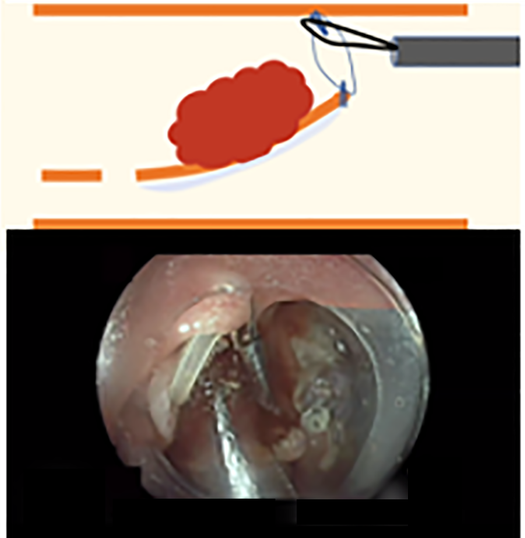
1098 colorectal ESD
374 rectal ESD
724 colonic ESD
Exclusion: 125
Recurrence: 61
Appendix: 37
Diverticula: 8
Tatoo: 6
Ileum: 6
IBD-associated dysplasia: 4
Submucosal lesions: 3
599 included lesions
En Bloc: 95.7%
RO 83.5%
Curative resection: 81.1%
Perforation: 4.9%
Bleeding: 4.2%

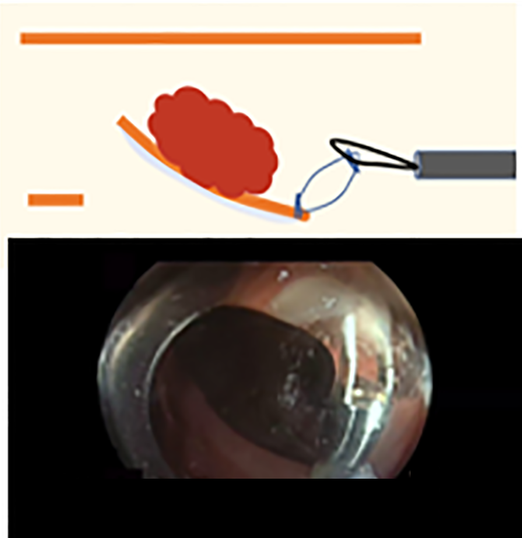


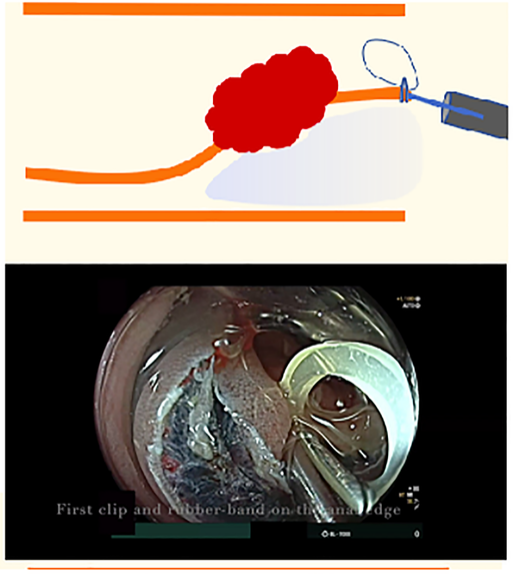


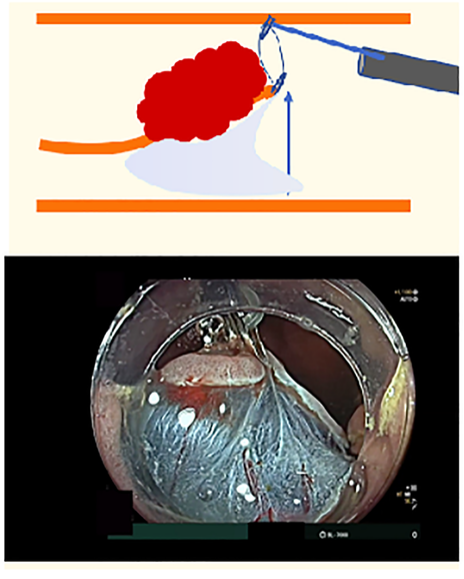












DCT- ESD for colonic lesions:

-en bloc resection: 95.7%
-R0 resection: 83.5%
-perforation: 4.9%
-procedure duration: 62.4 min
-speed of dissection: 39.4 mm^2/min
-largest diameter: 53 mm