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Endoscopic mucosal resection with a circumferential incision in the removal of colon neoplasms. Results of a randomized trial.

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ABSTRACT *AIM: to compare the early and late results of endoscopic mucosal resection with a circular incision (C-EMR) and endoscopic submucosal dissection (ESD) for large benign epithelial neoplasms of the colon.*
PATIENTS AND METHODS: a prospective randomized comparative study (November 2020 to July 2022) included 103 patients with benign epithelial neoplasms of the colon 20–30 mm sized. The C-EMR method was used in 52, ESD — 51 patients.
RESULTS: the removal of the tumor by the C-EMR required significantly less time, compared with the ESD method — 30 and 60 minutes, respectively ($p < 0.001$). Intra- and postoperative complications occurred in 13 (23.7%) patients in the C-EMR group and in 12 (23.5%) patients in the ESD group. The most frequently reported complication was post-coagulation syndrome in the main and control groups — in 9 (17.3%) and 11 (21.6%) cases, respectively. It was found that the difficult location of the tumor (OR = 18.3; $p = 0.01$) and intraoperative complications (OR = 37.5; $p = 0.04$) are independent conversion factors of endoscopic intervention. The incidence of tumor removal en bloc and negative resection margins (R0) in the main and control groups did not significantly differ — 47 (90.4%) and 49 (96.1%) ($p = 0.4$) and 40 (76.9%) and 45 (88.2%) ($p = 0.2$), respectively.
CONCLUSION: endoscopic mucosal resection with a circumferential incision is an effective and safe option comparable to endoscopic submucosal dissection, and can be the method of choice for benign epithelial neoplasms of the colon sized 20–30 mm. The operation time of C-EMR is two times less than ESD.

KEYWORDS: *EMR, ESD, C-EMR, hybrid method, circular incision, epithelial neoplasms*

CONFLICT OF INTEREST: *The authors declare no conflict of interest*

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INTRODUCTION

Classical endoscopic mucosal resection (EMR) is a simple and effective method widely used worldwide in the treatment of patients with epithelial tumors of the large intestine [1]. However, when tumors larger than 20 mm are removed by the EMR method, the rate of resection in *en bloc* progressively decreases, often due to tumor fragmentation, which ultimately negatively affects the local recurrence rate [2,3]. According to the basic principle of radical endoscopic intervention, which implies the removal of the tumor in *en bloc* with the achievement of negative resection margins (R0), endoscopic dissection in the submucosal layer is now wide used to overcome the disadvantages of mucosectomy. In addition, an important aspect is an accurate histological assessment of the resection margins of the removed tumor, which is difficult to achieve in the case of fragmentary removal of the lesion [4–6].

At the same time, despite the undeniable advantages of the technique of dissection in the submucosal layer (endoscopic submucosal dissection, ESD) over EMR in terms of resection margins control, this method has a higher risk of bowel perforation, requires more operation time and a high level of qualification of an endoscopist [7,8].

It seems that the hybrid approach, combining the advantages of one and the other methods of removing tumors, will overcome the disadvantages and achieve a high incidence of resection in *en bloc*. Thus, when performing endoscopic mucosal resection with circumferential incision (C-EMR) when removing epithelial neoplasms, a circular incision plays a leading role in achieving tumor-negative resection margins and the use of a loop when separating the tumor from the intestinal wall significantly reduces the operation time [9]. This is confirmed by the data of non-randomized studies that have demonstrated that the removal of epithelial tumors of the large intestine by the C-EMR method takes less time and is followed by a lower morbidity rate with a comparable with the ESD recurrence rate [10,11]. At the same time, according to some foreign authors, there is a negative correlation, manifested by a lower incidence of tumor removal in *en bloc* using the C-EMR method in the case of epithelial neoplasms of the large intestine larger than 20 mm in maximum dimension compared with ESD [8,12].

In this regard, to determine the effectiveness and safety of using the C-EMR technique for the removal of large epithelial benign neoplasms of the large intestine, we conducted a prospective randomized study.

PATIENTS AND METHODS

From November 2020 to July 2022, a prospective single center randomized clinical trial included 103 patients with benign epithelial neoplasms of the colon ranging in size from 20 to 30 mm without endoscopic signs of malignancy, with a pit pattern corresponding to types IIIs, IIIL, IV according to the Kudo, S. classification, and type II-O according to the classification of Kimura, T., and vascular pattern — type I and II according to Sano, Y. The study did not include patients with neoplasms in which the pit pattern corresponded to type Vi-Vn according to Kudo, S., and vascular pattern — type IIIa-IIIb according to Sano, Y., as well as patients with familial adenomatous polyposis, recurrent large intestine tumors. Patients with neoplasms who had incomplete or no tumor lifting were excluded from the study [5]. The study was approved by the local Ethics Committee, Protocol No. 10 and was registered on the website 'clinicaltrials.gov' (registration number NCT05690490).

The distribution of patients into groups was carried out intraoperatively using a random number generator on the website randomizer.org. Endoscopic submucosal dissection was performed for 51 patients, and endoscopic mucosal resection with circumferential incision (C-EMR) — for 52 patients.

There was no significant difference between the groups in age, gender, tumor site and size. The median size of colon neoplasms in the C-EMR group was 24 (20–27) mm, and in the ESD group — 25 (21.5–30) mm. Tumors were located mainly in the hepatic flexure of the colon — in 38 (73.1%) cases in the main group and in 40 (78.4%) in the control group (Table 1).

The Parisian and pragmatic classifications were used to describe the macroscopic structure of the tumor [13,14]. The assessment of the surface pattern of the tumor was carried out according to the classifications of Kudo, S. and Sano, Y., and with regard to the characteristics of dentate neoplasms, the classification of Kimura, T. was used [15–17].

It was noted that in the ESD group, a flat-raised laterally spreading non-granular type of neoplasms was observed somewhat more often according to the pragmatic classification (LST-NG-FE), and in the control group, a laterally spreading granular homogeneous type (LST-GH). The vascular pattern of the type II tumor surface according to the Sano, Y. classification was predominant in the C-EMR and ESD groups in 43 (82.7%) and 34 (66.7%) cases, respectively (Table 2).

Table 1. *General characteristics of patients and removed neoplasms*

Parameter	C-EMR (*n* = 52)	ESD (*n* = 51)	*p*
Age (median), years	63 (52-70)	61 (56-68)	0.5***
Gender			
Male	22 (42.3%)	28 (54.9%)	0.2**
Female	30 (57.7%)	23 (45.1%)	
Tumor site in the colon			
Hepatic flexure	38 (73.1%)	40 (78.4%)	0.5**
Splenic flexure	14 (26.9%)	11 (21,6%) 11 (21.6%)	0,5** 0.5**
Median tumor size (quartile), mm	24 (20-27.5)	25 (21.5-30)	0.2***

Note: p — Fisher exact criterion; p** — criterion χ^2; p*** — Mann–Whitney criterion*

Table 2. *Characteristics of colon neoplasms*

Parameter	C-EMR (n = 52)	ESD (n = 51)	*p*
Parisian Classification			
0-Is	9 (17.3%)	4 (7.8%)	0.2*
0-IIa	40 (76.9%)	45 (88.3%)	0.2*
0-Is + 0-IIa	3 (5.8%)	2 (3.9%)	1.0*
Pragmatic Classification			
LST-GH	24 (46.2%)	18 (35.3%)	0.3**
LST-GM	3 (5.8%)	5 (9.8%)	0.5*
LST-NG-FE	15 (28.8%)	24 (47.1%)	0.06**
LST-NG-PD	1 (1.9%)	0	1.0*
Classifications of S. Kudo and T. Kimura			
IIIs	8 (15.4%)	9 (17.6%)	0.8*
IIIL	23 (44.2%)	12 (23.5%)	0.03**
IIIL + IV	7 (13.5%)	5 (9.8%)	0.7*
IV	3 (5.8%)	2 (3.9%)	1.0*
IIIs + IIIL	2 (3.8%)	4 (7.8%)	0.4*
II-O	9 (17.3%)	19 (37.3%)	0.03**
Classification of Y. Sano			
I	9 (17.3%)	17 (33.3%)	0.06**
II	43 (82.7%)	34 (66.7%)	

Note: p — Fisher exact test; p** — χ^2 test*

All procedures were performed under intravenous sedation. When removing a large intestine tumor by endoscopic mucosal resection with circumferential incision (C-EMR), as well as ESD, the first stage was to create a submucosal 'cushion' by injecting gelofuzine solution stained with indigocarmine into the intestinal wall. Lifting was evaluated based on the Kato, H. classification [18]. In the case of complete lifting (type 1,2 according to Kato, H.), in the main group, a circular incision of the mucous layer around the neoplasm with an indentation of 2–3 mm from it was performed using an endoscopic knife to achieve a negative lateral resection margin. Further, to reduce the risk of thermal effects on the deep layers of the intestinal wall, repeated injection of a plasma-substituting solution into the submucosal layer in the projection of the neoplasm was mandatory. Then, after selecting the appropriate endoscopic loop, it was installed directly into the incision area, tightened, and electro excision of the tumor was performed. Upon completion of tumor removal, the postoperative surface was evaluated in accordance with the Sydney Classification to determine the depth of thermal lesion to the intestinal wall [19]. Visually detectable vessels in the resulting lesion were treated with hemostatic forceps, and, if necessary, the edges of the formed

lesion of the intestinal wall were connected to each other using endoscopic clips. The removed neoplasm was extracted and fixed on a foam plate in order to correctly assess the resection edges. If it was impossible to remove the neoplasm with one fragment, a decision was made to convert to another method of endoscopic intervention. ESD in the control group was performed according to the standard procedure. After creating a submucosal lift, an incision of the mucous layer around the tumor was performed with an indentation of 2–3 mm from its edges. Then, submucosal dissection was performed directly, in which the tumor was separated from the intestinal wall, upon successful completion of which, visual control of the resulting intestinal wall lesion was carried out and, in some cases, its closure with clips. The removed specimen was extracted for pathomorphology. After discharge from hospital, patients whose tumor was removed in *en bloc*, a control colonoscopy was recommended after 12 months, and in case of specimen fragmentation — after 3–6 months [20,21].

In the process of removing tumors using C-EMR and ESD endoscopic methods, endoscopists recorded technical difficulties that could potentially complicate the surgery, increasing the operation time, the likelihood of complications and conversion. These difficulties included: a difficult location of the tumor (along the mesenteric edge of the hepatic and splenic flexures of the colon, along the posterior surface of the intestinal fold, in the area of the lower lip of the ileocecal valve), making it hard to implement an adequate angle of attack, due to limited mobility of the distal end of the endoscope with maximum tension of its handle rods; the presence of excess fat, fibrosis, large vessels in the submucosal layer; increased peristalsis (when intestinal peristaltic waves took more than half the time of the entire surgery).

The results obtained were used in the analysis of risk factors for conversion of endoscopic intervention.

The primary patient data was entered into a specially designed Microsoft Office Excel 2018 spreadsheet. Statistical processing of the research results was carried out using IBM SPSS Statistics v.26 software. The analysis of the results of the study was carried out according to the 'intention to treat' protocol. The research materials were subjected to statistical analysis using parametric and non-parametric methods. When describing quantitative indicators with a normal distribution, the data obtained were combined into a series of variations in which the mean (M) and standard deviations (± SD), the margins of the 95% coincidence interval (95% CI) were calculated. Quantitative indicators, the distribution of which differed from the normal one, were described using median (Me) and interquartile range (Q1-Q3) values. When comparing values in normally distributed sets of quantitative data, the Student's t-test was used. The Mann-Whitney U-test was used to compare the medians. In the analysis of qualitative variables, the χ^2 test and the exact Fisher test were used. To assess risk factors, odds ratios (OR) were calculated using four-field tables with a 95% coincidence interval (CI). The identification of possible risk factors for the treatment was carried out using binary logistic regression.

RESULTS

The results of treatment were analyzed in 52 patients with colon neoplasms who underwent endoscopic resection of the mucous layer and in 51 patients who underwent dissection in the submucosal layer.

The median time to perform C-EMR upon removal of epithelial neoplasms of the colon was 30 (25–39), versus 60 (60–75) minutes in the ESD group.

Video 1. *Endoscopic mucosal resection with a circumferential incision in the removal of colon epithelial neoplasm*

Table 3. *Characteristics of endoscopic removal of neoplasms*

Parameter	C-EMR (*n* = 52)	ESD (*n* = 51)	*p*
Median operation time (quartiles), min.	30 (25–39)	60 (60–75)	0.001**
Rate of intraoperative complications, *n* (%)	3 (5.8%)	0	0.3*
Bleeding, *n* (%)	2 (3.8%)	0	0.5*
Perforation, *n* (%)	1 (1.9%)	0	1.0*
Rate of postoperative complications	10 (19.2%)	12 (23.5%)	0.6***
Postcoagulation syndrome, *n* (%)	9 (17.3%)	11 (21.6%)	0.6*
Bleeding, *n* (%)	0	2 (3.9%)	0.3*
Perforation, *n* (%)	1 (1.9%)	0	1.0*

Note: p — Fisher exact criterion; p** — Mann –Whitney criterion; p*** — criterion χ^2*

Table4. *Difficulties during endoscopic operation*

Parameter	C-EMR (*n* = 52)	ESD (*n* = 51)	*p*
Difficult tumor site for endoscopic intervention, *n* (%)	20 (38.5%)	15 (29.4%)	0.3***
Large vessels of the submucosal layer, *n* (%)	5 (9.6%)	10 (19.6%)	0.2*
Excess fat in the submucosal layer, *n* (%)	6 (11.5%)	15 (29.4%)	0.03***
Fibrosis of the submucosal layer, *n* (%)	3 (5.8%)	21 (41.2%)	0.001***
Increased intestinal peristalsis, *n* (%)	15 (28.8%)	9 (17.6%)	0.2*

Note: p — Fisher exact criterion; p** — Mann–Whitney criterion; p*** — criterion χ^2*

The differences in the operation duration were significant ($p = 0.001$) (Table 3).

Intraoperative bleeding developed in two patients 2/52 (3.8%) in the C-EMR group. In one patient, during the removal of a 30-mm sigmoid colon tumor, against the background of increased intestinal peristalsis and abdominal respiration, it was not possible to endoscopically stop bleeding from large vessels of the submucosal layer. The conversion to abdominal surgery was performed in the volume of sigmoid colon resection. In the second case, intraoperative bleeding was stopped endoscopically using hemostatic forceps. Intraoperative perforation of the intestinal wall occurred in one 1/52 (1.9%) patient in the C-EMR group during the removal of an ascending colon tumor measuring 30 mm in diameter. It was treated by reducing the edges of the lesion with endoscopic clips. The postoperative period proceeded without complications. On the 5th day after the surgery, the patient was discharged from hospital in a satisfactory condition. Here were no significant differences in the incidence of intraoperative complications between the main and control groups ($p = 0.3$).

In the postoperative period, complications developed in 10 (19.2%) patients in the C-EMR group and in 12 (23.5%) patients in the ESD group ($p = 0.6$). The most common postoperative complication was post-coagulation syndrome (PS), which occurred in 9 (17.3%) and 11 (21.6%) patients of the main and control groups, respectively ($p = 0.6$).

After performing C-EMR, in 1/52 (1.9%) patient in the postoperative period, perforation of the intestinal wall in the area of surgery developed on day 3. This complication required emergency surgery. Taking into account the localization of the perforation of the colon, the patient underwent a right-sided hemicolectomy with the formation of an ileotransversal anastomosis. In the ESD group, in 2 (3.9%) patients developed bleeding from the area of surgery in the postoperative period, the cessation of which required colonoscopy and clipping of the bleeding vessel, which was successfully performed (Table 3).

Based on the analysis of the results of the study, it was found that in the control group, excessive fat deposition in the submucosal layer in the neoplasm zone was significantly more often in patients — in 15 (29.4%) cases, while in the main group, this was noted only in 6 (11.5%) patients ($p = 0.03$). It was

Table 5. *Characteristics of quantitative features reduced to binary values*

Characteristics	Cut-off point	Sensitivity	Specificity	Are a under curve	The Iodene index
Tumor size, mm	⩾ 2.7	55.6	75.5	0.64 ± 0.1	0.31
Operation time, min.	⩾ 47.5	77.8	51.1	0.72 ± 0.08	0.29

also noted that in the ESD group, patients with fibrosis of the submucosal layer of the intestinal wall in the tumor zone were more common — 21 (41.2%) cases, and in the C-EMR group this was recorded in 3 (5.8%) cases (p = 0.001). This difference is explained by the fact that when performing endoscopic submucosal dissection, namely during the separation of the tumor from the muscular membrane of the intestinal wall, the submucosal layer is visually monitored throughout, which allows the endoscopist to assess the presence of certain changes with high probability. Whereas, in the case of using the C-EMR technique, after performing a circular incision, only a small part of the submucosal layer can be visualized (Table 4).

It was noted that in the group of endoscopic submucosal dissection, in 6/51 (11.7%) cases, the intervention was converted: in 4 (7.8%) patients — to the C-EMR method and in 2 (3.9%) cases — to the fragmentary loop resection method. The reason for the conversions in three observations was the neoplasm location difficult for ESD (in the area of the lower lip of the ileocecal valve, along the posterior surface of the fold) in combination with fibrosis and excessive fat deposition in the submucosal layer of the intestinal wall, in three other observations increased intestinal peristalsis against the background of abdominal breathing. And in the group of endoscopic mucosal resection with circumferential incision (C-EMR), conversion was noted in 3/52 (5.8%) cases. In 2 (3.8%) patients, a fragmentary loop resection method was used due to the difficult tumor site (along the mesenteric edge in the hepatic and splenic flexures of the colon), and in 1 (2.0%) patient, a cavity surgery due to intraoperative bleeding that could not be controlled endoscopically.

Taking into account the conversion of endoscopic intervention in the groups, we analyzed the factors that could potentially affect this outcome.

As risk factors, we analyzed such indicators as the size of the tumor to be removed, the presence of large vessels in the submucosal layer, a difficult tumor site, excessive fat in the submucosal layer of the intestinal wall, the presence of fibrosis of the submucosal layer, increased intestinal peristalsis, intraoperative complications, and the endoscopic operation time. Quantitative signs (the size of the tumor to be removed and the operation time) were reduced to binary values using ROC analysis (Table 5).

Univariate regression analysis showed that the factors statistically significantly increasing the probability of intervention conversion in the entire cohort of patients were: difficult tumor location (OR = 20.9; 95% CI:2.5–175.6; p = 0.02), intraoperative complications (OR = 26.6; 95% CI:2.2–33.1; p = 0.02), fibrosis of the submucosal layer (OR = 4.9 95% CI:1.2–20.2; p = 0.03), as well as increased intestinal peristalsis (OR = 15.8; 95% CI:3.1–83.1; p = 0.001) (Table 6).

Next, we developed a predictive model of the dependence of the conversion probability on factors that significantly increase the probability of developing an intervention conversion using the binary logistic regression method with the selection of factors by the exclusion method.

As a result of the multivariate analysis, independent factors that statistically significantly increase the likelihood of endoscopic intervention conversion turned out to be a difficult tumor site (OR = 18.3; 95% CI:1.9–176.8; p = 0.01) and an intraoperative complication (OR = 37.5; 95% CI:1.1 1317.9; p = 0.04). Analysis of the results of pathomorphological studies of surgical specimens showed that in the ESD group there was a slightly higher number of tumor resections in *en bloc* compared to the C-EMR group — 49 (96.1%) and 47 (90.4%) observations, respectively, but the differences were not significant (p = 0.4). The

Table 6. *Cox-regression analysis of factors influencing the conversion of endoscopic intervention*

Factor	Conversion			
	Univariate		Multivariate	
	OR CI 95%	*p*	OR CI 95%	*p*
Tumor size ⩾ 2.7 mm, present/no	2.08 (90.3–14.2)	0.4		
Operation time ⩾ 47.5 min., present/no	2.7 (0.36–20.6)	0.3		
Difficult tumor site, present/no	20.9 (2.5–175.6)	0.002	18.3 (1.9–176.8)	0.01
Large vessels of the submucosal layer, present/no	3.4 (0.7–15.5)	0.1		
Excessive fat in the submucosal layer, present/no	3.6 (0.8–14.9)	0.08		
Fibrosis of the submucosal layer, present/no	4.9 (1.2–20.2)	0.03	4.4 (0.8–23.2)	0.08
Increased intestinal peristalsis, present/no	15.8 (3.1–83.1)	0.001		
Intraoperative complications, present/no	26.6 (2.2–33.1)	0.02	37.5 (1.1–1317.9)	0.04

Table 7. *Results of the pathomorphology of specimens*

Parameter	C-EMR (*n* = 52)	ESD (*n* = 51)	*p*
Resection in *en bloc*, *n* (%)	47 (90.4%)	49 (96.1%)	0.4*
Resection margins, *n* (%)			
R0	40 (76.9%)	45 (88.2%)	0.2*
R1	4 (7.7%)	3 (5.9%)	1.0*
Rx	4 (7.7%)	1 (2.0%)	0.4*
Histological structure of neoplasms, *n* (%)			
Tubular adenoma	21 (40.4%)	16 (31.4%)	0.4**
Tubular villous adenoma	22 (42.3%)	17 (33.3)	0.4**
Dentate formation	9 (17.3%)	18 (35.3%)	0.04**

Note: p — the exact Fisher criterion; p** — the criterion* χ

tumor-positive lateral resection margins were noted in 4 (7.7%) cases — in the main and in 3 (5.9%) specimens — in the control group ($p = 1.0$) (Table 7).

In 4 (7.7%) cases of the main and in 1 (2.0%) case in the control group, due to deformation of the lateral edge of the specimen due to thermal exposure, it was difficult to clearly assess the resection margins, which corresponded to the Rx criterion ($p = 0.2$). According to the results of histological examination of the removed specimens, most of the neoplasms in the main and control groups were represented by adenomatous neoplasms with tubular and tubular-villous types of structure.

Also, taking into account the intervention conversion in the main and control groups in 3 (5.7%) and 6 (11.7%) cases, respectively, we analyzed the results of a pathomorphological study of surgical specimens in the groups with their exclusion according to the 'per protocol' analysis. There were no statistically significant differences in the groups in terms of R0, R1 and Rx resection margins (Table 8).

When analyzing late results after endoscopic removal of tumors using C-EMR and ESD methods, we revealed the incidence of local recurrences in the groups. The analysis was performed in 45 (86.5%) of 52 patients in the main group and in 46 (90.2%) of 51 patients in the control group. The median follow-up of patients in the C-EMR and ESD groups was 12 (12–15) and 12 (12–14) months, respectively ($p = 0.5$). Local recurrence was detected in 2 (3.8%) and 1 (2.0%) patients in the main and control groups, respectively ($p = 1.0$). The detected recurrences were removed during a control colonoscopy by mucosectomy. Patients were advised to undergo a control colonoscopy after 3–6 months. Repeated endoscopic examination revealed no recurrence of neoplasms.

DISCUSSION

Today, in the arsenal of an endoscopist, there are many techniques for endoscopic removal of tumors of the gastrointestinal tract. Each technique has both advantages and disadvantages. In this

Table 8. *Results of the pathomorphology of specimens according to the "per protocol" analysis*

Parameter	C-EMR (*n* = 49)	ESD (*n* = 45)	*p*
Resection margins, *n* (%)			
R0	43 (87.7%)	44 (97.8)	0.1*
R1	2 (4.1%)	0	0.5*
Rx	4 (8.2%)	1 (2.2%)	0.4*

*p** — *the exact Fisher criterion*

regard, it is a personalized approach when choosing a particular method of endoscopic tumor removal that plays a significant role in achieving the best treatment results for a particular patient.

The technique of endoscopic mucosal resection with circumferential incision (C-EMR)is a hybrid method combining the stages of mucosectomy and ESD.

A comparative analysis of the results of this study has demonstrated the safety of the C-EMR technique, comparable to the method of endoscopic submucosal dissection. The incidence of complications in the groups did not differ statistically significantly. It is important that the incidence of clinically significant complications is not high. They occurred in 3 (5.7%) cases when performing C-EMR and in 2 (3.9%) patients using the ESD method, which correlates with the results of previous studies [22,23]. However, some authors report a higher incidence of complications in the removal of large tumors of the large intestine by C-EMR, reaching 35.1%, of which 21.6% are perforations of the intestinal wall, and 13.5% are bleeding [24]. The most serious complications in our study, namely, intraoperative bleeding followed by intervention conversion and 'delayed' perforation requiring repeated surgery, occurred in the C-EMR group. In the first case, we attribute this to the presence of large vessels in the submucosal layer of the intestinal wall and increased peristalsis, which significantly hampered the endoscopic removal of the tumor of the distal third of the sigmoid colon. Perforation in the postoperative period in the second case is most likely associated with the location of the tumor in the cecum, where the intestinal wall is the thinnest. Since there were conversions in both groups during the study, we performed a regression analysis that helped to determine the factors that increase the likelihood of such an outcome: a difficult tumor site (OR = 18.3) and an intraoperative complication (OR = 37.5). Our experience has shown that careful selection of patients, taking into account the above factors, is extremely important and will help the endoscopist to identify the category of patients who should abandon ESD in favor of C-EMR and vice versa, since these endoscopic removal techniques provide a comparably high incidence of *en bloc* resection and, in this regard, are equivalent. Based on the results obtained, if the tumor is inconveniently positioned to perform ESD, as well as in the presence of submucosal fibrosis, it is necessary to give preference to the C-EMR method. And in cases where the tumor is localized in the hepatic flexure of the colon, where the intestinal wall is thinner or large vessels of the submucosal layer are detected at the base of the neoplasm, endoscopic submucosal dissection should be used.

Removal of the tumor in *en bloc* makes it possible to correctly histologically evaluate the specimen and reduces the risk of recurrence. Thus, according to a large meta-analysis by Belderbos, T.D. et al., which combined the results of 33 studies where all patients with epithelial neoplasms of the large intestine underwent mucosectomy, the recurrence rate was significantly lower after endoscopic resection in *en bloc* than after fragmentary removal — 3% and 20% of cases, respectively ($p < 0.0001$) [25]. The C-EMR and ESD methods have demonstrated good results regarding the radical removal of colon tumors.

The analysis of the results of the pathomorphology of the removed specimens in our study allows us to conclude that the ESD method is somewhat superior for negative resection margins to the C-EMR

method for removing benign epithelial neoplasms ranging in size from 20 mm to 30 mm. However, the differences did not reach statistical significance. Based on the results of a randomized study, it was found that the removal of large benign neoplasms of the colon by the C-EMR method required 2 times less time than using the endoscopic submucosal dissection method — 30 and 60 minutes, respectively (p = 0.001). This conclusion corresponds with the results of previously performed non-randomized studies [9,22]. Despite the fact that such a method of endoscopic removal of large intestine tumors as ESD, is characterized by a higher incidence of resection in *en bloc* compared to mucosectomy, nevertheless, this technique is still not routine when removing large tumors of the gastrointestinal tract. Despite the advantages of endoscopic dissection in the submucosal layer, due primarily to the possibility of constant control of the resection margins during the procedure, it loses to the method of endoscopic mucosal resection wit circumferential incision (C-EMR) in simplicity, requiring a high level of qualification of the operating endoscopist, especially when removing large tumors of the large intestine.

CONCLUSION

Endoscopic mucosal resection with circumferential incision can be an alternative to dissection in the submucosal layer when removing benign epithelial neoplasms of the colon ranging in size from 20 mm to 30 mm, due to its safety and effectiveness. In addition, an important advantage of the C-EMR technique is a 2-fold reduction in the operation time compared to endoscopic submucosal dissection with comparable quality of the removed specimen.

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