

## Predictive Factors and Surgical Impact of Colonoscopy Accuracy for Localization of Colorectal Malignancy

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### Rezumat

#### *Factorii predictivi și impactul chirurgical al acurateții colonoscopiei pentru localizarea leziunilor maligne colorectale*

**Context:** Colonoscopia este în prezent standardul de aur pentru detectarea leziunilor colorectale, dar cu o acuratețe limitată în localizarea neoplaziilor. Acest studiu își propune să determine acuratețea colonoscopiei în localizarea leziunilor colorectale maligne, să identifice posibili factori ce influențează această procedură și să evalueze consecințele chirurgicale ale unei localizări preoperatorii incorecte.

**Metode:** A fost efectuat un studiu transversal, retrospectiv ce a inclus toți pacienții cu leziuni maligne colorectale diagnosticate colonoscopic, la care s-a practicat rezecția chirurgicală ulterioară în perioada ianuarie 2019 - decembrie 2020. Precizia colonoscopiei a fost evaluată prin corespondența dintre localizarea colonoscopică a tumorii și cea intra-operatorie.

**Rezultate:** Au fost incluși 115 pacienți, majoritatea bărbați (63,5%), cu vârsta medie de 68,7 ani. A existat o concordanță între localizarea endoscopică și cea intraoperatorie în 76 de cazuri, ceea ce corespunde unei acuratețe de 66,1%. Colonoscopiile complete ( $p=0,008$ ) și pregătirea adecvată a intestinului ( $p=0,023$ ) au fost asociate semnificativ cu o concordanță mai mare între localizarea tumorii endoscopice a tumorii și cea intra-operatorie. Din cele 39 de leziuni localizate incorect, 19 (48,7%) au necesitat modificări în managementul chirurgical.

**Concluzie:** Colonoscopia este adesea inexactă pentru localizarea leziunilor colorectale maligne, ceea ce poate duce frecvent la modificări intraoperatorii ale strategiei chirurgicale. Colonoscopiile complete și pregătirea adecvată a intestinului au fost predictori

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semnificativi pentru o localizare endoscopică corectă, accentuând importanța calității colonoscopiei pentru această indicație specială.

Cuvinte cheie: colonoscopie, acuratețea colonoscopiei, calitatea colonoscopiei, malignitate colorectală, chirurgie colorectală

## Abstract

*Background:* Colonoscopy is currently the gold-standard for the detection of colorectal lesions, but its accuracy in tumor localization is limited. This study aims to determine the accuracy of colonoscopy in localization of colorectal malignancy, identify possible influencing factors and evaluate the surgical consequences of an incorrect preoperative localization.

*Methods:* A retrospective cross-sectional study of all patients with colorectal malignant lesions diagnosed by colonoscopy who underwent subsequent resection surgery between January 2019 and December 2020 was performed. Colonoscopy accuracy was evaluated in terms of correspondence between endoscopic and intra-operative tumor localization.

*Results:* A total of 115 patients were included, mostly males (63.5%), with mean age of 68.7 years. There was concordance between endoscopic and intra-operative localization in 76 cases, which corresponds to an accuracy of 66.1%. Colonoscopy completeness ( $p=0.008$ ) and adequate bowel preparation ( $p=0.023$ ) were significantly associated with greater concordance between endoscopic and intra-operative tumor location. Of the 39 incorrectly localized lesions, 19 (48.7%) required changes in surgical management.

*Conclusion:* Colonoscopy is often inaccurate for localizing malignant colorectal lesions, which may frequently result in intra-operative changes in surgical strategy. Colonoscopy completeness and adequate bowel preparation were significant predictors for a correct endoscopic localization, underscoring the importance of colonoscopy quality for this particular indication.

**Key words:** colonoscopy, colonoscopy accuracy, colonoscopy quality, colorectal malignancy, colorectal surgery

## Introduction

As the third most commonly diagnosed malignancy and the second leading cause of cancer death globally, colorectal cancer was responsible for approximately 1.9 million new cases and 0.9 million deaths in 2020. The incidence is higher in highly developed countries but an increasing trend is also observed in low-income countries. Although survival rates have been gradually improving worldwide over time, incidence rates are also expected to grow over the next years, which reinforces the need for more effective screening and treatment strategies to reduce its global burden (1,2).

Colonoscopy remains the gold-standard in diagnosis as well as preoperative tumor localization for colorectal malignancy. A clear and unequivocal preoperative localization is essential in definition of the most adequate surgical strategy. This becomes even more essential considering the recent shift in clinical practice from open to laparoscopic colorectal resections, mainly due to absence of tactile feedback and inability to visualize the tumor unless large and involving the serosal surface (3). This leads to frequent need for intraoperative colonoscopies, open conversion and, in the worst scenario, resection of the wrong bowel segment (4).

Previous studies have pointed the limita-

tions of colonoscopy in localization of colorectal malignant tumors, with a reported incidence of localization errors of approximately 15.4% (5). However, few studies have evaluated potential influencing factors and the surgical impact of erroneous colonoscopic localization. This study aimed to determine the accuracy of colonoscopy in localization of colorectal malignancy, to identify predictive factors of concordance with intra-operative localization and to evaluate the surgical consequences of an incorrect preoperative localization.

## Methods

All patients with colorectal malignant lesions diagnosed by colonoscopy and who underwent subsequent resection surgery at Centro Hospitalar Universitário de São João (Porto, Portugal) between January 2019 and December 2020 were eligible for this retrospective cross-sectional study. Patients were excluded if they had performed colonoscopy in other centers, if they had previous colorectal resection for other reasons, if more than one synchronous colorectal malignant lesions were found or if the lesion had been completely or partially resected by endoscopic techniques before surgery.

Clinical and demographic data were retrospectively reviewed from the hospital electronic medical records. All colonoscopy reports and operative notes were carefully reviewed to obtain information about preoperative colonoscopy and intraoperative findings. The location on colonoscopy was ascribed to one of eight anatomical segments: rectum, sigmoid colon, descending colon, splenic flexure, transverse colon, hepatic flexure, ascending colon and cecum. When the lesion location was reported as distance from the anal verge, the corresponding segment was estimated considering <20 cm rectum, 20-40 cm sigmoid colon, 40-50 cm descending colon and >50 cm transverse colon. When more than one preoperative colonoscopy had been performed, the endoscopic location and other characteristics were based in the index colonoscopy. The intra-

operative location was classified into the same eight groups based on operative notes and any change to the intended surgery was documented. Colonoscopy accuracy was defined in terms of correspondence between endoscopic and intra-operative location. When preoperative computed tomography (CT) was performed, location according to CT was also analyzed for accuracy and concordance.

All patients who underwent elective colonoscopy were instructed to ingest a low-fiber diet for the three days preceding the procedure and were prescribed 4L of an oral polyethylene glycol solution to take in split-dose during the day preceding the procedure. In emergency setting, bowel preparation also consisted of oral polyethylene glycol given until clear stool was obtained, except for patients presenting with intestinal obstruction who underwent emergency colonoscopy without any bowel preparation. Colonoscopies were either entirely performed by a senior gastroenterologist accredited for colonoscopy or by a gastroenterology training resident as the main operator under supervision of a specialist.

## Statistical Analysis

Statistical analysis was performed using the SPSS 27.0 software package (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages and compared using Chi-square or Fisher's exact test. Continuous variables were expressed as mean and standard deviation for variables with normal distribution or median and interquartile range for variables with skewed distribution and compared using Students' t-test or a nonparametric test. A two-tailed  $p < 0.05$  was considered statistically significant.

The present study complies with current regulations on bioethical research and was appropriately evaluated and approved by the Ethics Committee of Centro Hospitalar Universitário de São João in Porto, Portugal. The procedures used in this study adhere to

the tenets of the Declaration of Helsinki. This article does not contain personal information that could identify the study patients.

## Results

A total of 115 patients who underwent both colonoscopy and surgery in our center, 73 (63.5%) male and 42 (36.5%) female, were included (*Table 1*), with mean age of 68.7 ( $\pm 15.3$ ) years. The most common preoperative endoscopic tumor location was sigmoid colon (27.0%), followed by ascending (14.8%) and transverse (13.9%) colon. Colonoscopy was performed electively in 90 (78.3%) cases and in emergency setting in 25 (21.7%). The most common indications for colonoscopy were evaluation of previously recognized colorectal lesions (17.4%), iron-deficiency anemia (16.5%) and investigation of imaging abnormalities (15.7%). Procedures were performed by a total of 30 different operators from our center, including 19 specialists and 11 training residents. Five patients repeated colonoscopy before surgery and the lesion location was concordant with its location at index colonoscopy in all these patients.

The quality of bowel preparation was reported in 93 (80.9%) colonoscopies and described as adequate in 71 (76.3%) of these. Cecal intubation was obtained in 64 colonoscopies, leading to a colonoscopy completeness rate of 55.7%. An impassable tumor obstructing the lumen was documented in 39 (33.9%) cases, which partially explains this low frequency of cecal intubation; excluding these cases, colonoscopy completeness rate increases to 82.9%. Photographic documentation of cecal landmarks and lesion was present in 46 (40%) and 106 (92.2%) colonoscopy reports, respectively. Endoscopic tattoo distal to the lesion was performed in 63 (54.8%) cases. An evaluation in terms of distance to the anal verge was reported in 34 (29.6%) lesions and it was mostly reserved for left-sided lesions. Lesion size was described in 35 (30.4%) cases, with mean diameter of  $39.3 \pm 19.7$  mm (range 10-110).

The preoperative endoscopic location

**Table 1.** Patients' demographic and endoscopic data

Age, mean (range), years	68.7 (21-94)
Gender, n (%)	
Male	73 (63.5%)
Female	42 (36.5%)
Lesion size, mean (range), mm	39.3 (10-110)
Endoscopic lesion localization, n (%)	
Cecum	12 (10.4%)
Ascending colon	17 (14.8%)
Hepatic flexure	9 (7.8%)
Transverse colon	16 (13.9%)
Splenic flexure	9 (7.8%)
Descending colon	12 (10.4%)
Sigmoid colon	31 (27.0%)
Rectum	9 (7.8%)
Colonoscopy quality parameters, n (%)	
Bowel preparation quality reported	93 (80.9%)
Bowel preparation adequate	71 (76.3%)
Cecal intubation	64 (55.7%)
Cecal photographic documentation	46 (40.0%)
Lesion photographic documentation	106 (92.2%)
Endoscopic tattoo	63 (54.8%)

properly matched with intra-operative location in 76 out of 115 lesions, leading to a colonoscopy accuracy of 66.1% for localization of colorectal malignant lesions. Among the remaining 39 non-concordant cases (*Table 2*), most were minor discrepancies between neighboring segments, although localization errors by more than one segment also occurred in 8 cases (the most obvious was a lesion endoscopically

**Table 2.** Discrepancy between endoscopic and intraoperative localization

Endoscopic localization	n (%)	Intra-operative localization (n)
Cecum	2 (16.7%)	Ascending colon (1) Hepatic flexure (1)
Ascending colon	6 (35.3%)	Cecum (4) Hepatic flexure (1) Transverse colon (1)
Hepatic flexure	5 (55.6%)	Ascending colon (3) Transverse colon (2)
Transverse colon	5 (31.3%)	Ascending colon (3) Hepatic flexure (1) Descending colon (1)
Splenic flexure	3 (33.3%)	Transverse colon (1) Sigmoid colon (2)
Descending colon	7 (58.3%)	Transverse colon (1) Splenic flexure (3) Sigmoid colon (3)
Sigmoid colon	11 (35.5%)	Cecum (1) Descending colon (6) Rectum (4)

**Table 3.** Comparison between concordant and non-concordant cases

	Concordant (76)	Non-concordant (39)	P
Age, mean ( $\pm$ SD), years	68.0 ( $\pm$ 16.3)	70.1 ( $\pm$ 13.0)	0.50
Gender, male, n (%)	49 (64.5%)	24 (61.5%)	0.76
Lesion size, mean ( $\pm$ SD), mm	38.0 ( $\pm$ 21.2)	42.3 ( $\pm$ 16.8)	0.56
Bowel preparation description, n (%)	61 (80.3%)	32 (82.1%)	0.82
Bowel preparation adequate, n (%)	51 (67.1%)	20 (51.3%)	0.02
Colonoscopy completeness, n (%)	49 (64.5%)	15 (38.5%)	0.008
Cecal photograph, n (%)	34 (44.7%)	12 (30.8%)	0.15
Lesion photograph, n (%)	70 (92.1%)	36 (92.3%)	0.97
Endoscopic tattoo, n (%)	39 (51.3%)	24 (61.5%)	0.30
Colonoscopy training phase (resident), n (%)	41 (53.9%)	27 (69.2%)	0.16

localized to the sigmoid that was intra-operatively regarded as cecal). The descending colon was the anatomical segment with least concordance, whereas the rectum revealed the highest accuracy with all rectal lesions confirmed intra-operatively. Nevertheless, these differences among anatomical segments did not achieve statistical significance. No additional colorectal lesions were retrieved intra-operatively.

A comparison between concordant and non-concordant cases (*Table 3*) revealed that quality of bowel preparation and colonoscopy completeness appear to be significant predictors for increased accuracy, as both cecal intubation (64.5% vs 38.5%,  $p=0.008$ ) and an adequate bowel preparation (67.1% vs. 51.3%,  $p=0.02$ ) were significantly more frequent in concordant than non-concordant cases. No association was found regarding age, gender, lesion size, preoperative tattoo, photographic documentation or operator's level of experience.

After performing multivariate analysis, both cecal intubation ( $p=0.002$ ) and adequate bowel preparation ( $p=0.011$ ) remained statistically significant predictors of concordance between endoscopic and intra-operative localization.

Surgical resection was performed by laparoscopic approach in 61 (53.0%) patients and open approach in the remaining 54 (47.0%). Importantly, 19 (48.7%) out of the 39 non-concordant lesions required changes in the surgical management as a consequence of the incorrect localization (*Table 4*). Ten (52.6%) of these lesions were tattooed, which guided its correct intra-operative location. From the remaining non-tattooed lesions, 6 (31.6%) were large tumors that could be recognized at extra-tumoral serosal surface and 1 (5.2%) was found in relation to a previously placed dilation stent, whereas 2 (10.4%) required conversion from minimally invasive to open access due to the incorrect localization. The other non-concordant patients required

**Table 4.** Surgical management changes for incorrect endoscopic localization

Endoscopic localization (n)	Planned surgical resection	Intra-operative localization (n)	Surgical resection performed (n)
Ascending colon (1)	Right hemicolectomy	Transverse colon (1)	Right hemicolectomy extended to transverse (1)
Hepatic flexure (1)	Right hemicolectomy	Transverse colon (1)	Right hemicolectomy extended to transverse (1)
Transverse colon (1)	Transverse colon resection	Ascending colon (1)	Right hemicolectomy
Splenic flexure (3)	Left hemicolectomy	Transverse colon (1) Sigmoid colon (2)	Right hemicolectomy extended to transverse (1) Anterior rectal resection + segmental sigmoid resection (1) Segmental sigmoid resection (1)
Descending colon (5)	Left hemicolectomy	Transverse colon (1) Splenic flexure (2) Sigmoid colon (2)	Right hemicolectomy extended to transverse (1) Segmental splenic flexure resection (2) Segmental sigmoid resection (2)
Sigmoid colon (8)	Segmental sigmoid resection	Cecum (1) Descending colon (4) Rectum (3)	Right hemicolectomy + terminal ileostomy (1) Left hemicolectomy (4) Anterior rectal resection (3)

no change in surgical management due to the actual intra-operative lesion location still being included within the planned surgical resection. Regarding the post-operative course, no difference was evidenced in terms of surgical complications between concordant and non-concordant cases (3.9% vs. 10.3%,  $p=0.18$ ).

An additional concordance analysis was done between preoperative radiological, endoscopic and intra-operative localization. Preoperative CT scan was performed in 92 (80.0%) patients, and lesions were identified in 65 (70.7%) of those. Radiological localization of the lesions matched their endoscopic and intra-operative localization in 50 (76.9%) and 51 (78.5%) patients, respectively. Interestingly, 13 (54.2%) out of the 39 lesions incorrectly localized on colonoscopy were correctly localized on CT.

## Discussion

According to our findings, colonoscopy revealed

a significant rate of inaccuracy for localization of colorectal malignant lesions and this resulted in frequent intra-operative changes in surgical strategy. Prior studies (*Table 5*) have reported significant variation in colonoscopy accuracy for localization of colorectal lesions, from 59% to 96% (6-24). An elevated rate of changes in surgical strategy secondary to inaccurate preoperative location was also reported, ranging from 4% to 71% according to the criteria used to define “change” (6,8-11,14,15,18).

We identified colonoscopy completeness and quality of bowel preparation as significant predictors for accurate lesion localization, underscoring the importance of colonoscopy quality for this purpose. Colonoscopy completeness has been consistently reported as being predictive of increased accuracy in other studies (6,9,11,14,16). Nevertheless, to our best knowledge, this is the first time an association between bowel preparation quality and endoscopic localization accuracy is noted, possibly related to better visualiza-

**Table 5.** Summary of previous studies that evaluate colonoscopy accuracy in lesion localization

Authors	Number of patients	Colonoscopy accuracy	Influencing factors	Changes in surgical plan
Quero G, et al. (6)	154	74.5%	Colonoscopy completeness	37.5%
Fernandez LM, et al. (7)	203	83.3%	Lesion location	N/A
Nayor J, et al. (8)	110	70.9%	Lesion location	31.3%
Moug S, et al. (9)	364	82%	Colonoscopy completeness Scope use guide Colonoscopy accreditation Previous abdominal surgery	5.2%
Azin A, et al. (10)	557	92.1%	Specialty of the endoscopist	65.9%
Yap R, et al. (11)	210	79%	Colonoscopy completeness Specialty of the endoscopist	4%
Kanazawa H, et al. (12)	143	90%	N/A	N/A
Saleh F, et al. (13)	298	93.6%	N/A	N/A
Bryce AS, et al. (14)	111	79.3%	Colonoscopy completeness	6.3%
Johnstone MS, et al. (15)	79	81%	N/A	6.3%
Borda F, et al. (16)	237	87%	Colonoscopy completeness Lesion location	N/A
Feuerlein S, et al. (17)	49	78.7%	N/A	N/A
Vaziri K, et al. (18)	374	96%	N/A	73%
Lee J, et al. (19)	104	79.8%	N/A	N/A
Solon JG, et al. (20)	62	59%	N/A	N/A
Stanciu C, et al. (21)	161	86%	N/A	N/A
Cho YB, et al. (22)	310	88.9%	N/A	N/A
Hancock JH, et al. (23)	77	89%	N/A	N/A
Vignati P, et al. (24)	320	86%	N/A	N/A

tion of anatomical marks. Therefore, our findings suggest that the adoption of health-care policies aimed at improving colonoscopy quality indicators could be an effective strategy to increase preoperative endoscopic localization accuracy of malignant lesions. Prospective studies to evaluate whether different types of preparation regimen could influence this outcome could also be interesting.

Although we did not find a statistically significant association with anatomical location, previous studies have reported conflicting evidence with Fernandez et al. reporting that transverse or distal lesions were more likely to have a change in final surgical management (7) as opposed to Naylor et al. who stated that right-sided lesions were associated with increased inaccuracy (8), whereas Borda et al. found more frequent endoscopic localization mistakes in both descending colon and cecum (16). Other previously reported factors associated with increased accuracy include scope use guide (9), colonoscopy accreditation (9), absence of previous abdominal surgery (9) and surgical background of the endoscopist (10,11).

The increased accuracy of colonoscopy performed by surgeons could be related to increased focus in tumor localization for preoperative planning (10, 11), although other studies did not confirm an association with the specialty of the endoscopist (13). In our study, all colonoscopies were performed by gastroenterologists, which avoids observation bias but prevents similar analysis. Importantly, we did not find significant differences in colonoscopy accuracy according to the level of experience of the main operator, which is perhaps related to the fact that our center has a strong focus in training and residents are always accompanied by a senior specialist who will promptly take the lead in case any difficulty arises. Regardless of specialty or level of experience, most important is that endoscopists are aware of the consequences of an incorrect preoperative localization and there is an effective communication between endoscopists and surgeons in order to avoid unexpected

localization errors.

We reported a CT accuracy of 78.5% and, importantly, the lesion was correctly localized on CT in 54.2% of endoscopic localization errors. In fact, a combination of colonoscopy and CT scan appears to have greater accuracy for preoperative tumor localization than either alone (19). However, even when combined, the rate of inaccuracy in localization of right-sided lesions may reach 29% (20). The presence of endoscopic tattoo also helped in intraoperative location of 52.6% of tumors inaccurately localized by colonoscopy. Prior literature suggests that endoscopic tattoo placement distal to the lesion is a safe and effective technique that increases accuracy for tumor localization (22) and is associated with decreased operative times and blood loss (25). Until we find ways to improve endoscopic localization accuracy, tattoos and preoperative imaging may be helpful in guiding surgical excision.

Other endoscopic adjunctive techniques associated with improved accuracy in localization of colorectal lesions compared to standard colonoscopy alone include real-time view of the colonoscope position during examination with magnetic endoscopic imaging technology (26) or endoscopic placement of radiopaque marking clips followed by preoperative imaging (CT or plain radiograph) (27). Endoscopic placement of fluorescent marking clips detectable with a fluorescence laparoscope also demonstrated safety and effectiveness in assisting laparoscopic tumor visualization (28). CT colonography is another novel technique that has demonstrated not only accurate lesion localization but also additional important preoperative information related to proximal bowel and depth of invasion (29, 30). Further trials are needed to assess cost-effectiveness of these strategies before their adoption into clinical practice.

This study has limitations related to its retrospective single-center design and reduced number of patients. The endoscopic localization of some left-sided lesions was only reported as distance from anal verge and the endoscopist did not write the corresponding

segment; in such cases, our estimation of the anatomical segment can be inaccurate as it does not account for factors such as anatomical length variations or bowel looping. In fact, inter-human variability may also be a limitation considering that different endoscopists might use different techniques that may influence the accuracy in lesion localization. It is also possible that there can be some degree of inaccuracy in intra-operative localization that we assume as “true”, particularly in cases where mild discrepancy would not produce changes in surgical strategy.

Nevertheless, this is an important and clinically relevant study that brings important novel information related to predictive factors and surgical consequences of colonoscopy accuracy in localization of colorectal cancer. We hope it may raise awareness for the importance of an accurate preoperative endoscopic localization of colorectal malignant lesions and inspire the development of strategies to ameliorate this problem.

## Conclusions

In conclusion, endoscopic localization of colorectal malignant lesions is often inaccurate and an incorrect preoperative localization often results in intra-operative changes in surgical management. Colonoscopy completeness and adequate bowel preparation appear to be predictive factors for a more accurate endoscopic localization, underscoring the importance of colonoscopy quality for this particular indication. Novel strategies to reduce preoperative localization errors are clearly necessary.

## Authors' Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Emanuel Dias, João Santos-Antunes and Diana Gonçalves. The first draft of the manuscript was written by Emanuel Dias. Critical revision of the manuscript was performed by João Santos-Antunes, Diana Gonçalves and

Guilherme Macedo. All authors read and approved the final manuscript.

## Conflicts of interest and source of funding

The authors have no relevant financial, consultant or institutional conflicts of interest to declare. This work did not receive any funding.

## Ethical Statement

This study was approved by the Ethics Committee of Centro Hospitalar Universitário de São João.

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