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Preoperative segmental localization of colorectal carcinoma: CT colonography vs. optical colonoscopy

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Abstract

Background: Adequate preoperative segmental localization of colorectal cancer is important to indicate the right surgical treatment. Preoperative localization has become more important in the era of minimally invasive surgery. The aim of this study was to compare optical colonoscopy (OC) and CT colonography (CTC) with respect to the error rates in the segmental localization of colorectal carcinoma.
Methods: A total of 420 patients with histopathologically proven colorectal carcinoma underwent CTC between December 2006 and February 2017. 284 Of these patients underwent surgical resection and had their carcinomas located on CTC report as well as OC report and surgical report. The segmental localization error rates of OC and CTC were compared using surgery as golden standard. McNemar's test was used to evaluate the differences in error rate.
Results: 284 Patients with a total of 296 colorectal carcinomas were evaluated. The segmental localization error rate of CTC (39/296, 13.2%) was found to be lower than the segmental localization error rate of OC (64/296, 21.6%) ($p < 0.001$). Per segment analysis showed that OC had a significantly higher error rate for carcinomas located in the descending colon (60.6% vs. 21.2% [$p < 0.001$] and cecum(60.0% vs. 23.3% [$p = 0.001$]). In 9.2% of the patients (26/284), localization based on CTC would lead to a change in surgical plan.
Conclusion: CTC has a lower localization error rate than OC, which is most relevant for tumors located in the descending colon. If there is a doubtful localization on OC, particularly in the left-sided colon, an additional CTC should be performed to choose the best surgical treatment.
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Keywords: Computed tomographic colonography; Colonoscopy; Colorectal neoplasms

Introduction

Colorectal cancer is the third most common cancer in men and the second in women worldwide [1]. An oncological resection is the principal curative treatment for colorectal cancer and palliative surgery can play an important role in patients with incurable disease [2,3]. Correct preoperative localization is important to indicate adequate surgical treatment. The percentage of minimally invasive surgery performed is increasing in daily practice, as a result the surgeon is less able to palpate the bowel and locate the tumor [4].

Optical (endoscopic) colonoscopy (OC) is considered to be the golden standard for the detection of colorectal neoplasms. However, exact (segmental) localization of the lesions proves difficult, mainly because the estimate the gastroenterologist has to make depends on too many variables (i.e. length of the sigmoid colon, rate of insufflation, looping of the endoscope) to be highly accurate. Previous studies have shown a varying error rate of segmental

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localization of colorectal lesions, ranging from 4 to 21% [5–12]. Of these errors, 54–73% are said to be clinically significant because the surgical plan needs to be modified [6,7,11].

Computed tomography colonography (CTC) is a technique equivalent to OC in terms of detecting colorectal cancer [13,14]. The technique is well tolerated, rarely has complications, has the advantage of being able to detect synchronous lesions in case of obstructing lesions, can stage malignant lesions, and has the ability to visualize extra colonic findings [15]. Previous studies have shown that CTC has a low localization error rate ranging from 0 to 5.3% [9,16–21].

In terms of localization CTC seems to compare favorably with respect to OC. However, to our knowledge, few studies directly compare CTC and OC in terms of localization [9,18–21]. The aim of this study was to compare the error rate of OC and CTC in the segmental localization of colorectal carcinoma.

Materials and methods

This retrospective observational cohort study was performed at VieCuri Medical Centre, Venlo, The Netherlands, a large teaching hospital. A radiology database and electronic patient care database were merged for this study. The study was approved by the institutional ethical committees.

Patients

All patients with a histopathologically confirmed colorectal carcinoma visible on CTC between January 2007 and February 2017 were included in this study (n = 420). Patients were excluded if there was an absence of tumor localization on their CTC report (n = 17), OC report (n = 30), or surgical report (n = 89). A detailed flowchart of in- and exclusion criteria can be found in Fig. 1.

CTC protocol

In all patients bowel preparation consisted of a low-fibre diet for 48 h, with 150 ml magnesium citrate in the morning and Bisocadyl 10 mg in the morning as well as in the evening on the day before CTC. Feces was tagged using Barium Sulphate ingested the evening before the examination. The CTC was performed by trained technicians on a 64- MDCT (Brilliance 64, Philips Healthcare, Best, The Netherlands or on 128 MDCT (Somatom, Siemens, Erlangen, Germany), imaging in both supine and prone positions with a low-dose technique (120 kV and 50 mAs with dose modulation). Colonic distension was reached by administering 1 ml scopolamine butyl 20 mg/ml or, when this was contraindicated, 1 ml glucagon 1 mg/ml intravenously and subsequently automated low-pressure delivery of carbon dioxide (PROTOCO2L, E-Z-EM). Intravenous contrast was used in case of obstructing colorectal cancer at colonoscopy, allowing evaluation of distant metastasis, especially liver metastasis. Imaging data were reviewed by one of four trained radiologists on a dedicated three-dimensional workstation (Extended Brilliance Workspace 3.0 or 4.0, Philips Healthcare; Best, The Netherlands) using a three-dimensional analysis with endoview, filet view, and computer-assisted detection (CAD), in addition to the traditional two-dimensional images.

OC protocol

Bowel preparation consisted of a low-fibre diet for 72 h, with Bisocadyl 10 mg in the morning and one sachet Picoprep in the evening before OC. In addition, the patient drank 2 L of clear liquid. Another sachet of Picoprep was taken 4 h prior to the OC and another 2 L of clear liquid was taken 3 h before the examination. Kleanprep was used instead of Picoprep if the patient had low kreatinine clearance. Patients were sedated with Fentanyl 0.1 mg/2 ml or Midazolam 5mg/1 ml until conscious sedation was reached. Colonic distension was reached by inflating the bowel with carbon dioxide. If possible, cecal intubation was achieved followed by slow colonoscope withdrawal and mucosal inspection. Once a carcinoma was identified, biopsies were taken for histopathological examination and the lesions were marked with Spot Endoscopic Marker ™ (GI supply). All colonoscopies were performed by experienced gastroenterologists or specialized nurses supervised by these gastroenterologist. An OC was considered to be complete if cecal intubation was achieved.

Defining segments

Of each mass, the localization was determined according to the OC report as well as the CTC report and the surgical report. The colon was divided into the following segments: rectum, sigmoid colon (including rectosigmoid junction), descending colon (including splenic flexure), transverse colon, ascending colon (including hepatic flexure), and cecum. This is the most commonly used subdivision in previous literature [5,16,18,19,21].

If the CTC report defined the location of the carcinoma as centimeters above anus instead of segmental location, the images were reviewed by an experienced radiologist who was blinded to both OC report and surgical report, and assigned a segmental location (n = 10). If the OC report did not report a segmental localization but instead defined the location of the carcinoma as centimeters above anus, the following identification of different colonic segments was used: tumors located 0–40 cm above the anus that required a rectal MRI based on OC were defined as rectum tumors (n = 7); tumors located 0–40 cm above the anus that did not require a rectal MRI based on OC were defined as sigmoid tumors (n = 26) [5]; tumors located 41–70 cm above the anus were defined as descending colon tumors (n = 5).

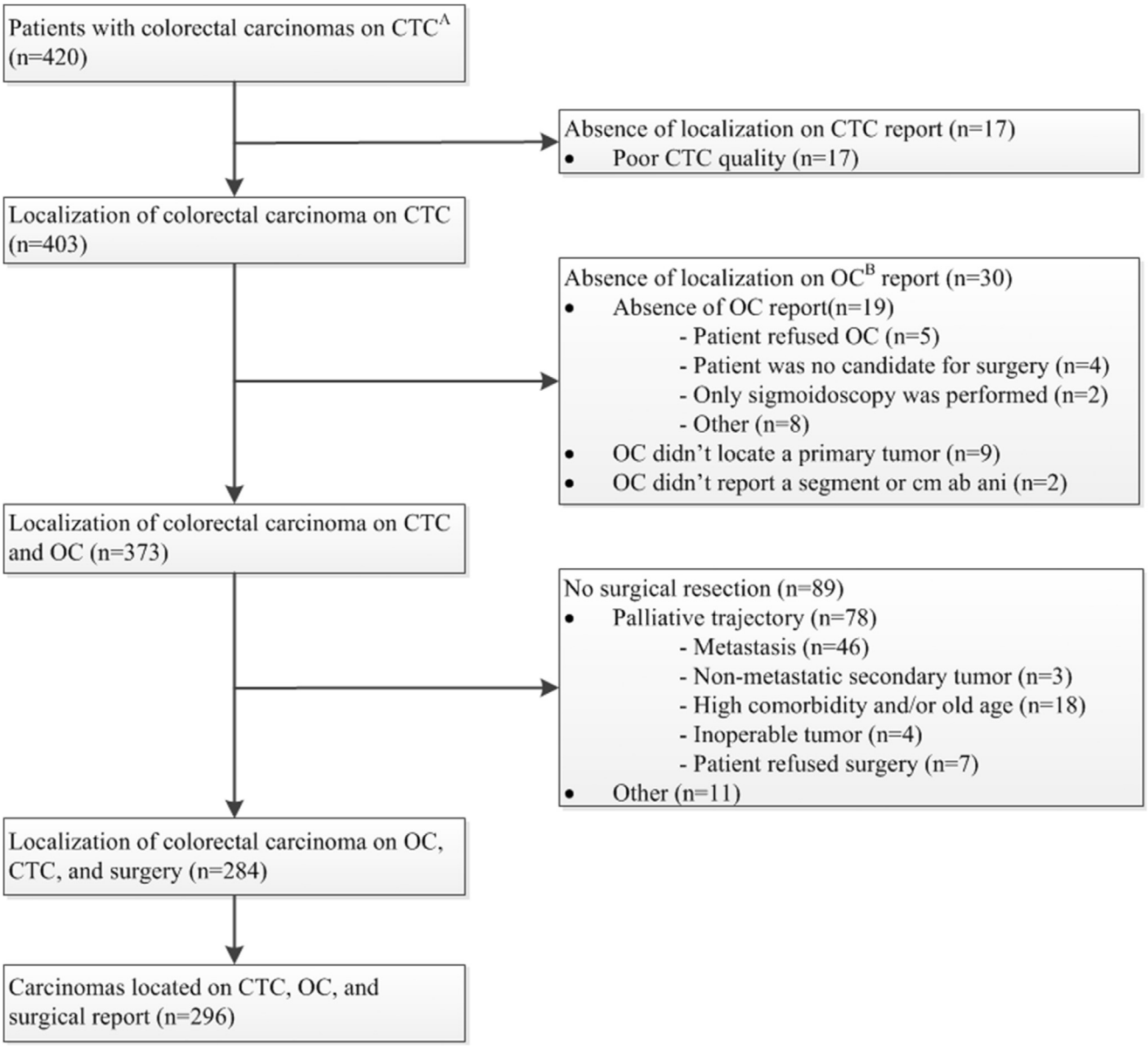

Fig. 1. Flowchart in- and exclusion criteria. [A] CT colonography. [B] Optical colonoscopy.

All tumors located ≥71 cm above the anus had a segmental localization on OC report. If the CTC report, OC report, or surgical report showed the carcinoma was located at the border between two colonic segments, the most distal segment was chosen for analysis (CTC, n = 15; OC, n = 9; surgery, n = 4). In addition, ileocecal tumors were considered to be cecum tumors for analysis.

Statistical analysis

The proportions of correct and incorrect localization of CTC and OC were calculated on a per lesion basis with surgery as the golden standard. McNemar's test was used to compare differences in proportions. A p-value of less than or equal to 0.05 indicated a statistically significant difference.

Results

The 284 analyzed patients had a total of 304 histopathologically confirmed colorectal carcinomas (18 patients had 2 carcinomas, 1 patient had 3 carcinomas). Eight of these synchronous carcinomas were excluded because OC could not locate these carcinomas due to an obstructing primary colorectal carcinoma. Patient characteristics are summarized in Table 1.

Segmental localization was determined using surgical location as the golden standard. The colorectal carcinomas

Table 1
Patient characteristics.

Total number of patients	284
Gender	
Male	148 (52%)
Female	136 (48%)
Mean age at CTC[a] yrs. (range)	69.6 (38–93)
Colonic lesion	245 (86%)
Rectal lesion	39 (14%)
Complete colonoscopy	39 (13%)
Incomplete colonoscopy	257 (87%)
CTC prior to colonoscopy	59 (20%)
Colonoscopy prior to CTC	237 (80%)
Patients with synchronous tumors	19 (6.7%)

[a] CT colonography.

were distributed as follows: rectum (n = 38, 12.8%), sigmoid colon (n = 129, 43.6%), descending colon (n = 33, 11.1%), transverse colon (n = 17, 5.7%), ascending colon (n = 49, 16.6%), and cecum (n = 30, 10.1%). Tables 2 and 3 shows the segmental localization according to CTC respectively OC compared to surgery. In 3 cases OC localization was more than one segment off. Two times a descending colon carcinoma was classified as an ascending colon carcinoma and once a transverse colon carcinoma classified as a sigmoid colon carcinoma. CTC was never more than one segment off.

The segmental localization error rate of CTC (39/296, 13.2%) was found to be lower than the segmental localization error rate of OC (64/296, 21.6%) ($p < 0.001$) (Table 4).Carcinomas located in the descending colon and cecum were found to have a higher error rate on OC compared to CTC (60.6% vs. 21.2% for descending colon carcinomas and 60.0% vs. 23.3% for cecum carcinomas). These difference were statistically significant ($p < 0.001$ and $p = 0.001$, respectively) (Table 4). All wrongly located cecum carcinomas on CTC and OC were ascending colon carcinomas according to surgical report (Tables 2 and 3).

Table 2
Segmental localization according to surgery and CTC.

		Surgery						
		Rectum	Sigmoid colon	Descending colon	Transverse colon	Ascending colon	Cecum	Total
CTC[a]	Rectum	35	9	0	0	0	0	44
		92%	7.0%	0%	0%	0%	0%	15%
	Sigmoid colon	3	113	2	0	0	0	118
		8%	88%	6%	0%	0%	0%	40%
	Descending colon	0	7	26	1	0	0	34
		0%	5%	79%	6%	0%	0%	12%
	Transverse colon	0	0	5	14	2	0	21
		0%	0%	15%	82%	4%	0%	7%
	Ascending colon	0	0	0	2	46	7	55
		0%	0%	0%	12%	94%	23%	19%
	Cecum	0	0	0	0	1	23	24
		0%	0%	0%	0%	2%	77%	8%
	Total	38	129	33	17	49	30	296
		100%	100%	100%	100%	100%	100%	100%

[a] CT colonography.

Table 3
Segmental localization according to surgery and OC.

		Surgery						
		Rectum	Sigmoid colon	Descending colon	Transverse colon	Ascending colon	Cecum	Total
OC[a]	Rectum	36	15	0	0	0	0	51
		95%	12%	0%	0%	0%	0%	17%
	Sigmoid colon	2	112	11	1	0	0	126
		5%	87%	33%	6%	0%	0%	43%
	Descending colon	0	2	13	3	0	0	18
		0%	2%	39%	18%	0%	0%	6.1%
	Transverse colon	0	0	7	12	1	0	20
		0%	0%	21%	71%	2%	0%	6.8%
	Ascending colon	0	0	2	1	47	18	68
		0%	0%	6%	6%	96%	60%	23%
	Cecum	0	0	0	0	1	12	13
		0%	0%	0%	0%	2%	40%	4.4%
	Total	38	129	33	17	49	30	296
		100%	100%	100%	100%	100%	100%	100%

[a] Optical colonoscopy.

Table 4
Segmental error rate of CTC and OC (compared to surgery as golden standard).

Segment	n	CTC[a] errors (%)	OC[b] errors (%)	P-value (McNemar's test)
Rectum	38	3 (7.9%)	2 (5.3%)	1.000
Sigmoid colon	129	16 (12.4%)	17 (13.2%)	1.000
Descending colon	33	7 (21.2%)	20 (60.6%)	0.000*
Transverse colon	17	3 (17.6%)	5 (29.4%)	0.625
Ascending colon	49	2 (4.1%)	3 (6.1%)	1.000
Cecum	30	7 (23.3%)	18 (60.0%)	0.001*
Total	296	39 (13.2%)	64 (21.6%)	0.000*

* p-value < 0.05.
[a] CT colonography.
[b] Optical colonoscopy.

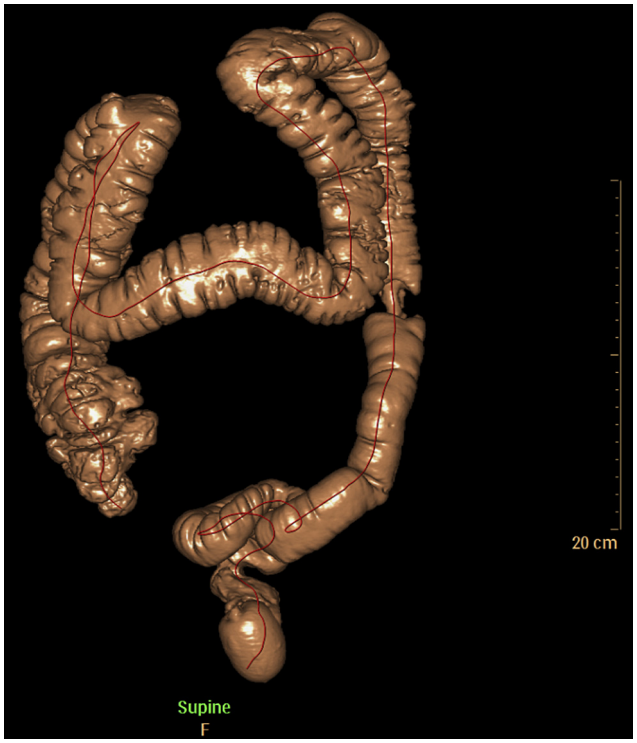

Fig. 2. A 41 year old woman with complaints of constipation and abdominal pain underwent optical colonoscopy (OC). OC showed an obstructing tumor in the sigmoid colon. A CT colonography (CTC) was performed to rule out synchronous tumors proximal to the obstructing tumor. No synchronous tumor was found, but CTC did show the obstructing tumor was located in the mid-descending colon, and not in the sigmoid colon. A left hemi colectomy was performed.

In 27 patients, both CTC and OC localized the carcinoma in a wrong segment. Nine of these tumors were located at the rectosigmoid junction and eight were located at the cecocolic junction. In 37 patients, CTC showed the correct segment where OC did not. In 26 of these 37 cases (9.2% of all colorectal cancer patients who underwent surgery), CTC would have changed the surgical plan (Fig. 2). In 11 cases of the 37 cases, CTC would not have changed the surgical plan as these carcinomas were located in the right hemicolon and a right hemi colectomy was done either way. In 12 patients (4.2%), OC showed the correct segment where CTC did not. In practice, the surgical plan was not altered in these cases because the tumors were located at the border of segments.

Error rates for OC were lower if a complete colonoscopy was performed compared to cases in whom a complete colonoscopy could not be performed (5/39 [12.8%] vs. 59/257 [23.0%], respectively). However, this difference was not found to be statistically significant (Chi-Square test, $p = 0.152$).

Discussion

Despite equal sensitivity for detecting CRC [13,14], CTC may have an extra benefit over OC in detecting the exact location of the CRC. Exact preoperative localization is important for surgical planning, especially since minimally invasive approaches are increasing in daily practice and the surgeon can't palpate the bowel anymore [4]. Better localization of the tumor does not only influence the type of resection but also optimizes the preoperative information given to the patient. The length and the quality of the colon (e.g. extensive diverticulosis or a dolichocolon) is important for the surgeon as it can influence the resection type and the estimated operation time. Also the chance of the need for mobilizing the splenic flexure is important to know preoperatively. In addition, position of the trocars used in laparoscopic surgery is different for a right-sided hemi-colectomy versus a transverse colon resection. In case of contrast-enhanced computed tomography colonography (CE-CTC), the CTC can also assess the anatomy of the mesenteric vessels in relation to the CRC, which limits the risk of unnecessary laparoscopic vessel ligation and/or lymph node dissection [22,23].

In this study, CTC was found to have a lower segmental localization error rate than OC (13.2% vs. 21.6%, respectively). Previous studies showed CTC compared favorably in terms of segmental localization with respect to OC as well [9,18–21]. This can be explained by the variable colon anatomy among individuals and the scarce amount of reference points during endoscopic examination. Also, linear distance measured by OC may be incorrect due to pleating and telescoping [24]. Endoscopic tattooing can drastically decrease the endoscopic error rate perioperatively [9]. However, it is not useful in preoperative planning. Furthermore, the tattoo is not always visible for example due to fatty overgrowth of the colon or due to a retroperitoneal location of the tattoo. In contrast, CTC calculates a three-dimensional volume of the colon and this visualizes the tumor localization more easily. CTC would correctly modify the surgical plan based on localization in 9.2% of the cases. Previous studies with smaller populations show that CTC correctly modified the surgical plan in 4–12% of the cases [20,25].

With respect to segments, the localization error rate for descending colon tumors and cecum tumors were high for both OC and CTC but were significantly lower in CTC compared to OC (25.0% vs. 62.5% for descending colon tumors and 23.3% vs. 60.0% for cecum tumors). A high localization error rate for OC in descending colon has been reported before [5–8,21]. It might be explained by the variable length and mobility of the sigmoid colon and the lack of anatomical and endoscopic marks to define the transition between the sigmoid and descending colon [5]. On CTC, locating the point where the retroperitoneal colon (descending colon) angles anteriorly and becomes intraperitoneal (sigmoid colon) can be quite challenging. The high error rate for cecum tumors on OC can be explained because cecum tumors can be so large that ileocecal valve visualization is difficult [5]. All wrongly located cecum carcinomas in this study were defined at surgical report as ascending colon carcinomas. These localization errors are not clinically relevant because these tumors are treated with a right hemi colectomy in either case. However, erroneous localization of descending colon tumors is clinically relevant because a(n) (extended) left hemi colectomy, transversectomy, or a sigmoidectomy might be performed based on the exact location.

The error rate of OC (20.3%) found in our study is relatively high compared to previous studies that showed error rates ranging from 4 to 21% [5–12]. A recent meta-analysis concluded the average error rate of OC was 15.4% (CI 12.0–18.7) [12]. The relatively high error rate in our study can be partially explained by the high number of incomplete colonoscopies (n = 257 [87%]) which had a, although not significantly, higher error rate compared to complete colonoscopies (23.0% vs. 12.8%, respectively). A previous study did show that incomplete colonoscopies were associated with a higher error rate [5]. The high amount of incomplete colonoscopies (86.8%) in our study is due to the fact that after an incomplete colonoscopy due to an obstructing tumor a CTC will always follow to exclude synchronous lesions. If there is a non-obstructing tumor on OC and the colonoscopy is complete, an additional CTC will not be performed. Therefore, these patients are not included in this study. The small percentage of complete colonoscopies occurred if the OC was performed after the CTC in order to take biopsies of a suspected lesion at CTC. The variability in error rates in studies can also be partially explained by different definitions of colon segments.

In our study we found a relatively high localization error rate of 13.2% in CTC, compared to 0–5.3% in other studies [9,16–21]. Localization was based on interpreting the reports and the volume-images of the colon were not reviewed for precise localization. In 17 out of these 39 errors, the carcinomas were located on the rectosigmoid junction or the cecocolic junction. At CTC and OC, tumors extending distally from the ileocecal valve were considered to be ascending colon tumors. At surgical report, tumors involving the ileocecal valve were considered to be cecum tumors, even if they extended distally. Similarly, at CTC, the rectosigmoid junction can be precisely defined by the proximal valve of Houston, whereas most colorectal surgeons use a linear distance, which is less precise. Moreover, although we considered surgery as a golden standard, the surgical report as a reference test may be imperfect as not all surgeons are that precise in there reports.

CTC does not only allow for segmental localization. Currently, according to the European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastrointestinal and Abdominal Radiology (ESGAR), CTC has a role in case of incomplete OC [26]. CTC can clarify the intra-segmental extension of the tumor, can assess the extent of possible diverticular disease that may be additionally excised, and can locate synchronous tumors proximal to an obstructing tumor on OC. In this study, 8 synchronous tumors located by CTC were not found by OC in 284 patients. This lead to a change in surgical plan based on CTC in an additional 1.8% of the population [19,27]. CTC is a safe procedure and may not only have a role in incomplete colonoscopy but also in complete colonoscopy for preoperative evaluation [28].

Our study had some limitations. First, because of the retrospective nature of the study, possible bias in interpreting the reports might have occurred. Second, CTC was not blinded to OC localization when performed after incomplete OC and OC was not blinded tot CTC localization when CRC was primarily detected on CTC. Localization given in the report might be biased because of this knowledge. Third, although we can estimate how many times CTC would have changed the surgical plan based on OC, a prospective study is required to accurately estimate the added clinical value of performing a CTC.

In conclusion, this study confirmed that CTC has a lower localization error rate than OC, especially for tumors located in the descending colon. If there is a doubtful localization on OC, a CTC should be performed preoperatively, particularly in case of left-sided colon tumors.

Conflict of interest

None of the authors had any financial or personal relationships with other people or organizations that could inappropriately influence their work. The study was not funded.

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