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Colonoscopy quality assessment and accuracy: analysis of the influencing factors and surgical sequelae on 216 colonoscopies

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Abstract. – OBJECTIVE: Colonoscopy is recognized as the primary screening test for colorectal cancer. However, its inaccuracy in identifying the exact tumor localization is still high. As a consequence, repeated colonoscopies and changes in the surgical management have been reported. This study aims to evaluate the quality of 216 colonoscopies, to define colonoscopy accuracy and to investigate the surgical sequelae of an incorrect localization.

PATIENTS AND METHODS: A retrospective analysis of 216 colonoscopies has been conducted. Colonoscopy quality was assessed on: quality of bowel preparation, completeness of the examination, video and/or photographic documentation, and reported the distance of the lesion from the anal verge. Colonoscopy accuracy was evaluated in terms of correspondence between the endoscopic and intra-operative tumor localization.

RESULTS: Bowel preparation adequateness was reported in 121 out of 216 (56%) colonoscopies, with an adequate grade in 68.6% of cases. A complete colonoscopy was accomplished in 86.9% of cases with photo documentation in only 59 colonoscopies (27.3%). The lesion distance from the anal verge was documented only in 93 out of 216 colonoscopies. Of the 157 lesions described at the colonoscopy, 117 matched with the intra-operative localization (accuracy 74.5%). Fifteen of the 40 incorrectly localized lesions (37.5%) required changes in the surgical management. At multivariate analysis, the colonoscopy completeness was the only influencing factor on the concordance between endoscopic and intra-operative localization.

CONCLUSIONS: Colonoscopy demonstrated adequate accuracy in localizing lesions. However, the incorrect tumor localization leads to a high rate of changes in surgical management. Increase in colonoscopy quality is needed to reduce the risk of incorrect localizations.

Key Words:
Colonoscopy quality, Colonoscopy accuracy, Colorectal surgery.

Introduction

Colonoscopy is widely used as the primary screening examination for colorectal cancers (CRCs) or as workup in case of positive blood fecal tests or radiologic examinations[1-3]. The direct visualization of the colonic mucosa and the possibility of taking biopsy and/or excising polyps and early cancers made colonoscopy an essential step in both the diagnosis and early treatment of CRCs[2,4]. However, its inaccuracy in tumor localization ranges between 4% and 21%[1,5]. Such a wide range could be mainly related to the endoscopists' experience and consequently to the quality of the colonoscopy performed[6-8]. As a matter of fact, 71% to 86% of interval cancers can be attributed to the inadequacy of the first colonoscopy, since they usually represent missed lesions or as a result of incompletely resected tumors[9-12].

The recent implementation of minimally invasive surgical (MIS) techniques has made endoscopic localization of colonic lesions even more essential for surgical planning, mainly due to the absence of tactile feedback[13]. Unlike the open approach, during which the tumor can be directly palpated, the tumor may not be readily apparent, unless large and involving the serosa surface. This leads to the frequent need for intraoperative colonoscopies, to open conversion and, in the worst cases, to the removal of a wrong segment of bowel[14,15].

Endoscopic tattooing significantly facilitates the intraoperative detection of tumors, but the dye

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injection into the mesenteric side or its excessive widespread in the peritoneal cavity make it difficult to be observed[16]. These concerns have led to the need for improvements in the quality of colonoscopy to maximize its ability to reduce CRC incidence and to reduce the rate of missing lesions or repeated colonoscopies. The Gastroenterology Societies have proposed multiple indicators of colonoscopy quality[17], but choosing and measuring the most appropriate parameters remains a work in progress.

The purpose of our study is to evaluate the quality of 216 colonoscopies performed, assessed on predefined parameters. In addition, the accuracy of preoperative colonoscopy lesion localization was evaluated. Furthermore, factors leading to incorrect localization and surgical and clinical sequelae were investigated.

Patients and Methods

After Institutional Review Board (IRB) approval, all patients with a CRC diagnosed by colonoscopy and who received a colorectal resection at the Digestive Surgery Unit of the "A. Gemelli" Hospital between February 2017 and January 2018 were included in the study. Open access procedures as well as laparoscopic and robotic resections were considered for analysis. Both patients who had colonoscopy performed in our or other centers were included. Demographic data, indication for colonoscopy and surgical procedures performed were retrospectively reviewed. Colonoscopy quality was assessed on predefined parameters: quality of bowel preparation, completeness of the examination, video and/or photographic documentation, and reported distance of the lesion from the anal verge. Lesion localization was ascribed to one of eight segments (rectum, sigmoid colon, descending colon, splenic flexure, transverse colon, hepatic flexure, ascending colon and caecum). Both positions from the endoscopic and surgical reports were registered and any change to the intended surgery was documented. When a preoperative computed tomography (CT) was performed, location according to the radiological exams was analyzed for accuracy and concordance with the endoscopic and surgical reports.

Statistical Analysis

Means and standard deviations (SDs) were used for all continuous data while numbers and percentages were calculated for all categorical data. Univariate analysis included Mann-Whitney U test, χ^2-test, and Fisher exact tests. All tests were two-tailed and a p-value ≤ 0.05 was considered statistically significant for all analyses. Multivariate analysis was performed by means of logistic regression on variables that were significant at univariate analysis. All data were analyzed using SPSS for Windows, version 21 (IBM Corp., IBM SPSS Statistics for Windows, Armonk, NY, USA).

Results

Patients' Demographic and Clinical Characteristics

A total of 154 patients who had a preoperative colonoscopy and who underwent surgical resection in our unit were identified and included in the study. Three patients had more than one lesion, while 46 (29.8%) and 8 (5.2%) patients underwent 2 and 3 pre-operative colonoscopies, respectively. Therefore, a total of 157 lesions were encountered and a total of 216 colonoscopies were analyzed.

Patients' demographic characteristics, lesion size and localization at the colonoscopy are reported in Table I. Patients' mean age was 66.4 years (range 41-86); 77 (50%) were male. Only five patients had a previous colorectal resection. Mean lesion size was 36.8 (5 to 110) mm, more frequently located in the sigmoid colon (38 out of 157 lesions – 24.2%). An endoscopic tattoo was performed in a total of 69 (44.8%) patients: during the first colonoscopy in 51 cases and during the second and third colonoscopy in 16 and 2 cases, respectively. An open surgical approach was performed in 66 out of 154 cases (42.8%), while 73 (47.4%) and 15 (9.7%) patients underwent a laparoscopic and robotic resection, respectively.

Colonoscopy Quality Assessment

Bowel preparation adequateness was reported in 121 out of 216 (56%) colonoscopies performed, while in the remaining 95 cases this data was missing. An objective evaluation by means of the Boston Bowel Preparation Scale (BBPS)[18] was present only in the 22.2% (48 out of 216) of cases. Colonic preparation was defined adequate in 83 (68.6%) out of 121 cases. Forty-eight (22.2%) out of 216 colonoscopies documented an impassable tumor obstructing the lumen and thus excluded from the colonoscopy completeness evaluation. Of the remaining 168 endoscopic exams, 146 (86.9%) were described as complete. Despite the

high completeness rate, photo documentation of caecal landmarks was available in only 59 (27.3%) out of 216 colonoscopies. An evaluation in terms of distance of the lesion from the anal verge was reported in the 43% of cases (93 out of 216 colonoscopies) and it was mostly reserved to the lesions located in the sigmoid colon and rectum (71 out of 93).

Endoscopic Localization Accuracy

Of the 157 lesions defined at the colonoscopy, 117 properly matched with the location evidenced intra-operatively, leading to a colonoscopy accuracy of 74.5% (Table II). Among the remaining 40 non-concordant cases, none of the lesions endoscopically described in the transverse colon (3 out of 3) were intra-operatively confirmed. Conversely, only two lesions out of 33 (6%) endoscopically described in the rectum did not match with the intraoperative report. Fifteen (37.5%) out of the 40 lesions, which differed between colonoscopy and surgery, required changes in the surgical management as a consequence of the incorrect localization. Ten out of 15 lesions were tattooed, and the appropriate localization was properly defined intra-operatively. In the remaining 5 non-tattooed lesions, 4 were recognized due to the extramural tumor diffusion, while in one case an intraoperative colonoscopy was needed. Details of the surgical management changes are reported in Table III. Of note, one patient required an anterior rectal resection and an unplanned temporary ileostomy, being the lesion located in the medium rectum rather than in the sigmoid colon. None of the patients required a conversion from minimally invasive to open access due to the incorrect localization. Surgery was not changed in the remaining 25 cases because of a minor location change not requiring variation of the surgical plan.

Table IV reports the comparison between the concordant and non-concordant colonoscopies. No difference was evidenced in terms of adequa-

Table I. Patients' demographic and clinical characteristics.

Age, mean (range), years	66.4 (41-86)
Gender, n (%)	
Male	77 (50)
Female	77 (50)
Lesion size, mean (range), mm	36.8 (5-110)
Endoscopic lesion localizationa, n (%)	
Rectum	33 (21)
Sigmoid colon	38 (24.2)
Descending colon	24 (15.3)
Splenic flexure	5 (3.2)
Transverse colon	3 (1.9)
Hepatic flexure	15 (9.6)
Ascending colon	17 (10.8)
Caecum	22 (14)
Endoscopic tattoo, n (%)	69 (44.8)
Surgical approach, n (%)	
Open	66 (42.8)
Laparoscopy	73 (47.4)
Robot-assisted	15 (9.7)

[a]Detected lesions: 157.

Table II. Discrepancy between endoscopic and intra-operative localization.

Endoscopic localization	n. (%)	Intra-operative localization	n.
Transverse colon	3 (100)	Descending colon	1
		Splenic flexure	1
		Hepatic flexure	1
Hepatic flexure	8 (53.3)	Splenic flexure	3
		Transverse colon	4
		Ascending colon	1
Splenic flexure	2 (20)	Descending colon	1
		Hepatic flexure	1
Ascending colon	3 (17.6)	Caecum	1
		Hepatic flexure	1
		Transverse colon	1
Descending colon	17 (70.8)	Sigmoid colon	10
		Transverse colon	7
Sigmoid colon	2 (5.2)	Rectum	2
Caecum	3 (13.6)	Ascending colon	3
Rectum	2 (6)	Sigmoid colon	2

Abbreviation: HR, hazard ratio; CI, confidence interval.

Table III. Surgical management changes for incorrect endoscopic localization.

Endoscopic localization	n.	Planned surgical resection	Intra-operative localization	Surgical resection performed	n.
Transverse colon	3	Laparoscopic transverse colon resection	Descending colon	Laparoscopic left hemicolectomy	1
			Splenic flexure	Laparoscopic left hemicolectomy	1
			Hepatic flexure	Open right hemi-colectomy	1
Hepatic flexure	4	Laparoscopic right hemi-colectomy	Splenic flexure	Laparoscopic left hemicolectomy	3
			Transverse colon	Laparoscopic trans-verse colon resection	1
Splenic flexure	1	Laparoscopic left hemi-colectomy	Hepatic flexure	Laparoscopic right hemicolectomy	1
Descending colon	6	Laparoscopic left hemi-colectomy	Transverse colon	Laparoscopic trans-verse resection	3
			Transverse colon	Open transverse re-section	3
Sigmoid colon	1	Laparoscopic left hemi-colectomy	Medium rectum	Open anterior rectal resection + tempo-rary ileostomy	1

teness of colon preparation (*p*: 0.82), photo/video recording (*p*:0.67) and reported distance from the anal verge (*p*: 0.18). Concordance was more frequent in case of complete colonoscopy (90.8% *vs.* 73% in the concordant and non-concordant groups, respectively; *p*: 0.004). Preoperative tattoo resulted more frequently performed in the non-concordant colonoscopies (45% *vs.* 29% in the concordant group; *p*: 0.05).

The lesion tattoo helped tumor localization in 57 out of 69 patients (82.6%). In the remaining cases, excessive adhesions (3 cases) and dye injection into the mesenteric side (6 cases) did not permit proper lesion localization. An excessive peritoneal dye spreading was encountered in three patients.

No difference was noted in terms of mean surgical time between the concordant and non-concordant groups (205.7 (±65.7) *vs.* 218 (±65.1) minutes, respectively; *p*: 0.21). No additional colorectal lesions were retrieved intraoperatively. Regarding the post-operative course, no difference was evidenced in terms of surgical complications between the two study cohorts (14.3% -16 patients *vs.* 15.1% - 6 patients in the concordant and non-concordant group, respectively; *p*=0.88).

At the multivariate analysis only, the colonoscopy completeness was observed as an independent influencing factor on the concordance between endoscopic and surgical localization (*p*: 0.037; OR: 10.8; 95% IC: 1.01-109.83).

An additional concordance analysis was done between the preoperative radiological, the endoscopic and the intra-operative lesion localization. CT scan was performed on 103 patients (66.8%). In the remaining cases, preoperative CT was not performed or available for analysis. Lesions were identified at the preoperative imaging in 100% of cases. A correct radiological localization was made in 94 out of 103 cases (91.3%), while the

Table IV. Comparison between concordant and non-concordant colonoscopies.

	Concordant (176)	Non-concordant (40)	*p*
Age, years, mean (SD)	67.4 (±10.2)	67.9 (±7.8)	0.84
Preparation Quality, n (%)			
Adequate	66 (37.5)	17 (42.5)	0.82
Not reported	77 (43.7)	18 (45)	
Colonoscopy completenessa, n (%)	119 (90.8)	27 (73)	0.004
Photo/video recording, n (%)	47 (26.7)	12 (30)	0.67
Distance from anal verge report-ed, n (%)	72 (40.9)	21 (52.5)	0.18
Preoperative tattoo, n (%)	51 (29)	18 (45)	0.05
Operative time, min (±SD)	205.7 (±65.7)	218 (±65.1)	0.21

[a]Evaluated on a total of 168 colonoscopies (131 concordant *vs.* 37 non-concordant).

concordance with the endoscopic reports was 88.3% (91 cases out of 103). Interestingly, 14 out of the 40 lesions (35%) incorrectly localized at the colonoscopy were correctly identified at the CT scan.

Discussion

According to our findings, there is a substantial rate of suboptimal quality of the index colonoscopy before surgery for CRC, with a 25.5% rate of inaccuracy in lesion localization, leading to change of the surgical plan in a high percentage of cases. These data are relevant for the following reason: an unexpected high rate of post-CRC surgery has been described after 1 year of follow-up, and it has been possibly related with miss rate at baseline colonoscopy. Our data showed that the cleansing grade was reported only in 121 out of 216 colonoscopies (56%), and an adequate bowel preparation in only 83 patients (68.6%). This is much lower than the 90% officially recommended. It has been already demonstrated how an inadequate bowel cleansing is a significant risk factor for missing lesions, prolonged caecal intubation and withdrawal time[17,19]. Despite "objective" bowel preparation scales have been validated and recommended[18,20,21], our study showed that their use is very limited. Of note, only the 22.2% of our cohort of study had a standardized definition of the bowel preparation, being the BBPS the only objective method used. Secondly, we analyzed the colonoscopy completeness rate. After excluding patients with obstructive tumors, the completion rate was 86.9% (146 out of 168). The need to ensure complete colon visualization is based on the findings that nearly 30% of CRCs are located in the proximal colon[22]. Even if our value is in line with other reports[17,23], such data was supported by photo documentation only in the 27.3% of cases. This lack does not permit an objective validation of the examination completeness. With the aim of investigating the colonoscopy accuracy, a comparison with the intra-operative lesion localization was also conducted. We demonstrated a preoperative accuracy rate of 74.5%, in line with other cases series present in the literature[1,24-27], but significantly lower than the 96% value documented by Vaziri et al[26]. This last discrepancy demonstrates how the endoscopist's expertise can influence the colonoscopy accuracy. As a matter of fact Vaziri et al[26] showed that one single high skilled surgeon performed both the colonoscopies and operations. Conversely, we have here reported a more real-life setting, including in the analysis colonoscopies performed both in our tertiary referral center and in small volume hospitals. Fifteen of the 40 incorrectly localized lesions required changes in the surgical management, representing the 9.7% of the study cohort, notably higher than the 4% and 3.3% reported by Yap et al[28] and Vaziri et al[26] respectively. One patient needed an intraoperative colonoscopy for the right localization, while in one case an unplanned temporary ileostomy was needed. Such a result furthermore reflects the need for high-quality endoscopic examinations, and the use of tattoo for localizing lesions outside clear anatomical landmarks, such as the rectum or the caecum. In this regard, we found the colonoscopy completeness as the most important influencing independent factor in predicting colonoscopy accuracy (*p*: 0.037; OR: 10.8; 95% IC: 1.01-109.83). This finding has been already showed by Borda et al[24] and Yap et al[28], while Piscatelli et al[29] recognized previous colorectal resections as a further influencing factor. Unfortunately, our small number of previous colorectal surgeries did not permit us to consider it for statistical analysis. Even if colonoscopy is the gold standard in CRCs diagnosis, we decided to investigate if the use of complementary diagnostic methods could increase the tumor localization accuracy. Various guidelines have proposed the endoscopic tattoo of the lesion as a safe, reliable and feasible technique[30,31]. However, the dye injection into the mesenteric side as well as the presence of adhesions and the excessive surrounding tissue spreading could represent a relevant limitation[32]. Additionally, despite its important role, the endoscopic tattoo is not yet widely used. As a matter of fact, only the 44.8% (69 patients) of our cohort of study underwent an endoscopic tattoo, similarly to other case series[28]. The endoscopic tattoo helped tumor localization in 82.6% of the tattooed lesions (57 out of 69). Interestingly, we found that it was more frequently performed in the non-concordant group of patients (45% *vs.* 29% in the concordant group; *p*: 0.05). This result would demonstrate the endoscopists' tattoo use especially in case of uncertain tumor localization, especially related to incomplete colonoscopies. As a further method, the complementary role of CT imaging was also investigated. Of note, the 35% of the incorrectly localized lesions at

the colonoscopy were correctly visualized at the CT scan. However, it should be underscored how such correspondence is directly related to the lesion dimension[28]. Our mean lesion size was 36.8 mm, similar to Yap et al's[28] cohort of study (40.6 mm), who demonstrated a correct CT localization in 38.6% of cases of an incorrect endoscopic localization. This rate reached 52.4% in Lee et al's[33] work for a mean tumor lesion of 57.2 mm. Only few other studies assessed the utility of CT in tumor localization. Feuerlein et al[34] documented an accuracy rate of 67.4% as compared with 78.7% for endoscopy. This value lowers to 62% in Solon et al[35] case load for transverse colonic lesions. Conversely, Loffeld et al[36] demonstrated an overall accuracy of 90.5% for radiological imaging in case of sigmoid or rectal cancers. These inhomogeneous results reflect the impossibility to draw a solid conclusion on the real role of CT in tumor localization. This is mainly due to the small sample sizes of most studies, and to the different selection criteria used by the authors. According to our practice, we do believe that CT scan might give a significant contribution in tumor localization when used selectively and in concert with colonoscopy, especially in case of larger lesions.

Conclusions

We acknowledge that the retrospective design of the study represents its main limitation. However, the involvement of both a tertiary referral center and small volume hospitals does represent a real-life situation. Colonoscopy has demonstrated an adequate accuracy, but in case of incorrect localization, a dramatic change into the surgical management has been reported. In this regard, it is essential to define proper parameters to increase the colonoscopy quality. Additionally, an appropriate endoscopist's expertise is mandatory. Colonoscopy training should emphasize the need to properly recognize colonoscopy positions as well as defining appropriate complementary methods to reduce the risk of incorrect localizations.

Conflict of Interest

Authors have no conflicts of interests or financial ties to disclose.

Declaration of funding interests

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References

1) Stanciu C, Trifan A, Khder SA. Accuracy of colonoscopy in localizing colonic cancer. Rev Med Chir Soc Med Nat Iasi 2007; 111: 39-43.
2) Zauber AG, Lansdorp-Vogelaar I, Knudsen AB, Wilschut J, van Ballegooijen M, Kuntz KM. Evaluating test strategies for colorectal cancer screening: a decision analysis for the U.S. Preventive Services Task Force. Ann Intern Med 2008; 149: 659-669.
3) Stagnitti A, Barchetti F, Barchetti G, Pasqualitto E, Sartori A, Glorioso M, Gigli S, Buonocore V, Monti ML, Marini A, Mele C, Stagnitti F, Laghi A. Preoperative staging of colorectal cancer using virtual colonoscopy: correlation with surgical results. Eur Rev Med Pharmacol Sci 2015; 19: 1645-1651.
4) Allegretti A, Bargallò-Carulla D, Bertelè A, Franzè A, Kouroumalis EA, Mancini MA, Paspatis G, Reina-Serrano S. Efficacy and safety of bowel cleansing solutions for colonoscopy: a prospective observational study. Eur Rev Med Pharmacol Sci 2010; 14: 979-985.
5) Huang RX, Xiao ZL, Li F, Ji DN, Zhou J, Xiang P, Bao ZJ. Black hood assisted colonoscopy for detection of colorectal polyps: a prospective randomized controlled study. Eur Rev Med Pharmacol Sci 2016; 20: 3266-3272.
6) Kaminski MF, Regula J, Kraszewska E, Polkowski M, Wojciechowska U, Didkowska J, Zwierko M, Rupinski M, Nowacki MP, Butruk E. Quality indicators for colonoscopy and the risk of interval cancer. N Engl J Med 2010; 362: 1795-1803.
7) Costamagna G, Marchese M. Progress in endoscopic imaging of gastrointestinal tumors. Eur Rev Med Pharmacol Sci 2010; 14: 272-276.
8) Tumino E, Parisi G, Bertoni M, Bertini M, Metrangolo S, Ierardi E, Cervelli R, Bresci G, Sacco R. Use of robotic colonoscopy in patients with previous incomplete colonoscopy. Eur Rev Med Pharmacol Sci 2017; 21: 819-826.
9) Huang Y, Gong W, Su B, Zhi F, Liu S, Jiang B. Risk and cause of interval colorectal cancer after colonoscopic polypectomy. Digestion 2012; 86: 148-154.
10) Le Clercq CM, Bouwens MW, Rondagh EJ, Bakker CM, Keulen ET, de Ridder RJ, Winkens B, Masclee AA, Sanduleanu S. Postcolonoscopy colorectal cancers are preventable: a population-based study. Gut 2014; 63: 957-963.
11) Pohl H, Robertson DJ. Colorectal cancers detected after colonoscopy frequently result from missed lesions. Clin Gastroenterol Hepatol 2010; 8: 858-864.
12) Robertson DJ, Lieberman DA, Winawer SJ, Ahnen DJ, Baron JA, Schatzkin A, Cross AJ, Zauber AG, Church TR, Lance P, Greenberg ER, Martínez ME. Colorectal

cancers soon after colonoscopy: a pooled multicohort analysis. Gut 2014; 63: 949-956.

13) Holzman MD, Eubanks S. Laparoscopic colectomy. Prospects and problems. Gastrointest Endosc Clin N Am 1997; 7: 525-539.

14) Wexner SD, Cohen SM, Ulrich A, Reissman P. Laparoscopic colorectal surgery--are we being honest with our patients? Dis Colon Rectum 1995; 38: 723-727.

15) Kuhry E, Schwenk WF, Gaupset R, Romild U, Bonjer HJ. Long-term results of laparoscopic colorectal cancer resection. Cochrane Database Syst Rev 2008: CD003432.

16) Yeung JM, Maxwell-Armstrong C, Acheson AG. Colonic tattooing in laparoscopic surgery - making the mark? Colorectal Dis 2009; 11: 527-530.

17) Rex DK, Petrini JL, Baron TH, Chak A, Cohen J, Deal SE, Hoffman B, Jacobson BC, Mergener K, Petersen BT, Safdi MA, Faigel DO, Pike IM; ASGE/ACG Taskforce on Quality in Endoscopy. Quality indicators for colonoscopy. Am J Gastroenterol 2006; 101: 873-885.

18) Lai EJ, Calderwood AH, Doros G, Fix OK, Jacobson BC. The Boston bowel preparation scale: a valid and reliable instrument for colonoscopy-oriented research. Gastrointest Endosc 2009; 69: 620-625.

19) Robertson DJ, Greenberg ER, Beach M, Sandler RS, Ahnen D, Haile RW, Burke CA, Snover DC, Bresalier RS, McKeown-Eyssen G, Mandel JS, Bond JH, Van Stolk RU, Summers RW, Rothstein R, Church TR, Cole BF, Byers T, Mott L, Baron JA. Colorectal cancer in patients under close colonoscopic surveillance. Gastroenterology 2005; 129: 34-41.

20) Aronchick CA, Lipshutz WH, Wright SH, Dufrayne F, Bergman G. A novel tableted purgative for colonoscopic preparation: efficacy and safety comparisons with Colyte and Fleet Phospho-Soda. Gastrointest Endosc 2000; 52: 346-352.

21) Rostom A, Jolicoeur E. Validation of a new scale for the assessment of bowel preparation quality. Gastrointest Endosc 2004; 59: 482-486.

22) Binefa G, García M, Milà N, Rodríguez L, Rodríguez-Moranta F, Guardiola J, Moreno V. Colonoscopy quality assessment in a mass population screening programme based on faecal occult blood test. Rev Esp Enferm Dig 2013; 105: 400-408.

23) Aslinia F, Uradomo L, Steele A, Greenwald BD, Raufman JP. Quality assessment of colonoscopic cecal intubation: an analysis of 6 years of continuous practice at a university hospital. Am J Gastroenterol 2006; 101: 721-731.

24) Borda F, Jiménez FJ, Borda A, Urman J, Goñi S, Ostiz M, Zozaya JM. Endoscopic localization of colorectal cancer: study of its accuracy and possible error factors. Rev Esp Enferm Dig 2012; 104: 512-517.

25) Cho YB, Lee WY, Yun HR, Lee WS, Yun SH, Chun HK. Tumor localization for laparoscopic colorectal surgery. World J Surg 2007; 31: 1491-1495.

26) Vaziri K, Choxi SC, Orkin BA. Accuracy of colonoscopic localization. Surg Endosc 2010; 24: 2502-2505.

27) Vignati P, Welch JP, Cohen JL. Endoscopic localization of colon cancers. Surg Endosc 1994; 8: 1085-1087.

28) Yap R, Ianno D, Burgess A. Colonoscopic localization accuracy for colorectal resections in the laparoscopic era. Am J Surg 2016; 212: 258-263.

29) Piscatelli N, Hyman N, Osler T. Localizing colorectal cancer by colonoscopy. Arch Surg 2005; 140: 932-935.

30) CCACSW P. Clinical Practice Guidelines for Surveillance Colonoscopy-in adenoma follow-up; following curative resection of colorectal cancer; and for cancer surveillance in inflammatory bowel disease. Cancer Council Australia 2011.

31) Rembacken B, Hassan C, Riemann JF, Chilton A, Rutter M, Dumonceau JM, Omar M, Ponchon T. Quality in screening colonoscopy: position statement of the European Society of Gastrointestinal Endoscopy (ESGE). Endoscopy 2012; 44: 957-968.

32) Yeung J, MaxwellÐArmstrong C, Acheson A. Colonic tattooing in laparoscopic surgery–making the mark? Colorectal Dis 2009; 11: 527-530.

33) Lee J, Voytovich A, Pennoyer W, Thurston K, Kozol RA. Accuracy of colon tumor localization: computed tomography scanning as a complement to colonoscopy. World J Gastrointest Surg 2010; 2: 22-25.

34) Feuerlein S, Grimm LJ, Davenport MS, Haystead CM, Miller CM, Neville AM, Jaffe TA. Can the localization of primary colonic tumors be improved by staging CT without specific bowel preparation compared to optical colonoscopy? Eur J Radiol 2012; 81: 2538-2542.

35) Solon JG, Al-Azawi D, Hill A, Deasy J, McNamara DA. Colonoscopy and computerized tomography scan are not sufficient to localize right-sided colonic lesions accurately. Colorectal Dis 2010; 12: 267-272.

36) Loffeld RJ, Flens M, Fransen G, den Boer FC, van Bochove A. The localization of cancer in the sigmoid, rectum or rectosigmoid junction using endoscopy or radiology-What is the most accurate method? J Gastrointest Oncol 2014; 5: 469-473.