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Double-Balloon Endoscopy after Incomplete Colonoscopy and Its Comparison with Computed Tomography Colonography

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Background/Aims: Because of the national screening program for colorectal carcinoma in The Netherlands, the number of colonoscopies has increased. In case of incomplete colonoscopy, computed tomography colonography (CTC) and double-balloon colonoscopy (DBc) are alternative options. This study evaluated cecal intubation rate and pathology detection rate in the previously unexplored part of the colon, complication rate of DBc, and CTC results after incomplete colonoscopy.
Methods: Retrospective observational study in a tertiary referral hospital regarding DBc and CTC reports from cases with incomplete colonoscopy.
Results: Sixty-three DBcs were performed after incomplete colonoscopy. Cecal intubation rate was 95%. Detection rate was 58% (5% carcinoma and 3% high-grade dysplastic adenoma). CTC preceded 54% of DBcs and 62% of CTC findings were confirmed. In 16%, a biopsy was taken, and in 60%, an intervention (mostly polypectomy) was performed. One major complication (1.5%) occurred, i.e., arterial bleeding due to polypectomy necessitating right hemicolectomy. CTC (n=213) showed a possible lesion in 35%, and could be confirmed by follow-up endoscopy or surgery in 65%.
Conclusions: DBc is effective and safe for completion of colon inspection in incomplete colonoscopy. In patients with a high likelihood of pathology, DBc is preferred over CTC. **Clin Endosc 2018;51:66-71**

Key Words: Double-balloon colonoscopy; Colonography, computed tomographic; Colon carcinoma; Colon visualization; Cecum

INTRODUCTION

For diagnosis and screening of colonic disease, colonoscopy is considered to be the most effective procedure, because of its diagnostic and therapeutic capability.[1,2] With a rising incidence of colorectal cancer (CRC) in many parts of the world,[3] population screening programs for CRC have been initiated in many countries. Colonoscopy with polypectomy has been shown to reduce both the incidence and mortality of subsequent CRC.[4-6] In The Netherlands, a population screening program was started in 2014 in which a positive immunological fecal occult blood test is followed by colonoscopy.

Cecal intubation is the primary quality index in colonoscopy.[2] Even experienced endoscopists fail to reach the cecum in 2%–10% of colonoscopies,[7-9] because of dolichocolon, loop formation, and angulation of the colon.[9-14] Previous literature has shown that several factors have been associated with a higher risk of incomplete colonoscopy, namely female gender, advanced age, low body mass index, women with a history of hysterectomy, diverticular disease, inflammatory bowel disease, and poor bowel cleansing.[13,15]

Pathology in the lower gastrointestinal tract can be missed by incomplete colonoscopy if additional tests are not performed. Several options are available: re-colonoscopy with a conventional endoscope, computed tomography colonography (CTC), barium enema colonography, or colonoscopy with a double-balloon endoscope. A previous study showed that a secondary colonoscopy after incomplete colonoscopy yielded initially missed advanced neoplasia (CRC or advanced adeno-

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ma) in 4.3% of patients.[16]

The double-balloon technique allows the endoscope to pass through difficult fixed angles using the overtube balloon as a fixed point in order to avoid pushing maneuvers off the axis of the colonic loop and potentially dangerous stretching.[17] An additional advantage of the technique is that it makes shortening of long loops easier by fixing both the endoscope and the overtube.[17]

Since 2007, double-balloon endoscopy (DBE) has been available in our center. This study evaluated all patients who underwent colonoscopy with a double-balloon endoscope after previous incomplete conventional colonoscopy. The results included the cecal intubation rate with double-balloon colonoscopy (DBc), the diagnostic rate using DBc in the unexplored area of the colon, and the complication rate with DBc. In addition, CTC results performed after incomplete colonoscopy were compared with DBc findings.

MATERIALS AND METHODS

This was a retrospective, observational, single-center study performed in the Catharina Hospital, a tertiary referral center for DBE and DBc in Eindhoven, The Netherlands. The study included all consecutive patients who underwent DBc and CTC after incomplete conventional colonoscopy between October 2007 and September 2014. All indications for DBc were included. DBE ileocolonoscopies via the anal route with the intention to investigate the small bowel were excluded. All reports of CTC performed in the Catharina Hospital in the same time interval were examined. In case of a positive CTC after incomplete colonoscopy, the CTC findings and clinical course were examined in detail, including the results of subsequent examinations (DBc, sigmoidoscopy, or colonoscopy) or surgery. Data were retrospectively collected from the local hospital information system or from the referring hospitals in case of missing data.

The primary aim of this study was to determine the cecal intubation rate using DBc. Secondary study aims were to determine the diagnostic rate using DBc in the unexplored part of the colon and the complication rate with DBc, and to compare the results of CTC performed after incomplete colonoscopy with DBc findings.

Double-balloon colonoscopy

All DBc procedures were performed using the Fujinon Double-Balloon Enteroscopy System (EN-450T5; Fujinon GMBH, Willich, Germany). The working length of the DBc scope is 200 cm. The outer diameter of this endoscope is 9.4 mm, with a forceps channel diameter of 2.8 mm. All patients who underwent DBE had bowel preparation with polyethylene glycol solution (Moviprep; Norgine Limited, Hengoed, UK). From 2007 until 2012, bowel preparation used 2 L of Moviprep the evening before the examination; in the last 2 years a split-dose preparation was performed using 1 L of Moviprep the evening before the examination and 1 L in the morning on the day of examination. DBc was carried out in patients under conscious sedation, which was achieved with intravenous midazolam and fentanyl.

All DBcs were performed by one of two experienced double-balloon endoscopists in our department. The findings, including location in the colon, interventions, and complications were carefully recorded in the endoscopy report and digital patient file. An advanced adenoma was defined as a large polyp (>10 mm) or a polyp with high-grade dysplastic lesions. The location of the abnormality was determined by the insertion depth of the endoscope and clinical landmarks (e.g., the appendiceal orifice, Bauhin's Valve, hepatic or splenic flexure, and triangular lumen in the transverse colon). Cecal intubation was defined as visualization of the appendiceal orifice. In some patients, one or more interventions were performed during DBc, e.g., biopsy, argon plasma coagulation, clipping, or dilation.

Computed tomography colonography

Since 2009, CTC has been performed in our center as an alternative to colonoscopy, and includes a non-enhanced scan in the supine and prone position. For a dedicated CTC exam, bowel preparation consists of low-fiber diet the day before the exam combined with 50 mL oral contrast medium for all 3 meals, and a liquid breakfast on the day of the exam. Before the exam, 50 mL of oral contrast is given for optimal fecal tagging. All colonic and extracolonic findings are evaluated and classified according to a CTC Reporting and Data System.[18]

In case of incomplete colonoscopy, the patient undergoes CTC on the same day after receiving 100 mL of oral contrast medium at least 1 h prior to the exam. No ingestion of food is allowed between the incomplete colonoscopy and the CTC. In our institution Telebrix Gastro® (Guerbet, Aulnay-sous-Bois, France) is the contrast medium of choice.

Data analysis

Continuous variables were presented as mean with standard deviation or median with range, depending on normality. Categorical variables were presented as frequencies and percentages. Differences were evaluated using the chi-square test or Fisher's exact test in case of small numbers. $P<0.05$ was considered statistically significant.

All data were analyzed with Statistical Package for Social Science (SPSS) software version 21.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Between October 2007 and September 2014 a total of 63 DBcs were performed after incomplete routine colonoscopy in a total of 61 patients. Baseline characteristics of these patients are presented in Table 1. Indications for original colonoscopy and follow-up DBc were screening or surveillance for adenoma or carcinoma (74%), abdominal pain (13%), diarrhea (3%), macroscopic blood loss (5%), and occult blood loss or iron-deficiency anemia (5%). Colonoscopy failure was because of dolichocolon in 41 procedures (65%), looping of the endoscope in 13 (21%), combined dolichocolon and looping in 5 (8%), and colon fixation because of adhesions in 4 (6%).

Table 1. Characteristics of Patients that Underwent Double-Balloon Colonoscopy after Incomplete Colonoscopy (*n*=61 patients and 63 DBc procedures)

	Patients that underwent DBc (*n*=61)
Mean age (range) (yr)	65 (29–82)
Men/Women, *n* (%)	34/27 (56%/44%)
Previous abdominal surgery, *n* (%)	24 (39%)
Indication for total colonoscopy, *n* (%)	*n*=63 DBc
Screening or surveillance for adenomas or carcinoma	47 (74%)
Abdominal pain	8 (13%)
Diarrhea	2 (3%)
Macroscopic blood loss	3 (5%)
Occult blood loss or iron deficient anemia	3 (5%)
Extent of incomplete colonoscopy, *n* (%)	*n*=63 DBc
Rectosigmoid	2 (3%)
Colon descendens	3 (4%)
Colon transversum	40 (63%)
Colon ascendens	18 (30%)
Reasons for incomplete colonoscopy, *n* (%)	*n*=63 DBc
Dolichocolon	41 (65%)
Looping	13 (21%)
Dolichocolon and looping	5 (8%)
Adhesions	4 (6%)

DBc, double-balloon colonoscopy.

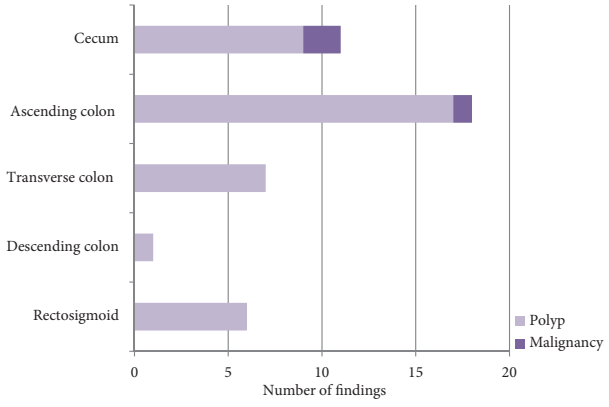

Fig. 1. Findings in double balloon colonoscopy after incomplete colonoscopy (*n*=63 procedures) in the unexplored part of the colon.

DBc cecal intubation rate was 95%. Two incomplete procedures (both indicated for screening or surveillance for adenoma or carcinoma) were caused by inadequate colon cleansing. One of these patients underwent laparoscopy afterwards for persistent ileus, and an obstructive adenocarcinoma was found in the ascending colon. The other patient underwent successful second DBc after extra bowel cleansing and an adenoma was found in the ascending colon. Looping of the endoscope caused incomplete DBc in one patient. The indication for this DBc was abdominal pain. CT of the colon showed no abnormalities in this patient.

The detection rate of polyps or (suspected) carcinomas using DBc in the previously unexplored part of the colon was 58%. A carcinoma was found in 3 procedures (5%), high-grade dysplastic adenoma in 2 (3%), and sessile serrated adenoma in 2 (3%), as shown in Fig. 1. Two or more polyps were seen in 26 procedures (41%). Table 2 presents the main diagnosis in the previously uninvestigated parts of the colon, reached using DBc. According to indication, the detection rate was 68% for screening or surveillance for adenoma or carcinoma (32/47), 13% for abdominal pain (1/8), 0% for diarrhea (0/2), 67% for macroscopic blood loss (2/3), and 67% for occult blood loss or iron-deficiency anemia (2/3).

Diagnostic biopsy was taken in 16% of DBE procedures, revealing carcinoma (*n*=3), sessile serrated adenoma (*n*=1), nonspecific chronic inflammation (*n*=1), or no abnormality (*n*=5). An intervention was performed in 38 of 63 procedures (60%), i.e., 35 polypectomies and 3 cases of argon plasma coagulation. Argon plasma coagulation was used to remove small residual adenomatous spots and/or coagulate small vessels to prevent

Table 2. Main Diagnosis Found during Double-Balloon Colonoscopy after Incomplete Colonoscopy (*n*=63 procedures)

Diagnosis	*n* (%)	Therapeutic consequences
No diagnosis	26 (41%)	-
Carcinoma	3 (5%)	Surgical resection
Adenoma(s)		
Low grade dysplasia	20 (32%)	Endoscopic resection
High grade dysplasia	2 (3%)	Endoscopic resection
Sessile serrated	2 (3%)	Endoscopic resection
Hyperplastic polyp(s)	10 (16%)	Endoscopic resection

Table 3. Findings of Computed Tomography Colonography in Patients with Prior Incomplete Colonoscopy (*n*=213 procedures) and Subsequent Diagnostic Steps with Eventual Results

Findings diagnostic CTC	*n* (%)	Subsequent examinations or surgery	Subsequent findings
No abnormalities in colon	139 (65%)	-	-
Suspicion of colon carcinoma	6 (3%)	Surgical resection (4)	Adenocarcinoma (2) Diverticulitis (2)
		Repeat endoscopy - Colonoscopy (1) - Sigmoidoscopy (1)	Adenocarcinoma (1) Diverticulitis (1)
Aspecific wall thickness	13 (6%)	Surgical resection (1)	Diverticulitis (1)
		Repeat endoscopy - Colonoscopy (2) - Sigmoidoscopy (1)	Diverticulitis (3)
		No action (9)	
Polypoid lesion	55 (26%)	Repeat endoscopy - DBc (19) - Colonoscopy (16) - Sigmoidoscopy (4)	Adenoma (20) Adenocarcinoma (1) Hyperplastic lesion (1) Lipoma (1) No lesion confirmed (16)
		No action (16)	

CTC, computed tomography colonography; DBc, double-balloon colonoscopy.

post-polypectomy bleeding in these 3 procedures

In the 63 DBc procedures, no minor and only 1 major complication (1.5%) occurred, i.e., arterial bleeding in the ascending colon immediately after adenomatous polyp removal (low-grade dysplasia, 14 mm). Adrenalin injections and clipping were not effective, finally resulting in a right hemicolectomy, which was performed without complications.

The procedure time of DBc was not precisely monitored during the study period. However, all DBc procedures were planned for a maximum duration of 1 h; most procedures were performed within 45 min.

Thirty-four DBcs were preceded by CTC (54%). Two CTCs were performed in another hospital. Twenty-one (62%) DBcs confirmed the prior CTC diagnosis and 13 (38%) could not.

During the study period, 760 CTCs were performed in our center for several indications. The results of all 213 CTCs after prior incomplete conventional colonoscopy were divided into 4 groups: no abnormalities (139), suspicion of a malignant lesion (6), nonspecific wall thickening (13), and polypoid lesion (55) (Table 3). In the absence of abnormalities, no follow-up endoscopy was performed. In the group with suspected malignant lesions, surgery was performed in 4 cases and repeat endoscopy in 2. Three adenocarcinomas of the colon and 1 case of diverticulitis were found in resected specimens. Repeat endoscopy confirmed carcinoma in 1 case and diverticulitis in the other. Overall CTC diagnosis was correct in 67% of these suspected cases. Polypoid lesions found in CTC were confirmed using re-endoscopy in 23 cases. Re-endoscopy found 20 adenomas with low-grade dysplasia, 1 hyperplastic lesion, 1 lipoma, and 1 malignant polyp. No polyp was found with re-endoscopy in 16 cases, and no repeat endoscopy was performed in 16 cases. Of 19 re-endoscopies performed with DBc, 17 confirmed CTC findings. Nonspecific wall thickening of the colon was seen in 13 CTCs. Subsequent endoscopic analysis showed no malignancy, but 4 cases of diverticulitis were found in these patients.

In 33 patients, no further examination was performed after CTC with a positive finding for several reasons: age, patient condition, location of a possible lesion in the previously examined part of the colon, or clinical signs of diverticulitis.

The positive predictive value of CTC for clinically significant lesions (malignancy, polyp, diverticulitis) was 65%. This calculation included only patients with follow-up endoscopy or surgery. In the 6 patients with a strong suspicion of malignancy on CTC, 4 had a malignant lesion (67%); the other 2 were diagnosed with diverticulitis. A negative predictive value could not be determined because a negative CTC was not followed by subsequent examinations in this retrospective study design.

DISCUSSION

This retrospective observational study of DBE procedures of the colon (DBc) after incomplete colonoscopy showed successful cecal intubation in the vast majority of cases (95%).

More importantly, it demonstrated a pathology detection rate of 58% in the previously unexplored part of the colon, and revealed 5% carcinoma rate and another 6% advanced adenoma rate (large polyps or high-grade dysplastic lesions).

The DBc cecal intubation rate of 95% is comparable to that in other studies, which reported success rates of 88.6%–100%.[11,12,17,19-23] Two of the 3 incomplete DBcs were because of inadequate cleansing of the bowel, which should be avoidable in future to improve intubation rates.

Various alternative techniques are available to complete colon inspection after previous incomplete colonoscopy, e.g., the use of a gastroscope,[24] push enteroscopy,[25] a variable-stiffness colonoscope,[26] or a pediatric colonoscope,[27,28] which showed a somewhat lower average cecal intubation success rates[24-28] compared to balloon-assisted endoscopy. Rex[14] stated that the reason for previous incomplete colonoscopy determines the optimal choice of endoscope in a subsequent procedure. In case of dolichocolon or looping, DBc or push enteroscopy with an overtube is recommended, whereas a pediatric colonoscope is indicated for a difficult sigmoid, e.g., with diverticulosis/diverticulitis or adhesions, because of the smaller diameter of the endoscope. Gawron et al.[29] showed a high cecal intubation rate of 96% with use of standard endoscopes, mostly in patients with a looping or tortuous colon, whereas patients with a dolichocolon needed other endoscopes more frequently. Our study showed no differences in cecal intubation success rates among reasons for previous incomplete colonoscopy; thus, DBc appears useful for all difficult colon types. CTC is often used as an alternative to visualize the colon. The advantages of CTC are high diagnostic performance,[30] less-invasive imaging technique, no need for sedation, short recovery time, and little patient discomfort. Another advantage is the detection of extracolonic findings. In patients with a positive immunochemical fecal blood test (iFOBT), CTC is also considered an adequate option because of a sensitivity of 88.8%, as shown by a major systematic review and meta-analysis by Plumb et al. in 2014.[31]

This study also demonstrated that DBc is a safe procedure: only 1 patient had a major complication, i.e., arterial bleeding due to polypectomy with a need for right hemicolectomy because of failure of conservative therapies. Most studies reported no or few major complications.[21-23] Another Dutch clinical study reported a complication rate of 1.8%, consisting of 2 cases of arterial bleeding.[12]

The most important limitation of this study is its retrospective nature. In addition, the DBc detection rate may have been influenced by selection bias, as some patients had CTC prior to DBc. However, the patients who did not have CTC prior to DBc had a similar detection rate and CTC results were not confirmed in 38%. Moreover, no subsequent control examination was performed in case of negative DBc or CTC. The procedure times for DBc were not precisely recorded, but all were performed within 60 min. Nevertheless, this study from an experienced center performing DBc as well as CTC shows important clinical findings that are applicable in daily clinical decision-making in case of incomplete colonoscopy.

The choice of examination following incomplete colonoscopy is difficult. We advise use of DBc in patients with a high likelihood of an abnormality and need for intervention. In this study, patients who underwent DBc for screening or surveillance for adenoma or carcinoma, macroscopic blood loss, and occult blood loss or iron-deficiency anemia had the highest detection rate (67%–68%). Patients with a positive iFOBT in the national screening program for CRC have a similar risk. The invasiveness of DBc is a point mentioned frequently as a disadvantage, but we think the invasiveness is similar to that of colonoscopy, and is therefore feasible in patients who underwent previous colonoscopy. A disadvantage of DBc is the availability, whereas CTC is available in more places. The clinical predictors that can determine which examination is best after incomplete colonoscopy require further investigation.

To conclude, DBc is safe and effective for complete inspection of the entire colon in difficult cases in which conventional colonoscopy failed. Because of the high detection rate, possibility of intervention in DBc, and false-positive findings in CTC, DBc is preferred over CTC, especially in patients with a high likelihood of abnormalities, such as those identified via colorectal screening programs.

Conflicts of Interest

The authors have no financial conflicts of interest.

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