Cecal intubation rates in different eras of endoscopic technological development

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Abstract

Introduction: *Colonoscopy plays a critical role in colorectal cancer (CRC) screening and has been widely regarded as the gold standard. Cecal intubation rate (CIR) is one of the well-defined quality indicators used to assess colonoscopy.*
Aim: *To assess the impact of new technologies on the quality of colonoscopy by assessing completion rates.*
Material and methods: *This was a dual-center study at the 2nd Department of Surgery at Jagiellonian University Medical College and at the Specialist Center "Medicina" in Krakow, Poland. The CIR and cecal intubation time (CIT) in three different eras of technological advancement were determined. The study enrolled 27 463 patients who underwent colonoscopy as part of a national CRC screening program. The patients were divided into three groups: group I – 3408 patients examined between 2000 and 2003 (optical endoscopes); group II – 10 405 patients examined between 2004 and 2008 (standard electronic endoscopes); and group III – 13 650 patients examined between 2009 and 2014 (modern endoscopes).*
Results: *There were statistically significant differences in the CIR between successive eras. The CIR in group I (2000–2003) was 69.75%, in group II (2004–2008) was 92.32%, and in group III (2009–2014) was 95.17%. The mean CIT was significantly reduced in group III.*
Conclusions: *Our study shows that the technological innovation of novel endoscopy devices has a great influence on the effectiveness of the CRC screening program. The new era of endoscopic technological development has the potential to reduce examination-related patient discomfort, obviate the need for sedation and increase diagnostic yields.*

Key words: *technology, quality, endoscopy, cecal intubation rate, cecal intubation time.*

Introduction

Colonoscopy is widely used for the diagnosis and treatment of disorders of the colon. It allows to visualize the entire large intestine mucosa and distal terminal ileum. It also plays a critical role in colorectal cancer (CRC) screening in many countries and has been widely regarded as the gold standard, decreasing the incidence of CRC by up to 80% and allowing early detection and removal of precancerous lesions [1, 2]. The performance of a 'complete colonoscopy' by passage of the colonoscope along the whole length of the colon to the cecum or terminal ileum is a key parameter for measuring the quality of the procedure. Hence, the cecal intubation rate (CIR) is one of the well-defined quality indicators used to assess colonoscopy [3]. A poor cecum intubation rate is closely correlated

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with a low adenoma detection rate and increased risk of post-colonoscopy colorectal cancer (PCCRC) [4]. However, the CIR not only is a quality indicator but also reveals the endoscopic skills of a physician. Experienced colonoscopists have been shown to intubate the cecum in more than 90% of cases [5]. Reasons for failing to reach the cecum include excessive loop formation and failure to traverse angulated, fixed, or strictured sigmoids. These problems occur most commonly among female patients with prior gynecological surgery and patients with advanced diverticular disease [6, 7]. The chance of reaching the cecum decreases with patients' age and increases with a higher body mass index (BMI). Cecal intubation in a young healthy patient is most likely to be successful [8]. On the other hand, endoscopes have evolved over time through continual improvements. The transition from fiberscopes to videoscopes has significantly increased the diagnostic and therapeutic potential of the endoscopes. Following the introduction of videoscopes, there continued to be numerous technological advances facilitating scope insertion and operation, such as responsive insertion technology (RIT), which is a unique combination of three technologies: passive bending (PB), high-force transmission (HFT), and variable stiffness. Thus, the structure of endoscopes has been altered to facilitate the feasibility of the examination increasing the CIR, reducing the cecal intubation time (CIT) and diminishing patient discomfort during the examination. The new endoscopes also include narrow band imaging (NBI) and magnetic endoscopic imaging (MEI).

Aim

The aim of this study was to assess the impact of new technologies on colonoscopy completion rates. Therefore, we determined the most important colonoscopy quality indicators, the CIR and CIT, in three different eras of technological advancement.

Material and methods

This was a retrospective study at the 2nd Department of Surgery at Jagiellonian University Medical College and at the Specialist Diagnostic and Therapeutic Center "Medicina" in Krakow, Poland. The study enrolled 27 463 patients who underwent colonoscopy as part of a national colorectal cancer screening program, which was financed by the Polish Ministry of Health. Polish citizens ages 50–65 years or 40–65 with a first-degree relative with abdominal cancer took part in the analysis. The inclusion criteria were that patients were between 40 and 65 years of age, were able to provide informed consent, had an indication for colonoscopy as colorectal cancer screening and for whom this was a first or follow-up colonoscopy. We excluded all patients with a prior history of abdominopelvic surgery, inflammatory bowel disease, an active malignancy, and a high anesthetic risk (ASA IV); who were pregnant; who were unable to provide informed consent; and who

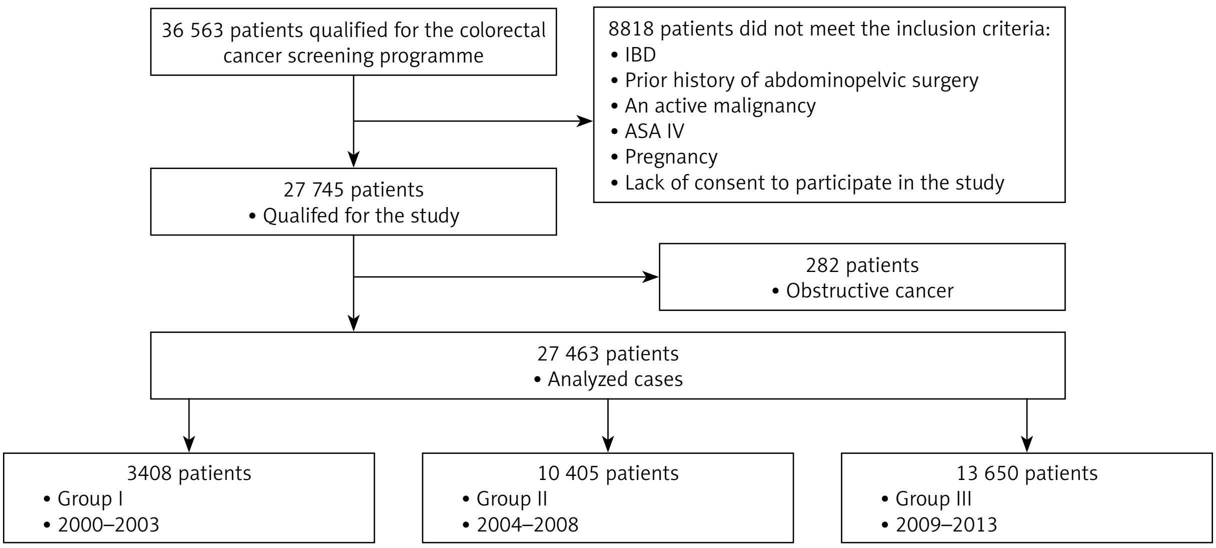

Figure 1. CONSORT diagram of patient enrollment

had obstructive cancer (Figure 1). All of the patients had to personally sign a written consent form before embarking on the study, which was approved by the local ethics committee and conducted in accordance with the principles of the Declaration of Helsinki (KBN no 122.6120.36.2016).

The instruments used in all of the colonoscopies were from the Olympus series (Olympus Optical Co. Ltd, Tokyo, Japan). We compared the cecal intubation rates of three different eras of endoscopic technological development regarding the series of endoscope used. According to the technological era, the patients were divided into three groups. Group I consisted of 3408 patients who underwent colonoscopy between 2000 and 2003. This was the era of optical endoscopes (CF-Q10 and CF-Q20), which had the following parameters: insertion tube diameter: 13.3 mm, biopsy working channel: 3.2 mm, working length: 168 cm, and field of view: 120°. Group II included 10 405 patients examined between 2004 and 2008. This period constitutes the era of electronic endoscopes with standard resolution (CF-Q145, CF-Q165, and CF-Q180), which had the following parameters: insertion tube diameter: 12.8 mm, working length: 168 cm, instrument channel: 3.7 mm, field of view: 140°, and angulation range: up: 180°, down: 180°, right: 160°, and left: 160°. Between 2009 and 2014, we performed 13 650 colonoscopies using the CF-HQ190L (these patients formed group III). This was the era of endoscopes with a high-definition resolution, magnetic scope guide, responsive insertion technology (RIT) and narrow band imaging (NBI) with dual focus two-stage optical lens technology. The endoscopes used in this era had the following parameters: channel width: 3.7 mm, working length: 168 cm, field of view: normal: 170°, near: 160°, outer diameter: 13.2 mm, outer diameter insertion tube: 12.8 mm, max angulation up: 180°, max angulation down: 180°, max angulation right: 160°, and max angulation left: 160°. Ten experienced endoscopists conducted the procedures, each having independently performed over 1000 colonoscopies. Assisting the endoscopists during the colonoscopies were experienced endoscopy nurses, each having participated in more than 2 000 procedures.

The patients were initially placed onto their left side, whereas the endoscopic technique depended on the personal preference and experience of the endoscopist. During the course of the procedure, maneuvers such as manual abdominal pressure, repositioning of the patient, and instrument rotations, twists, stiffening, and straightening were applied where needed. The data collected related to the patient were the age, gender, height, weight, and BMI. Cecum intubation was considered to be attained when the ileocecal valve (Bauhin's valve) and appendiceal entrance were properly identified (Photos 1, 2). The endoscopies were performed under local anesthesia using lidocaine 2% gel topically on the anal canal. All of the patients were given the same bowel preparation guidelines based on the oral ingestion of liquid propulsive agents (i.e., 420 g of polyethylene glycol (PEG) in 4 l of water, taken in 4 doses every 6 h one day before the colonoscopy).

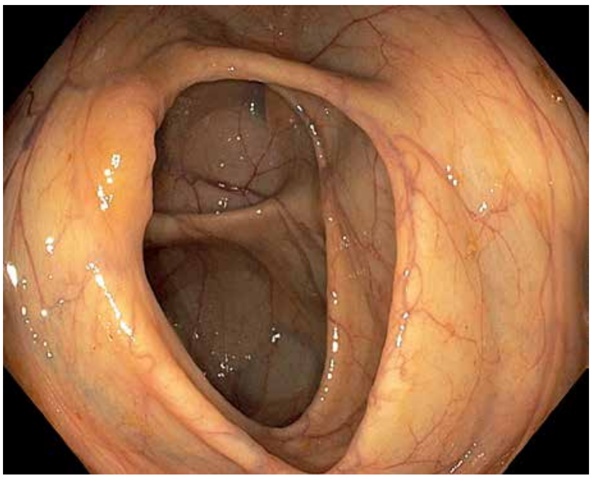

Photo 1. Endoscopic view showing Bauhin's valve

Photo 2. Endoscopic view showing appendiceal orifice

Table I. Characteristics of individuals subjected to colonoscopy in the 3 technological eras

Group	Gender	*N*	Age		BMI	
			Mean	SD	Mean	SD
I	F	2078	54.19	4.20	26.34	4.58
	M	1330	53.94	4.18	27.41	4.44
II	F	6289	54.29	4.31	26.20	3.95
	M	4116	54.16	4.28	27.09	4.32
III	F	8276	54.61	4.41	26.57	4.15
	M	5374	53.87	4.39	27.57	4.19
P-value		0.326	0.151		0.316	

During and after the colonoscopy, data on the procedure-related outcomes, such as the cecal intubation time (CIT) and cecal intubation rate (CIR), were collected. These procedure-related times were recorded by an assistant nurse using the stopwatch function on the endoscopy equipment. Cecal intubation was considered successful through the visualization of colonoscopic landmarks, i.e., the ileocecal valve (ICV) and appendiceal orifice (AO), and the CIT was defined as the time required from the introduction of the colonoscope until it reached the base of the cecum. After the cecum was identified, still photographs of the cecal landmarks were taken.

Statistical analysis

The materials acquired in this study were systematized and analyzed, and the distribution of variables was established. Since the analyzed parameters did not have a normal distribution, nonparametric tests were applied in the analysis. The qualitative variables were compared using the independent χ^2 test.

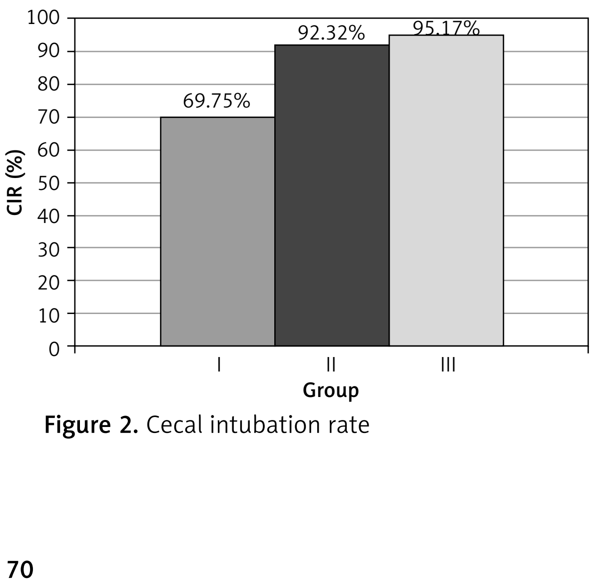

Figure 2. Cecal intubation rate

For comparison of the quantitative variables, the Mann-Whitney test was used. Comparison of quantitative data for more than two groups was done using the Kruskal-Wallis test. The statistical significance threshold was established at $p \le 0.05$.

Results

A total of 27 463 colonoscopies performed from January 2000 to December 2014 were included in the study. Three groups of patients, each from an era of endoscopic technological development, were compared in terms of age, sex, and BMI. No differences in the distributions of sex, age, and BMI were observed between the groups (Table I).

No complications were observed from any of the procedures included in the study. All of the patients recovered and were discharged from the endoscopy unit.

There were statistically significant differences in the cecal intubation rates between the patients of the subsequent eras of endoscopic technological development. The CIR in group I (2000–2003) was 69.75%, the CIR in group II (2004–2008) was 92.32% and the CIR in group III (2009–2014) was 95.17% (Figure 2).

The mean cecal intubation time of group III, which was 209 s and SD: 93.75 s, was significantly lower than that of group I, which was 250 s and SD: 92.75 s. The mean CIT in group II was 224 s, which had an SD of 103.07 s ($p < 0.05$) (Table II).

Discussion

The cecal intubation rate has become one of the most important indicators of quality in endoscopy procedures. Cecal intubation is defined as a deep intubation into the cecum with the tip of the endoscope so that it is able to touch the appendiceal orifice. The current guidelines of the European Society of Gastrointestinal Endoscopy (ESGE) and the English National Health Service (NHS) Bowel Cancer Screening Programme (BCSP) expect a completion rate above 90% as a minimum standard. The European Commission guideline also expects a 90% cecal intubation rate (excluding cases with obstructive cancer) [9]. The US Multi-Society Task Force on Colorectal Cancer recommends different benchmarks depending on whether it is a "screening" or "symptomatic" population of patients (95% and 90%, respectively) [10, 11]. Canadian standards set the minimum adjusted CIR at the level of 95% [12]. Over the years, the requirements of the author guidelines regarding the CIR have become stricter. However, it is completely understandable because complete examinations of the colon and rectum are crucial to any endoscopy and especially to a colorectal cancer screening program.

The companies are constantly trying to respond to the expectations of endoscopists to successfully accomplish cecal intubation, inventing equipment that is easier to insert and is applied without patient discomfort [13]. Failure to reach the cecum is not only inconvenient but also expensive for the patient (it requires another endoscopy or a radiological examination such as virtual colonoscopy) [14].

In 2000, we started a national colorectal cancer screening program with simple optical endoscopes. Over the years, we have been introduced to new technologies in endoscopy. Sophisticated technological innovations and advanced endoscopes have been developed in an effort to eliminate the drawbacks of colonoscopy, maximize its ability to detect precancerous lesions and maximize its ability to reach the cecum. Our study has shown that technological improvement has a significant influence on the quality of endoscopy.

We observed differences in the CIRs between the three technological eras. Huge advances in the era of electronic endoscopes (2004–2008) have led us to improve our results of successful cecal intubations from 69.75% to 92.32%. The difference between the era of high-quality advanced endoscopes and standard instruments was also statistically significant. Despite the fact that the total cecal intubation rate in group II was very high in our department (most of the colonoscopies are performed by experienced endoscopists), colonoscopes equipped with a variable stiffness, which are currently used, improve the percentage of cecal intubation [15–18].

Table II. Cecal intubation time

Group	Cecal intubation time [s] Mean ± SD
I	250 ±92.75
II	224 ±103.07
III	209 ±93.75

Another important finding of this study was that the time needed to reach the cecum was reduced in the RIT endoscope group compared with the conventional group and optical endoscopes group. This finding has also already been previously reported [19]. The time differences obtained in our study were small between the RIT group and the standard electronic group but substantial when compared to the optical endoscopes group, and these differences were statistically significant.

One of the major causes of unsuccessful cecal intubation is pain during colonoscopy. The CIR is lower in patients with previous abdominal procedures. It is most often caused by the looping of the instrument during insertion, which causes discomfort by stretching the intestinal mesentery [20–22].

Endoscopies that are performed with the most advanced endoscopes according to our study are most likely to be complete. This result is likely from the use of responsive insertion technology. During the procedure, secondary bending occurs when a section of the endoscope, which is extremely flexible, bends passively, which is beneficial when the sharply angulated sigmoid looping is present. The bending function, which is not present in conventional endoscopes, is useful for preventing the stick phenomenon, which causes severe pain for patients during colonoscopic insertion into splenic or hepatic flexures [23]. Reduced loop formation and auxiliary maneuvers while using the RIT lead to a higher CIR [24]. Another feature of the most advanced endoscopes that might have improved the CIR and CIT is magnetic endoscope imaging (scope guide). According to previous publications, colonoscopies performed using magnetic endoscope imaging demonstrated significantly lower rates of loop formation [25].

We also noted an association between BMI and the technical difficulty in successfully achieving cecal intubation. In our study, a lower BMI was an independent factor associated with a lower CIR. It is possible that the low fat and muscle content of a low-BMI patient may lead to loop formation and patient intolerance.

Conclusions

We have gone through a technological revolution since the earliest flexible endoscope was presented by Hirschowitz in 1957 at the American Gastroscopy Society annual meeting [26]. Our study shows that technological innovation, novel endoscopy devices and diagnostic techniques have a great influence on the effectiveness of the colorectal cancer screening program. A new era of endoscopic technological development has the potential to reduce examination-related patient discomfort, obviate the need for sedation and increase diagnostic yields. A higher CIR and shorter CIT indicate better endoscope insertability and ergonomics.

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Conflict of interest

The authors declare no conflict of interest.

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