Techniques in Gastrointestinal Endoscopy 17 (2015) 192–198

Contents lists available at ScienceDirect

Techniques in Gastrointestinal Endoscopy

journal homepage: www.techgiendoscopy.com/locate/tgie

Advanced colonoscopy techniques and technologies

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ARTICLE INFO

Article history:
Received 10 August 2015
Received in revised form
13 November 2015
Accepted 26 January 2016

Keywords:
Colonoscopy
Advanced techniques and technologies
Stent
Endoscopic mucosal resection
Endoscopic submucosal dissection
Chromoendoscopy

ABSTRACT

Colonoscopy is the most frequently performed endoscopic procedure in the United States. It is the mainstay of diagnostic and therapeutic options for the practicing gastroenterologist. It plays a fundamental role in colorectal cancer (CRC) prevention, with a dominant position among the screening options for CRC and precancerous lesions. Over the past decade, there have been significant advances in the field of CRC and colonoscopy, including a better understanding of the importance of right-sided lesions, the sessile serrated pathway, and recognition of the significance of operator dependence in colonoscopy. This has been paralleled by an array of technological and technical advances that has transformed the field of colonoscopy and improved patient care. This article addresses the diverse and expanding field of advanced colonoscopy techniques and technologies. It is intended to be a primer on recent and effective developments in advanced technologies for screening or imaging, mucosal resection techniques, and endoscopic management of CRC.

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1. Introduction

Colonoscopy is the most frequently performed endoscopic procedure in the United States. It is the mainstay of diagnostic and therapeutic options for the practicing gastroenterologist. It plays a fundamental role in colorectal cancer (CRC) prevention, with a dominant position among the screening options for CRC and precancerous lesions [1].

Over the past decade, there have been significant advances in the field of CRC and colonoscopy, including a better understanding of the importance of right-sided lesions, the sessile serrated pathway, and recognition of the significance of operator dependence in colonoscopy. This has been paralleled by an array of technological and technical advances that has transformed the field of colonoscopy and improved patient care.

This article addresses the diverse and expanding field of advanced colonoscopy techniques and technologies. It is intended to be a primer on recent and effective developments in advanced technologies for screening or imaging, mucosal resection techniques, and endoscopic management of CRC (Table).

2. Techniques and technologies to improve polyp detection

The removal of polyps during colonoscopy decreases the risk of CRC [2]. This paradigm depends upon the accurate identification of polyps, which has been shown to vary considerably among different operators [3,4]. A systematic review and meta-analysis including 6 tandem colonoscopy studies found an overall miss rate of 22% of polyps in screening colonoscopies [5]. There have been a number of technologies developed to aid mucosal exposure and improve polyp detection.

2.1. Accessories

The use of a transparent cap placed at the distal tip of the colonoscope ("cap-assisted colonoscopy") has been proposed to improve mucosal visualization by allowing flattening of colonic folds. The effect on polyp detection has not been consistent [6,7]. A meta-analysis from 2012 that included 16 randomized controlled trials of cap-assisted colonoscopy and nearly 9000 patients showed a small benefit from the use of the transparent cap, with a relative risk of identifying polyps of 1.08 (95% CI: 1.00-1.17), although adenoma detection was not significantly increased with cap use [8]. Another meta-analysis showed similar results, with a relative risk of 1.13 [9].

EndoRings (EndoAid Ltd, Caesarea, Israel) is a mucosal detection aid that fits on the distal tip of the colonoscope, composed of a series of sequentially spaced silicone disks that emanate from the

The author reports no direct financial interests that might pose a conflict of interest in connection with the submitted manuscript.

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http://dx.doi.org/10.1016/j.tgie.2016.01.003
0049-0172/Published by Elsevier Inc.

Table
Advanced colonoscopy techniques and technologies.

Techniques and technologies to improve polyp detection • Accessories (transparent cap, EndoRings, endocuff, ThirdEye Retroscope, and NaviAid G-EYE) • Colonoscope technology for increased mucosal visualization (wide-angle colonoscopes, FUSE) • High-definition and magnification • Dye-based chromocolonoscopy Electronic chromocolonoscopy (NBI, FICE, and i-SCAN)	Mucosal resection techniques • EMR • ESD Inflammatory bowel disease • Dye-based chromocolonoscopy Stricture management • Crohn's-related strictures • Stenting of malignant obstruction • Dilation of anastomotic stricture

Abbreviations: FUSE, full-spectrum endoscopy.

distal tip cuff (Figure 1) [6,7]. The disks are flexible and engage the mucosa to flatten folds through stretching. They also maintain some traction during loop reduction and during interventions [10]. A multicenter tandem colonoscopy crossover study (currently in abstract form) of 66 patients showed an adenoma miss rate of 15% in the group receiving EndoRings-assisted colonoscopy (followed by standard colonoscopy) vs a 48% miss rate in the group receiving standard colonoscopy first (followed by EndoRings-assisted colonoscopy, $P < 0.01$) [10].

The endocuff (Arc Medical Design Ltd, Leeds, UK) is a cylindrical cuff with thin flexible arms, which is placed at the distal tip of the colonoscope (Figure 2). These projections engage the mucosa on withdrawal and allow for manipulation of folds for close interrogation. Similar to the EndoRings device, the endocuff maintains a degree of traction to avoid slipping during reduction and interventions [6,7]. A multicenter randomized trial of standard colonoscopy vs endocuff-assisted colonoscopy showed a higher median number of polyps detected per colonoscopy (1 vs 2, $P = 0.002$) [11]. Another randomized trial of standard vs endocuff-assisted colonoscopy included 500 patients at 4 centers in Germany and reported an adenoma detection rate (ADR) of 35% in the endocuff-assisted group when compared with 21% in the standard colonoscopy group ($P < 0.0001$) [12]. There have not been any major adverse events associated with its use.

Fig. 1. EndoRings. (Color version of figure is available online.)

Right-sided mucosal lesions can be missed because of a propensity for lesions in the right colon to be flat and covered with mucus. The presence of large folds and increased difficulty in maneuvering the colonoscope in the right colon and around the hepatic flexure also may contribute to missed mucosal lesions. A "second-look" examination of the right colon by either forward viewing or retroflexion can result in increased adenoma detection [13,14]. A second-look evaluation of the right colon has been demonstrated to identify an additional polyp in 4%-10% of cases [13,14]. The Third Eye Retroscope (Avantis Medical Systems, Inc, Sunnyvale, CA) is a through-the-scope retrograde viewing system composed of a light-emitting diode (LED) light source and camera, which was developed to allow the examination of proximal aspects of folds without the need for retroflexion. A nonrandomized study showed a 15% increase in polyp detection and 16% increase in adenoma detection rate among 298 subjects [14]. A randomized back-to-back study of 349 subjects showed 23% additional adenomas detected on repeat colonoscopy (standard colonoscopy then third-eye–assisted colonoscopy) when compared with standard colonoscopy alone [15]. The device has limitations, including cost, decreased ability to suction, and the need to remove the device to insert polypectomy tools. To mitigate some of these limitations, the manufacturer is developing a panoramic camera (330° visualization) that attaches to the distal tip of the colonoscope. It requires a separate video processing unit. Preliminary feasibility data have described its use in a small number of patients, and the device has recently received Food and Drug Administration (FDA) clearance [16].

The NaviAid G-EYE system (Smart Medical Systems Ltd, Ra'anana, Israel) is a system that has a balloon integrated permanently into the distal portion of the colonoscope shaft. The balloon is deflated during insertion, but can be inflated at varying pressures via a foot-pedal control system to assist in minimizing folds during withdrawal. As it is a permanent component, it undergoes reprocessing along with the colonoscope [6,7]. A multicenter prospective study using the G-EYE system demonstrated an ADR of 45% [17]. A randomized trial of tandem colonoscopies showed that the adenoma miss rate was significantly lower for the G-EYE system when compared with standard colonoscopy (8% vs 45%, $P < 0.0002$) [18].

2.2. Colonoscope technology for increased mucosal visualization

Increasing the angle of visualization attainable by colonoscopes has been proposed to increase the examined mucosal surface area. The standard colonoscopes produced by the major endoscope manufacturers have typically had a field of view of 140°. The latest

Fig. 2. Endocuff. (Color version of figure is available online.)