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Stents for colonic strictures: Materials, designs, and more

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ABSTRACT

Colonic obstruction is one of the common manifestations of colon cancer. Historically, the treatment of malignant colonic obstruction consisted of surgical removal of the obstructing tumor, if possible, and decompression of the bowel with an ostomy. Self-expandable metal stents (SEMS) have now been used effectively for nonsurgical relief of malignant colonic obstruction, either for palliative care or as a bridge to elective surgery. Since the introduction of SEMS insertion technique in the early 1990s, multiple studies and reports have been published on the outcomes of SEMS in treating large bowel obstruction. SEMS are now recommended as an initial treatment of choice for acute left-sided colonic obstruction by surgical groups. SEMS insertion may be helpful to complete colonoscopy screening before surgery to detect any synchronous neoplasm proximal to a malignant colonic obstruction. SEMS insertion would also buy more time for a selected group of patients who may benefit from chemoradiation before surgery. This article reviews the development of colorectal stents, designs, materials, various types of colonic stents used in the treatment of colonic strictures, indications for their insertion, outcomes, limitations, complications, and future directions of the colonic stents.

1. Introduction

Colorectal cancer is the third leading cause of cancer-related deaths in the United States. The overall lifetime risk for developing colorectal cancer is approximately 5% (1 of 20). The American cancer society estimates 96,830 new colon cancer and 40,000 new rectal cancer cases in 2014 [1]. Acute colonic obstruction is a surgical emergency and is the initial presentation in 7%-29% of patients with colorectal cancer [2]. The sigmoid colon is the most common location for obstructing colorectal cancer, and 75% of tumors are located distal to the splenic flexure [3]. Self-expandable metal stents (SEMS) have been used as a bridge to surgery in patients with obstructive colorectal cancer to avoid emergent surgery or as palliation to relieve obstruction for those who are not surgical candidates. SEMS are also a reasonable first-treatment option in patients with malignant colorectal obstruction by non-colonic malignancy with peritoneal carcinomatosis [4].

2. Historical development, design, and delivery systems of colorectal stents

Lelcuk et al. in 1986 first described successful colon decompression in 3 of 4 patients with left-sided malignant colonic obstruction using transanal insertion of a nasogastric tube [5]. In 1991, the first expandable metal stent placement for palliation of malignant rectal obstruction was reported by Dohmoto et al [6]. In 1994, Tejero et al [7] reported the first 2 cases of acute malignant colonic obstruction successfully treated with the placement of a stent before elective surgery. Before the development of dedicated colorectal stents, stents developed for other anatomical locations, such as biliary, esophageal, and tracheobronchial stents, were used to treat left-sided malignant colonic obstructions [6,8-10]. A larger (diameter of 18-20 mm) version of a stainless steel enteral Wallstent (Boston Scientific) was introduced subsequently with the advantage of a small but longer length delivery system that could be passed through a colonoscope channel (diameter [10 Fr]) [10]. The first prototype nitinol colonic stent was developed in 1998. The latter stent resisted radial compression and conformed to the bends and tortuous colorectal anatomy. Tack et al [11] successfully tested the first prototype nitinol SEMS in a prospective trial in 10 patients with advanced obstructive colorectal cancer after an initial yttrium aluminum garnet (YAG) laser therapy to allow passage of a gastroscope and placement of the SEMS. To overcome the issue of tumor ingrowth through uncovered SEMS interstices, polyurethane-covered SEMS were introduced in 1998 [12].

In an attempt to address the high migration issue noted with fully covered stents (up to 50%), and the tumor ingrowth issue associated with uncovered SEMS, a dual-design colorectal stent, consisting of an outer partially covered stent and an inner uncovered nitinol stent was introduced in 2007 [13]. Although this dual stent design was noted to have low stent migration (2.7%) and tumor ingrowth (3.4%), perforation occurred in 11% of treated patients [13]. This high perforation rate was thought to

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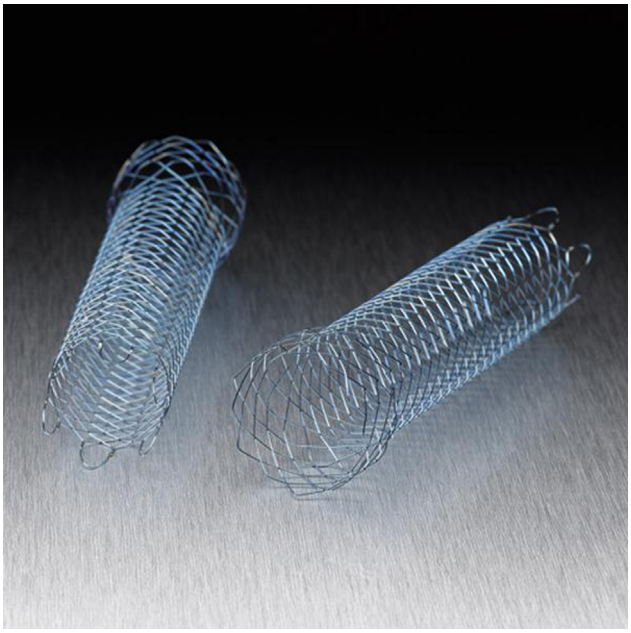

Fig. 1. Wallflex colonic stent. (Courtesy of Boston Scientific Corp, Natick, Mass.) (Color version of figure is available online.)

be due to uncovered flared ends and a large stent diameter (38 mm) [13].

In 2007, the larger diameter Ultraflex Precision colonic stent (Boston Scientific Corp, Natick, MA) with a 25-mm stent body and 30-mm proximal flare was introduced, and in 2008, the through-the-scope Wallflex colonic stent (Boston Scientific Corp, Natick, MA) (Figure 1) with either a 22- or 25-mm stent body and 27- or 30-mm proximal flare were marketed in an attempt to prolong relief of obstruction and reduce the risk of migration compared with the predecessor, smaller diameter enteral stents [14-17].

A triple-layer construction ComVi stent (TaeWoong Medical Co) (Figure 2) was subsequently introduced in 2010 by Park et al. This triple-layer design has a biocompatible polytetrafluoroethylene membrane tube that is held between an inner and outer unfixed cell mesh structure to prevent stent migration and tumor ingrowth [18]. Compared with the uncovered Wallflex stent, the ComVi stent had lower tumor ingrowth (3.8% vs 14.5%) but a higher migration rate (21.1% vs 1.8%). The mean patency did not differ between the 2 stent groups [18].

Stents can be divided into 2 classes based on the stent deployment system.

Through-the-scope stents (Figures 3 and 4) are mounted on a small-diameter catheter that can be passed through an endoscopic working channel of at least 3.7 mm. The second kind of stents, the so-called over-the-wire stents, are mounted onto a larger delivery system that cannot pass through the working channel of an endoscope [8].

Stent shortening during expansion is invariable after stent deployment and may vary from 20%-45%, contingent on the stent model employed [19].

3. Covered vs uncovered SEMS

Self-expandable colonic metal stents can be further divided into covered and uncovered types depending on the presence or absence of a covering membrane around the metal stent. Covered stents were developed to prevent or reduce tumor ingrowth and thereby early stent occlusion, an important problem with uncovered stents [20-23]. However, covered SEMS have higher stent migration rates compared with uncovered SEMS. A systematic review and meta-analysis of 6 studies with 464 patients comparing the clinical outcomes for patients treated with covered and uncovered SEMS found that uncovered SEMS had significantly higher rates of tumor ingrowth (relative risk = 5.99; 95% CI: 2.23-16.10; $P = 0.0004$) but significantly reduced late migration (>7 days) rate (relative risk = 0.25; 95% CI: 0.08-0.80; $P = 0.02$) [23].

A prospective multicenter study compared the double-layered colonic stent (Niti-S enteral colonic stent, ComVi type) (Figure 2) and the double-wire woven uncovered colonic stent (Niti-S enteral colonic stent, D-type) in the treatment of patients ($n = 68$) with malignant colonic obstruction. In this study, despite a trend toward late stent occlusion in the combination covered stent (Niti-S enteral colonic stent, ComVi type) group (0% vs 20%, $P = 0.11$), there was no significant difference in the overall stent patency between the 2 groups. Late stent migration occurred more often with the combination covered stent group than the uncovered stent group (22.2% vs 0%, respectively, $P = 0.041$) [24].

4. Stent material

SEMS are composed of various metals such as stainless steel (Figure 5), Elgiloy, or nitinol (Table). Currently, nitinol stents

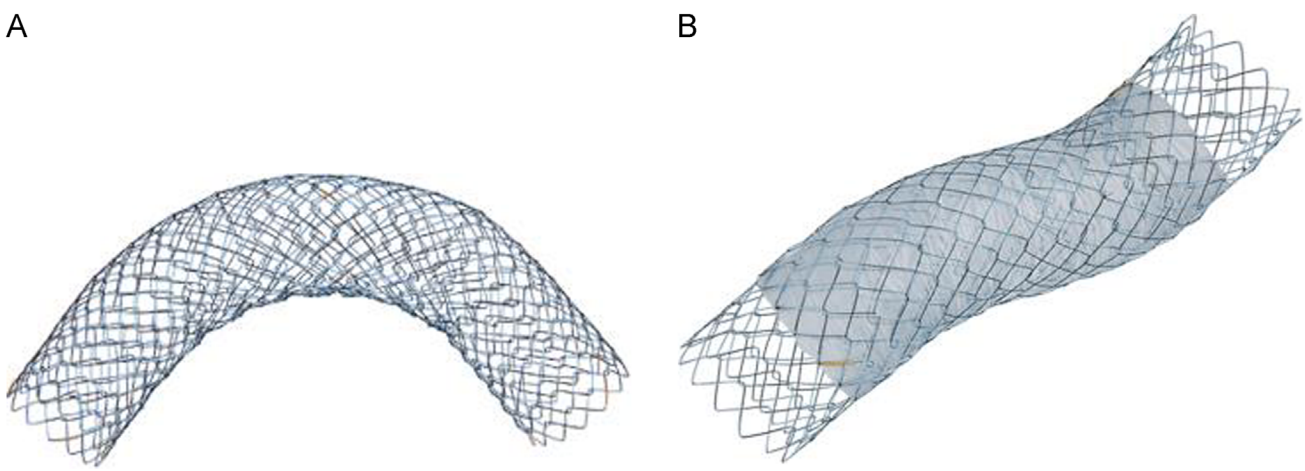

Fig. 2. Niti-S enteral colonic stent (left) and ComVi colonic stent (right). (Courtesy of TaeWoong medical, South Korea.) (Color version of figure is available online.)