EDITORIALS

Expandable Metal Stents for the Treatment of Esophageal Malignant Obstruction

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Esophageal cancer is the sixth leading cause of death from cancer worldwide [1]. Due to the esophagus distensible characteristics, patients may not recognize any symptoms until 50% of the luminal diameter is compromised explaining why cancer of the esophagus is generally associated with late presentation and poor prognosis [2]. Esophageal stents are devices used to maintain or restore the lumen of the esophagus. It is recommended that stents be placed in patients who have dysphagia caused by esophageal or gastric cardia cancer and a calculated life expectancy of 3 months or less [3]. All metallic stents used in the esophagus are self-expanding [4, 5]. No balloon-expandable endoprostheses are dedicated for use in the esophagus [5]. Stents are inserted using radiologic placement or endoscopic stenting. Both of them have similar success rates and complications [6]. Current self expandable metal stents (SEMS) use nitinol, which is an alloy of nickel and titanium, and is a good material for expandable metal stents [5]. Expandable metal stents based on nitinol are the alloys most frequently used in commercial applications. Nitinol stent exhibits shape memory on the basis of a phase transformation. In recent years, nitinol shape memory stents have been widely accepted for the treatment of gastrointestinal malignant obstruction. Importantly, anatomy-conforming nitinol stents or individual stents have been designed and used in patients.

History

In 1962, Buehler and his co-workers discovered the shape memory effect in an equiatomic Ni-Ti alloy which became known as nitinol. Raychem developed the first industrial application of shape memory alloy for the aeronautic industry during the 1960’s. In 1975, Andresen made the first implant of a hyperelastic orthodontic device [7]. After that, the shape memory property of Ni-Ti alloy was developed in different fields of science and engineering. The biomedical study of Ni-Ti shape memory alloys has been ongoing in China since 1978 [8]. In the 1990s, biliary SEMS became commercially available in the United States with a high success rate and minimum complications, followed several years later by esophageal SEMS [9]. Since 1992, a series of stents have been developed by Fan et al for the management of esophageal [10], tracheal, biliary strictures and urethrostenosis for tumors. The first esophageal nitinol stent placement in patients with malignant esophageal strictures was reported by Cwikiel et al in 1993 [11]. Cwikiel’s stents were knitted as a strecker shape and were called “Strecker stents”. Almost at the same time, Dong in China [12] reported his clinical observations of using the nitinol alloy stents designed by himself to treat benign esophageal stenosis caused by chemical burns. This was the first spiral shape stent designed and placed in the esophagus. However, Dong’s spiral stent had drawbacks, such as a high rate of dysfunction and difficulty to place. To overcome these problems, in 1992, Fan et al designed a new nitinol stent which was knitted as mesh and applied for a Chinese patent. In 1997, Gastrointestinal Endoscopy published our design of reticulate nitinol stents and clinical experiences of placement in patients with esophageal cancer [10]. After the applications of the mesh stents, several makes of stents, including uncovered stents and covered stents, involving reticulate shapes or designs were made in different countries [13, 14]. In the September 2007 issue of the Journal of Gastrointestinal and Liver Diseases, Keller et al reported a new covered nitinol stent [14]. They mentioned that our publication in 1997 was the first report which described the uncovered nitinol stent (Garson stent, China). Clinically, the uncovered or covered nitinol mesh stents displayed their advantages for the relief of dysphagia, reducing migration and placing easily and safely. Now, it has been proved that the nitinol stent with the mesh structure has become the most commonly used stent type worldwide [13].

Current stents and stents selection

Esophageal stent placement is a safe, minimally invasive,
effective treatment for esophageal strictures and associated bronchoesophageal fistulas. There are several types of devices available such as the: Ultraflex stent, Wallstent, Niti-S stent, Garson stent, Gianturco Z-stent, Flamingo stent, Polyflex stent, Choo stent and Song stent.

To prevent tumor ingrowth, the interstices between the metal mesh of esophageal SEMS may be wholly or partially covered by a plastic membrane. The covered metallic stent placement is now the primary treatment for malignant dysphagia and associated bronchoesophageal fistulas in patients with poor functional status or previous therapy failure [15, 16]. Covered metal stents are used for the palliation treatment of dysphagia in esophageal cancer, but a major drawback is the risk of stent migration, which occurs in up to 20% of patients [16].

The Ultraflex stents, Flamingo stents and Wallstents are made of nitinol and covered at their midsections with a polyester cover. The Z-stent is made of stainless steel and covered with polyethylene over its entire length. No statistically significant differences have been found between the stents for dysphagia improvement, the occurrence of complications, such as perforation or hemorrhage, and the occurrence of recurrent dysphagia, as determined by stent migration or tissue overgrowth and ingrowth [5]. As with other SEMS, Ultraflex esophageal stents have a high reintervention rate which remains a challenging problem [17]. The Z-stent has an antireflux valve allowing patients to belch or vomit; however, it has minimal flexibility making it less appropriate for tortuous anatomic structures [17].

An ongoing issue with stents is the occurrence of recurrent dysphagia because of stent migration, tumoral or nontumoral tissue growth and food obstruction [5]. Recurrent dysphagia occurs in 30–40% of patients after a mean follow-up of 2–3 months [18]. Reintervention for stent-related recurrent dysphagia is effective in more than 90% of patients [18]. According to our experience, the most effective treatment strategy for tissue overgrowth or ingrowth and stent migration is the placement of a second stent, or, in some cases of migration, stent repositioning [5]. For cases of food obstruction, endoscopic stent clearance is an easy and effective strategy to employ. After treatment for recurrent dysphagia, the median survival of patients has been shown to be longer than two months [18]. Nonetheless, reintervention is expensive because in many cases endoscopy, a new stent or even admission to hospital is required.

In order to reduce the need for reinterventions, two new stent designs, the Polyflex stent and the Niti-S double stent, have been developed [5]. Polyflex stents are made of silicone and polyester, fully covered, and have been designed to reduce nontumoral tissue overgrowth and ingrowth, which is mostly seen after the placement of partially covered stents made of nitinol because of hyperplastic tissue growth. By contrast, the Niti-S double stent was developed to reduce stent migration: it combines a flare at both ends and a double layer configuration, with an inner cover and an outer uncovered nitinol wire tube to allow the mesh of the stent to embed itself in the esophageal wall. The Niti-S stent consists of an inner polyurethane layer to prevent tumor ingrowth and an outer uncovered nitinol wire tube to allow the mesh of the stent to embed itself in the esophageal wall [16].

Self expandable metal stents have drawbacks including risk of migration (for covered SEMS), malignant or granulomatous ingrowth through the stent mesh or overgrowth at the stent ends, difficulties in stent removal or repositioning, and high cost. A self-expanding plastic stent, the Polyflex, has been marketed. A trial in Italy, France and Germany studied the complications of the placement of a Polyflex (N = 47) or a partially covered Ultraflex (N = 54) stent [19]. The percentage of major complications in Polyflex patients became significantly more than those having the Ultraflex stent. Polyflex stents are less flexible than SEMS, and migration can occur more frequently in patients.

Worldwide, the most frequently used method to treat dysphagia caused by esophageal or gastric cardia cancer is stent placement. We emphasize an algorithm [5] used at the University Medical Center Utrecht, the Netherlands for the management of malignant esophageal strictures. It is recommended that stents be placed in patients who have dysphagia caused by esophageal or gastric cardia cancer and a calculated life expectancy of 3 months or less [5].

**Individual stents for individual treatment**

Although the use of self-expanding metal stents is now an established part of the palliative treatment for esophageal carcinomas, late complications are frequent, especially in a transcardial position. The relatively high rate of late complications such as stent migration, hemorrhage, and gastroesophageal mucosal prolapse has led to a recent debate on the role of metal stents in palliative therapy [20]. Recently, some talented endoscopists and researchers have attempted to design individual stents specific to the anatomic structures in different positions of the esophagus, especially for transcardial application, which is intended to prevent bleeding due to mechanical mucosal lesions caused by the distal end of the stent extending into the stomach [20, 21].

We also carried out palliative stent implantation to treat the esophageal stenosis. The impulse to provide these individual treatments came from our experiences and convenience for designing and providing individual stents (Garson stent, Changzhou, China). We named these stents as anatomy-conforming nitinol stent or individual stents. Decisive factors in developing these new designed nitinol stents included the special anatomic conditions in patients with special anatomic conditions, such as gastroesophageal long strictures and esophageal hernia.

Although individually designed nitinol stents in special anatomic conditions [21], based on our long term observations and follow-up has forced further discussion, these individual anatomy-conforming nitinol stents have played important roles in reducing short-term complications and long-term complications, including bleeding, vomiting, migration to the stomach, recurrent dysphagia. For implanting individual stents, as in commercial stents, the patient’s informed consent was obtained before the individual design.
Stent migrations that are frequently reported occur much less often when a partially covered stent with a large diameter is used, and previous dilation of the tumor stenosis has not been carried out [22]. Nevertheless, bleeding, particularly due to mechanical lesions caused by the distal end of the stent which extends into the stomach, and mucosal prolapse with occlusion of the stent, still continue to be major problems. In our experience, individual stent design has provided an optimal solution in the palliative situation for patients. It is particularly suitable for palliative treatment of stenotic distal esophageal carcinomas. Further optimization of the design and in addition, studies comparing it with conventional stents are required. Individual stent designing could alleviate many of the late complications associated with stent treatment. The optimal stent graft is not yet available on the market, but hopefully will come with further development.

**Future directions**

A variety of SEMS are available for the management of esophageal obstruction. However, improvements in stent designs are required to prevent migration while maintaining removability. In patients with cancer, the use of expandable metal stents that emit radiation or release chemotherapeutic agents may cause tumor regression. in the future, drug-coated metal stents that emit radiation or release chemotherapeutic removability. in patients with cancer, the use of expandable esophageal stent: experiences with a new nitinol stent end 129 patients. Gastrointest Endosc 1997; 46: 352-357.


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**Conflicts of interest**

None to declare.

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