To my family
The present study is based on the following articles which are referred to in the text by their Roman numerals.


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ABBREVIATIONS

AS anastomotic stricture
ASA American Society of Anesthesiologists grade
BMI body mass index
CCI Charlson comorbidity index
CD Crohn’s disease
CRC colorectal cancer
CRO colorectal obstruction
CT computed tomography
DS diverticular stricture
EBD endoscopic balloon dilation
ECM extracolonic malignancies
ERC endoscopic retrograde cholangiography
ERCP endoscopic retrograde cholangiopancreatography
ES endoscopic stenting
GI gastrointestinal
GJ gastrojejunostomy
GOO gastric outlet obstruction
GOOSS gastric outlet obstruction scoring system
LGJ laparoscopic gastrojejunostomy
MRI magnetic resonance imaging
OGJ open gastrojejunostomy
PEG/PEJ percutaneous gastrostomy/ percutaneous jejunostomy
PR palliative resection
PTC percutaneous transhepatic cholangiography
PTD percutaneous transhepatic drainage
QoL quality of life
SEMS self-expanding metal stent
TME total mesorectal excision
WHO World Health Organization score
ABSTRACT

Aim: Gastric outlet obstruction (GOO) is a preterminal event in incurable malignancies of the gastrointestinal (GI) tract. Pancreatic cancer and gastric cancer are the most common causes for GOO. Colorectal cancer (CRC) is the most common etiology for colorectal obstruction (CRO). Other causes for CRO include extracolonic malignancies (ECM) and benign causes. Traditional treatment of GOO and CRO is surgery, but it carries a high rate of complications. Self-expanding metal stents (SEMS) have become an alternative for surgery in GOO and CRO.

The principle aim of this work was to evaluate the results of endoscopic stenting in GOO and CRO. The utility of SEMS in incurable GOO was studied and the results of stenting, gastrojejunostomy (GJ), and palliative resection (PR) in advanced gastric cancer and GOO was compared. The utility of SEMS in benign CRO was studied and in malignant CRO, the utility of SEMS was assessed as a bridge to surgery and as palliation.

Patients and methods: The study material consisted of 323 patients with GOO or CRO treated at Meilahti Hospital between January 1998 and December 2010. Patients with incurable GOO (I), advanced gastric cancer and GOO (II), benign CRO (III), and malignant CRO (IV) treated with SEMS were identified from the endoscopy unit’s database. Patients who underwent GJ or PR caused by advanced gastric cancer were identified from the surgical unit’s database (II). For all studies, the data was analysed retrospectively.

In study I, 104 patients were included in the analysis. The study II population consisted of 97 patients, and of these 50 underwent endoscopic stenting, 26 PR, and 21 GJ. In study III, 21 patients were included in the analysis. The study IV population comprised 101 patients, and of these 11 were stented as a bridge to surgery. Of 101 patients, 66 underwent palliative stenting due to CRC and 24 due to ECM.

Results: In patients with incurable GOO (I), a median GOOSS (gastric outlet scoring system) improved significantly from 0 to 2 after stenting, and 73% of the patients managed with only one stenting procedure until death. Repeated stenting became necessary for 21 patients (20.2%). Combined enteral and biliary stenting succeeded in 10/11 (91%) patients. A median survival was 62 days (range 1-933).

In patients with advanced gastric cancer (II), stenting resulted in a more rapid improvement in oral intake and a shorter hospital stay than GJ or PR. Complication rates were similar between three groups. For patients who underwent PR, symptom-free and overall survival were longest. In multivariate survival analysis, independent
prognostic factors were age, BMI, pre-procedure GOOSS, palliative resection as treatment modality, and chemotherapy.

In benign CRO (III), technical success of stenting was achieved for all patients and clinical success for 16/21 (76%) of the patients. Of eight anastomotic strictures (AS), five (63%) were resolved with SEMS. Of ten diverticular strictures (DS), three (30%) were resolved with SEMS. Complications occurred for nine patients (43%) in ten procedures. Of the complications, 67% occurred for patients with DS or Crohn’s disease strictures.

In malignant CRO (IV), overall technical and clinical success rates were 99% and 87%, respectively. A total complication rate was 20%. A primary anastomosis in elective operations was possible for 90% (9/10) of the patients who were stented as a bridge to surgery. In palliative stenting, clinical success rates were significantly lower for patients with extracolonic malignancies than for patients with colorectal cancer (63% vs. 94%, p<0.001). Between palliation groups, complication, operation, and stoma rates were similar.

**Conclusions:** SEMS provides good palliation for patients with incurable GOO. In advanced gastric cancer and GOO, SEMS is a treatment of choice for patients unfit for surgery. PR seems to provide survival benefit, and should be considered as a treatment option for patients fit for surgery. In benign CRO, SEMS is a good treatment option in AS for selected patients. In DS and Crohn’s disease strictures, a high rate of complications limit the utility of SEMS. In malignant CRO, SEMS can be used as a bridge to surgery and as palliation. A higher clinical failure rate is associated with palliative stenting for ECM than for CRC.
1. INTRODUCTION

Obstruction of the gastrointestinal (GI) tract occurs frequently in abdominal malignancies. Pancreatic cancer and gastric cancer are the most common etiologies of gastric outlet obstruction (GOO) (Del Piano et al. 2005). GOO limits oral intake and leads into malnutrition and weakening of the clinical condition of the patient. GOO also substantially deteriorates the quality of life (QoL) and is commonly associated with biliary obstruction.

Colorectal obstruction (CRO) is most often caused by colorectal cancer (CRC). Of CRC patients, 15% to 20% experience an obstruction of the bowel (Kyllonen 1987). CRO can be also caused by extracolonic malignancies (ECM) such as ovarian cancer or by benign etiology.

The traditional treatment for GOO is gastrojejunostomy (GJ). After GJ, a relief of symptoms is achieved in about 80% of the patients (Jeurnink et al. 2010). GJ is associated with a high rate of complications, however. An important complication is delayed gastric emptying, occurring in 11% to 57% of the patients, which can prevent oral intake, despite the technical success of a procedure (Doberneck and Berndt 1987; Woods and Mitchell 1989). In advanced gastric cancer, surgical treatment options for GOO include GJ and palliative resection (PR) (Ouchi et al. 1998).

The standard approach in malignant CRO is surgery. Emergency surgery for acute CRO is associated with higher morbidity and mortality rates than elective surgery (Runkel et al. 1991). In addition, patients undergoing emergency surgery have poorer 5-year survival than patients who are operated on electively (McArdle and Hole 2004). For incurable metastasized disease, palliative surgery options for obstruction include bowel resection, colostomy, or entero-enterostomy. A multidisciplinary team is recommended when planning the treatment for each patient. The standard management of benign CRO caused by anastomotic strictures (AS), diverticular strictures (DS), or Crohn`s disease (CD) strictures is endoscopic dilation or surgery. Multiple endoscopic procedures are often needed when treating AS or CD strictures (Stienecker et al. 2009; Suchan et al. 2003).

Self-expanding metal stents (SEMS) were introduced as a treatment alternative for obstructions of the GI tract in the 1990s (Dohmoto 1991; Kozarek et al. 1992). As a palliative method for GOO, SEMS have shown to result in a more rapid tolerance of oral intake, less morbidity, lower incidence of delayed gastric emptying, and shorter hospital stay than GJ (Hosono et al. 2007). Rather little data exists on combined biliary and enteral stenting, but the results have been promising (Kaw et al. 2003). SEMS have also been used in malignant and benign CRO. In preoperative stenting of acute malignant CRO, SEMS have resulted in higher primary anastomosis rates and lower stoma rates than emergency operations (Cennamo et al. 2013). In
palliation of CRO, SEMS have been associated with shorter hospital stay and fewer complications than palliative surgery (Ptok et al. 2006). Data on SEMS and CRO caused by ECM is limited, and the results vary (Keswani et al. 2009). SEMS have also been used in benign CRO, but there is only little data on this subject (Small et al. 2008).

In this thesis, efficacy, safety, and outcome of endoscopic stenting in GI tract obstructions were evaluated. The efficacy of SEMS in malignant incurable GOO was studied, and compared to the results of stenting to GJ and PR in advanced gastric cancer. The feasibility of combined stenting in biliary obstruction and duodenal obstruction was also studied. The utility of SEMS in benign CRO was evaluated. In malignant CRO, the feasibility of SEMS as a bridge to surgery and as palliation was assessed. The outcomes of palliative stenting between two etiologies, primary CRC and ECM, was also compared.
2. REVIEW OF THE LITERATURE

2.1 MALIGNANT GASTRIC OUTLET OBSTRUCTION

2.1.1 DEFINITIONS AND CLINICAL PRESENTATION

Gastric outlet obstruction (GOO) or gastroduodenal obstruction is a condition where the normal outflow from the stomach is obstructed. Obstruction can develop from the intraluminal tumour growth, tumour ingrowth from surrounding structures, or from extraluminal tumour compression. GOO causes nausea, vomiting, and early satiety which result in dehydration and malnutrition, and eventually weakening of the clinical condition of the patient. The symptoms of GOO substantially limit the quality and quantity of the remaining life of the patient. The gastric outlet obstruction scoring system (GOOSS) (Table 1) was presented by Adler (Adler and Baron 2002), and can be used to define a patient’s ability of oral intake.

Table 1. The Gastric Outlet Obstruction Scoring System (GOOSS)

<table>
<thead>
<tr>
<th>Level of oral intake</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>No oral intake</td>
<td>0</td>
</tr>
<tr>
<td>Liquids only</td>
<td>1</td>
</tr>
<tr>
<td>Soft solids</td>
<td>2</td>
</tr>
<tr>
<td>Low-residue or full diet</td>
<td>3</td>
</tr>
</tbody>
</table>

2.1.2 ETIOLOGY AND DIAGNOSIS

Malignant GOO is caused by advanced malignancies of the upper-GI tract. Pancreatic and gastric carcinomas are the most common causes of GOO; additional causes include other periampullary tumours than pancreatic head (duodenum, distal bile duct, ampulla of Vater), lymphoma and metastases of other malignancies (Del Piano et al. 2005; Jeurnink et al. 2010).

2.1.2.1 Pancreatic cancer

In developed countries, pancreatic cancer is the ninth most common cancer diagnosis with an estimated 165,000 new cases diagnosed annually, and the fifth
most common cause of cancer death for men and the fourth for women. In developing countries, pancreatic cancer is rarer (Jemal et al. 2011). Approximately 1000 new pancreatic cancers are diagnosed annually in Finland. Although representing only 3.5% of all new cancer diagnoses, up to 9% of cancer deaths are caused by pancreatic cancer in Finland. The prognosis of pancreatic cancer is extremely poor; a five-year survival is only 5% (Finnish cancer registry). Surgical resection by pancreaticoduodenectomy is the treatment of choice for pancreatic cancer. Of the patients with periampullary tumours who undergo exploratory laparotomy with an intention to perform pancreaticoduodenectomy, 25% to 75% are found to have an unresectable disease (Singh et al. 1990; Trede 1985). Symptomatic GOO develops in 19% to 41% of patients with pancreatic and periampullary cancers and therefore prophylactic gastrojejunostomy is indicated with unresectable patients undergoing exploratory laparotomy (Lillemoe et al. 1999; Van Heek et al. 2003).

2.1.2.2. Gastric cancer

In developed countries, gastric cancer is the fifth most common cancer diagnosis with an estimated 275,000 new cases diagnosed annually, the fourth most common cause of cancer death for men and the fifth for women. In developing countries, gastric cancer is more common. Over 70% of new cases and deaths occur in developing countries (Jemal et al. 2011). In Finland, approximately 700 new diagnoses are made annually. In spite of declining incidence of gastric cancer, it is the fifth most common cause of cancer death for men and the sixth for women with five-year survival of 25% (Finnish cancer registry). Surgical resection is the treatment of choice for gastric cancer. Unfortunately, a significant number of patients have an advanced disease at the time of the diagnosis, and curative surgery is possible for only 20% to 50% of the patients (Akoh et al. 1991; Allum et al. 1989; Kokkola et al. 2008). Cardia of the stomach is the most common location of tumour, in 37% of patients, followed by antrum in 20%, corpus in 5%, fundus in 4%, pylorus in 3%, and multiple or overlapping locations in 31% (Cunningham et al. 2005). In antral gastric cancer, the incidence of GOO is 15% (Watanabe et al. 1998).

The diagnosis of malignant GOO is based on clinical symptoms, malignant histology, endoscopy findings of tumour obstruction, and radiologic examinations such as computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, and oral contrast meal study (Figure 1)
2.1.3 PALLIATION OF GASTRIC OUTLET OBSTRUCTION

The World Health Organization (WHO) has defined palliative care as “the total active care of patients whose disease is not responsive to curative treatment. Control of pain, of other symptoms, and of psychologic, social, and spiritual problems is paramount. The goal of palliative care is the achievement of the best quality of life for patients and their families.” (WHO 1990). Palliation should not be regarded as an opposite of cure. For patients suffering from symptoms of GOO, the goal of palliative treatment is to maintain oral food intake and to prevent worsening of clinical condition due to vomiting, dehydration, and malnutrition. As the median survival of patients with unresectable pancreatic cancer is 3-6 months (Ghaneh et al. 2007) and with advanced gastric cancer 9-13 months (Miner et al. 2004) it is essential that the palliation of symptoms of GOO is fast, with low morbidity, and with short hospital stay.

2.1.3.1. Open and laparoscopic gastrojejunostomy

The standard treatment for GOO has been open gastrojejunostomy (OGJ). In this procedure, through midline or rooftop incision, a jejunal loop 40-60 cm distal to the ligament of Treitz is used to form an antecolic or retrocolic side-to-side gastrojejunostomy. An anastomosis can be either hand-sewn or stapled to the anterior or posterior surface of the stomach.
Previous prospective studies have demonstrated the technical success rate of OGJ to be 94% to 100% (Fiori et al. 2004b; Jeurnink et al. 2010; Johnsson et al. 2004). After OGJ, relief of obstructive symptoms is achieved in 66% to 83% of the patients. A high rate of complications limits the usefulness of OGJ in the treatment of GOO. Earlier studies have reported a high complication rate even up to 90% with patients undergoing OGJ (Doberneck and Berndt 1987; Weaver et al. 1987). Complications may be major or minor. Major, life threatening, complications associated with OGJ include anastomotic leakage, perforation and peritonitis, and postoperative haemorrhage. Minor complications include delayed gastric emptying, wound infections, and pain (Jeurnink et al. 2010). More previous studies report major complication rates up to 13%, and minor up to 30% (Fiori et al. 2004b; Jeurnink et al. 2010; Johnsson et al. 2004). One of the complications after OGJ is delayed gastric emptying, which can lead to clinical failure. Etiology for this complication can be a diminished motility of the dilated stomach and unphysiologic passage of food. In earlier studies, the occurrence of delayed gastric emptying has been between 11% and 57% (Doberneck and Berndt 1987; Woods and Mitchell 1989). More recent prospective studies report a slightly diminished rate of delayed gastric emptying between 11% and 30% (Fiori et al. 2004b; Jeurnink et al. 2010). After OGJ, median hospital stay has been between 10 days and 15 days.

As mini-invasive techniques have evolved, laparoscopic gastrojejunostomy (LGJ) has become a treatment alternative for GOO. Compared to OGJ, LGJ has been proposed to result in more rapid improvement in oral intake and symptom relief, reduction of post-operative morbidity, and shorter hospital stay. Limited data on the usefulness of LGJ in the treatment of malignant GOO exists, however. Croce et al. (Croce et al. 1999) performed 25 LGJs with a complication rate of 4% (1/25) and a median post-operative hospital stay of 3 days. In a retrospective report, comprising 16 patients with malignant and 12 patients with benign GOO, the reported major and minor complication rate was 14% and 18%, respectively, with a median hospital stay of 8 days (Zhang et al. 2011). In a prospective study by Mehta et al. (Mehta et al. 2006), the complication rate was 61% and mean hospital stay 11 days.

In two retrospective comparative studies, compared to OGJ, LGJ resulted in a shorter hospital stay (Al-Rashedy et al. 2005; Bergamaschi et al. 1998), less estimated intraoperative blood loss (Bergamaschi et al. 1998), shorter duration of postoperative intravenous hydration and opioid analgesia, and morbidity (Al-Rashedy et al. 2005). The clinical outcomes of OGJ and LGJ in GOO were compared in a prospective randomized trial. Results from the study show less intraoperative blood loss (38 ml vs. 170 ml), fewer postoperative complications (0% vs. 16%), and faster tolerance of oral intake (4 days vs. 6 days) in the LGJ group compared to OGJ (Navarra et al. 2006).
2.1.3.2. Palliative resection in gastric cancer

A significant number of gastric cancer patients present with locally advanced or metastasized disease excluding curative surgery. Non-curative resection in gastric cancer is by definition patients without major symptoms undergoing resection with microscopic (R1) or macroscopic (R2) tumour residual, or with metastatic disease (M1) disease (Miner et al. 2004). In many cases, non-curative operations are started (R2) or performed (R1) with a curative intent. Palliative surgery of advanced malignancy can be defined as a procedure intended to improve patients’ QoL or to relieve symptoms (Mc Cahill et al. 2002; Miner et al. 1999; Miner et al. 2002).

For locally advanced and/or metastasized gastric cancer, palliative chemotherapy is the treatment of choice. Compared to supportive care only, palliative chemotherapy provides survival benefit and improvement in QoL (Glimelius et al. 1997; Murad et al. 1993; Pyrhonen et al. 1995). A role of non-curative surgery in the absence of major symptoms for gastric cancer is unclear due to lack of sufficient data. No randomized studies comparing non-curative resection with chemotherapy versus chemotherapy alone exist, and the study populations are heterogeneous consisting of patients with and without major symptoms. Some studies have reported improved survival after non-curative surgery, particularly if metastatic sites are limited to two at most (Hartgrink et al. 2002; Haugstvedt et al. 1989; Samarasam et al. 2006). Resection combined with chemotherapy has also been beneficial in terms of survival (Chang et al. 2012; Lin et al. 2008; Saidi et al. 2006). Some studies have found no survival benefit after resection (Kokkola et al. 2012; Ouchi et al. 1998; Park et al. 2009a). Morbidity rates after resection have ranged between 13% to 38% and mortality rates between 0% and 12% (Chang et al. 2012; Hartgrink et al. 2002).

In the event of major symptoms, such as bleeding or GOO, palliation of symptoms becomes essential. The options for palliation include palliative surgery with resection or bypass, or stent deployment. Based on the possible survival benefit after resection, PRs in the event of GOO are widely performed. The suitability of the patient for major operation, such as resection should be carefully discussed. The nutritional status and general health for patients with GOO are often poor. Nutritional deficiency has been regarded as a significant factor for postoperative complications in abdominal surgery (Sungurtekin et al. 2004). Preoperative symptoms of GOO for patients undergoing curative resections for gastric cancer adversely affect overall survival (Park et al. 2009b). Also in advanced disease, it has been shown that survival is better for asymptomatic patients undergoing non-curative resections than for patients with major symptoms undergoing PRs (Miner et al. 2004). Similarly, a study by Kahlke et al. (Kahlke et al. 2004), consisting of gastric cancer patients undergoing PR or exploration only, showed that the intensity of preoperative symptoms affects survival and is shortest for patients with major symptoms like GOO. Survival was not influenced by the type of operation. QoL is an important issue in palliation, particularly when considering operative treatment, but little data exists on the
subject. Kahlke et al. (Kahlke et al. 2004) used a standardized EORTC QLQ-C30 questionnaire to measure QoL before and after operation. QoL did not differ in patients with major and minor symptoms preoperatively. For patients with major symptoms, general QoL was significantly better before discharge and at 3 months after operation than for patients with minor symptoms.

2.1.3.3. Self-expanding metal stents in gastric outlet obstruction

2.1.3.3.1. Definition, stenting technique, and stent types

A self-expanding metal stent (SEMS) is a cylindrical prosthesis made of cross-hatched, braided or interconnecting rows of metal that are assembled into a tube-like structure (Figure 2). SEMS are typically used as a palliative treatment for obstructions in the GI tract.

SEMS was introduced as palliation of GOO in the early 1990s. In 1992, Topazian (Topazian et al. 1992) used SEMS for palliation of obstructing gastric cancer and Kozarek (Kozarek et al. 1992) for stenosis of afferent and efferent loop. Since then, SEMS have been increasingly used for palliation of malignant GOO. A SEMS can be deployed under endoscopic, fluoroscopic, or combined endoscopic and fluoroscopic control. Fluoroscopic technique is preferred by interventional radiologists. Before the stenting procedure, the stomach should be decompressed with a nasogastric tube. In the combined technique, the insertion of a guidewire or stent through the disfigured stomach is usually easier. Procedures are usually
performed under conscious sedation. In combined endoscopic and fluoroscopic technique, the stricture is approached with a therapeutic gastroscope or side viewing duodenoscope. A guidewire and a catheter are passed beyond the stricture. A contrast media is injected to confirm successful passage through the stricture, to assess the morphology and length of the stricture, and to assure correct position of the guidewire. For larger diameter stents, the endoscope is removed and the stent delivery system is deployed over the wire. Smaller diameter stents can be deployed through the working channel of the endoscope. A stent length should be 2 to 4 cm longer than the stricture in case of possible shortening of the stent and for preventing migration (Mauro et al. 2000).

An ideal stent should be easy to deploy, with a wide enough internal diameter to restore normal eating, and with sufficient radial force to expand inside hard tumour tissue. Stents should be strong enough to prevent stent fractures and collapses; at the same time they should be flexible to conform to angled strictures. Stents should also hold their length, stay in the position, and prevent tumour ingrowth and subsequent stent obstruction. Two main types of SEMS are available – uncovered and covered – with their own advantages and disadvantages (Figure 3). The majority of the stents used are uncovered. Uncovered stents get more easily obstructed in the long-term due to tumour ingrowth through small openings between the stent wire filaments (Graber et al. 2007; Nevitt et al. 1998). Covered stents have a membrane that prevents the tumour ingrowth, but migration occurs more frequently (Jeong et al. 2002; Jung et al. 2000). In two recent prospective studies, of which one was randomized, comparing uncovered and covered stents as palliation of GOO,
the technical and clinical success rates were comparable (Kim et al. 2010; Lee et al. 2009). In both studies, migration rate was higher for covered stents than for uncovered stents (17%-25% vs. 0%-3%). Recurrent obstruction due to tumour ingrowth was more common for uncovered stents (16%-25% vs. 0%-3%). There was no difference in stent patency time and overall survival. To resolve the problems of migration and reobstruction, newly designed double-layered or partially covered stents have been introduced. The reported migration rates have ranged between 6% and 10%, and reobstruction rates between 10% and 18% (Isayama et al. 2012; Kim et al. 2011).

2.1.3.3.2. Overall outcome

A 2004 meta-analysis pooled data from a total of 32 case series between 1992 and 2003 (10 prospectively collected) with 606 patients (Dormann et al. 2004). Technical success of SEMS placement was achieved in 97%, and clinical success in 89% of those in whom technical success was achieved. Total complication rate was 28%. Of complications, perforation or bleeding occurred in 1%, stent migration in 5%, and recurrent obstruction in 18% of the patients. There was no procedure related mortality.

In more previous prospective single centre reports, the technical success rate of SEMS deployment as palliation for GOO has ranged between 91% and 94% and clinical success rate between 88% and 94%. Total complication rate has ranged from 11% to 24% (Havemann et al. 2009; Holt et al. 2004; Kim et al. 2007). In multicentre studies, the technical success rates have been between 95% and 98%, and clinical success rates between 77% and 92%. Total complication rates have ranged from 15% to 36% (Costamagna et al. 2012; Graber et al. 2007; Nassif et al. 2003; Piesman et al. 2009; Telford et al. 2004; van Hooft et al. 2009). The majority of the stents used in the aforementioned studies are uncovered stents. Major complications associated with SEMS placement include perforation of the bowel and bleeding. Reported rate for perforation has ranged between 1% and 5% and for bleeding between 1% and 6%. The most common late complication, occurring with a rate of 9% to 22%, is stent obstruction which can develop due to tumour ingrowth or due to tissue granulation, or from extrinsic compression of the surrounding tumour resulting in stent collapse. Treatment options for stent obstruction include repeated stenting, endoluminal endoscopic procedures such as laser ablation, or surgery. Stent migration rate has been up to 7%. Other complications related to stent placement include cholangitis and abdominal pain. Most of the studies report no procedure related mortality. However, Graber et al. (Graber et al. 2007) reported stent placement related mortality in 5 of 51 (9.8%) patients with major complications.
2.1.3.4. **Self-expanding metal stents versus gastrojejunostomy in gastric outlet obstruction**

### 2.1.3.4.1. Efficacy and safety

According to a meta-analysis, consisting of one randomized prospective trial and eight retrospective studies (307 patients) published between 2001 and 2006, endoscopic stenting was associated with higher clinical success ($p=0.007$), a shorter time for tolerance of oral diet ($p<0.001$), less morbidity ($p=0.02$), lower incidence of delayed gastric emptying ($p=0.002$), and a shorter hospital stay ($p<0.001$) than surgical gastrojejunostomy. Between the groups, no significant difference was found in 30-day mortality (Hosono et al. 2007).

Since this meta-analysis, two randomized studies have compared the results of SEMS placement and gastrojejunostomy. Mehta et al. (Mehta et al. 2006) randomized 27 patients to the LGJ (n=14) or stent group (n=13). Eight patients in the LGJ group had a complication which included delayed gastric emptying (n=3), hematemesis (n=2), port site infection (n=1), deep venous thrombosis (n=1), and respiratory tract infection (n=1). All complications were managed conservatively. No complications occurred in the stent group. Hospital stay was shorter in the SEMS group (5.2 days vs. 11.4 days). The authors reported no times for restoration of oral intake. The cumulative survival rates were similar among groups. In another study, 18 patients were randomized to the GJ group and 21 to the stent group. For the stent group, the tolerance of oral diet was faster (GOOSS ≥ 2: median 5 vs. 8 days) and hospital stay shorter (median 7 vs. 15 days) than for the GJ group. The long-term relief was better for GJ (GOOSS ≥2: 72 vs. 50 days). In the stent group, more major complications, recurrent obstructive symptoms, and reinterventions were recorded. There was no difference in survival (Jeurnink et al. 2010). In a prospective, non-randomized study, comparing SEMS, GJ and PEG/PEJ (percutaneous gastostomy or percutaneous jejunostomy), 50 patients were enrolled to a cohort (Schmidt et al. 2009). After withdrawal of three patients, 47 were included into analysis. Stenting was attempted in 34 patients with a success rate of 25/34 (74%). Ten patients were initially operated on. Six patients from the stent group underwent GJ, thus, eventually there were 16 patients in the GJ group. Three patients underwent PEG/PEJ initially, as well as four patients who failed stent placement, leaving seven patients to the PEG/PEJ group. A median hospital stay was shortest for the SEMS group (SEMS 2.5 vs. GJ 10 vs. PEG/PEJ 9 days). There were no significant differences in tolerance of oral diet at 1 or 3 months, 30-d mortality, or need for reinterventions due to recurrent GOO. A median survival did not differ between SEMS and GJ groups (94 vs. 73 days).
**2.1.3.4.2. Long-term outcome and predictive factors for stent patency and complications**

For patients with incurable malignancies and symptoms of GOO, the patency of the stent is an important issue. After SEMS placement, 48% to 63% of the patients tolerate solid food until death (Canena et al. 2012; Piesman et al. 2009). According to a report of 51 patients after 135 days of SEMS placement, for 75% of the patients a stent remained patent (van Hooft et al. 2009).

As shown by several studies, chemotherapy is a prognostic factor for longer stent patency (Kim et al. 2012; Kim et al. 2007; Telford et al. 2004). The mechanism for longer patency is probably due to decrease in tumour mass which results in diminished chance of stent collapse and tumour ingrowth into the stent. At the same time, increased rate of migration is associated with administration of chemotherapy after SEMS placement. The etiology of the malignancy may also effect outcome and complications. Stent collapse is more frequent in gastric cancer, but major complications, such as perforation and bleeding are more commonly related to pancreatic cancer (Kim et al. 2009a).

Clearly, the patency of the stent depends on the patient’s clinical condition and prognosis of the malignancy. Ascites and poor performance status are predictive factors for poor solid food intake (Sasaki et al. 2012). For patients with symptoms of GOO, poor WHO performance status, pain and use of opioid analgesia are prognostic factors for short survival (Jeurnink et al. 2011; van Hooft et al. 2010). As some studies have reported a higher rate of late complications for stent placement than for GJ, it has been suggested that GJ should be preferable treatment for patients with good performance status and life expectancy over 2 months (Jeurnink et al. 2010; No et al. 2013).

**2.1.3.4.3. Quality of life and costs**

The evaluation of quality of life (QoL) when treating malignant GOO is difficult due to lack of sufficient data. For OGJ, most QoL scores are shown to deteriorate temporarily after surgery, but they are restored to initial levels within 4 months (Van Heek et al. 2003). A problem with gathering data from the QoL aspect is that different questionnaires are used, and often only physical function is assessed which is considered inadequate for evaluation of GOO (Fayers and Machin 2007).

In two prospective, randomized studies, QoL was assessed (Jeurnink et al. 2010; Mehta et al. 2006). An improved physical health at one month after stent placement, measured by using the Short-Form-36 (SF-36) questionnaire, was found by Mehta et al. (Mehta et al. 2006). A significant increase in pain was found at day one after LGJ; no difference was found in the SEMS group (Mehta et al. 2006). The pain scores (EuroQol-VAS) decreased faster after SEMS placement than after GJ. Other QoL scores were similar between stent and GJ groups (Jeurnink et al. 2010). In a prospective study by Schmidt et al. (Schmidt et al. 2009), at three months, SEMS placement was associated with significant improvement in global health status and
nausea and vomiting assessed by the EORTC QLQ-C30 instrument. Gastric-specific symptoms such as dysphagia, eating restrictions, dry mouth and reflux, assessed by the EORTC QLQ-STO22 instrument, improved in stented patients. GJ was associated with improvements in dysphagia and eating restrictions, but decrease in physical functioning at one month after operation (Schmidt et al. 2009). Other prospective studies found no difference in QoL before and after SEMS placement (Dolz et al. 2011; Piesman et al. 2009; van Hooft et al. 2009).

In a prospective, randomized study by Jeurnink et al. (Jeurnink et al. 2010), total medical costs were higher for the GJ than for the stent group ($16535 vs. $11720). Similarly in other studies, stent placement was cost-effective compared to GJ (Mittal et al. 2004; Roy et al. 2012; Yim et al. 2001). Johnsson et al. (Johnsson et al. 2004), however, reported no significant difference in total medical (comprising initial and all additional procedures until patient’s death) costs.

2.1.4 GASTRIC OUTLET OBSTRUCTION AND BILIARY OBSTRUCTION

Up to 75% of the patients with pancreatic cancer have symptomatic biliary obstruction due to tumour infiltration into the intrapancreatic portion of the common bile duct (Sohn et al. 1999). Patients with malignant GOO often have symptomatic biliary obstruction. The treatment options for biliary obstruction include surgical bypass (usually hepaticojejunostomy), endoscopic retrograde cholangiopancreatography (ERCP) with stent placement, and percutaneous transhepatic cholangiography/drainage (PTC/PTD). Compared to surgical bypass, the endoscopic approach is considered an initial treatment for biliary obstruction due to lower complication rate and shorter hospital stay (Shepherd et al. 1988; Smith et al. 1994). Endoscopic stenting has proved to be more cost-effective and provide better QoL than surgery (Artifon et al. 2006; Raikar et al. 1996). Endoscopic stenting has shown higher success and lower complication rates than PTC, and is thus also the first line treatment over PTC (Speer et al. 1987). Biliary stent options include plastic and SEMS. Plastic stents can be removed and are recommended if the resectability of the tumour is unclear. Patency for plastic stents is 3 to 4 months, occlusion resulting in a need of stent exchange (Davids et al. 1992; Prat et al. 1998). SEMS remain patent longer, but are more expensive than plastic ones. According to a cost analysis, metallic stents are advantageous in patients surviving over 6 months (Prat et al. 1998). Also for extremely elderly patients, plastic stent is effective enough in the treatment of biliary obstruction (Gronroos et al. 2010).

Biliary obstruction usually develops before duodenal obstruction, when it most often can be treated with a biliary stent, but it can also occur simultaneously or after the duodenal obstruction (Kaw et al. 2003; Mutignani et al. 2007). Very little data exists regarding combined biliary and duodenal stenting, and the case series are rather small. In the event of simultaneous obstruction of common bile duct and
duodenum, usually the biliary obstruction is treated first due to difficulty to access the papilla Vateri through enteral SEMS. Simultaneous, endoscopic stenting has shown success rates of 86% to 94% (Kaw et al. 2003; Maire et al. 2006; Mutignani et al. 2007). The endoscopic biliary stenting success rates for recurrent biliary obstruction after combined stenting range between 50% and 100%. The number of patients treated is small, however (Kaw et al. 2003; Maire et al. 2006; Mutignani et al. 2007). Another option for combined endoscopic stenting is to treat biliary obstruction by means of PTC. The results show similar success rates compared to a combined endoscopic approach (Akinci et al. 2007; Profili et al. 2003).

2.2 COLORECTAL OBSTRUCTION

2.2.1 ETIOLOGY AND DIAGNOSIS

The clinical picture of colorectal obstruction (CRO) can range from an incidental tight stricture found in colonoscopy, surgery, or radiologic examinations, to an acute and complete obstruction. Up to 80% of the cases of CRO are caused by malignancy (Valerio and Jones 1978).

The symptoms of CRO include abdominal pain, distension, constipation, and vomiting. Abdominal distension is more likely in the event of a closed bowel loop or competent ileocecal valve. In contrast, vomiting is more common when the ileocecal valve is incompetent, allowing colonic decompression into the small bowel. The diagnosis of obstruction is based on symptoms, clinical examination, and endoscopic and/or radiologic examinations. The diagnosis of non-acute CRO is usually confirmed by colonoscopy which also enables the histological diagnosis. Radiologic examinations include plain x-ray of the abdomen, oral contrast meal study, CT, and MRI.

2.2.1.1 Malignant etiology for obstruction

Colorectal cancer (CRC) is the third most common cancer for men worldwide and the second for women with an estimated 1.2 million new cases diagnosed annually. CRC is the fourth most common cause of cancer deaths for men and the third for women with an estimated 600,000 deaths per year. In developed countries, the incidence rates are highest (Jemal et al. 2011). In Finland, approximately 2700 new CRCs are diagnosed annually, and of them 1000 (37%) are rectal cancers (Finnish cancer registry). CRC is the most common cause of acute CRO which occurs in 15% to 20% (Kyllonen 1987; Phillips et al. 1985; Umpleby and Williamson 1984) of the CRC patients. Among patients with CRO, older patients are the majority (Anderson et al. 1992). The left side of the colon is the most common place for acute obstruction (Tekkis et al. 2004).
CRO can also be caused by extracolonic malignancies (ECM). Intracolonic metastases of other carcinomas, melanoma, or lymphoma can cause intrinsic bowel obstruction. Pelvic malignancies, such as ovarian, endometrium, bladder, and prostate cancers can lead into extrinsic compression and obstruction of the bowel. Furthermore, peritoneal carcinomatosis of, for example, breast, gastric or pancreatic cancer can cause bowel obstruction. Bowel obstructions may be multifocal involving both small and large bowel. Multifocal obstruction was detected in 76% of patients in an autopsy series of ovarian cancer (Dvoretsky et al. 1988). For ovarian cancer, the reported rate of large bowel obstruction is up to 33% (Rubin et al. 1989).

### 2.2.1.2. Benign etiology for obstruction

A minority of colorectal obstructions are caused by benign etiology. The rate of anastomotic strictures after colorectal surgery is 3% to 30% (Luchtefeld et al. 1989). Diverticular stricture occurs in 7% of all cases of diverticular disease (McConnell et al. 2003). In Crohn’s disease, up to 33% of patients will develop strictures within 10 years of diagnosis (Cosnes et al. 2002). Also in advanced cancer, the obstruction can be caused by benign causes such as adhesions, post radiation strictures, or hernia (Spears et al. 1988; Tunca et al. 1981).

### 2.2.2 SURGICAL MANAGEMENT OF MALIGNANT COLORECTAL OBSTRUCTION

Acute CRO is a surgical emergency. Obstruction leads to perforation of the bowel, sepsis, and death if left untreated. Emergency surgery for acute CRO has been associated with a morbidity rate of 40% to 50% and a mortality rate of 15% to 20% (Phillips et al. 1985; Smothers et al. 2003; Tekkis et al. 2004), which are higher than in elective operations (Runkel et al. 1991; Runkel et al. 1998; Smothers et al. 2003). Other risk factors than emergency operation for increased mortality include patients age greater than 65 years, ASA greater than 1, Dukes staging other than A (Tekkis et al. 2004), and preoperative renal failure (Tan and Sim 2010). In addition, it is shown that CRC patients presenting as surgical emergencies are older and have more advanced cancer (Scott et al. 1995). Moreover, 5-year survival for patients undergoing emergency colorectal operations has shown to be poorer than for electively operated patients (McArdle and Hole 2004; Paulson et al. 2010).
2.2.2.1. Non-palliative surgery

In general, surgical options for colorectal obstruction depend on the location of the tumour, extent of the disease, the patient`s clinical status and co-morbidities, and surgeon`s experience. In all colorectal resections, the principles of oncologic resection should be followed. The feeding artery of the tumour should be ligated at its origin for allowing adequate lymphadenectomy. The tumour and its mesocolon should be resected en bloc with distal and proximal margins of 5 cm to 10 cm (Nelson et al. 2001). For rectum tumours, the treatment of choice is total mesorectal excision (TME) (Heald et al. 1982) where the rectum and mesorectum with its lymphovascular structures within the fascia propria are excised en bloc.

Widely accepted procedure for obstructions located between the cecum and the splenic flexure is right hemicolectomy, extended if necessary, with primary anastomosis (Fielding et al. 1979; Finan et al. 2007; Phillips et al. 1985). The management of acute left-sided CRO is controversial and various surgical strategies exist. The classic three-stage operation in which primarily diverting colostomy is performed to decompress bowel, followed by definitive bowel resection, and finally the stoma closure has been challenged because of prolonged hospital stay and the need for multiple procedures. Primary resection with end-colostomy, known as Hartmann`s procedure is a safe option in the event of acute CRO (Meyer et al. 2004). It is widely performed since the patients presenting with large bowel obstruction are often critically ill having increased risk for morbidity and mortality. Hartmann`s procedure enables tumour resection without a risk for anastomotic leakage, and it can be performed by a less experienced surgeon. Disadvantages for Hartmann`s procedure include a stoma formation, and a need for a major operation for stoma reversal. The reversal rate of Hartmann`s procedure for diverticulitis is approximately 50% (Salem et al. 2005). However, for patients undergoing Hartmann`s operation due to CRC, the reversal rate is much lower, even less than 10% (David et al. 2009). It is shown that colostomy significantly diminishes patient`s quality of life (Marquis et al. 2003; Nugent et al. 1999). Moreover, Hartmann`s reversal carries a morbidity rate of 29% to 54% of which anastomotic leakage comprises 2.3% to 16% (David et al. 2009; Pearce et al. 1992; Roque-Castellano et al. 2007; Wigmore et al. 1995). Reported mortality associated with reversal is up to 3.75% (David et al. 2009; Pearce et al. 1992).

For left-sided large bowel obstruction, one-stage primary resection with anastomosis is now widely preferred due to the advantage that it is a definitive procedure without need for further surgery (Finan et al. 2007). Mortality rates for one-stage operation have shown to be comparable or lower than for staged operations (0%-22% vs. 0%-33%) (Fielding and Wells 1974; Kasperk et al. 1992; Lau et al. 1995; Watters 1969). The options for one-stage operation include subtotal colectomy or segmental resection. In the case of a dilated proximal colon with ischemia, serosal tear, or perforation, subtotal colectomy is indicated. The benefits
for subtotal colectomy include that it deals with a risk (approximately 7%) of synchronous tumours of the proximal colon and usually there is no need for stoma creation due to a rich blood supply in the terminal ileum (Arnaud and Bergamaschi 1994; Halevy et al. 1989). The disadvantages for subtotal colectomy include the procedure’s `extensiveness and high incidence of postoperative diarrhea (Arnaud and Bergamaschi 1994; Halevy et al. 1989; Hennekinne-Mucci et al. 2006). A prospective randomized study (The SCOTIA study group 1995) and another report (Villar et al. 2005) showed a slightly diminished risk of mortality and morbidity for segmental resection compared to subtotal colectomy. Long-term results between segmental resection and subtotal resection are better for segmental resection in terms of complications, bowel function, and QoL (You et al. 2008).

Laparoscopic approach for elective colon resections is widely accepted. In the short-term, laparoscopy provides shorter hospital stay, less postoperative pain and morbidity, shorter duration of postoperative ileus, and better QoL. Long-term results concerning morbidity, rates of cancer recurrences and mortality are similar between open and laparoscopic approaches (Guillou et al. 2005; Lacy et al. 1995; Lacy et al. 2002; Weeks et al. 2002). In acute CRO, laparoscopy is challenging, and somewhat contraindicated due to abdominal distension and fragility of the colon. Only a few studies have reported the utility of laparoscopy for the management of CRO. Some reports have suggested that laparoscopic approaches may be feasible in terms of shorter hospital stay and acceptable morbidity and mortality (Gash et al. 2011; Ng et al. 2006b; Ng et al. 2008).

2.2.2.2. Palliative surgery

Up to 25% of patients with CRC have synchronous metastases at the time of diagnosis (Ballantyne and Quin 1993; Manfredi et al. 2006), and only a minority of these patients is candidates for curative surgery. Improvement in oncologic therapy has increased the survival of these patients to 18 months (Poultsides et al. 2009). For CRC patients with synchronous metastases and absence of major symptoms, such as obstruction and bleeding, the issue of primary tumour resection followed by chemotherapy or immediate chemotherapy without tumour resection is controversial. Some have reported survival benefit for patients with good performance status undergoing resection of primary tumour followed by chemotherapy (Karoui et al. 2011; Stillwell et al. 2010), and less complications from the primary tumour (Stillwell et al. 2010). Others have found no improvement in survival, but increased mortality and delay of chemotherapy initiation (Liu et al. 1997).

Palliative surgery becomes essential in the event of bowel obstruction. The aim of palliative surgery is to resolve obstruction and to improve QoL. In the case of palliative resection being impossible, stoma creation or entero-enterostomy may be the only options for palliative surgery. A multidisciplinary approach including
surgeon, oncologist, and pain control specialist is recommended in the treatment of incurable CRO (Ripamonti et al. 2008).

2.2.3 SELF-EXPANDING METAL STENTS IN MALIGNANT COLORECTAL OBSTRUCTION

2.2.3.1. Stenting technique and stent types

Stenting procedures can be performed under endoscopic and fluoroscopic control or using only fluoroscopic guidance. A combined endoscopic and fluoroscopic procedure is the most common technique (Sebastian et al. 2004). Procedures are usually performed under sedation and the stricture is approached with an endoscope. When approaching proximal strictures, a colonoscope is often needed. The site and length of the stricture can be measured by injecting water-soluble contrast media through the stricture, or by using a biliary balloon. Through-the-scope stents are smaller in diameter and can be passed over a guidewire and deployed through the working channel of a therapeutic endoscope. Larger diameter stents are deployed beside the scope using stiff guidewire. After SEMS deployment, the decompression of the bowel must be ensured.

The characteristics for an ideal stent are similar for the upper and lower gastrointestinal tract, see page 19, second paragraph. As for GOO, SEMS used in CRO can be classified into two types, uncovered and covered. Uncovered stents are preferred over covered stents. In long-term follow-up, more complications, such as migration and loss of stent patency are associated with covered stents (Choi et al. 2013; Lee et al. 2007).

2.2.3.2. Overall outcome

SEMS was introduced as palliation of CRO in the year 1991, when it was used to decompress bowel obstruction caused by advanced rectal cancer (Dohmoto 1991). In 1994, SEMS was used as a bridge to surgery in acute CRO (Tejero et al. 1994). Since then, SEMS have been increasingly used as a bridge to surgery for acute CRO and as palliation of malignant CRO. In two large pooled analyses consisting of patients stented as a bridge to surgery and as palliation, the overall technical success rate was between 92% and 94% and clinical success rate between 88% and 91% (Khot et al. 2002; Sebastian et al. 2004). In these large series, perforation rate was up to 4%, migration rate between 10% and 12%, and stent reobstruction rate between 7% and 10%. Minor complications such as bleeding and abdominal or rectal pain occurred in 5%. Mortality rate was low, only 1%.
A meta-analysis, consisting of eight randomized studies involving both palliatively and preoperatively stented patients, found no difference in morbidity or mortality between stented and operated patients. For stented patients, primary anastomosis rates were higher and stoma rates lower than for operated patients (Cennamo et al. 2013).

2.2.3.3. Self-expanding metal stents as a bridge to surgery

The aim of SEMS placement in the event of acute CRO is to avoid emergency operations that carry higher morbidity and mortality rates than elective operations. Decompression of acute CRO with SEMS can allow patient stabilization and bowel preparation, tumour staging, and a subsequent elective resection. In prospective studies, technical success rates have ranged from 83% to 95% and clinical success rates from 77% to 95%. After stent placement, an elective operation was possible for 70% to 95% of the patients, and 77% to 88% of the patients could avoid a stoma (Alcantara et al. 2007; Brehant et al. 2009). In non-randomized comparative studies, stent placement before surgery has been associated with lower rates of colostomies, morbidity, and mortality than in emergency operations (Martinez-Santos et al. 2002; Ng et al. 2006a).

The results from randomized studies are somewhat controversial. According to reports, stent placement and subsequent surgery resulted in reduced morbidity, anastomotic leakages (Alcantara et al. 2011; Cheung et al. 2009), and stoma rate compared to the emergency surgery group (Cheung et al. 2009). In a Spanish study, no complications occurred in the SEMS group. A high rate of anastomotic leakages in the emergency surgery group led to a premature closure of the study (Alcantara et al. 2011). The most dangerous complication of SEMS placement is perforation. In addition to acute rise in mortality due to peritonitis, it may adversely affect the oncological outcome due to tumour spill. Two randomized multicentre studies on left-sided preoperative stenting versus emergency surgery were closed prematurely due to increase in complications in the SEMS arm (Pirlet et al. 2011; van Hooft et al. 2011). A lower technical success rate than average, 47% to 70%, was reported in those studies. Neither of the studies found differences in total morbidity, stoma rates, or mortality. Both studies reported high rates of overt (6% and 13%) and silent perforations (6% and 27%) in the stent groups (Pirlet et al. 2011; van Hooft et al. 2011). The effect of stent perforation on long-term oncological outcome is unclear. The data from non-randomized studies is heterogeneous, ranging from no difference between SEMS and emergency surgery to a reduced or increased survival for patients treated with preoperative stenting (Dastur et al. 2008; Gianotti et al. 2013; Kim et al. 2013a; Kim et al. 2009b; Saida et al. 2003).

An ideal time from SEMS placement to surgery is unknown. The stent creates inflammation to surrounding tissues and may increase technical difficulties in
operation, as well as complications (Alcantara et al. 2007). Therefore, an elective operation should be performed promptly after SEMS placement. In randomized studies, patients underwent an operation mostly between 5 to 14 days and at latest within four weeks (Alcantara et al. 2011; Cheung et al. 2009; Pirlet et al. 2011; van Hooft et al. 2011). Elective operations can be performed either via laparotomy or laparoscopically (Cheung et al. 2009; Dulucq et al. 2006; Stipa et al. 2008).

2.2.3.4. **Self-expanding metal stents as palliation**

The data from non-comparative studies show technical success rates between 73% and 100%, clinical success rates between 62% and 96%, and total complication rates between 11% and 25% (Im et al. 2008; Law et al. 2004; Repici et al. 2007; Varpe et al. 2008). Perforation rates have been 0% to 16%, migration rates 0% to 16%, and stent re-obstruction rates 0% to 16%. For palliatively stented patients, non-randomized comparative studies report shorter hospital stay, less acute complications, and similar survival to operated patients (Faragher et al. 2008; Ptok et al. 2006; Vemulpalli et al. 2010).

To date, three randomized studies have compared the results of palliative SEMS placement and surgery, and they provide inconsistent results (Fiori et al. 2004a; Fiori et al. 2012; van Hooft et al. 2008; Xinopoulos et al. 2004). In an Italian study, SEMS was associated with shorter operative time, faster return to oral intake, shorter hospital stay, and similar short- and long-term complication rates and survival compared to the operative group (Fiori et al. 2004a; Fiori et al. 2012). No perforations occurred in the Italian study. On the contrary, an unexpected high rate of perforations in the SEMS-arm led to a premature closure of another multicentre randomized study (van Hooft et al. 2008).

For almost 85% of the patients who undergo SEMS placement for CRO, the etiology for obstruction is primary CRC (Sebastian et al. 2004). For CRC, the mechanism of obstruction is different from ECM, where the obstruction may develop from intracolonic invasion or metastasis or from extracolonic compression. When CRO is caused by ECM, the bowel is often immobilized due to multiple strictures, carcinomatosis, and adhesions after previous surgery or radiation therapy making the stenting procedures potentially technically more difficult. The results on SEMS placement for obstruction caused by ECM are more inconsistent than for CRC etiology. Technical success rates vary between 42% and 95% and clinical success rates between 20% and 86% (Keswani et al. 2009; Kim et al. 2013b; Shin et al. 2008; Trompetas et al. 2010). Results from comparative studies vary; some report lower clinical success rates and higher complication rates for ECM, while others find no difference in outcomes between CRC and ECM (Keswani et al. 2009; Kim et al. 2013b).
2.2.3.5. Long-term outcome and complication factors

For patients undergoing palliative stenting due to incurable malignancy, it is important to evaluate the long-term outcome of SEMS placement. The median stent patency has ranged between 90 days and 204 days (Im et al. 2008; Small et al. 2010; Suh et al. 2010). The amount of patients remaining free of re-obstruction from stent placement to death has ranged from 77% to 88% (Manes et al. 2011; Small et al. 2010). The rate of long-term complications has been mostly between 11% and 24% (Jung et al. 2010; Small et al. 2010), but higher complication rates up to 51% have also been reported (Fernandez-Esparrach et al. 2010). A Karnofsky performance status of ≤ 50 is associated with shorter survival and almost 4 times higher risk of death within 6 months after the SEMS placement (Manes et al. 2011).

In stenting malignant CRO, male gender, complete obstruction, stent diameter ≤ 22 mm, stricture dilation during SEMS insertion, and inexperienced endoscopist in pancreatobiliary endoscopy are significant risk factors for complication (Small et al. 2010), as well as long length of the stricture (Jung et al. 2010; Manes et al. 2011). The impact of etiology (CRC vs. ECM) and site of the stricture (proximal vs. distal) on outcome is unclear (Jung et al. 2010; Manes et al. 2011; Small et al. 2010). Risk factors for the most dangerous complication, perforation, include bevacizumab therapy and stricture dilation (Manes et al. 2011; Small et al. 2010).

2.2.3.6. Quality of life and costs

Data on the impact of SEMS placement or surgery on symptoms or QoL in CRO are few. In a prospective study of palliative stenting or stoma creation, Nagula et al. (Nagula et al. 2010), found that both treatment methods improved the CRO symptoms. SEMS placement was associated with improved overall QoL, however. In a Dutch randomized study comparing preoperative stenting and emergency surgery, the primary outcome measure was mean global health status measured by EORTC QLQ-C30. The authors found no difference in QoL and patient comfort between two study groups (van Hooft et al. 2011). In another report by an Italian group on palliative stenting versus colostomy, colostomy had a negative impact on patients’ and family members’ social life and daily activities (Fiori et al. 2012). The patients and family members scored the following parameters from 1 to 4: satisfaction with the procedure, lifestyle, acceptance of stoma, and abdominal symptoms. No standardized questionnaires were used.

Two randomized studies include cost analysis. Total costs were equal for palliatively stented or operated patients (Xinopoulos et al. 2004), as well as for bridge to surgery or emergency operation groups (Ho et al. 2012).
2.2.4 MANAGEMENT OF BENIGN COLORECTAL OBSTRUCTION

2.2.4.1. Anastomotic stricture

An anastomotic stricture (AS) is defined by Luchtefeld et al. (Luchtefeld et al. 1989) as "chronic narrowing or obstruction to the flow of intestinal contents resulting in clinical signs or symptoms of either complete or partial obstruction." In practice, AS is usually defined as a stenosis ≤12 mm, preventing the passage of a 12 mm sigmoideoscope. Risk factors for AS include: preoperative obesity, sepsis, radiation therapy, and incomplete doughnuts, and in the postoperative period anastomotic leakage, pelvic infection, and radiotherapy (Luchtefeld et al. 1989).

The initial treatment method for AS is dilation, which can be performed manually if the stricture is located distally. Endoscopic balloon dilation (EBD) is an effective technique for uncomplicated strictures with a stricture resolution rate of up to 100% (Ambrosetti et al. 2008). Multiple dilatation sessions are often needed, however. Complications related to EBD include perforation (5%), abscess (2%), and recurrent stricture (10%) (Suchan et al. 2003). Long-term health-related QoL has been reported to be diminished after EBD due to gastrointestinal symptoms and stress by treatment (Nguyen-Tang et al. 2008). EBD is more likely to fail if stricture is irregular, kinked, fixed, and longer than 1 cm. A surgical resection is often needed to manage these complex strictures (Schlegel et al. 2001).

2.2.4.2. Diverticular stricture

A diverticular stricture (DS) develops from chronic inflammation due to recurrent diverticulitis. Bowel obstruction can occur acutely, demanding emergency management, or with chronic symptoms. The incidence of DS is 7% of all cases of diverticular disease (McConnell et al. 2003). A symptomatic DS, in particular with chronic symptoms and a possibility of underlying malignant etiology, is an indication for surgery (King et al. 1990; Klarenbeek et al. 2010). A laparoscopic resection with primary anastomosis can be performed with a low rate of morbidity in DS. For elective surgery of DS, conversion and stoma rates are higher and the length of hospital stay longer than for surgery of uncomplicated diverticulosis (Royds et al. 2012).

2.2.4.3. Crohn’s disease stricture

Strictures of the gastrointestinal tract are common complications of Crohn’s disease (CD), occurring in one third of patients within 10 years of diagnosis (Cosnes et al. 2002). The most common locations for strictures are the terminal ileum,
ileocolonic anastomosis, and colon (Landi et al. 1992). Clinically relevant strictures with prestenotic dilation and obstructive symptoms are usually treated surgically. Surgical options include resection and stricturoplasty. Morbidity rates associated with bowel resections and stricturoplasties are up to 35% and 23%, respectively (Bruewer et al. 2003; Fearnhead et al. 2006). In addition, reoperation rate due to new stricture or recurrence of stricture is between 15% and 45% within 5 years (Legnani and Kornbluth 2002; Tichansky et al. 2000). Since CD is surgically incurable chronic disease, multiple operations can lead into short bowel syndrome in the long term. EBD is an effective alternative for surgery with a clinical success rate of 90% to 96%. The relapse rate of stricture is up to 46% within 6 years (Ajlouni et al. 2007; Stienecker et al. 2009). The reported perforation rate is less than 3% (Foster et al. 2008; Stienecker et al. 2009).

2.2.4.4. Self-expanding metal stents in benign colorectal obstruction

SEMS have been rarely used for benign CRO; only 3% of stenting procedures are due to benign etiology (Khot et al. 2002). The first case report on SEMS placement for benign rectal anastomotic stricture was published in the year 1997 (Salinas et al. 1997). In the same year, CD stricture was treated with an endoscopic stent placement (Matsuhashi et al. 1997). Since then, also DS (Davidson and Sweeney 1998) and radiation stricture were managed with stenting (Yates and Baron 1999).

Stents have been used as a bridge to surgery in diverticulosis and CD, and as a definitive treatment in AS and in patients unfit for surgery. Data on SEMS placement for benign CRO consists mainly of case reports and small size series. No randomized studies on the use of SEMS for benign strictures exist. Although the technical success rate of stent placement in benign stricture is comparable with malignant etiology, a higher rate of complications is associated with benign etiology, ranging between 23% and 71% (Dai et al. 2010; Pommergaard et al. 2009). Diverticular disease, in particular, is associated with a high incidence of complications (Forshaw et al. 2006; Pommergaard et al. 2009). A reported rate of perforations in diverticular disease is up to 42%. Migration is more common in benign etiology due to absence of tumour ingrowth into the stent (Suzuki et al. 2004).

In a series of 23 patients, the indications for stenting were DS (n=16), AS (n=3), radiation stricture (n=3), and CD (n=1). Technical and clinical success rates were 100% and 95%, respectively. The long-term follow-up was available for 21 patients. Major complication occurred for 38% of the patients (perforation 2, migration 2, reobstruction 4), and of these complications 87% occurred after 7 days. An operation was performed for 19 patients, and of those, SEMS served as a bridge to surgery for 16 patients with a median time to surgery of 12 days (range 2 days- 18 months). An emergency operation was performed for three patients due to perforation or reobstruction within 1 to 49 days of stenting. Despite of SEMS, a
stoma was constructed for 58% of the patients. The authors concluded that SEMS placement for benign etiology is associated with a high rate of late complications, and if an elective operation is planned it should be performed within 7 days of SEMS placement. (Small et al. 2008)

SEMS placement for AS has shown promising results. For 75% of the patients, the AS was resolved with SEMS allowing closure of defunctioning stomas (Forshaw et al. 2006). In another report, 50% of the strictures were resolved initially, but the long-term success was achieved for 36% during the follow-up period of a mean of 3 years (Dai et al. 2010). To date, the largest study of SEMS and benign CRO included 43 patients, of whom 40 were patients with AS (Vanbiervliet et al. 2013). The clinical success rate was 81%, but for 53% of the patients, the stricture recurred. The migration rate was 63%. In multivariate analysis, no predictive factors for clinical efficacy or recurrence were found.

The data on SEMS’s efficacy in Crohn’s stricture is variable. For selected patients, long term successful outcomes with a stent even up to nine years have been reported (Levine et al. 2012). At the same time, a prospective study with 11 CD patients showed an 18% major morbidity rate requiring surgery and a 70% migration rate. For only 1 of 11 (9%) patients, a planned stent removal was performed with no recurrence of obstructive symptoms; for the rest of the patients, the stricture recurred ultimately (Attar et al. 2012). To date, the largest study of SEMS and CD strictures includes 17 patients with 25 SEMS deployed (Loras et al. 2012). The stents were maintained in their place for a mean of 28 days. The authors reported 64% success rate with a mean follow up period of 67 weeks. The recurrence rate of stricture was 43%, which led to additional endoscopic procedures or surgery. Of 17 patients, 7 (42%) underwent operation eventually. The migration rate was 52% and no perforations occurred.
3. **AIMS OF THE STUDY**

The aims of this present study were the following:

1. To study the efficacy and safety of SEMS as palliation of malignant GOO. To evaluate the feasibility of combined endoscopic stenting of malignant biliary and duodenal obstruction.

2. To study advanced primary gastric cancer and GOO. To compare the results of stent placement, PR, and GJ as palliation of GOO due to advanced primary gastric cancer.

3. To study the utility of SEMS in benign CRO.

4. To evaluate the efficacy and safety of SEMS as bridge to surgery and as palliation in malignant CRO. To compare the results of stent placement as palliation for CRC and ECM.
4. PATIENTS AND METHODS

4.1 PATIENTS

All the patients (n=323) were treated at Meilahti Hospital, part of Helsinki University Central Hospital between January 1998 and December 2010. The patients who underwent SEMS placement were identified from the endoscopy unit’s database. For study II, surgically treated patients were identified from the surgical unit’s database. For all studies, the data were recorded in a structured template and the results were analyzed retrospectively. The study was approved by the Institutional Review Board of Department of Surgery, Helsinki University Central Hospital.

Patients (n=104) who underwent enteral stent placement for malignant, noncurable GOO between January 1999 and May 2007 were included in study I. Patients (n=97) who underwent palliative resection (PR), open gastrojejunostomy (GJ), or endoscopic stenting (ES) for GOO caused by advanced, primary gastric cancer between January 1999 and December 2010 were included in study II. Of the stented gastric cancer patients, 24 were included in both study I and II. The patients were followed until their death (I, II) or the study end point (December 2011) (II). Occurrence and treatment of biliary obstruction were also recorded. The clinical characteristics of the patients in study I are presented in Table 2. In study II, gastric cancer was defined as advanced in cases with distant metastases, with invasion to adjacent organs and radical operation (Ro) being impossible, or with unresectable lymph node metastases. Palliative total gastrectomies were excluded from the study. An accurate TNM stage for ES and GJ groups was unavailable; therefore a comparison of M stage between three groups was based on radiology, surgery, and histology. For the PR group, the distribution of T stage was: T3 17 patients (65%), T4 6 patients (23%), and Tx 3 patients (12%). For the GJ group the distribution of T stage was: T3 2 patients (10%), T4 9 patients (43%), and Tx 10 patients (48%). Re-admissions to hospital with symptoms of re-obstruction, but without radiologic or endoscopic confirmation, were obtained from the medical records. Between the three groups, the distributions of histology (p= 0.152), site of obstruction (p= 0.202), and M-stage (p= 0.478) were similar. From baseline characteristics, pre-procedure albumin levels, WHO scores, and pre-procedure GOOSS were statistically different between the groups (Table 3). Distributions of ASA grades (p= 0.133), BMIs (p= 0.083), and CCIs (p= 0.785) were similar between the groups.
Table 2. Clinical characteristics of 104 patients with malignant gastric outlet obstruction (I)

<table>
<thead>
<tr>
<th>NO. OF PATIENTS</th>
<th>104</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex ratio, M/W (%)</td>
<td>43/61 (41/59)</td>
</tr>
<tr>
<td>Age, median (range)</td>
<td>72 (40-89)</td>
</tr>
<tr>
<td>Tumour origin, n (%)</td>
<td></td>
</tr>
<tr>
<td>Pancreatic</td>
<td>51 (49)</td>
</tr>
<tr>
<td>Gastric</td>
<td>24 (23)</td>
</tr>
<tr>
<td>Duodenal</td>
<td>7 (7)</td>
</tr>
<tr>
<td>Biliary</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Other malignancies</td>
<td>17 (16)</td>
</tr>
<tr>
<td>Site of obstruction, n (%)</td>
<td></td>
</tr>
<tr>
<td>Antrum/pylorus</td>
<td>21 (20)</td>
</tr>
<tr>
<td>D1</td>
<td>23 (22)</td>
</tr>
<tr>
<td>D2</td>
<td>35 (34)</td>
</tr>
<tr>
<td>D3</td>
<td>23 (22)</td>
</tr>
<tr>
<td>D4</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Follow-up, days, median (range)</td>
<td>62 (1-933)</td>
</tr>
</tbody>
</table>

M/W, men/women; D1, first part of duodenum; D2, second part of duodenum; D3, third part of duodenum; D4, fourth part of duodenum

Table 3. Clinical characteristics of 97 patients with gastric cancer and gastric outlet obstruction (II)

<table>
<thead>
<tr>
<th></th>
<th>ES</th>
<th>PR</th>
<th>GJ</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>50</td>
<td>26</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Age, median (range)</td>
<td>73 (40-94)</td>
<td>70 (33-92)</td>
<td>69 (31-88)</td>
<td>0.155</td>
</tr>
<tr>
<td>Sex ratio (M:W)</td>
<td>24:26</td>
<td>17:9</td>
<td>10:11</td>
<td>0.311</td>
</tr>
<tr>
<td>Albumin g/l, median (range)</td>
<td>25.0 (16.1-43.0)</td>
<td>33.1 (23.8-47.0)</td>
<td>30.3 (19.7-42.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>WHO score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>17</td>
<td>22</td>
<td>12</td>
<td>0.001</td>
</tr>
<tr>
<td>II</td>
<td>12</td>
<td>4</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>15</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pre-procedure GOOSS</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>0 = No oral intake</td>
<td>38</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>1 = Liquids only</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2 = Soft solids</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>3 = Low-residue or full diet</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

ES, endoscopic stenting; PR, palliative resection; GJ, gastrojejunostomy; M/W, men/women; GOOSS, gastric outlet obstruction scoring system
Patients (n=21) who underwent colorectal stent placement for benign CRO between January 1998 and December 2008 were included in study III. The patients were followed until their death or study end point (September 2009), or until a complication demanding surgical intervention after stent placement occurred. The etiologies for strictures included anastomotic strictures after prior colorectal surgery (eight patients), DS (ten patients), stricture after radiation therapy (one patient), and anastomotic strictures and CD (two patients). The patients (n=101) who underwent colorectal stent placement for malignant CRO between January 1998 and December 2009 were included in study IV. The patients underwent SEMS placement either as a bridge to surgery or as palliation. The patients were followed until definitive operation after stenting, until a complication demanding surgical intervention after stenting, until the study end point (November 2010), or until their death. The strictures had developed on the basis of CRC (77 patients) or ECM (24 patients). The tumour origins for ECM were the following: gynecologic 7, breast 6, pancreas 3, prostate 3, stomach 3, bladder 1, small bowel neuroendocrine 1. For palliatively stented patients, preprocedure body mass index (BMI), American Society of Anesthesiologists (ASA) grade, and Charlson Comorbidity Index (CCI) (Charlson et al. 1987) were recorded. Of preprocedure patient characteristics, median age (p=0.162), BMI (p=0.052), and ASA grade (p=0.381) were statistically similar between the two palliative groups. In palliation groups, women were the majority in the ECM group (CRC: 43/23 vs. ECM 8/16, p=0.007). Median CCIs were higher in the CRC group. The patient characteristics in studies III and IV are presented in Table 4.

Table 4. Clinical characteristics of 21 patients with benign and 101 patients with malignant colorectal obstruction (III and IV)

<table>
<thead>
<tr>
<th></th>
<th>BENIGN CRO (III)</th>
<th>MALIGNANT CRO (IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>21</td>
<td>101</td>
</tr>
<tr>
<td>Sex ratio, M/W (%)</td>
<td>9/12 (43/57)</td>
<td>58/43 (57/43)</td>
</tr>
<tr>
<td>Age, median (range)</td>
<td>64 (34-89)</td>
<td>66 (36-98)</td>
</tr>
<tr>
<td>Degree of obstruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>55</td>
</tr>
<tr>
<td>Subtotal</td>
<td>5</td>
<td>42</td>
</tr>
<tr>
<td>Site of obstruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sigmoid colon</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>Rectum</td>
<td>4</td>
<td>42</td>
</tr>
<tr>
<td>Transverse colon</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Descending colon</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Hepatic flexure</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ileorectal anastomosis</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Follow-up, days, median (range)</td>
<td>137 (2-2250)</td>
<td>91 (0-1035)</td>
</tr>
</tbody>
</table>

CRO, colorectal obstruction; M/W, men/women
4.2 DIAGNOSIS AND DEFINITIONS

For GOO, the location of the obstruction was limited from the corpus of the stomach to the fourth part of the duodenum (I, II). The diagnosis of GOO was based on clinical examination and symptoms of the patient, endoscopic findings, and radiologic examinations (plain x-ray of the abdomen, oral contrast meal study, CT) (I, II). The information of pre- and post-procedural oral intake was obtained from medical records, including also nurses’ notes for each day during the hospital stay. The diagnosis of CRO was based on clinical and radiological examinations (plain x-ray of the abdomen, barium enema, CT, MRI), or endoscopic findings prior to SEMS placement (III, IV).

In all studies, the definition of technical success of stenting was successful stent placement and deployment to the stricture site. In upper-GI stenting, clinical success was defined as the ability to tolerate at least liquid food (I, II). In colorectal stenting, a definition of clinical success was effective decompression and symptom relief within 72 h of stent placement without endoscopic or surgical reinterventions (III, IV). Clinical success rate was calculated as a percentage relative to all patients (intention to treat analysis). Complications were classified into early (within 7 days after stenting) and late (after 7 days of stenting) complications (III, IV). In benign colorectal stenting, the complications were divided into major (perforation) and minor (migration, abscess, colovesical fistula) complications (III). In II, symptom-free survival was defined as a time interval from the first stenting or operation to recurrent GOO causing re-intervention, or to study end point, or to patient’s death.

In all studies, if the patient underwent multiple procedures, only the first one was used in the analysis.

4.3 SCORING SYSTEMS

The gastric outlet obstruction scoring system (Adler and Baron 2002) (Table 1) was used to assess tolerance of oral intake before and after stenting (I, II). For assessing the patients' clinical condition and comorbidities, the American Society of Anesthesiologists (ASA) grade (II, III, IV), Charlson comorbidity index (CCI) (Charlson et al. 1987) (II, IV), and WHO score (Oken et al. 1982) (Table 5) (II) were used.
Table 5. WHO score

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Asymptomatic (Fully active, able to carry on all predisease activities without restriction)</td>
</tr>
<tr>
<td>1</td>
<td>Symptomatic but completely ambulatory (Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature. For example, light housework, office work)</td>
</tr>
<tr>
<td>2</td>
<td>Symptomatic, &lt;50% in bed during the day (Ambulatory and capable of all self-care but unable to carry out any work activities. Up and about more than 50% of waking hours)</td>
</tr>
<tr>
<td>3</td>
<td>Symptomatic, &gt;50% in bed, but not bedbound (Capable of only limited self-care, confined to bed or chair 50% or more of waking hours)</td>
</tr>
<tr>
<td>4</td>
<td>Bedbound (Completely disabled. Cannot carry on any self-care. Totally confined to bed or chair)</td>
</tr>
<tr>
<td>5</td>
<td>Death</td>
</tr>
</tbody>
</table>

4.4 STENTING TECHNIQUES

4.4.1 STENT PLACEMENT FOR MALIGNANT GASTRIC OUTLET OBSTRUCTION

The procedures were performed under monitored anesthesia and intravenous sedation with the patient in a prone position. A therapeutic gastroscope or duodenoscope was used for SEMS placement. The majority of procedures were performed by using gastroscope, but for strictures located in the third or fourth part of the duodenum, a large-channel duodenoscope was used if needed. When the stricture site had been approached with a scope, a long guidewire was passed beyond the stricture. Contrast media was often injected to verify the location and length of the stricture. When necessary, an 18-mm biliary balloon was used for definition of the exact site and length of the stricture. Then, a stent delivery system was inserted through the scope and SEMS was deployed under endoscopic and fluoroscopic control (Figure 4). A dilatation of the stent was carried out, if necessary.

The stents used for palliation of GOO included Wallstent®, Wallflex® (Boston Scientific, Natick, MA, USA), and Hanarostent® (M.I.Tech, Seoul, Korea). The majority of the stents were either Wallstent® or Wallflex®. For combined biliary and duodenal stenting, a self-expanding metal biliary stent was inserted before the duodenal stent was deployed.

4.4.2 STENT PLACEMENT FOR COLORECTAL OBSTRUCTION

The procedures were performed under intravenous sedation. The site of obstruction was approached by using a colonoscope, sigmoidoscope, or therapeutic upper endoscope, as appropriate. A 200-cm, triple-lumen, 18-mm biliary balloon (Endoflex® extraction balloon, Voerde, Germany) and 0.035-in 450 cm guidewire (Jagwire®, Boston Scientific, Miami, Fl, USA) was passed beyond the stricture to the proximal colon under endoscopic and fluoroscopic control. A contrast was often
injected to verify the site and length of the stricture and positioning of the wire above the obstruction. The 18-mm balloon was also used in order to measure the length of the stricture. Usually, the stricture was marked out with radiopaque markers. When deploying through-the-scope stents, a regular guide wire (Jagwire®) was used, but with stents deployed beside the endoscope, a stiff 0.035-in 300 cm guidewire (Back-Up Meier®, Boston Scientific, Natick MA, USA) was used. Dilations of the strictures or stents were not routinely performed but, when necessary, dilations were carried out to 15–18 mm with a 240 cm through-the-scope balloon catheter (CRE® wire-guided, Boston Scientific, Natick, MA, USA) (Figure 5).

Stents used for malignant CRO included Memotherm® (Bard, Angiomed, Karlsruhe, Germany), Ultraflex®, Ultraflex Precision®, Wallflex®, Wallstent® (Boston Scientific, Natick, MA, USA), Choo® (M.I.Tech, Seoul, Korea), Instent® and Bard® (Olympus Corporation, Tokyo, Japan). For malignant CRO, the majority of the stents deployed included Ultraflex Precision® (n=43) or Wallflex® (n=34). For stenting benign CRO, Hanarostent® (M.I.Tech, Seoul, Korea), Memotherm® (Bard, Angiomed, Karlsruhe, Germany), Ultraflex®, Ultraflex Precision®, Wallflex®, Wallstent®, and Polyflex® (Boston Scientific, Natick, MA, USA) were used. The majority of the stents deployed included Hanarostent® (n=10), Wallflex® (n=5), and Ultraflex Precision® (n=4).

An uncovered stent was deployed through the working channel of the scope (Wallflex®, Wallstent®) or beside the endoscope (Ultraflex Precision®). The covered stents were deployed beside the scope (Hanarostent®, Polyflex®). Both uncovered and covered stents were deployed under endoscopic and fluoroscopic control. In benign CRO, a scheduled removal of the covered stent was planned unless a spontaneous migration had occurred indicating successful dilation of the stricture.
PATIENTS AND METHODS

4.5 SURGICAL TREATMENT

In II, all operations were started with an intention to perform a resection. Based on laparotomy findings, a surgeon made the decision of whether to perform a palliative resection or gastrojejunostomy. All operations were performed through upper midline or rooftop laparotomy incision. The patients who were operated on underwent either gastric resection with Billroth II- or Roux-en-Y-reconstruction, or retro- or antecolic gastrojejunostomy.

4.6 STATISTICAL ANALYSIS

All the statistical analyses were performed by using SPSS (Statistical Package for the Social Sciences) for Windows (SPSS inc., Chicago, IL, USA). Values of p < 0.05 were considered statistically significant.

Categorical variables were reported as frequencies and percentages. Comparison of categorical variables was performed by using \( \chi^2 \) test or Fisher’s exact test, as appropriate. Continuous variables were reported as medians and ranges and were compared by using Mann-Whitney U test. Comparison of continuous variables between three groups was performed by using Kruskal-Wallis test (II). Wilcoxon signed rank test was used for the analysis of difference between the dysphagia scores before and after stent placement (I). Kaplan-Meier life-tables were calculated and for assessing the significance of the difference between survivals of the groups the log rank test was used (II). A Cox proportional hazards model was used for multivariate survival analysis (II).

Figure 5. CRO caused by colon tumour has been released with an uncovered SEMS
5. RESULTS

5.1 STENTING MALIGNANT GASTRIC OUTLET OBSTRUCTION (I)

Overall results
A total of 104 patients with 130 stenting procedures were included in the analysis. Technical success was achieved for 100% and clinical success for 93% of the patients (Table 6). One patient received two stents into two different stricture sites in a single session. Chemotherapy was administered for 31 (30%) patients before stenting, and 21 (20%) patients could start or continue chemotherapy after stenting. A median GOOSS after stent placement was 2, and the dysphagia scores improved significantly after stenting (p< 0.001). Of 104 patients, 76 (73%) managed until death with one stenting procedure, and the median survival time for them was 56 days (9-933). Immediate failure occurred in ten procedures for nine patients, and three of them occurred after the first stenting. The failures included three perforations, six kinkings of stent, and one abscess with sepsis. Complications occurred for 13 patients (12.5%). Complications included five kinkings of stent, three perforations, and abscess with sepsis, pulmonary embolism, aspiration pneumonia, brain stroke, and cholangitis 1 patient each. Four patients underwent operation, and of those three patients due to persistent obstruction. One patient was operated on due to a suspicion of perforation on abdominal X-ray, but no perforation was found in laparotomy. Three patients died of technical complications (perforation two patients, abscess with sepsis one patient), and three died of procedure-related complications (pulmonary embolism, aspiration pneumonia, stroke one patient each). Procedure-related mortality was 5.8% (6/104). The overall 30 day mortality rate was 28.8% (30/104).
RESULTS

Table 6. Procedure details and overall outcome for 104 patients with gastric outlet obstruction (I)

<table>
<thead>
<tr>
<th>Procedure details</th>
<th>Technical success %</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clinical success %</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of stricture, cm*</td>
<td>3 (1-6)</td>
<td></td>
</tr>
<tr>
<td>Length of stent, cm*</td>
<td>6 (6-12)</td>
<td></td>
</tr>
<tr>
<td>Procedure time, min*</td>
<td>30 (10-90)</td>
<td></td>
</tr>
<tr>
<td>Pre-procedure GO OSS, n (%)</td>
<td>0= No oral intake</td>
<td>92 (88.5)</td>
</tr>
<tr>
<td></td>
<td>1= Liquids only</td>
<td>12 (11.5)</td>
</tr>
<tr>
<td></td>
<td>Post-procedure GO OSS, n (%)</td>
<td>0= No oral intake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1= Liquids only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2= Soft solids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3= Low-residue or full diet</td>
</tr>
<tr>
<td></td>
<td>Hospital stay, days*</td>
<td>3 (1-26)</td>
</tr>
<tr>
<td></td>
<td>Survival, days*</td>
<td>62 (1-933)</td>
</tr>
</tbody>
</table>

*median (range); GO OSS, gastric outlet obstruction scoring system

Repeated stenting
Repeated stenting became necessary for 21 patients (20.2%). Two patients were stented immediately due to kinking of first stent and failure to decompress. Those patients had a perforation and died. The remaining 19 patients underwent a second procedure because of re-obstruction after a median of 93 days (range 8-282) of the primary procedure. Of 19 patients, three patients failed to decompress, one had an abscess with septicemia leading to death, and one had perforation which also led to death. Of three patients who failed to decompress, two underwent an operation and one underwent a third stenting. The median survival time for 19 re-stented patients was 265 days (range 20-734), which was significantly longer than for patients who underwent only one stenting procedure (p< 0.001).

Of 104 patients, four (3.8%) were stented thrice after a median of 136 days (range 90-146) of the second procedure. For one patient, stent placement became necessary four times.

Gastric outlet obstruction and biliary obstruction
A total of 56 (53.8%) patients had biliary obstruction. In 46 patients, the biliary obstruction occurred before the enteral stent placement, and for them biliary obstruction had been treated with plastic (n=16) or metallic (n=25) stent or with PTD (n=5). Concomitant biliary and enteral obstruction occurred in 11 (10.6%)
patients. For nine patients, biliary obstruction had been treated with a stent (8 plastic, 1 metallic) previously. Combined stenting was successful in 10/11 (91%) patients. One patient underwent PTD.

None of the combined stent placement patients had recurrent biliary obstruction during the follow-up. After enteral stenting, biliary obstruction developed in 15 patients (14.4%), and seven of them had a previous biliary stent (2 plastic, 3 metallic, 2 PTD). Of 15 patients, six (40%) underwent successful ERC and SEMS placement and six underwent PTD. No intervention was possible for three patients due to their poor clinical status.

5.2 PALLIATION OF GASTRIC OUTLET OBSTRUCTION IN GASTRIC CANCER (II)

Overall results
There was no difference in clinical success rates (ES 88% vs. PR 100% vs. GJ 81%, p=0.057) among three groups. The tolerance of liquid and soft solid diet was faster for stented patients than for operated patients (Table 7). For operated patients, the hospital stay was longer than for patients who underwent SEMS placement. The differences in re-admission rates to hospital were insignificant (ES 16% vs. PR 12% vs. GJ 19%, p=0.770) between the groups. The number of patients receiving chemotherapy after treatment (ES 22% vs. PR 46% vs. GJ 29%, p=0.078) and the occurrence of biliary obstruction (ES 8% vs. PR 19% vs. GJ 14%, p=0.353) were highest for the PR group but the differences were not statistically significant between three palliation groups. The biliary obstruction was managed mainly by ERC and metallic stent placement or PTC (ES: ERC 3 patients, cholecystojejunostomy 1 patient; PR: PTC 3 patients, conservative 2 patients; GJ: combined PTC and ERC 1 patient, PTC 1 patient, conservative 1 patient).

In univariate survival analysis, the differences in symptom-free survival (p=0.004) and overall survival (p=0.003) were significant between the groups, and for the PR group both symptom-free and overall survivals were longest. Multivariate survival analysis identified patient’s age, BMI, pre-procedure GOOSS, treatment modality, and chemotherapy as independent prognostic factors (Table 8). ASA grade, WHO score, albumin level, and sex were found to be insignificant factors.

Complications, re-interventions, and mortality
Of 13 complications in the ES group, 12 were re-obstructions and one was bleeding. Five of the reobstructed patients underwent re-stenting once, one patient twice, and one patient had two re-stentings and an operation due to persistent obstruction. For one patient, stent dilation and afterwards an operation became necessary due to recurrent re-obstruction. The four remaining patients with re-obstruction were treated conservatively due to poor clinical status. A perforation occurred for a
RESULTS

restented patient, and it was treated conservatively due to the poor clinical status of the patient.

In the PR group, two patients with re-obstructions and one patient with an abscess underwent operation. Three patients with re-obstruction underwent re-stenting but obstruction persisted in two of them. One patient underwent two endoscopic procedures and the other three endoscopic procedures and an operation. For one patient, an abscess was drained percutaneously, and afterwards re-obstruction was treated with a stent. Two remaining complications in the PR group, one bleeding and one re-obstruction, were treated conservatively due to the poor clinical status of the patients.

In the GJ group, both complications were re-obstructions. Treatment of obstruction was conservative for one patient due to poor general health. The other patient was operated on twice.

The overall mortality rate within 30 days was 18.6% (12/50 ES, 1/26 PR, 5/21 GJ). For one patient, the cause of death was perforation and peritonitis after duodenal stent placement; the remaining six patients died of advanced gastric cancer.

Table 7. Outcome data for patients with gastric outlet obstruction in gastric cancer (II)

<table>
<thead>
<tr>
<th></th>
<th>ES</th>
<th>PR</th>
<th>GJ</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to free liquids (GO OSS 1), days*</td>
<td>0 (0-4)</td>
<td>3 (2-4)</td>
<td>2 (1-9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time to soft solids (GO OSS 2), days*</td>
<td>1 (0-7)</td>
<td>4 (3-11)</td>
<td>4 (3-10)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hospital stay, days*</td>
<td>3 (0-28)</td>
<td>9 (3-15)</td>
<td>8 (4-27)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Complications n (%)</td>
<td>13 (26)</td>
<td>9 (35)</td>
<td>2 (10)</td>
<td>0.134</td>
</tr>
<tr>
<td>Re-obstruction</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Abscess</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Bleeding</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Time to complication, days*</td>
<td>95 (5-304)</td>
<td>183 (10-908)</td>
<td>40 (18-61)</td>
<td>0.202</td>
</tr>
<tr>
<td>Discharge from hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>24</td>
<td>24</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Other hospital or hospice</td>
<td>22</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Hospital death</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Symptom-free survival, days*</td>
<td>43 (1-453)</td>
<td>223 (25-2784)</td>
<td>121 (11-656)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Survival, days*</td>
<td>50 (1-453)</td>
<td>241 (25-2784)</td>
<td>141 (11-656)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

ES, endoscopic stenting; PR, palliative resection; GJ, gastrojejunostomy; GO OSS, gastric outlet scoring system; *median (range)
Table 8. Multivariate survival analysis in gastric cancer (II)

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Wald</th>
<th>P</th>
<th>HR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES</td>
<td>17.093</td>
<td>&lt;0.001</td>
<td>1.700</td>
<td>0.611-1.282</td>
</tr>
<tr>
<td>PR</td>
<td>16.943</td>
<td>&lt;0.001</td>
<td>0.246</td>
<td>0.126-0.479</td>
</tr>
<tr>
<td>GJ</td>
<td>1.700</td>
<td>0.192</td>
<td>0.611</td>
<td>0.291-1.282</td>
</tr>
<tr>
<td>Age</td>
<td>6.092</td>
<td>0.014</td>
<td>0.980</td>
<td>0.965-0.996</td>
</tr>
<tr>
<td>Pre-procedure GOOSS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 = No oral intake</td>
<td>8.987</td>
<td>0.029</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 = Liquids only</td>
<td>1.869</td>
<td>0.172</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 = Soft solids</td>
<td>1.479</td>
<td>0.224</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 = Low-residue or full diet</td>
<td>4.568</td>
<td>0.033</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>6.064</td>
<td>0.014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-procedure chemotherapy</td>
<td>45.738</td>
<td>&lt;0.001</td>
<td>0.073</td>
<td>0.034-0.156</td>
</tr>
</tbody>
</table>

HR, hazard ratio; 95% CI, 95% confidence interval; ES, endoscopic stenting; PR, palliative resection; GJ, gastrojejunostomy; GOOSS, gastric outlet scoring system; BMI, body mass index

5.3 STENTING BENIGN AND MALIGNANT COLORECTAL OBSTRUCTION (III AND IV)

Overall results
A total of 122 patients with 131 stenting procedures were included in the analysis. Of the patients, 21 patients with 23 stenting procedures underwent stent placement due to benign etiology (III) and 101 patients with 108 stenting procedures due to malignant etiology (IV). Overall technical and clinical success rates were 99% (121/122) and 85% (104/122), respectively. A loop-colostomy was performed for the patient with technical failure. Two co-axial stents were inserted in a single session for two patients with benign CRO and for four patients with malignant CRO. After treatment in our unit, seven patients with benign CRO and 38 patients with malignant CRO were transferred to other hospitals, and for these patients the total inpatient time was unavailable. Procedure details for studies III and IV are presented in Table 9.

Of 21 patients stented for benign CRO (III), 9 (43%) had a complication in 10 of 23 procedures. Of the complications, six were major (perforation n=6) and four were minor (abscess n=2, migration n=1, fistula n=1). Of the complications, three occurred early, within a week, and seven occurred late. No procedure-related mortality occurred. The patient characteristics, complications, and patient outcomes are presented in Table 10.
RESULTS

Of 101 patients stented for malignant CRO (IV), for 23 (23%) chemotherapy was administered before stenting and 46 (46%) patients could start or continue chemotherapy after stent placement. The complication rate was 20% (20 patients in 22 procedures), and the median time to complication was 81.5 days (range 0-561). The majority of 22 complications occurred late; only three perforations occurred early, within a week of the procedure. Stent placement related mortality was 2% (2/101). At the end point of the study, seven patients were alive.

Table 9. Procedure details for patients stented for benign and malignant colorectal obstruction (III and IV)

<table>
<thead>
<tr>
<th></th>
<th>BENIGN CRO</th>
<th>MALIGNANT CRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical success, n (%)</td>
<td>21/21 (100)</td>
<td>100/101 (99)</td>
</tr>
<tr>
<td>Clinical success, n (%)</td>
<td>16/21 (76)</td>
<td>88/101 (87)</td>
</tr>
<tr>
<td>Length of stenosis, cm*</td>
<td>4.5 (2-8)</td>
<td>5 (1-12)</td>
</tr>
<tr>
<td>Length of stent, cm*</td>
<td>9 (6-12)</td>
<td>9 (6-12)</td>
</tr>
<tr>
<td>Reported procedure time, min*</td>
<td>45 (10-100)</td>
<td>30 (10-145)</td>
</tr>
<tr>
<td>Hospital stay, days*</td>
<td>3 (1-60)</td>
<td>1 (1-20)</td>
</tr>
</tbody>
</table>

CRO, colorectal obstruction; * median (range)

Anastomotic strictures (III)
For patients with AS, the initial indication for surgery had been CRC (n=4), diverticular disease (n=2), ovarian cancer (n=1) and obstipation (n=1). Of eight patients with AS, five (63%) were successfully treated with SEMS. For three patients, the stricture recurred after the discharge of SEMS. One patient underwent laparoscopic anastomosis resection four months after the SEMS discharge. The other patient underwent eventually three stenting procedures due to recurrent stricture, of which the last one resulted in a perforation and a surgery with permanent colostomy nine months after the first SEMS placement. The third patient with unsuccessful outcome underwent operation with colectomy and ileostomy due to perforation four months after stenting. The patients with perforations were even prior to SEMS treatment complicated cases with histories of anastomotic leakages and abscesses, and with strong refusal of permanent stoma. Stents migrated in three patients. One patient with immediate migration and failure to decompress underwent restenting. In two patients, the stent discharged spontaneously after 6 and 14 days, but the strictures were resolved.

Diverticular and radiation strictures (III)
The patient with radiation stricture had an uneventful recovery. For five DS patients, the indication of SEMS placement was a bridge to surgery. The five remaining patients were considered unsuitable for surgery due to poor clinical status, high age, and/or obesity. Four clinical failures occurred after SEMS placement for diverticular
strictures. Two of them were treated successfully with dilatation of the stent and with a decompression tube. Two patients required surgical treatment, both two days after stenting, and a permanent stoma was constructed for one of them. Perforation occurred in three preoperatively stented patients after 3, 5, and 67 days of stent placement. All underwent surgery, and Hartmann’s operation with permanent stoma was performed for two of them. Two minor late complications occurred. One patient with colovesical fistula due to penetration of the stent was treated with sigmoid resection 73 days after stenting. This particular patient had been waiting for an elective sigmoid resection. The other patient developed an abscess and underwent Hartmann’s operation with permanent stoma construction 14 days after stenting. Eventually, 70% of the DS patients were operated on.

Anastomotic strictures in Crohn’s disease (III)
Both patients had a history of long-lasting CD with numerous operations, and were highly selected cases for endoscopic stenting. For one patient, the indication for SEMS placement was an attempt to postpone the operation due to the patient’s poor clinical status. The stent’s efficacy for symptoms was inadequate, but the surgery could still be postponed by one month. Bowel resection with stent removal was performed 42 days after SEMS placement. The other patient refused stoma and surgery. AS stricture was stented with an uncovered stent. The patient underwent operation due to perforation 51 months after stenting.
<table>
<thead>
<tr>
<th>Patient No</th>
<th>Age</th>
<th>ASA</th>
<th>Etiology of stricture and indication for stenting</th>
<th>Stent type</th>
<th>Clinical failure</th>
<th>Complications</th>
<th>Treatment of complication or clinical failure</th>
<th>Duration of stenting</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66</td>
<td>2</td>
<td>AS, anastomotic stricture</td>
<td>C</td>
<td>No</td>
<td>None</td>
<td>Endoscopy, stent placement</td>
<td>48 days</td>
<td>3 years, 3 months</td>
</tr>
<tr>
<td>2</td>
<td>69</td>
<td>4</td>
<td>AS, perforation of the anastomose site after colography</td>
<td>C</td>
<td>No</td>
<td>Minor, migration</td>
<td>Endoscopy, stent placement</td>
<td>264 days</td>
<td>8 months</td>
</tr>
<tr>
<td>3</td>
<td>67</td>
<td>4</td>
<td>AS, poor clinical condition, objection of stoma</td>
<td>C</td>
<td>No</td>
<td>Minor, Abscess</td>
<td>Surgery, evacuation</td>
<td>50 days</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>61</td>
<td>4</td>
<td>AS, obesity, objection of stoma</td>
<td>UC</td>
<td>No</td>
<td>None</td>
<td>Endoscopy, stent placement</td>
<td>128 days</td>
<td>4 months, 8 days</td>
</tr>
<tr>
<td>5</td>
<td>58</td>
<td>2</td>
<td>AS</td>
<td>C</td>
<td>No</td>
<td>None</td>
<td>Endoscopy, stent placement</td>
<td>42 days</td>
<td>3 years</td>
</tr>
<tr>
<td>6</td>
<td>51</td>
<td>1</td>
<td>AS</td>
<td>C</td>
<td>No</td>
<td>None</td>
<td>Endoscopy, stent placement</td>
<td>6 days</td>
<td>2 years, 10 months</td>
</tr>
<tr>
<td>7</td>
<td>46</td>
<td>3</td>
<td>AS</td>
<td>C</td>
<td>No</td>
<td>None</td>
<td>Endoscopy, stent placement</td>
<td>16 days</td>
<td>2 years, 7 months</td>
</tr>
<tr>
<td>8</td>
<td>34</td>
<td>2</td>
<td>AS</td>
<td>C</td>
<td>No</td>
<td>None</td>
<td>Endoscopy, stent placement</td>
<td>14 days</td>
<td>4 months, 14 days</td>
</tr>
<tr>
<td>9</td>
<td>64</td>
<td>2</td>
<td>DS, bridge to surgery</td>
<td>C</td>
<td>No</td>
<td>Major, Perforation</td>
<td>Surgery, Hartmann</td>
<td>3 days</td>
<td>3 days</td>
</tr>
<tr>
<td>10</td>
<td>63</td>
<td>3</td>
<td>DS, bridge to surgery, obesity</td>
<td>UC</td>
<td>No</td>
<td>Major, Perforation</td>
<td>Surgery, Hartmann</td>
<td>5 days</td>
<td>5 days</td>
</tr>
<tr>
<td>11</td>
<td>75</td>
<td>3</td>
<td>DS, bridge to surgery</td>
<td>UC</td>
<td>No</td>
<td>Minor, Colovesical fistula</td>
<td>73 days</td>
<td>2 months, 13 days</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>61</td>
<td>2</td>
<td>DS, bridge to surgery, rheumatoid arthritis</td>
<td>UC</td>
<td>Yes</td>
<td>None</td>
<td>Surgery, Hartmann</td>
<td>2 days</td>
<td>2 days</td>
</tr>
<tr>
<td>13</td>
<td>64</td>
<td>4</td>
<td>DS, bridge to surgery, universal arteriosclerosis</td>
<td>UC</td>
<td>No</td>
<td>Major, Perforation</td>
<td>Surgery, resection</td>
<td>67 days</td>
<td>2 months, 7 days</td>
</tr>
<tr>
<td>14</td>
<td>88</td>
<td>4</td>
<td>DS, high age</td>
<td>UC</td>
<td>No</td>
<td>Minor, Abscess</td>
<td>Surgery, Hartmann</td>
<td>14 days</td>
<td>14 days</td>
</tr>
<tr>
<td>15</td>
<td>89</td>
<td>4</td>
<td>DS, high age, poor general condition</td>
<td>UC</td>
<td>Yes</td>
<td>None</td>
<td>Endoscopy, dilation</td>
<td>7 days</td>
<td>7 days</td>
</tr>
<tr>
<td>16</td>
<td>80</td>
<td>4</td>
<td>DS, Alzheimer´s disease</td>
<td>UC</td>
<td>Yes</td>
<td>None</td>
<td>Surgery, resection</td>
<td>2 days</td>
<td>2 days</td>
</tr>
<tr>
<td>17</td>
<td>58</td>
<td>3</td>
<td>DS, obesity, poor general condition</td>
<td>UC</td>
<td>No</td>
<td>None</td>
<td>Endoscopy, stent placement</td>
<td>75 months</td>
<td>6 years, 3 months</td>
</tr>
<tr>
<td>18</td>
<td>74</td>
<td>4</td>
<td>DS, paraplegia</td>
<td>UC</td>
<td>Yes</td>
<td>None</td>
<td>Endoscopy, decompression tube</td>
<td>55 months</td>
<td>4 years, 7 months</td>
</tr>
<tr>
<td>19</td>
<td>77</td>
<td>3</td>
<td>Stricture after radiation therapy, bridge to surgery</td>
<td>UC</td>
<td>No</td>
<td>None</td>
<td>Endoscopy, stent placement</td>
<td>63 months</td>
<td>5 years, 3 months</td>
</tr>
<tr>
<td>20</td>
<td>36</td>
<td>4</td>
<td>AS, Crohn´s disease, an attempt to postpone surgery</td>
<td>C</td>
<td>Yes</td>
<td>None</td>
<td>Bowel resection and stent removal</td>
<td>42 days</td>
<td>1 month, 12 days</td>
</tr>
<tr>
<td>21</td>
<td>47</td>
<td>3</td>
<td>AS, Crohn´s disease, the patient refused to be operated</td>
<td>UC</td>
<td>No</td>
<td>Major, Perforation</td>
<td>Surgery, ileostomy</td>
<td>51 months</td>
<td>4 years, 3 months</td>
</tr>
</tbody>
</table>

AS, anastomotic stricture; DS, diverticular stricture; C, covered; UC, uncovered
**Bridge to surgery in colorectal cancer (IV)**

For 11 patients, SEMS served as a bridge to surgery. Technical and clinical success was achieved for every patient. Among 11 patients, four had Dukes D cancer and those patients were considered operable after favorable outcome in oncologic treatment. An elective operation was performed after a median of 51 days (range 17-453) of SEMS placement with a primary anastomosis rate of 90% (9/10). A Hartmann’s procedure was performed for one patient. For three patients with rectal cancer, a defunctioning loop stoma was performed.

Complication occurred for two patients. One patient underwent emergency operation with primary anastomosis due to early perforation; for the other patient, late recurrent obstruction was treated with a dilatation of the stent. Four (36%) patients were alive at the end point of the study. A median survival was 1284 days (range 255-2346).

**Palliation of malignant colorectal obstruction (IV)**

The palliation group consisted of 66 (69 procedures) CRC patients and 24 (28 procedures) ECM patients. The procedure details and patient outcomes are presented in Table 11. Of complications, all perforations were operated on. For all patients, excluding one in the ECM group, a permanent colostomy (n=2) or loop-colostomy (n=2) was performed. Two patients in each palliation group underwent operation with loop-colostomy due to recurrent obstruction. In the CRC group, one stent migration resulted in Hartmann’s procedure and one fistula was managed by loop-colostomy. All the remaining complications were managed either endoscopically or conservatively. Two perforations in the CRC group occurred early; the remaining complications occurred late.
### Table 11. Procedure details, complications, and clinical outcomes for patients stented as palliation for malignant colorectal obstruction (IV)

<table>
<thead>
<tr>
<th></th>
<th>CRC, PALLIATION</th>
<th>ECM, PALLIATION</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>66</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Technical success, n (%)</td>
<td>66 (100)</td>
<td>23 (96)</td>
<td>NS</td>
</tr>
<tr>
<td>Clinical success, n (%)</td>
<td>62 (94)</td>
<td>15 (63)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Procedure time, minutes, median (range)</td>
<td>30 (10-145)</td>
<td>45 (10-95)</td>
<td>0.021</td>
</tr>
<tr>
<td>Stricture length, cm, median (range)</td>
<td>4 (1-12)</td>
<td>5.50 (2-12)</td>
<td>0.064</td>
</tr>
<tr>
<td>Hospital stay, days, median (range)</td>
<td>1 (1-20)</td>
<td>2.5 (1-20)</td>
<td>0.314</td>
</tr>
<tr>
<td>Complication*, n (%)</td>
<td>13 (20)</td>
<td>7 (29)</td>
<td>0.497</td>
</tr>
<tr>
<td>Perforation</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Recurrent obstruction</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Migration</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Fistula</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Abscess</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Hematoma</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Operation*, n (%)</td>
<td>7 (11)</td>
<td>4 (17)</td>
<td>0.535</td>
</tr>
<tr>
<td>Stoma*, n (%)</td>
<td>7 (11)</td>
<td>3 (13)</td>
<td>0.907</td>
</tr>
<tr>
<td>Time to complication, days, median (range)</td>
<td>114 (0-561)</td>
<td>23 (10-218)</td>
<td>0.218</td>
</tr>
<tr>
<td>Follow-up, days, median (range)</td>
<td>131 (0-1035)</td>
<td>23 (0-643)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Survival, days, median (range)</td>
<td>158 (4-1035)</td>
<td>49 (0-1460)</td>
<td>0.030</td>
</tr>
</tbody>
</table>

CRC, colorectal cancer; ECM, extracolonic malignancies; *after all endoscopic procedures
6. DISCUSSION

6.1 MANAGEMENT OF MALIGNANT GASTRIC OUTLET OBSTRUCTION (I, II)

For patients with incurable malignancies, GOO is a preterminal event. Frequently, the degradation of oral intake has lasted for some time before the diagnosis of incurable malignancy is made. Therefore, at the time of diagnosis it is common that the patients suffering from symptoms of GOO are in poor clinical condition, and when considering treatment options, they are also poor candidates for surgery. For these patients, the main goal of treatment is adequate symptom relief and preservation of reasonable quality of life.

As shown by previous studies, endoscopic stent placement provides good palliation in GOO with rapid improvement in oral intake, short hospital stay, and acceptable rate of complications (Adler and Baron 2002; Holt et al. 2004; van Hooft et al. 2009). Our results on the efficacy of SEMS placement for malignant GOO are consistent with previous data. After SEMS placement, tolerance of oral intake increased markedly, from a median GOOSS 0 to 2. For 73% of the patients, one SEMS placement was sufficient treatment until death. Our comparative study of ES, GJ, and PR as palliation of GOO in advanced gastric cancer showed faster improvement of oral intake and shorter hospital stay for the ES group than for surgically treated patients.

Choosing the right treatment for each patient with GOO and limited survival is an important issue. The majority of the current data on palliation of GOO favors SEMS over GJ due to faster symptom relief and shorter hospital stay. SEMS placement carries a complication rate of about 20%, and even though most complications are minor and can be managed with additional stent placement, complications limit the value of SEMS placement in the treatment of GOO. Short-term outcome has been shown to be better for ES, but long-term outcome in terms of complications, food intake, and re-interventions is better for GJ, and it has been suggested that GJ should be a preferred treatment for patients whose expected survival is over 2 months (Jeurnink et al. 2010). In addition to ES and GJ, for GOO caused by gastric cancer, the treatment options include also palliative resection.

Previous reports have shown that patient’s pain, use of opioids, and WHO score predict survival (Jeurnink et al. 2011; van Hooft et al. 2010). In gastric cancer, intensity of preoperative symptoms correlates with prognosis which is poorest in patients with major symptoms such as GOO (Kahlke et al. 2004). Our study on GOO in gastric cancer shows similar results on the effect of symptoms and patient’s general condition on survival. In multivariate analysis, independent prognostic
factors were GOOSS and BMI which indicate patient’s symptoms, nutritional status, and clinical condition. In the ES group, pre-procedure albumin levels, BMIs, and oral intakes were lowest, and WHO scores poorest. For ES group, survival was also shortest.

In multivariate analysis, in addition to GOOSS and BMI, PR as a treatment modality, patients young age, and chemotherapy were independent predictive factors for survival. Chemotherapy is a known predictive factor for better survival in advanced gastric cancer (Murad et al. 1993; Pyrhonen et al. 1995), but the influence of resection on survival in advanced gastric cancer has been unclear (Haugstvedt et al. 1989; Kokkola et al. 2012). The survival for the PR group was longest, but the patients who underwent resection were healthier than stented patients. Interestingly, in a subgroup analysis, pre-operative clinical characteristics were similar for GJ and PR groups, as well as the number of patients who received post-operative chemotherapy indicating survival benefit after PR.

Biliary obstruction developed for about half of the patients with incurable GOO. Our results on combined enteral and biliary stenting are in concordance with previous studies. For 10 of 11 (91%) patients, combined stenting succeeded. Biliary obstruction occurring after enteral stent placement is more challenging to treat. Cannulation of papilla is more difficult or even impossible due to tumour tissue and stent in situ. For 40% (6/15) of the patients who developed jaundice after enteral SEMS, treatment of biliary obstruction by means of ERC was successful. In failure cases, though, PTC is a good treatment modality.

In our comparative study on GOO in gastric cancer, the complication rates were equal between three palliation groups. In our other study on stenting incurable GOO, one fifth of the patients needed repeated stenting. Most of the complications were minor, and were managed endoscopically or conservatively. Only 2.9% of the patients underwent an operation due to persistent obstruction. Perforation is a rare, but dangerous complication of SEMS placement and can cause mortality. In our study on incurable GOO, four major complications occurred. Three of them were perforations and one was abscess with sepsis, and of four patients, three died. It is noteworthy that no serious late complications, such as perforation or migration, occurred. For patients stented due to gastric cancer, the median time to complications was three months. When considering short survival—a median of 2 months—for stented patients, the majority of the patients die before complications, typically re-obstruction, develop. Therefore SEMS provides good palliation for these patients. In addition, the majority of the patients with poorest WHO scores (WHO 3 and 4) underwent stenting; thus our patient and treatment selection can be considered optimal.

In addition to overall survival, symptom-free survival is also an important issue when considering treatment alternatives. In our comparative study on gastric cancer and GOO, symptom-free survival was shortest for stented patients and longest for patients who underwent palliative resection. Interestingly, for all three treatment
groups, symptom-free survival was nearly similar to overall survival indicating that all three treatment modalities provide good palliation for selected patients.

As shown by previous reports (Schmidt et al. 2009; van Hooft et al. 2009), QoL either improves or remains the same after stent placement of malignant GOO. GOO is a preterminal situation which leads to a weakening of the general condition of the patient. In GOO, the baseline assumption is gradual decrease in QoL. Thus, QoL remaining at the same level after SEMS placement should be considered as a good outcome. In our studies, QoL aspect was not assessed. In our cohort of incurable GOO, almost 75% of the patients avoided surgery by means of one SEMS placement. Therefore, QoL benefit for those stented patients with poor general health and poor survival may be assumed, however.

6.2 SELF-EXPANDING METAL STENTS IN BENIGN COLORECTAL OBSTRUCTION (III)

The standard treatment for benign strictures such as anastomotic strictures, diverticular strictures, Crohn’s disease strictures, and radiation strictures is dilation or surgery. Current data on stent placement for benign CRO is scarce with no randomized studies. Therefore, it cannot be considered as a standard of care for patients with CRO due to benign etiology.

In our series, each of 21 patients had a specific indication for SEMS placement. Of ten DS patients, five underwent stent placement as a bridge to surgery and five patients were considered unsuitable for surgery due to high age, severe comorbidities, or obesity. Among ten DS patients, we treated eight AS patients, two Crohn’s disease patients, and one radiation stricture patient with SEMS. Our series shows similar results as two previously published reports (Dai et al. 2010; Vanbiervliet et al. 2013): SEMS seems to be beneficial for patients with AS. Of eight AS patients, stricture was resolved with SEMS in five (63%). All three patients with unfavourable outcome underwent operation eventually. For one patient with unsuccessful outcome, stricture was resolved at first, in spite of stent migration. The patient underwent laparoscopic anastomosis resection four months after stenting due to recurrent stricture, but even after the operation the stricture recurred. The remaining two patients with unfavourable outcome had a perforation and a permanent stoma was performed for both of them. These patients were complicated cases with a history of multiple operations, anastomotic leakages, and abscesses in the pelvis. Both patients had a strong objection to receiving a stoma. To date, the largest study of SEMS placement for AS found no predictive factors for recurrence or clinical efficacy (Vanbiervliet et al. 2013). Considering the medical history of the two patients with perforation in our study, SEMS placement was worth a try because surgical reanastomosis would have been technically challenging with no guarantee for avoidance of stoma, anyway.
The advantage of a covered stent in temporary stent placement situations, such as AS, is that it is removable. A higher rate of migration is associated with covered stent. Interestingly, the migration seems not to be associated with initial clinical success or later recurrence of stricture (Vanbiervliet et al. 2013). As shown by a report, stent duration in its place for five days is enough for a stricture to resolve (Geiger et al. 2008). Therefore, migration of covered stent in the treatment of AS may be considered as a successful resolution of the stricture rather than an adverse effect. We used covered stents for 9 of 10 patients in AS. A migration occurred for three patients, and of three migrations only one was clinically relevant resulting in a new stent placement. For two patients, the SEMS migrated spontaneously after 6 and 14 days. The strictures were resolved; for one patient permanently and for one patient for four months.

In concordance with previous reports (Forshaw et al. 2006; Pommergaard et al. 2009), high clinical failure and complication rate limit the usefulness of stenting in DS. In our study, only 30% truly gained benefit from stenting. The rest of the patients were operated on due to failure to decompress or due to a complication. For bridge to surgery patients, the outcome of SEMS placement was rather disappointing; all underwent emergency surgery, and Hartmann’s operation with end colostomy was performed for three of them. Stenting DS is associated with a high rate of delayed complications, and as suggested by Small et al. (Small et al. 2008), if an elective operation is planned it should be performed promptly, within a week of stenting. In our series, two late complications (perforation and colovesical fistula) might have been avoided if the patients had been operated in time.

We treated only two CD patients with a stent; thus, it is impossible to evaluate the usefulness of stenting in general in Crohn’s strictures. Of importance are the strictures etiology and possibility of both early and late complications. As indicated by previous studies (Forshaw et al. 2006; Pommergaard et al. 2009; Small et al. 2008), inflammatory disease of the bowel seems to be associated with a higher complication rate than AS. Our results on the impact of etiology on complications are similar; 67% of the complications occurred in DS and CD strictures. We used uncovered stents when stenting was considered as a definitive treatment. Uncovered stents are more prone to ulcerating the bowel and with an underlying transmural inflammation of the bowel complications such as perforation, fistula, or abscess may result. Noteworthy, for one patient with chronic and incurable CD, a perforation occurred four years after stenting. CD is also associated with higher risk of CRC than the general population (Ekbom et al. 1990), and the detection of dysplasia in colonoscopy is difficult. Therefore, in Crohn’s disease, stenting should be attempted only in special cases.

Patients who undergo SEMS placement for benign causes should be carefully monitored for bowel decompression and for a possibility of complications. In the event of failure to decompress, an immediate endoscopy with dilation, re-stenting,
or insertion of decompression tube should be undertaken, and if these measures fail, surgery has to be performed.

6.3 SELF-EXPANDING METAL STENTS IN MALIGNANT COLORECTAL OBSTRUCTION (IV)

The purpose of the preoperative stent placement in acute obstruction is to enable an elective operation with primary anastomosis. In our study, a primary anastomosis was achieved in 90% of the elective operations. An end colostomy was performed for only one patient. Additionally, for three patients with middle and low rectal cancers, a defunctioning loop stoma was performed. The treatment of choice for rectal tumours located in the middle or low part of the rectum is total mesorectal excision (TME) with low anastomosis. For low anastomosis, a defunctioning loop stoma is recommended because it has been shown to reduce symptomatic anastomotic leakages and complications demanding reoperations (Matthiessen et al. 2007). As a stent may induce inflammation and fibrosis into surrounding tissues combined with radiotherapy often administered before rectal surgery, the subsequent operation may be technically more challenging than without the stent. Thus, for obstructive tumours located in the middle or low part of the rectum, preoperative loop stoma may provide a better option rather than a stent.

The results from randomized studies concerning preoperative SEMS placement and emergency surgery are inconsistent. In single center studies, the outcome for the preoperative SEMS group is better than for the emergency surgery group (Alcantara et al. 2011; Cheung et al. 2009). In multicentre studies, the high rate of complications related to SEMS led to premature closure of the studies (Pirlet et al. 2011; van Hooft et al. 2011). Technical success rates for SEMS placement were rather low, 47% and 70%. The number of patients with complete obstruction was high in both studies which may have contributed to low technical success rates. Also, the centre’s experience in SEMS placement may have affected the outcome. In a French study (Pirlet et al. 2011), there were nine centres for 30 SEMS placements and in Dutch study (van Hooft et al. 2011), 25 centres for 47 SEMS placements. It is worth noting that patients who were successfully stented underwent an uneventful surgery and recovery in both multicentre studies. Thus, proper patient selection may decrease the amount of complications, as well as the centre’s high volume and expertise in colorectal SEMS placement. Stenting procedures for acute CRO should also be performed promptly, within eight hours, to avoid cecum necrosis and subsequent subtotal colectomy. Therefore, procedures should be performed in large enough centres with emergency surgery facilities.

The high rate of silent and overt perforations associated with SEMS placement, and the possible negative impact on survival is alarming (Pirlet et al. 2011; van Hooft et al. 2011). The oncological outcome after SEMS placement is unclear, though.
According to reports, the long-term survival between SEMS and emergency surgery groups has been similar (Dastur et al. 2008; Saida et al. 2003). One study reported a worse outcome for the SEMS group than for the surgical group (Kim et al. 2009b). In a prospective non-randomized study, survival was significantly better for the preoperative SEMS group (p=0.004) (Gianotti et al. 2013). In our study, we had one perforation in the bridge to surgery group. Fortunately, the perforation was noticed during the SEMS placement which led to an emergency operation and the patient could avoid a stoma. Among 11 preoperatively stented patients, four patients had Dukes D carcinoma. With these four Dukes D patients included, the median survival for preoperatively stented patients was 3.5 years. With an absence of control group -based on our results- conclusions on the impact of stenting on survival cannot be drawn, however. When stenting potentially curable CRC patients, the rate of SEMS related perforations should be comparable with tumour perforations in surgery. Therefore, a high rate of overt and silent perforations associated with SEMS markedly limits the value of preoperative stenting in acute CRO.

The efficacy of stenting for CRO caused by ECM is controversial. The clinical success rates, in particular, have shown significant variation in previous studies (Kim et al. 2013b; Trompetas et al. 2010). In our study we found that although the technical success rates were similar among CRC and ECM palliative stenting groups, for ECM the clinical success was achieved less frequently. Some have suggested that the etiology of the malignancy would contribute to the outcome (Keswani et al. 2009); the best outcome is reported by Koreans where the predominant malignancy is gastric cancer (Kim et al. 2013b; Shin et al. 2008). At the same time, the worst outcome is found in studies where the most common etiology for CRO is gynecologic malignancy (Keswani et al. 2009; Trompetas et al. 2010). In our series, gynecologic malignancy was the most common etiology for CRO, and of the malignancies, only 25% were derived from the upper-GI tract.

Apparently, reasons for a clinical failure are multifactorial. When considering pelvic malignancies, such as gynecologic or prostate cancer, patients often receive radiotherapy. For ovarian cancer, in particular, carcinomatosis is common with multiple stricture sites (Dvoretsky et al. 1988). The contribution of all of these factors can make the bowel fixed and immobilized, with long and angled strictures. In our series, for ECM, the procedures lasted longer and also strictures were longer than for CRC, indicating that the circumstances for stenting might have been more challenging for ECM than for CRC. Consequently, even if stenting is technically possible the result may be a clinical failure.

In study IV, of preoperative characteristics, median age, BMI, and ASA grade were similar between the groups. In the CRC group, CCI was higher indicating a higher prevalence of comorbidities. Despite the higher CCI and comorbidities, the median survival was significantly longer for CRC than for ECM patients. It seems that for ECM patients, and in particular for gynecological etiology, CRO is a preterminal event with limited survival. However, for patients achieving clinical
success after stenting, the complication, operation, and stoma rates were comparable between two palliative stenting groups. Thus, considering the limited survival and the burden of surgical treatment, SEMS placement as palliation is worth trying for ECM patients suffering symptoms of CRO.

Our high overall technical and clinical success rates are comparable with other reports (Khot et al. 2002; Sebastian et al. 2004). Of the stenting procedures, 97% were carried out by two highly experienced pancreatobiliary endoscopists. According to a report, strictures located in the proximal colon were associated with poorer outcome (Jung et al. 2010). In our cohort, 92% of the patients had a stricture distal to splenic flexure which may have affected on the technical and clinical success rates. A half of the strictures were incomplete which also may have contributed to the good outcome. Our total complication rate of 20% is also in comparison with previous studies (Khot et al. 2002; Sebastian et al. 2004). Of complications, only three perforations occurred early, within a week. When considering palliative stenting, the possibility of late complications should be considered when the treatment is planned. In our cohort, the median time to complication for CRC patients was almost four months. Interestingly, we had one perforation leading to death almost two months of SEMS placement. Of 11 late complications in the CRC group, only five required surgery; the remaining six could be managed either endoscopically or conservatively, however.

6.4 STRENGTHS AND LIMITATIONS OF THE STUDY

All the stenting procedures were performed in the Endoscopy Unit of Meilahti Hospital, which is a high volume unit specialized in demanding interventional endoscopy. Therefore, the endoscopists are experienced in pancreatobiliary procedures which diminish the risk for complications when considering duodenal and colorectal stent placements. The majority of the SEMS placements were performed by two endoscopists enabling standardized technique for stenting procedures. Moreover, the endoscopists who performed SEMS placements are GI-surgeons which can be considered beneficial when evaluating treatment options and indications of stenting for surgical patients.

All the procedures are recorded into the endoscopy unit’s own database which enables the identification of the patients for analysis. The patient samples in studies I, II, and IV are large enough for drawing conclusions on stenting malignant GOO and CRO. Even in study III, the number of patients is large when compared to existing literature on benign stenting.

The main limitation of this study is its retrospective aspect. As such, the information, of for example oral intake, may have been unreliable for some patients. Some follow-up data may have also been incomplete, and indications and treatment policies may have changed during the study period. In addition to being
retrospective, the studies were performed in a single-centre and the results may not be adjusted to general practice in every surgical unit. Furthermore, the studies were non-randomized which may cause selection bias between treatment groups in comparative studies (II, IV). In particular in study II, the fittest and youngest patients may have been selected to the PR group, and older patients are more likely offered to undergo SEMS placement. Possibly the patients who underwent palliative resection had less advanced disease, and in particular if they received chemotherapy, they survived longer. In gastric cancer and GOO, some variables may have emerged statistically significant if the number of patients who were operated on would have been larger giving sufficient statistical power. Finally, when considering palliative treatment for incurable malignancies of the GI-tract, the lack of QoL aspect is also a major limitation in this study.

6.5 FUTURE ASPECTS

Many aspects of stenting GOO and CRO are still developing or require further studies.

The stents and stenting techniques are developing continuously. In GOO, individually designed stents that adjust to the anatomy of the proximal gastric lumen may prevent migration and stent obstruction. In benign colorectal strictures, biodegradable stents may be a safer option than SEMS.

The survival benefit of non-curative resection in the absence of major symptoms in gastric cancer is unclear. A randomized study comparing chemotherapy alone and combined chemotherapy and resection is warranted. Thereby, the results from the randomized study would help in choosing an optimal treatment also for patients with advanced gastric cancer and symptoms of GOO. In stenting malignant CRO as a bridge to surgery, the impact of overt and silent perforations on long-term oncological outcome is still unclear. Further studies are needed to define the value of preoperative stenting in acute malignant CRO. In benign CRO, SEMS seems to be a potential treatment alternative for selected patients with AS. The utility of SEMS in AS should be proved in a randomized study comparing EBD and SEMS, however.
7. CONCLUSIONS

1) In the study of 104 patients with incurable GOO and limited survival we found that stent placement provides good palliation. Stenting restores oral intake rapidly with an acceptable rate of complications and a short hospital stay. Combined stenting of concomitant biliary and enteral stenting carries a high success rate of 90%.

2) In patients with advanced gastric cancer and GOO, clinical condition of the patient affects survival and should be carefully evaluated when deciding treatment. For patients unfit for surgery, stenting provides rapid improvement in oral intake with short hospital stay. Stenting should be the treatment of choice for poor performance status patients. PR as a treatment modality seems to provide survival benefit. Therefore, PR should be considered as a treatment modality for patients fit for surgery. In addition, chemotherapy seems to provide survival benefit for patients with advanced gastric cancer and GOO.

3) Our study on stenting benign CRO adds information to scarce existing data on the subject. SEMS seems to be a good treatment option in resistant anastomotic strictures for selected patients unfit for surgery. In diverticular disease, stenting seems less beneficial with lower clinical success rate and higher rate of complications. If stenting is attempted in diverticular disease, patients need careful monitoring after procedure. After stenting DS, a definitive operation should be performed promptly, at the latest within a month.

4) Stenting malignant CRO should be performed in high volume centres due to the possibility of major complications, such as perforations. SEMS as a bridge to surgery is associated with a high rate of primary anastomosis. A possibility of overt or silent perforations limits the value of preoperative stenting in malignant CRO, however. Palliative stenting in incurable malignancies provides good palliation. Higher clinical failure rate is associated with CRO caused by ECM.
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Ilona Keränen
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