

Value of temporary stents for the management of perivaterian perforation during endoscopic retrograde cholangiopancreatography

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Core tip: Although the evidence supporting the use of fully covered self-expandable metallic stent in perivaterian perforations is still insufficient, the clinical outcomes were encouraging.

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Abstract

Endoscopic retrograde cholangiopancreatography (ERCP) has become the mainstay of treatment in hepato-pancreato-biliary disease. However, ERCP requires a high level of technical skills and experience in therapeutic endoscopy, there is always a risk of complications. Especially, the perforation *per se* affects the patient adversely, and the clinical course may lead to a poor prognosis, even with appropriate management. The treatments for ERCP-related perforation are diverse, depending on the location and mechanism of the bowel perforation and the time of diagnosis. Thus, we reviewed the appropriate surgical and non-surgical management options for therapeutic ERCP-related perforations, especially, evaluating metallic stenting as a treatment modality in perivaterian perforation.

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Key words: Endoscopic retrograde cholangiopancreatography; Perforation; Self-expandable metallic stent; Duodenum; Perivaterian

INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP) has become the mainstay of treatment in hepato-pancreato-biliary disease since its introduction in 1968^[1]. In the past, ERCP had been used as a *diagnostic* tool in choledocholithiasis presenting with jaundice, dilated common bile duct, acute pancreatitis, and cholangitis, but recently ERCP combined with sphincterotomy and stone removal has become a valuable *therapeutic* procedure^[2].

Because ERCP requires a high level of technical skills and experience in therapeutic endoscopy, there is always a risk of complications, such as bleeding, perforation, pancreatitis, and cholangitis. Indeed, complication rates range from 5.4% to 11.2%^[3-11], among which the rate of perforation, a potentially fatal complication, is 0.3%-1.0%^[3,12,13], and the rate of mortality in perforated patients is high (8%-23%)^[3,12-14]. Moreover, perforation *per se* affects the patient adversely, and the clinical course may lead to a poor prognosis, even with appropriate management. Delayed diagnosis and management can further affect clinical outcomes adversely^[15,16].

The treatments for ERCP-related perforation are diverse, depending on the location and mechanism of the

Table 1 Classification of endoscopic retrograde cholangiopancreatography-related perforations

Ref.	Type
Stapfer <i>et al</i> ^[18]	Type I, duodenal perforation of medial or lateral wall Type II, perivaterian perforation Type III, perforation of distal bile duct Type IV, retroperitoneal air alone
Howard <i>et al</i> ^[17]	Group I, guidewire perforation Group II, periampullary retroperitoneal perforation Group III, duodenal perforation remote from the ampulla

bowel perforation and the time of diagnosis^[17,18]. Previously, most ERCP-related perforations, regardless of the above factors, were managed using surgery, and the mortality rate with such surgery was generally high. However, after the introduction of treatment strategies according to the type of perforation, nonsurgical management, such as radiologic interventions using percutaneous transhepatic biliary drainage (PTBD) and endoscopic management using endoscopic nasobiliary drainage (ENBD), endoscopic retrograde biliary drainage (ERBD), endoclips, and fibrin glue, have been developed. Consequently, treatment outcomes have improved greatly over time^[12,15-24].

Now, nonsurgical techniques are being used in suitable select patients more than often than surgery. Among the various nonsurgical options, several recent studies have reported that fully covered self-expandable metallic stents (SEMSs) could be used in ERCP-related perforation, especially in periampullary perforations^[25-28]. Thus, we reviewed the appropriate surgical and non-surgical management options for therapeutic ERCP-related perforations, especially, evaluating metallic stenting as a treatment modality in perivaterian perforation.

CLASSIFICATION OF ERCP-RELATED PERFORATION

The treatment modality in ERCP-related perforations is associated with the type of the perforation (Table 1). Stapfer *et al*^[18] classified perforations into four types according to anatomical location and severity. Type I duodenal injuries are perforations of the lateral or medial wall, caused by the endoscope itself. Type II duodenal injuries are perforations of the medial wall. These are perivaterian or periampullary perforations, and most occur during endoscopic sphincterotomies. Type III duodenal injuries are perforations of the distal bile duct, typically due to wire or basket instrumentation. Type IV duodenal injuries are diminutive retroperitoneal perforations due to excessive use of compressed air to retain a patent bowel lumen.

Similar to Stapfer's classification, Howard *et al*^[17] reported three types of ERCP-related perforations in accordance with the mechanism of injury. Group I perforations are guidewire perforations of the duct, group II perforations

are periampullary perforations, and group III perforations are duodenal perforations remote from the ampulla.

Regarding incidence by type of perforation, generally, periampullary perforations caused by endoscopic sphincterotomies are most common, 15%-55%^[12,17-19]. Polydorou *et al*^[23] reported incidences using a modified classification of ERCP-related perforation. Type I, and type II injuries are identical with Stapfer's type I and II injuries, but type III injuries are ductal or duodenal perforations caused by endoscopic instruments, but not guidewires, and type IV injuries are guidewire perforations with the presence of retroperitoneal air on X-ray examination. They showed incidences of 68% for type II, 16% for type I, 11% for type III, and 4% for type IV perforations. Another study showed that guidewire-related perforations were most common (32%)^[19]. Moreover, 15% were sphincterotomy-related perforations, 11% occurred during passage of the endoscope, and 9% occurred due to stent migration. Morgan *et al*^[22] reported that 12 of 24 cases of ERCP-related perforations were related to sphincterotomy, and the other 12 cases were perforations remote from the papilla. Although the incidence of ERCP-related perforations varied slightly among the previous studies, sphincterotomy-related perforations tend to be most common, followed by guidewire-related perforations and free wall perforations.

RISK FACTORS FOR ERCP-RELATED PERFORATIONS

Several studies have reported risk factors for ERCP-related perforations. Overall risk factors, regardless of the type of ERCP-related perforation, include old age and a longer ERCP procedure time. Enns *et al*^[12] demonstrated that patients older than 65 years had a greater risk of ERCP-related perforation. Longer procedure times are often accompanied by repeated cannulation or more invasive methods to achieve "good" results. Thus, there tends to also be a greater risk of perforation. Additionally, ERCP-related perforation may be increased when performed by a trainee endoscopist. However, experts in the therapeutic ERCP field operate frequently and especially with severe and difficult cases; thus, there is always a risk of perforation during the procedure regardless of the surgeon's experience.

Risk factors for Stapfer's type I perforation are abnormal anatomical structures, such as gastrojejunostomy, pancreaticoduodenectomy, duodenal diverticulum or stricture, and situs inversus^[22,29-31]. With anatomical features that differ from those of normal situations, it may be difficult to penetrate the bowel lumen using a side-viewing endoscope, increasing the risk of perforation by the endoscope itself.

Risk factors for Stapfer's type II, III, and IV perforations are similar and overlapping. They include sphincter of Oddi dysfunction, precut sphincterotomy, and a dilated common bile duct on abdominal imaging^[12]. Precut sphincterotomy has been reported as a known risk factor

for pancreatitis^[6,7,32]. However, several studies have demonstrated that precut sphincterotomy also increases the risk of perforation compared with a conventional sphincterotomy. In fact, the risk of perforation increases if the incision for the sphincterotomy is outside of the usually recommended sector (11 to 1 o'clock position)^[6,33-35]. A previous report demonstrated that 7 of 13 sphincterotomy-related perforations were associated with precutting^[12]. Since a dilated common bile duct is associated with distal common bile duct stricture, the risk of perforation may be related to the deep manipulation needed to achieve a deep cannulation. Additionally, an ampullectomy can increase the risk of perforations. Alfieri *et al*^[15] reported that ampullectomy had been performed in 7 of 30 (23%) cases of ERCP-related perforations.

CLINICAL MANIFESTATIONS AND DIAGNOSIS

Patients with ERCP-related perforations may complain mainly of epigastric pain and tenderness, but obviously these complaints are very nonspecific. Other symptoms and signs include fever, tachycardia, leukocytosis, and mildly elevated serum amylase levels. Several studies have reported rare complications after ERCP, such as pneumomediastinum, pneumothorax, and gas in the portal system^[36-42], whereas patients with retroperitoneal air present on abdominal imaging, after an endoscopic sphincterotomy, can be asymptomatic clinically. Generally, the patients did not require intervention but only conservative management. Genzlinger *et al*^[43] showed that asymptomatic patients with retroperitoneal air evident on a computed tomography (CT) scan did not require surgical intervention. As the range is diverse, from asymptomatic to severe signs of peritonitis, to suspect and recognize the possibility of perforation early, during and after ERCP is most important. For early detection of perforation, it is necessary to check the patient's condition immediately after ERCP. If the patient complains severe abdominal pain, abdominal X-ray and CT are good methods to identify ERCP-related perforation. If retroperitoneal air is visible during the procedure, abdominal X-ray and CT are also useful.

ERCP-related perforation can sometimes be diagnosed readily by imaging if suspected. Typically, an abdominal X-ray may show retroperitoneal air around the right kidney. Suspected perforation may not be confirmed by an abdominal X-ray, but a contrast CT scan or upper gastrointestinal oral contrast evaluation should be helpful. However, this could be delayed unless the physician suspects a perforation. Furthermore, if the patient has elevated serum amylase levels and complaints of epigastric pain, it is difficult to distinguish between perforation and pancreatitis. Gottlieb *et al*^[44] reported that post-ERCP pancreatitis can be excluded if their values of amylase and lipase 2 h after ERCP are below 276 U/L and 1000 U/L, respectively. Another study demonstrated that post-ERCP pancreatitis cases showed serum amylase levels

greater than five-fold the normal level^[45]. Thus, laboratory findings, especially serum amylase and lipase levels, may be important clues for differentiating perforation from pancreatitis.

Although a physical examination is frequently useful in suspected patients, not all perforated patients show signs of acute peritonitis^[43]. Bell *et al*^[46] demonstrated positive physical findings in 75% of the included patients, but no specific finding of perforations. Thus, it is important to consider not only a physical examination and laboratory findings but also abdominal imaging, such as abdominal X-ray and abdominal CT scans, for an accurate diagnosis.

TREATMENT OF ERCP-RELATED PERFORATION

Traditionally, ERCP-related perforation has been managed surgically. The objectives of such surgical management include control of infection and inflammation (drainage of the retroperitoneal/intraperitoneal fluid and air and drainage of the biliary system) and closure of the perforation, with or without bypass^[2]. However, the recent trend has been towards a selective approach according to the type of perforation and, more recently, according to the overall status of the patient, considering issues such as age, vital signs, peritoneal signs, comorbidities, and CT images.

Duodenal free wall perforations (Stapfer type I or Howard Group III) tend to be larger and located remotely from the ampulla and to cause substantial collections in the peritoneal or retroperitoneal space. Thus, these perforations should be subjected to prompt surgical intervention. One study reported three of four cases of type I perforation that underwent surgery immediately^[12]. One case had abnormal anatomy, a gastrojejunostomy, and the others cases had duodenal diverticulum and stricture. All three patients were suspected and diagnosed immediately; there was no mortality. The one patient without surgical management had severe comorbidities, thus receiving only conservative management but died 2 d later. Polydorou *et al*^[23] reported that 83% (6/7) of Stapfer's type I perforation cases underwent surgery. Three patients with type I perforation showed abnormal anatomy due to Billroth II gastrectomies. Among the patients who underwent surgery, two died as a result of respiratory insufficiency and aspiration pneumonia. One patient with a type I perforation, caused by rupture of the diverticulum, was managed conservatively. The patient had no fever or signs of peritonitis but only complained of mild abdominal pain.

In the studies mentioned above, in general most of the type I perforations were treated using surgery due to the large size of the perforation. Recently, some studies have introduced endoscopic management using simple metallic endoclips or an endoloop with multiple endoclips and fibrin glue for free wall duodenal perforations^[28,34,47-50]. In addition, an over-the-scope-clip, used

Table 2 Treatment of periampullary perforations (Stapfer's type II perforations)

Ref.	Patients (n)	Patients according to treatment method, n (%)	Treatment method	Mortality n (%)
Alfieri <i>et al</i> ^[15]	15	6 (40.0)	Conservative management + ENBD ± PTBD	0 (0.0)
		9 (60.0)	Surgery	1 (11.1)
Wu <i>et al</i> ^[16]	11	6 (54.5)	Conservative management	0 (0.0)
		5 (45.5)	Surgery	4 (80.0)
Kim <i>et al</i> ^[58]	5	2 (40.0)	Conservative management	0 (0.0)
		3 (60.0)	Surgery	0 (0.0)
Enns <i>et al</i> ^[12]	13	11 (84.6)	Conservative management ± biliary drainage (PTBD, ERBD)	0 (0.0)
		2 (13.4)	Surgery	0 (0.0)
Polydorou <i>et al</i> ^[23]	30	24 (80.0)	Conservative management ± biliary drainage (PTBD, ERBD)	0 (0.0)
		6 (20.0)	Surgery	0 (0.0)
Stapfer <i>et al</i> ^[18]	6	3 (50.0)	Conservative management	0 (0.0)
		3 (50.0)	Surgery	0 (0.0)
Howard <i>et al</i> ^[17]	22	18 (81.8)	Conservative management ± biliary drainage (ENBD, ERBD)	0 (0.0)
		4 (18.2)	Surgery	1 (25)
Morgan <i>et al</i> ^[22]	12	12 (100.0)	Conservative management	0 (0.0)
		0 (0.0)	Surgery	0 (0.0)
Kim <i>et al</i> ^[59]	9	8 (88.8)	Conservative management ± ENBD	0 (0.0)
		1 (11.2)	Surgery	0 (0.0)

Conservative management: intravenous antibiotics, fluids, pain control, nil-by-mouth, close monitoring, and nasogastric drainage. ENBD: Endoscopic naso-biliary drainage; PTBD: Percutaneous transhepatic biliary drainage; ERBD: Endoscopic retrograde biliary drainage.

primarily in gastrointestinal bleeding or perforation, could be considered for use in post-ERCP perforations^[51,52].

Distal bile duct injuries (Stapfer type III or Howard Group I), caused by penetration of the guidewire through the bile duct during cannulation in a narrow or obstructed duct, tend to be smaller than duodenal free wall perforations. Commonly, these perforations tend to become obstructed spontaneously, and these patients can be 'cured' by conservative management with intravenous antibiotics, hydration, pain control, or nil-by-mouth^[12,17,18,53]. However, since some patients have ongoing bile leakage, endoscopic management to prevent bile leakage to the retroperitoneum may be necessary. To prevent such leakage, ENBD or ERBD together with insertion of a plastic or metallic stent can be used. If endoscopic management is not possible, PTBD can be performed.

Diminutive duodenal perforation (Stapfer type IV) is not a true perforation; generally, it can be treated sufficiently with conservative management alone. In fact, Genzlinger *et al*^[43] reported that retroperitoneal air alone, with no abnormal clinical signs or symptoms, does not require surgical intervention. However, regardless of the type of perforation, patients with retained stones or unalleviated biliary obstruction should undergo surgery^[18].

Perivaterian perforations (Stapfer type II or Howard group II) occurring after endoscopic sphincterotomy are controversial issues in the treatment field presently because of variation in clinical outcomes^[14,18,34,41,53-57]. Surgical intervention is not an issue but is an abstruse problem, because it seems that conservative management alone, including biliary drainage, may aggravate or fail to cure the perforation. Several studies have demonstrated that conservative management with or without biliary drainage was successful in peri-ampullary perforation pa-

tients^[18,53-55].

Wu *et al*^[16] reported that 55% (6/11) of patients with type II perforations were treated with conservative management with or without biliary drainage. In all patients, clinical signs and symptoms improved rapidly. However, 80% (4/5) of the patients who underwent surgery died, due to delayed diagnosis and operation as well as sepsis. The surgical indications for those patients were large retroperitoneal fluid collections, liver abscess on abdominal CT scan, and severe abdominal pain. Enns *et al*^[12] demonstrated that 46% (6/13) of patients with type II perforations were treated using conservative management with or without nasogastric suction. In 38% (5/13) of the patients, biliary drainage (stent insertion with three, PTBD with two) was performed. The mortality rate was zero in patients managed conservatively and with biliary drainage. Alfieri *et al*^[15] showed that 40% (6/15) of patients with type II perforations were treated successfully by conservative management with biliary drainage (PTBD or nasobiliary drainage).

The rates of nonsurgical management *vs* surgical intervention in peri-ampullary perforation vary widely (Table 2)^[12,15-18,22,23,58,59]. Thus, the appropriate choice of treatment modality for peri-ampullary perforation remains an important issue. Most surgical indications in peri-ampullary perforations include hemodynamic instability, signs of peritonitis, continuing leakage, septic conditions, and a perforation of large size. One author also suggested that patients with a large amount of fluid collection in the peritoneum or retroperitoneum on abdominal CT should be treated aggressively^[12], because the possibility of continuing leakage is high. If there is no surgical indication, the essential aspects of nonsurgical management consist of diversion of duodenal, biliary, and pancreatic drainage^[21]. A nasogastric or nasoduodenal tube for duodenal

Table 3 Temporary self-expandable metallic stent used for peri-ampullary perforations

Ref.	Age/sex	ERCP indication	Abdominal CT scan	Stent indication	Type of stent/duration (d)
Vezakis <i>et al</i> ^[28]	61/F	Stones or sphincter of Oddi dysfunction	Retroperitoneal air	Duodenal fistula, Continuing leakage	Partially covered SEMS/14
Jeon <i>et al</i> ^[26]	82/F	Stones	Retroperitoneal air and fluid	Continuing leakage	Fully covered SEMS/28
Canena <i>et al</i> ^[25]	55/F	Stones	Retroperitoneal air and fluid	Perforation	Fully covered SEMS/21
	29/F	Stones	Retroperitoneal air and fluid	Perforation	Fully covered SEMS/30
	31/M	Stones	Retroperitoneal air and fluid	Perforation	Fully covered SEMS/30
	76/F	Stones	Retroperitoneal air and fluid	Perforation	Fully covered SEMS/29
Park <i>et al</i> ^[27]	61/F	Biliary tree dilatation	Retroperitoneal air and fluid	Perforation	Fully covered SEMS/10
Unpublished	46/M	Stones	Retroperitoneal air	Perforation	Fully covered SEMS/ spontaneously fell out

CT: Computed tomography; SEMS: Self-expandable metallic stent; ERCP: Endoscopic retrograde cholangiopancreatography.

decompression can be used. ENBD or ERBD can be used in internal biliary drainage to prevent leakage of bile juice into the perforation site. For external biliary drainage, PTBD is used as well.

However, some conditions, such as severe common bile duct dilatation or a large perforation hole, may reduce the diversion of biliary drainage using ENBD or ERBD^[27]. Thus, several studies have reported that fully covered self-expandable metallic stents (SEMS) can be useful in biliary stenting for perivaterian perforations^[25-28].

Initially, most periampullary perforation patients receive conservative management with or without biliary drainage, according to most previous studies. If conservative management failed and a delayed operation was then performed, the subsequent clinical course was found to be poor in some studies^[15,16]. Thus, there is a need to treat using active conservative management. Taking advantage of biliary drainage by ENBD, ERBD, use of plastic or metallic stents, PTBD, duodenal drainage *via* a nasogastric or nasoduodenal tube, pancreatic drainage, and inflammation control are essential. "Conservative management" indicating only intravenous antibiotics, hydration, pain control, and nil-by-mouth is inadequate. Indeed, it is important to combine methods to prevent bile leakage into the perforation site.

ARE FULLY COVERED SEMS IN ERCP-RELATED PERFORATIONS VALUABLE?

As mentioned above, it is important to divert biliary drainage to prevent leakage of bile juice into the peritoneum in a peri-ampullary perforation. For such diversion, fully covered SEMS occlude the perforation site by radial force, and the perforation site can heal quickly. That is, recovery of the epithelium in the injury site, stent-associated reepithelialization, is achieved. A similar procedure has been performed previously in esophageal perforations. Siersema *et al*^[60,61] reported that a fully covered SEMS was useful in nonmalignant and traumatic esophageal perforations; however, in general fully covered SEMS have been used for malignant perforations or fistulas for palliative management. A fully covered SEMS enabled the sealing of an esophageal perforation and prevented mediastinal

infection.

Some case series have reported the use of SEMS in ERCP-related perforations (Table 3)^[25-28]. Vezakis *et al*^[28] reported a case of a persistent high-volume duodenal fistula, caused during an endoscopic sphincterotomy, that was treated successfully using a partially covered SEMS. Jeon *et al*^[26] also reported the use of a fully covered SEMS in a sphincterotomy-related duodenal perforation. Although this patient had retroperitoneal fluid collections and peritonitis, she was not considered a candidate for surgery. She was treated with multiple plastic stents for internal biliary drainage and with PTBD for external biliary drainage due to her poor medical condition and old age (82 years). However, because of persistent percutaneous catheter drainage (> 150 mL/d) and contrast leakage from a distal common bile duct on tubogram, a fully covered SEMS was inserted after removing the previous plastic stents. She then recovered completely, and the fully covered SEMS was removed 1 mo later.

Park *et al*^[27] also considered duodenal perforation after endoscopic sphincterotomy, similar to the above two studies. Their case was a 61-year-old female complaining of right upper quadrant pain. Biliary duct dilatation had been detected on an abdominal CT scan, and therefore ERCP with sphincterotomy was performed. The day after ERCP, she developed severe abdominal pain, fever, and leukocytosis according to laboratory findings. An abdominal CT showed retroperitoneal air and fluid collection, and the diagnosis was peri-ampullary perforation. A fully covered SEMS (5-cm-long, 10 mm in diameter) was inserted immediately after identifying the perforation, and the patient recovered completely. The retroperitoneal fluid collection seen on the abdominal CT scan resolved. The stent was then removed 10 d after insertion.

In another previously unpublished case, a 46-year-old male was referred to the hospital for right quadrant abdominal pain. He had previously undergone a Billroth I operation for gastric ulcer perforation. Because the patient developed abnormal liver functioning and gallbladder stones on abdominal CT scan, ERCP was performed to identify the biliary duct stone. However, after endoscopic sphincterotomy, a peri-ampullary perforation was detected, and a fully covered SEMS was placed immediately during the ERCP (Figures 1 and 2). After stent-

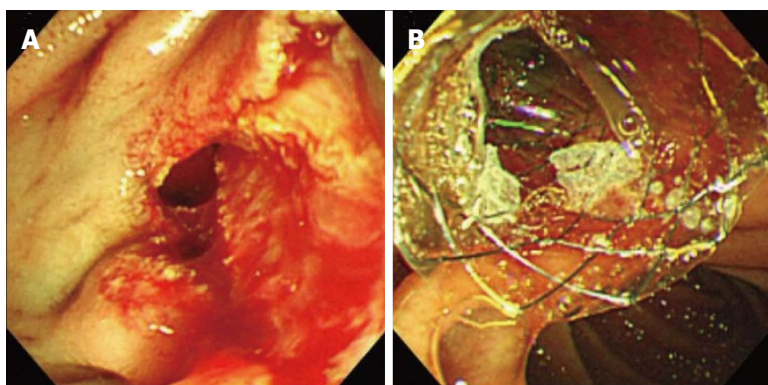


Figure 1 Insertion of fully covered self-expandable metallic stent for the management of periampullary perforation immediately after endoscopic sphincterotomy. A: A peri-ampullary perforation was seen after endoscopic sphincterotomy; B: A fully covered self-expandable metallic stent (5-cm-long, 10 mm in diameter) inserted into the common bile duct to prevent bile entering the perforation site can be seen at the ampulla of Vater.

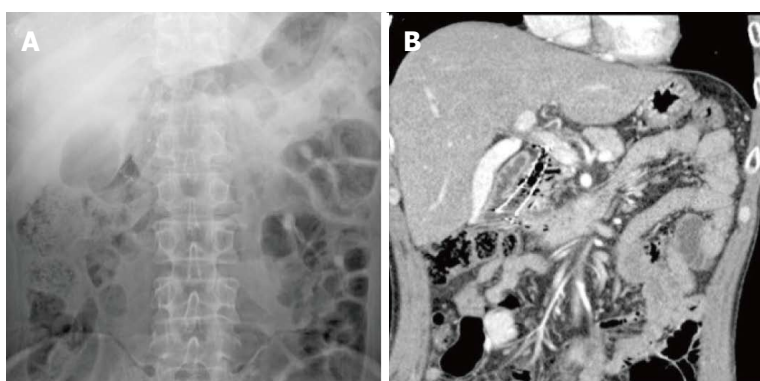


Figure 2 Deployed fully covered self-expandable metallic stent on (A) abdominal X-ray and (B) abdominal computed tomography scan.

ing, the patient was stable and was discharged without complications. Although he underwent endoscopy for removal of the stent on day 28 after insertion, the stent had already fallen out spontaneously.

Because fully covered SEMS are available in large diameters, they can be used in a dilated common bile duct without stent migration. They are capable of maintaining long-term patency of the lumen, in contrast to plastic stents. Also, in comparison with uncovered SEMS, fully covered SEMS have several benefits. Uncovered SEMS tend to embed readily in the duct, making it difficult to remove the stent^[62-64]. Thus, it is inappropriate to use them for benign conditions, such as strictures, obstructions, and traumatic perforations. The fully covered SEMS overcomes these disadvantage, and can be removed readily^[64-66].

However, the optimal duration of stenting has not been established. Bakken *et al.*^[67] reported that the mean duration of stent placement was 67 (range, 0-279) d for benign strictures and 59 (range, 1-601) d for leaks, fistulas, and perforations. Another study showed that the mean duration was 37 (range, 4-84) d for benign conditions^[68]. While discrepancies exist among studies, the time until stent removal is approximately 2 mo for benign esophageal conditions. Several studies have reported stenting durations in peri-ampullary perforations ranging from 10 to 30 d^[25-28]. Moreover, because the treatment outcome did not seem to depend on the duration of stenting, and the stent was removed according to the status of the patient, a stent should be removed when the patient shows improved perforation-related symptoms, signs, and imaging results, such as simple abdominal X-rays and abdomi-

nal CT scans, even after 1 wk of stenting.

Although several studies have demonstrated good outcomes using temporary fully covered SEMS in ERCP-related perforations, clinically, the situation has not been clarified entirely. Because treatment failure after non-surgical treatment, including the insertion of plastic stents and fully covered SEMS, can cause high mortality and morbidity, close attention must be paid to the decision on treatment modality. A decision taking into consideration the surgery time, while performed non-surgical treatment, is also important. Unrelieved abdominal pain, continued leakage on abdominal CT scans, or hemodynamic instability despite non-surgical management are considerations relevant to surgical intervention. Thus, frequent physical examinations and serial follow-up using abdominal CT scans are helpful in checking for adverse events or treatment failure. However, a patient's condition, such as cardiopulmonary comorbidity, hemodynamic instability, and old age, is also highly relevant to postoperative mortality. If a patient with peri-ampullary perforation has an inoperable condition due to high postoperative risks, a fully covered SEMS can be attempted for palliative treatment^[26]. First, it is better to use a fully covered SEMS, especially for a major leakage and large perforation, because ENBD and ERBD may not prevent bile flow into the perforation site completely. Although it is essential to select cases according to their condition, optimal conservative management using a fully covered SEMS may be a good treatment option.

In conclusion, early diagnosis of ERCP-related duodenal perforation is important, and according to the type of perforation, its treatment varies from conservative

management to surgical intervention. Although conservative management is the mainstay for all types of perforations, except type I perforations, the most appropriate treatment modality should be established by performing a comprehensive evaluation of the patient. In particular, a fully covered SEMS for perivaterian perforations was used in selected cases, and the clinical outcomes were encouraging. However, the evidence supporting the use of fully covered SEMS in perivaterian perforations is still insufficient, and further studies are required.

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