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Case Report

Post-cholecystectomy total bile duct strictures: Cases for magnetic compression anastomosis

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Bile duct injuries are a serious issue, and their surgical treatment carries the risk of morbidity and mortality. In selected cases, non-surgical treatments are possible, even for total strictures. We outline the technique and results of using magnetic compression anastomosis (MCA) to treat post-cholecystectomy bile duct stricture (PCBDS), in two female patients. Initially, a bilio-cutaneous tract was established via external biliary drainage, followed by the positioning of both endoscopic and percutaneous biliary magnets. After their approximation and subsequent removal, a fully covered self-expandable metal stent (FCSEMS) was deployed across the stricture. The magnet coupling was successfully achieved within the first two weeks of placement. The FCSEMS was maintained for durations of 12 and 16 months. Follow-up durations were 28 and 15 months post-FCSEMS removal. Both patients remain asymptomatic, with normal laboratory and imaging studies, and no adverse events were reported. MCA proves to be a safe and effective method for treating selected cases of total PCBDS. However, further studies and long-term follow-up are required to fully assess the efficacy of this technique.

Key Words: Biliary tract; Bile ducts; Stricture; Magnetics

INTRODUCTION

Bile duct injuries (BDIs), associated with cholecystectomy are rare, but pose serious concerns, affecting not only patients but also impacting their families and potentially incurring legal liabilities for the surgical team [1].

BDI are categorized into types A through E, following the Strasberg classification [2], which integrates Bismuth's classification with type E [3]. This type includes the majority of post-cholecystectomy bile duct strictures (PCBDS) (Fig. 1).

Various therapeutic strategies, both surgical and non-surgical, have been employed to restore biliary-enteric continuity and achieve long-term patency, depending on the type, location, and severity of PCBDS [4]. While surgical hepaticojejunostomy has consistently shown favorable outcomes for treating PCBDS, certain specialized teams have achieved comparable results with endoscopic progressive biliary dilation, which carries lower morbidity and mortality risks [1]. However, advancing a guidewire through the biliary stricture, essential to this non-surgical approach, poses significant challenges in cases of total biliary occlusion.

Biliary magnetic compression anastomosis (MCA) is a therapeutic option that involves the reestablishment of the lumen between two non-communicating biliary segments through a process of progressive tissue necrosis. This technique has primarily been described for treating biliary strictures associated with liver transplantation [5,6], but its use in patients with PCBDS has been limited to a few case studies.

We describe and demonstrate the application of MCA in two patients with PCBDS who had unsuccessful previous endoscopic and/or percutaneous recanalization attempts.

CASES

The procedures were explained to the patients and informed

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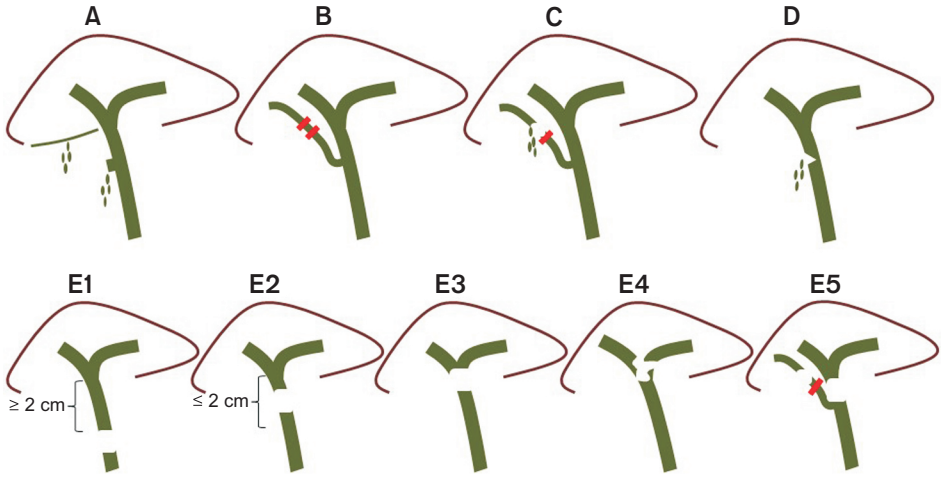

Fig. 1. Strasberg´s classification for bile duct injuries. Type A: bile leak from cystic duct stump or small biliary ducts in the gallbladder bed, type B: clipping or occlusion of aberrant right hepatic duct(s), type C: bile leak from right posterior sectoral duct injuries, type D: bile leak from a lateral injury of the common hepatic duct (CHD), type E (Bismuth classification): injury of CHD. Depending on the stricture level, below the confluence of hepatic ducts: E1: > 2 cm, E2: < 2 cm, E3: preserved hepatic ducts confluence, E4: injury at the biliary confluence or above, separating the right and left hepatic ducts, E5: injury of the CHD + an aberrant right hepatic duct.

consent was obtained, and authorization was granted for the publication of images.

Following clinical evaluation, laboratory studies, and imaging via abdominal ultrasound, hepatic CT angiography, and magnetic resonance cholangiopancreatography, the treatment was conducted in three phases: 1) Percutaneous transhepatic cholangiography, external biliary drainage, and the creation of a biliocutaneous tract using a 10-Fr catheter. 2) Percutaneous and endoscopic placement of two cylindrical biliary magnets made of Samarium and Cobalt (Taewoong Medical®), with each magnet measuring 4 mm in diameter and 8 mm in length, possessing a magnetic strength of 5500 Gauss. A 3-0 silk suture was attached to the magnets' ends to aid in their manipulation (Fig. 2). The magnets were positioned as close together as possible to maximize their magnetic attraction. Additionally, the major duodenal papilla was dilated with a 10 mm pneumatic balloon, and the percutaneous biliary tract was expanded up to 16 Fr to facilitate the placement of the magnets (Fig. 3) [7]. Weekly radiological checks were conducted until magnetic

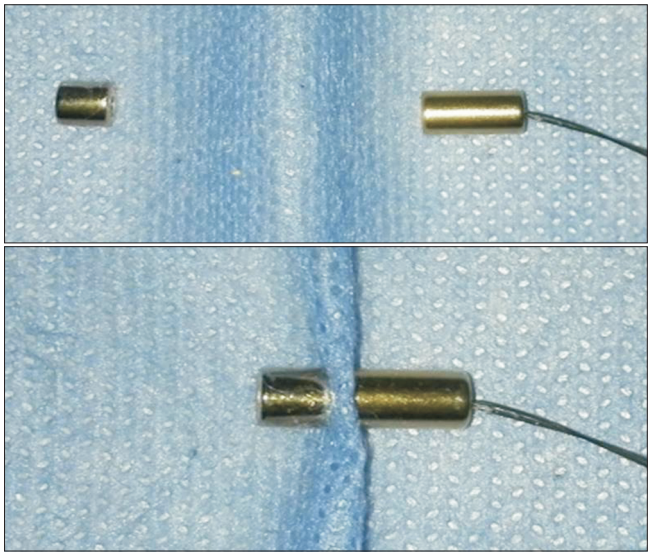

Fig. 2. Samarium and Cobalt magnets (4 mm × 8 mm) (Taewoong Medical®).

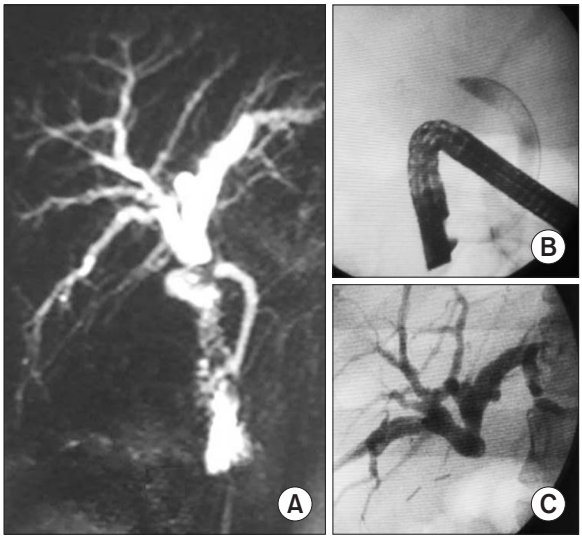

Fig. 3. Strasberg type E2 biliary stricture. Magnetic resonance cholangiopancreatography reveals a 5-mm gap between the ends of the main bile duct (A). There is no contrast passage through the stricture during endoscopic (B) and percutaneous cholangiography (C).

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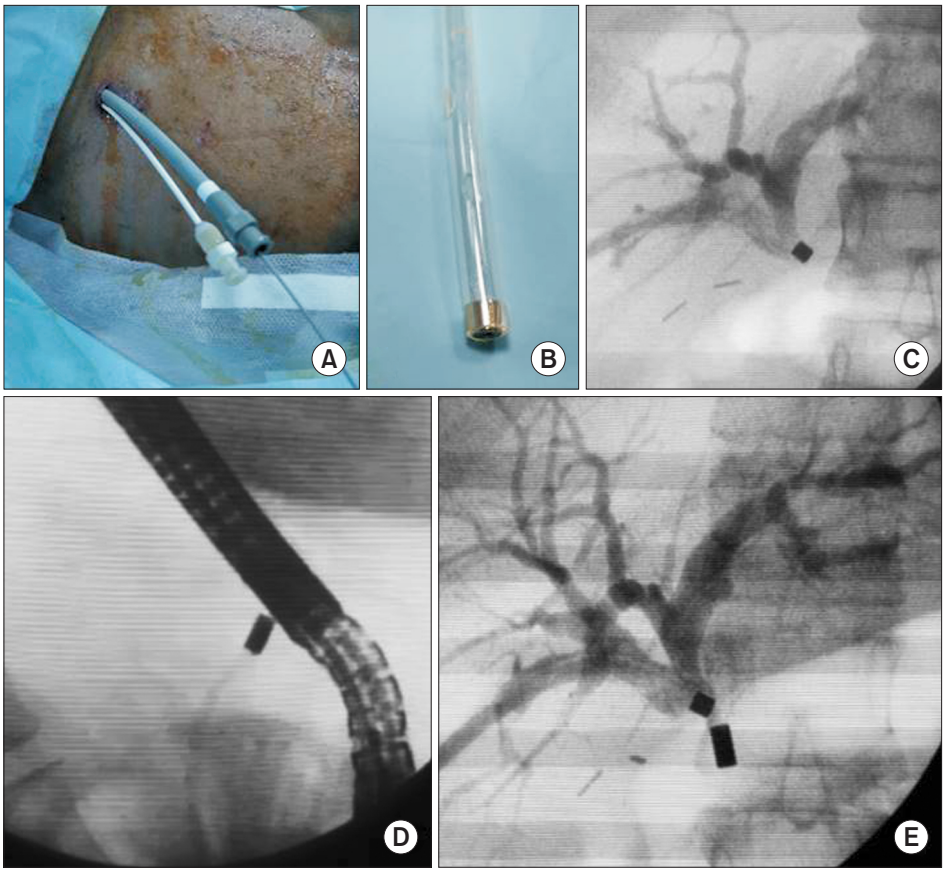

Fig. 4. Sequence of percutaneous and endoscopic insertion of biliary magnets. Dilating the percutaneous biliary tract (A), the proximal magnet is anchored to a 16 Fr silicone feeding tube (B); subsequent fluoroscopic guidance allows pushing the magnet until it reaches the proximal biliary end (C). The endoscopic magnet is then advanced (D) until both magnets are aligned as closely as possible (E).

approximation was confirmed. 3) Percutaneous removal of the magnets and insertion of a 60 mm × 10 mm fully covered self-expandable metal stent (FCSEMS) (Hanarostent®, MITech) above the stricture, ensuring no obstruction of primary hepatic ducts, using a combined percutaneous-endoscopic technique with fluoroscopic guidance (Fig. 4, 5). During follow-up, clinical examinations, laboratory tests, and abdominal ultrasound were performed at 1, 3, 6, and 12 months post stent removal, then annually.

No experimental activities involving human subjects were conducted, and the methods used have been extensively studied and reported by other research groups [7].

Case 1

A 34-year-old female with a history of laparoscopic cholecystectomy and subsequent biliary peritonitis due to a lateral injury to the main bile duct presented. She underwent laparoscopic drainage of the intra-abdominal collection, intraoperative cholangiography, and suturing of the lateral BDI. Five months after the reintervention, she was referred to our hospital due to obstructive jaundice. Laboratory results included: total bilirubin: 5.95 mg% (direct: 1.24 mg%), alkaline phosphatase (ALP):

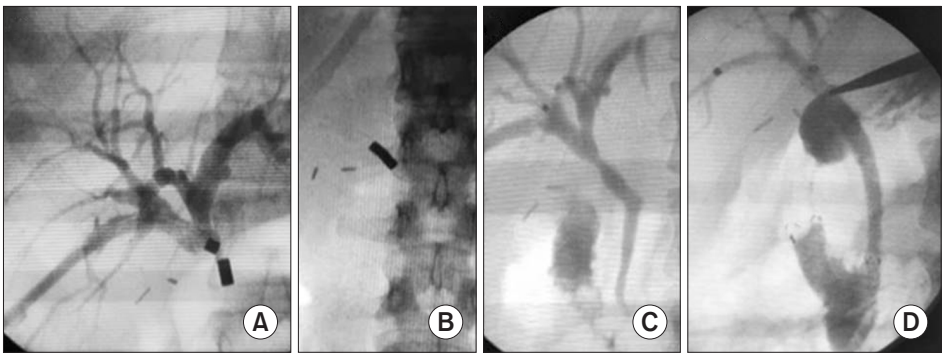

Fig. 5. Magnet coupling (A, B), biliary recanalization (C), and placement of a fully covered self-expandable metal stent (D).

Table 1. Biliary magnetic compression anastomosis

Case	Age (yr)	Type of bile duct stricture (Strasberg)	Evolution	PTBD	Magnets placement	Magnetic tract permeabilization	FCSEMS indwelling	Follow-up without FCSEMS
1	34	E2	5 mon	5th mon	8 mon	2nd wk	12 mon	28 mon
2	26	E2	2 wk	3rd wk	3.5 mon	1st wk	16 mon	15 mon

Epidemiological data, procedures and follow-up.
PTBD, percutaneous transhepatic biliary drainage; FCSEMS, fully covered self-expandable metal stent.

399 U/L, alanine aminotransferase (ALT): 39 U/L, aspartate aminotransferase (AST): 94 U/L, all with a normal coagulation profile. Magnetic resonance cholangiopancreatography (MRCP) showed a total bile duct stricture, classified as Strasberg type E2, with a 0.5 cm gap between the ends of the main bile duct (Fig. 3A). Attempts at endoscopic biliary drainage (ERCP) were unsuccessful due to the inability to pass contrast medium and a guidewire through the biliary stricture (Fig. 3B). Consequently, a right-sided external percutaneous transhepatic biliary drainage (PTBD) catheter was positioned (Fig. 3C), leading to clinical improvement. The procedures adhered to the timeline detailed in Table 1 and shown in Fig. 4 and 5. The patient, following stent removal and 28 months of follow-up, remains asymptomatic with laboratory tests and abdominal ultrasound within normal limits.

Case 2

A 26-year-old female presented with obstructive jaundice three weeks after an open cholecystectomy. Laboratory results showed: total bilirubin: 5.8 mg% (indirect: 3.6 mg%), ALP: 406 U/L, gamma-glutamyl transferase: 140 U/L, ALT: 366 U/L, AST: 530 U/L. MRCP identified a Bismuth-Strasberg type E2 bile duct stricture with a 1 cm gap between the bile duct ends. As in the previous case, placement of a right-sided external PTBD catheter occurred, followed by installation of biliary magnets and subsequently, a FCSEMS which was maintained for 16 months and removed post-pregnancy completion (Fig. 6). At 15 months post-treatment, the patient remains symptom-free with laboratory values and abdominal ultrasound results within normal limits.

Both patients reported a high level of satisfaction with the outcome.

Ethical consideration

This report was approved by the Bioethics Committee for Human Research on 28/03/2021, in accordance with the Declaration of Helsinki and good clinical practice guidelines. Both patients provided signed consent allowing the publication of this material.

DISCUSSION

BDI related to cholecystectomy covers a wide range of injuries, from leaks at the cystic duct remnant or hepatic bed ducts to severe injuries affecting the intrahepatic bile ducts, with some cases also involving vascular injuries [2,3,8]. In referral centers, most total bile duct strictures are managed surgically, achieving long-term success rates of approximately 80%, with a morbidity rate of 15% and a late mortality rate of 2% [1].

A select group of patients with PCBDS can be managed non-surgically, utilizing endoscopic procedures for the placement of multiple plastic biliary stents or FCSEMS. However, successful passage of the guidewire through the stricture is essential for these therapies. When this is not possible, MCA is essential in the initial phase of treatment, enabling safe recanalization of the interrupted biliary tract and focusing on progressive and sustained dilation to ensure long-term patency. The therapeutic success of endoscopic procedures for treating

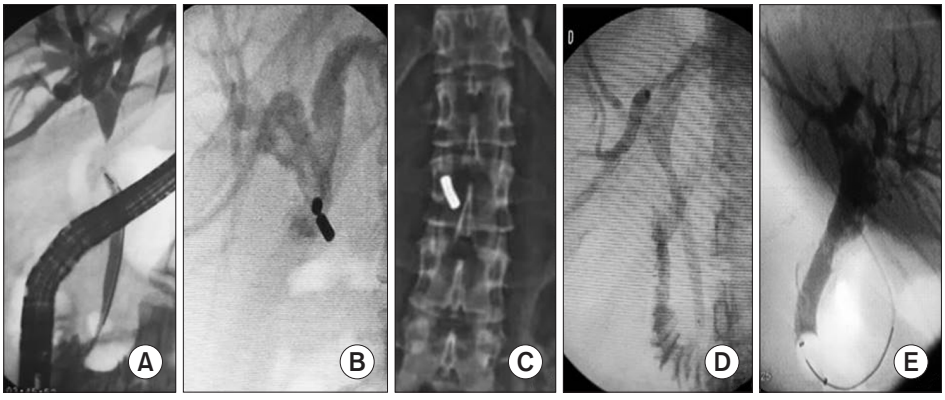

Fig. 6. Percutaneous-endoscopic cholangiogram (A), bile duct tract reestablished (B, C), fully covered self-expandable metal stent dilating the biliary stricture (D), and an endoscopic cholangiogram following stent retrieval (E).

PCBDS, using multiple plastic stents or FCSEMS, exceeds 80% [9,10].

Yamanouchi (1998) [11] developed the method of bilio-enteric "anastomosis" by magnetic compression, based on the concept of creating a "fistula" through progressive tissue ischemia, as described by Denan in 1826 [12]. Various groups have developed more efficient variations of this technique for addressing biliary strictures of different etiologies. In the patients described, we used two Samarium-Cobalt (SmCo5) magnets (Taewoong Medical®), an alloy that serves as a powerful magnet with high resistance to demagnetization.

The treatment initiated during the first year after the stricture installation has yielded good results. In our patients, the evolution of PCBDS at the time of magnet placement was less than 8 months, with magnetic approximation observed within the first two weeks. Previous reports show an average approximation time of 53 days (range of 9–181 days) [7,13].

A short-time biliary recanalization and biliary patency could be associated with specific characteristics of the bile duct ends involved: regular surface, alignment on their axis, non-rotation, and a separation distance not exceeding 1 cm, as previously described [14,15]. These characteristics are similar to those observed in biliary strictures post-liver transplantation.

The majority of series from Asia primarily describe the use of MCA in post-liver transplant patients [5,6], however, the global experience with MCA for treating post-cholecystectomy strictures remains limited. Recently, Jang et al. [16] reported on 10 patients with PCBDS who had unsuccessful endoscopic or percutaneous treatments. They used MCA and FCSEMS, which were initially in place for three months and then replaced for an additional three months, achieving 100% technical success. Do utilized MCA and FCSEMS for six months, in a 60-year-old patient with a Strasberg type E4 PCBDS, achieving satisfactory results [17]. Additionally, Ödemiş et al. [18] described the use of MCA in 10 patients with PCBDS (9: Bismuth-Strasberg type E2 and 1: Bismuth-Strasberg type E4), employing Neodymium iron boron magnets (N52 and N35) with 100% effectiveness. In these cases, the distance between the bile duct ends was less than 10 mm, and metallic stents were placed in half of the cases (5 patients), which remained indwelling for less than two months .

MCA is an innovative technique in the Americas, and to our knowledge, there are no previous reports on its application for PCBDS within this region.

We believe that further studies with long-term follow-up are essential to assess the outcomes of this technique.

To conclude, MCA is an effective and safe therapeutic option for the recanalization of selected PCBDS cases. Evaluating long-term outcomes is the most reliable method to ascertain the true effectiveness of this treatment modality.

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Conceptualization: FPG. Data curation: FPG, FSM, YVB. Methodology: FPG, FSM, YVB. Visualization: FPG, YRM. Writing - original draft: FPG. Writing - review & editing: FPG, YRM, DKL.

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