Perforated Duodenal Diverticulum With Postoperative Diverticulum Bleeding Successfully Treated Using Transcatheter Arterial Embolization

Hidenori Tomida 1, Kan Nakagawa 2, Hideyasu Matsumura 2, Imai Shinichiro 2, Akimasa Matsushita 2, Shoichiro Koike 2

1. Surgery, Shindu University School of Medicine, Matsumoto, JPN  2. Surgery, National Hospital Organization Matsumoto Medical Center, Matsumoto, JPN

Corresponding author: Hidenori Tomida, hidenori.tomida.0920@gmail.com

Abstract

A diverticulum is a relatively common finding that is generally discovered incidentally; it is most commonly observed in the colon, followed by the duodenum. However, duodenal diverticulum perforation (DDP) is a rare complication. Due to its rarity, its diagnosis is often challenging and the appropriate treatment remains unclear, possibly contributing to its high mortality rate. Traditionally, surgical repair is the primary mode of treatment. However, with the recent advancements in medical technology, conservative management such as bowel rest and endoscopic drainage help successfully manage DDP. Duodenal diverticulum bleeding (DDB) is a rare cause of upper gastrointestinal bleeding. While endoscopic, angiographical, and surgical treatments have been performed to achieve hemostasis, there is no consensus regarding the optimal treatment for DDB. We describe a case of a perforated duodenal diverticulum (DD) with postoperative diverticulum bleeding. Our patient, an elderly female, complained of abdominal pain. Computed tomography images revealed free air in the retroperitoneum, and gastrointestinal perforation was suspected. During the emergency surgery, a perforated DD was detected in the third portion of the duodenum. Due to severe inflammation, diverticulectomy was not performed as it was deemed risky. Instead, we directly sutured the orifice using an omental patch. Duodenal leakage was observed from postoperative day (POD) 3 with bleeding from the remnant DD occurred on PODs 6 and 15. An attempt at endoscopic hemostasis failed, but transcatheter arterial embolization (TAE) was successfully performed. The postoperative course was complicated, and the patient died on POD 54. To the best of our knowledge, this is the first report on DD perforation with postoperative DDB. The remnant DD may be damaged by the digestive juices and result in bleeding. Precautionary measures for duodenal leakage should be undertaken when the DD is unresectable. Additionally, TAE is effective for postoperative DDB.

Introduction

Following the colon, the duodenum is the second most common site of a diverticulum, and it is a relatively common finding that is generally discovered incidentally during endoscopic or imaging studies [1]. However, duodenal diverticulum perforation (DDP) is a rare complication. Due to its rarity, its diagnosis is often challenging and the appropriate treatment is still unclear, possibly contributing to its high mortality rate. A recent study reported an 8% mortality rate for DDP [2]. Traditionally, surgical repair is the primary mode of treatment. However, with the recent advancements in medical technology, conservative management such as bowel rest and endoscopic drainage have been successful in managing DDP [2]. Surgical treatments range from drainage-only to pancreatoduodenectomy (PD), but diverticulectomy (excision of the diverticulum and repair of the duodenum) is the most commonly performed intervention [2].

Duodenal diverticulum bleeding (DDB) is a rare cause of upper gastrointestinal (GI) bleeding, accounting for as low as 0.14% of all cases [3]. While endoscopic, angiographical, and surgical treatments have been performed to achieve hemostasis, there is no consensus regarding the optimal treatment for DDB [4]. Owing to the difficulty in reaching DD via standard upper GI endoscopy, very few cases of successful endoscopic hemostasis have been reported [5], and angiographic hemostasis should be considered as the first-line treatment for DDB [6].

Case Presentation

A frail 83-year-old female presented at our hospital with a five-day history of appetite loss and right-sided back pain. Her body weight, height, and body mass index were 33.0 kg, 150.0 cm, and 14.67, respectively. Her medical comorbidities included chronic heart failure, valvular disease, paroxysmal atrial fibrillation, and...
chronic kidney disease.

Blood examination results on admission revealed renal dysfunction (creatinine: 2.96 mg/dL), but the inflammatory marker levels were normal (white blood cell count: 4,260 U/L, C-reactive protein: 0.34 mg/dL). Hepatobiliary and pancreatic enzymes were within the normal range. Non-contrast computed tomography (CT) images revealed an old right rib fracture. The initial diagnoses were dehydration and rib fracture, and she was followed up as an inpatient and continuously received conservative treatment.

On day 10 of hospitalization, the patient complained of right lower quadrant (RLQ) abdominal pain. Abdominal examination revealed tenderness in the RLQ without guarding. Blood test results revealed significantly elevated inflammatory marker levels (white blood cell count: 13,700 U/L, C-reactive protein: 28.73 mg/dL) and renal dysfunction (creatinine: 2.59 mg/dL). Non-contrast CT was repeated, and the images revealed the presence of retroperitoneal free air in the pararenal area (Figure 1). The CT results and the patient’s symptoms suggested gastrointestinal perforation, including duodenal perforation and colonic perforation.

We decided to perform an emergency operation. During exploratory laparotomy, a small amount of non-contaminated ascites was detected. The dorsal side of the ascending colon and the retroperitoneal space exhibited severe inflammatory changes. On the approach to the duodenum, periduodenal dark gray pus was observed. After mobilization of the duodenum, we discovered the perforated diverticulum at the superior wall of the third portion of the duodenum (Figure 2). There were no findings of mucosal inflammation suggestive of ulceration. Therefore, a diagnosis of a perforated DD in the third portion of the duodenum was made. The DD was encircled by the pancreatic head, and the entire diverticulum could not be visualized. Due to the severe damage of the surrounding tissue and the location of the DD, diverticulectomy was deemed risky. We instead directly sutured an omental patch to repair the orifice with subsequent placement of a retroperitoneal drain.
FIGURE 2: Intraoperative findings.

Intraoperative photographs showing perforated diverticulum at the superior wall of D3.

DD: duodenal diverticulum; D2: the second portion of duodenum; D3: the third portion of duodenum; P: pancreas.

From postoperative day (POD) 3, leakage of bile and pancreatic juices continued (amylase and total bilirubin levels in the drainage fluid: 17,546 IU/L and 2.8 mg/dL, respectively), but this effectively controlled the inflammatory marker levels. We considered performing an endoscopic drainage of the bile juice, but the patient appeared unable to tolerate endoscopic retrograde cholangiopancreatography (ERCP) because of postoperative respiratory disorder.

On POD 6, the drainage was observed to be bloody and contrast-enhanced CT images revealed extravasation from the neck of the DD (Figure 3a). Emergency endoscopy revealed acute bleeding from the eroded mucosa of the DD in the third portion of the duodenum. The exact source of bleeding could not be identified, but temporary hemostasis was successfully achieved using clips and injecting 5 cc of hypertonic saline-epinephrine solution. Intraprocedural duodenography revealed a DD with a small neck arising from the third portion of the duodenum (Figure 3b).
On POD 13, re-bleeding occurred due to the presence of bloody drainage. Contrast-enhanced CT images revealed extravasation from the same portion of the DD, and the previously attached clips were detached from the bleeding point (Figure 4a). Emergency angiography showed extravasation of the contrast material from a distal branch of the anterior superior pancreaticoduodenal artery, and subsequent hemostasis was achieved by embolization using eight microcoils (Figure 4b, c). After an endovascular procedure, no further bleeding was observed.
FIGURE 4: Computed tomography and emergency angiography.

(a) CT scan showing extravasation (red arrow) from the neck of the duodenal diverticulum (as seen previously). (b) Emergency angiography showing extravasation (red arrow) from a distal branch of the anterior superior pancreaticoduodenal artery. (c) Hemostasis is achieved by embolization.

Complete wound dehiscence and a burst abdomen occurred on POD 26. Severe malnutrition was suspected as the cause, and re-closure was needed. While the patient was on the medical service, she was intubated and tracheotomy was performed for acute decompensation due to chronic heart failure. She subsequently developed multiorgan failure and died of acute kidney injury on POD 54.

Discussion

A DD is a pouch attached to the duodenum and can be commonly found at the medial wall of the second (D2) or superior wall of the third (D3) portions of the duodenum [7]. It is a relatively common finding, and it is seen in up to 23% of asymptomatic cases, the majority of which remain asymptomatic throughout life [8]. However, complications such as inflammation, perforation, bleeding, pancreatitis, and obstructive jaundice can occur in 5%-10% of cases [1].

DDP is a rare but potentially severe complication that has been previously reported in the literature, mainly in case reports and series. The diagnosis of DDP is challenging and tends to be delayed because the symptoms are vague and non-specific. The duodenum is mainly located in the retroperitoneum, and the DD usually perforates into the retroperitoneal space. Therefore, the initial physical examination can be comparatively normal or indicate mild tenderness; some patients may complain of back pain, as in our case. CT provides an effective and accurate examination method in diagnosing DDP as it may reveal extraluminal
gas and fluid collection [8]. Retroperitoneal free air in the pararenal area on CT images was reported as a suspicious finding for DDP [9].

Once DDP has been diagnosed, surgical management is traditionally performed. The operative method is selected based on the condition and location of the perforated DD and the general condition of the patient. A previous report revealed that diverticulectomy with drainage is the most commonly performed procedure [2]. Conservative treatment based on bowel rest and broad-spectrum antibiotics may be considered in some stable patients when an early diagnosis is made, or in elderly patients with severe comorbidities who are poor surgical candidates [10,11]. Although DDP is rare, the mortality rate was reportedly 13%-34% in older series [1,12]. A recent study of DDP cases from 1989 to 2012 indicated that the mortality rate was 8% [2].

Based on our search on PubMed (2013-present), there have been 29 reports of non-traumatic, non-iatrogenic DDP (Table 1) [11-32]. Including our case, the location of DDP was at D2 in 20 cases (67%) and D3 in six cases (20%). The most frequently performed treatments were diverticulectomy and direct suture in 15 cases (50%) and 14 cases (46%), respectively, similar to the previous report [2]. For the purpose of duodenal decompression, duodenostomy has been performed in three cases [28,32]. As a diversion procedure, duodenojejunostomy (two cases) and pyloric exclusion (one case) have been reported [16,19,25]. Biliary drainage was performed in three cases (bilio-duodenal drain, cystic duct tube, and postoperative endoscopic nasobiliary drainage, one case each) [14,28,29]. In some cases, dissection of the duodenum and performance of PD had to be undertaken because of severe inflammation and the risk of postoperative leakage [26, 28]. An intraduodenal suture using a Lap-Protector mini® was performed in one case in which DD was located near the inflamed pancreatic head and diverticulectomy would have been difficult [30]. Interestingly, three of the patients had undergone post-gastrectomy with Roux-en-Y gastric bypass reconstruction [28,32]. An increased intraduodenal pressure due to a blind loop has been a suggested cause of DDP [28]. A total of six cases (20%) were treated using conservative therapy, which consisted mainly of bowel rest, intravenous antibiotics, and endoscopic drainage. All cases had uncomplicated courses of recovery without recurrences of leakage or progression to a fatal condition. There were three deaths, which included our case, indicating a mortality rate of 10% (D2: one case and D3: two cases) [14,23].

| Author            | Year | Age (years) | Sex | Operation                                      | Location | Complications         |
|-------------------|------|-------------|-----|-----------------------------------------------|----------|-----------------------|
| Barillaro et al.  | 2013 | 83          | F   | Diverticulectomy, intraduodenally drainage tube | D3       | None                  |
| Rossetti et al.   | 2013 | 91          | ND  | Diverticulectomy, jejunostomy                 | D2       | None                  |
|                   | 2013 | 83          | ND  | Diverticulectomy, jejunostomy                 | D2       | None                  |
|                   | 2013 | 78          | ND  | Diverticulectomy                              | D2       | Leakage               |
|                   | 2013 | 76          | ND  | No operation                                  | D2       | None                  |
|                   | 2013 | 68          | ND  | Drainage                                      | D2       | Cardiac comorbidity/death |
|                   | 2013 | 65          | ND  | Diverticulectomy                              | D2       | None                  |
|                   | 2013 | 48          | ND  | Diverticulectomy, jejunostomy, bilio-duodenal drain | D3       | None                  |
| Haboubi et al.    | 2014 | 78          | F   | Diverticulectomy                              | D2       | None                  |
| Fujisaki et al.   | 2014 | 69          | M   | Diverticulectomy, Roux-en Y duodenoejejunostomy, cholecystectomy | D2       | Leakage               |
| Costa et al.      | 2014 | 79          | F   | Partial duodenal resection, duodenoejejunostomy | D4       | None                  |
| Yeh               | 2016 | 67          | F   | Laparoscopically diverticulectomy              | D2       | None                  |
| Glener et al.     | 2016 | 65          | F   | Diverticulectomy, pyloric exclusion, gastrojejunostomy, jejunostomy | ND       | None                  |
| Branco et al.     | 2017 | 80          | M   | Diverticulectomy                              | D2       | None                  |
| Fan and Talbot    | 2017 | 75          | F   | No operation                                  | D2       | None                  |
| Degheili et al.   | 2017 | 81          | M   | No operation                                  | ND       | None                  |
| Shirobe et al.    | 2017 | 52          | F   | No operation                                  | D2       | None                  |
### TABLE 1: Cases of duodenal diverticulum perforation.

ND: Not described.

| Study                  | Year | Age | Sex | Procedure                                    | Drainage | Other Complications                      |
|------------------------|------|-----|-----|----------------------------------------------|----------|------------------------------------------|
| Shen and Leong [24]    | 2017 | 85  | M   | Partial duodenal resection, duodenojejunostomy | ND       | ND                                      |
| Khan et al. [25]       | 2018 | 82  | F   | Diverticulectomy, duodenojejunostomy, gastrostomy | D3       | Sepsis/death                             |
| Kim and Park [11]      | 2018 | 68  | M   | No operation                                  | ND       | None                                     |
| Philip and Coieier [26]| 2019 | 70  | F   | Pancreatoduodenectomy                         | D2       | None                                     |
| Sahned et al. [27]     | 2019 | 77  | F   | Diverticulectomy, jejunal serosal patch        | D2       | None                                     |
| Yagi et al. [28]       | 2019 | 66  | M   | Pancreatoduodenectomy                         | D2       | None                                     |
|                       | 2019 | 52  | M   | Direct suture, duodenostomy, jejunostomy, cystic duct tube | D2 and D3 | None                                     |
| Shimada et al. [29]    | 2020 | 60  | F   | Omental patch                                 | D2       | Leakage                                  |
| Maki et al. [30]       | 2020 | 94  | F   | Intraduodenal diverticulectomy                 | D2       | None                                     |
| Moysidis et al. [31]   | 2020 | 51  | F   | Diverticulectomy                              | D2       | None                                     |
|                       | 2020 | 58  | F   | No operation                                  | D2       | Upper respiratory infection              |
| Kabelitz et al. [32]   | 2020 | 47  | F   | Direct suture, duodenostomy                    | D3       | None                                     |
| Our case               | 2021 | 83  | F   | Direct suture, omental patch                   | D3       | Leakage, Diverticulum bleeding/death     |

Except for our case, there have been no reported cases of DDP with postoperative DDB. In our case, the unresectable portion of the DD may have been damaged by postoperative leakage, resulting in DDB. Pancreatic juice is activated by bile juice and duodenal juice. Activated pancreatic juice can cause severe damage to fragile tissues, and bleeding can occur from eroded vessels adjacent to the inflamed DD. Based on the above, postoperative duodenal leakage may be a potential risk factor for DDB, and drainage of digestive juices (duodenal, bile, and pancreatic juice) should be considered. The effectiveness of endoscopic nasobiliary and nasopancreatic drainage for postoperative leakage of DDP has been reported [29]. However, postoperative ERCP for unstable patients, as in our case, presents several risks. In cases wherein postoperative leakage is highly suspected, intraoperative procedures for drainage of bile or duodenal juice, such as cystic duct tube placement and duodenostomy, should be considered.

DDB is extremely rare and accounts for as low as 0.14% of all upper GI bleeding [3]. Bleeding can occur from the eroded vessels adjacent to the inflamed diverticulum [33]. DDB has been reported to occur most commonly from the D3 and fourth portions (D4) but rarely from D2 [34]. Gastrointestinal endoscopy is usually the initial examination for GI bleeding, which also allows for hemostasis if bleeding is detected. However, performing endoscopic examination in the distal duodenal lumen is challenging due to poor operability. As it is difficult to access the DD via a standard upper GI endoscopy, very few cases of successful endoscopic hemostasis have been reported to date [5]. Transcatheter arterial embolization (TAE) has been performed as a diagnostic and therapeutic procedure for GI bleeding. Several studies have reported that an angiographic embolization is considered an initial therapy for colonic bleeding [35,36]. TAE for upper GI bleeding had been used when endoscopic hemostasis was unsuccessful and surgical intervention is not recommended [37]. TAE is less invasive than surgery and is a viable option for candidates with a poor medical condition, such as for elderly patients and surgically high-risk cases [37]. It is also believed that performing endoscopic hemostasis for bleeding from D3 or D4 is sometimes difficult due to their positions; therefore, TAE and surgical intervention should be considered in these portions [38].

Including our case, a summary of all 11 cases (2005–present) is provided in Table 2 [5,6,39-45]. The bleeding site was D2 in five cases and D3 in five cases. In nine cases, endoscopic treatment was initially performed, but five cases required further endoscopic, radiological, or surgical treatment. A notable fact is that in three of the five cases of endoscopic failure, TAE achieved hemostasis.
| Author               | Year | Age (years) | Sex | Location | Treatment               |
|---------------------|------|-------------|-----|----------|-------------------------|
| Kua et al. [39]     | 2005 | 69          | F   | D2       | Endoscopic surgery      |
| Kobayashi et al. [40]| 2008 | 59          | M   | D2       | Endoscopic TAE          |
| Kwon et al. [6]     | 2009 | 69          | F   | D3       | TAE surgery             |
| Lee et al. [41]     | 2010 | 67          | M   | D2       | Endoscopic TAE          |
| Nishiyama et al. [42]| 2012 | 71          | F   | D2       | Endoscopic              |
| Whilhelmsen et al. [43]| 2014 | 69          | M   | D3       | Endoscopic TAE          |
| Matuso et al. [5]   | 2015 | 68          | F   | D3       | Endoscopic              |
| Hatt and Mills [44] | 2016 | 66          | F   | D4       | Surgery                 |
| Chatila et al. [45] | 2019 | 57          | M   | D2       | Endoscopic              |
| Our case            | 2021 | 83          | F   | D3       | Endoscopic TAE          |

**TABLE 2: Cases of duodenal diverticulum bleeding.**

TAE: transcatheter arterial embolization; D2: second portion of the duodenum; D3: third portion of the duodenum; D4: fourth portion of the duodenum.

**Conclusions**

DD is a relatively common finding and is rarely complicated; however, DDP is a potentially serious complication. Management of DDP is still controversial, but the remnant DD could be damaged by postoperative leakage, which could result in DDB. During surgery, precautionary measures for duodenal leakage are important when the DD is unresectable. TAE for DDB may be as effective as endoscopic hemostasis, including postoperative cases. When endoscopy fails to reveal the exact source of bleeding, TAE should be investigated.

**Additional Information**

**Disclosures**

**Human subjects:** Consent was obtained or waived by all participants in this study. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

**Acknowledgements**

We would like to thank Editage (http://www.editage.jp) for English language editing.

**References**

1. Juler GL, List JW, Stemmer EA, Connolly JE: Perforating duodenal diverticulitis. Arch Surg. 1969, 99:572-8. 10.1001/archsurg.1969.01340170024006
2. Thorson CM, Paz Ruiz PS, Roeder RA, Sleeman D, Casillas VI: The perforated duodenal diverticulum. Arch Surg. 2012, 147:81-8. 10.1001/archsurg.2011.821
3. Chen YY, Yen HH, Soon MS: Impact of endoscopy in the management of duodenal diverticular bleeding: experience of a single medical center and a review of recent literature. Gastrointest Endosc. 2007, 66:831-5. 10.1016/j.gie.2007.06.001
4. Ferreira-Aparicio FE, Gutiérrez-Vega R, Gálvez-Molina Y, Ontiveros-Navares P, Athie-Gutiérrez C, Montalvo-Javé EE: Diverticular disease of the small bowel. Case Rep Gastroenterol. 2012, 6:668-76. 10.1159/000343598
5. Matuso Y, Yasuda H, Suzuki M, et al.: Hemostasis achieved endoscopically for diverticular bleeding from the horizontal portion of the duodenum. Clin Med Insights Gastroenterol. 2015, 8:61-4. 10.4157/CGast.552421
6. Kwon YJ, Kim BH, Kim SH, Kim BS, Kim HU, Choi EK, Jeong IH: Duodenal obstruction after successful...
embolization for duodenal diverticular hemorrhage: a case report. World J Gastroenterol. 2009, 15:3819-22. 10.3748/wjg.15.3819

7. Pearl MS, Hill MC, Zeman RK: CT findings in duodenal diverticulitis. AJR Am J Roentgenol. 2006, 187:W392-5. 10.2214/AJR.06.0215

8. Bittle MM, Gunn ML, Gross JA, Rohrmann CA: Imaging of duodenal diverticula and their complications. Cure Probl Diagn Radiol. 2012, 41:20-9. 10.1067/cpradiol.2011.07.001

9. Buyukkaya A, Buyukkaya R, Ozturk B, Ozel MA, Santas A: Characteristic imaging findings of duodenal perforation. Acta Gastroenterol Belg. 2015, 78:248-9.

10. Oukachchi N, Broutzes S: Management of complicated duodenal diverticula. J Visc Surg. 2015, 150:173-9. 10.1016/j.jviscsurg.2015.04.006

11. Kim KH, Park SH: Conservative treatment of duodenal diverticulitis perforation: a case report and literature review. Open Access Emerg Med. 2018, 10:101-4. 10.2147/OAEM.S168487

12. Duarte B, Nagy KK, Cintron J: Perforated duodenal diverticulum. Br J Surg. 1992, 79:877-81. 10.1002/bjs.1800790907

13. Barillaro J, Grassi V, De Sol A, et al.: Endoscopic rendezvous after damage control surgery in treatment of retroperitoneal abscess from perforated duodenal diverticulum: a technical note and literature review. World J Emerg Surg. 2015, 8:26. 10.1186/s1749-729X-8-26

14. Rossetti A, Christian BN, Pascall B, Stephens D, Philippe M: Perforated duodenal diverticulum, a rare complication of a common pathology: a seven-patient case series. World J Gastrointest Surg. 2015, 7:45-50. 10.4240/wjgs.v5.15.47

15. Haboubi D, Thapar A, Bhan C, Oshowo A: Perforated duodenal diverticulae: importance for the surgeon and gastroenterologist. BMJ Case Rep. 2014, 2014:1-3. 10.1136/bcr-2014-205859

16. Fujiiski S, Takashina M, Sakurui K, Tomita R, Takayama T: Simple diversion by duodenoejejunostomy for a retroperitoneal perforation of the second portion of the duodenal diverticulum. Int Surg. 2014, 99:628-31. 10.9738/INTSURG-D.15-00103.1

17. Costa Simões V, Santos B, Magalhães S, Faria G, Sousa Silva D, Davide J: Perforated duodenal diverticulum: surgical treatment and literature review. Int J Surg Case Rep. 2014, 5:547-50. 10.1016/j.ijscr.2014.06.008

18. Yeh TC: Laparoscopic resection of perforated duodenal diverticulum - A case report and literature review. Int J Surg Case Rep. 2016, 28:204-10. 10.1016/j.ijscr.2016.10.001

19. Glener J, Poris S, Foles B, Harmon R: Perforated duodenal diverticulum case report. Int J Surg Case Rep. 2016, 29:100-2. 10.1016/j.ijscr.2016.10.049

20. Branco C, Carneiro T, Luis D, Gomes A: Perforated duodenal diverticulitis: a rare complication in a common condition. BMJ Case Rep. 2017, 2017:9-10. 10.1136/bcr-2017-219881

21. Fan HS, Talbot ML: Successful management of perforated duodenal diverticulum by use of endoscopic drainage. VideoGIE. 2017, 2:29-31. 10.1016/j.vgie.2016.11.006

22. Degheele JA, Abdallah MH, Haydar AA, Moskalled A, Hallal AH: Perforated duodenal diverticulum treated conservatively: Another two successful cases. Case Rep Surg. 2017, 2017:1-5. 10.1155/2017/4045970

23. Shirobe T, Kawakami H, Abe S, Yokochi T: Retroperitoneal perforation arising from duodenal diverticulum treated by endoscopic drainage: a case report. Clin Case Rep. 2017, 5:654-7. 10.1002/ccr3.921

24. Shen Y, Leong MK: Perforated duodenal diverticulum with subtle pneumoretroperitoneum on abdominal X-ray. Case Rep Emerg Med. 2017, 2017:1-4. 10.1155/2017/7089573

25. Khan K, Saeed S, Maria H, Sheli M, Iqbal F, Ramcharan A, Donallson B: Duodenal diverticular perforation after small bowel obstruction: a case report. Case Rep Surg. 2018, 2018:1-4. 10.1155/2018/6197828

26. Philip J, Ciceroi A: Pancreatoduodenectomy in patient with perforated duodenal diverticulum and peritonitis: case report. Int J Surg Case Rep. 2019, 58:48-9. 10.1016/j.ijscr.2019.04.011

27. Sahned J, Hung Fong S, Mohammed Saeed D, Mitha S, Park IS: Duodenal diverticulitis: to operate or not to operate?. Cureus. 2019, 11:e256. 10.7759/cureus.6256

28. Yagi S, Ida S, Ohashi M, Kumagai K, Hiki N, Sano T, Nunobe S: Two cases of a perforated duodenal diverticulum after gastrectomy with Roux-en-Y reconstruction. Surg Case Rep. 2019, 5:169. 10.1186/s40792-019-0738-y

29. Shimada A, Fujita K, Kitago M, et al.: Perforated duodenal diverticulum successfully treated by a combination of surgical drainage and endoscopic nasobiliary and nasopancreatic drainage: a case report. Surg Case Rep. 2020, 6:129. 10.1186/s40792-020-00891-0

30. Maki H, Yuasa Y, Matsuo Y, et al.: Repair of a perforated duodenal diverticulum using intraduodenal suture in 94 year old woman: A case report. Int J Surg Case Rep. 2020, 71:163-7. 10.1016/j.ijscr.2020.04.083

31. Moshidin M, Parnamymhotit D, Karakatsanis A, Amanatidou E, Psoma E, Movropoulos X, Michalopoulos A: The challenging diagnosis and treatment of duodenal diverticulum perforation: a report of two cases. BMC Gastroenterol. 2020, 20:1-6. 10.1186/s12876-019-1154-2

32. Kabehlitz N, Brinken B, Bumm R: Retroperitoneal perforation of a duodenal diverticulum containing a large enterolith after Roux-en-Y bypass and cholecystectomy. J Surg Case Rep. 2020, 2020:1-5. 10.1053/j.jscr.2020.05.011

33. Samalha E, Rahmi G, Landi B, et al.: Long-term outcome of patients treated with double balloon enteroscopy for small bowel vascular lesions. Am J Gastroenterol. 2012, 107:240-6. 10.1038/ajar.2011.325

34. Dalal AA, Rogers SJ, Cello JP: Endoscopic management of hemorrhage from a duodenal diverticulum. Gastrointest Endosc. 1998, 48:418-20. 10.1016/s0016-5107(98)70015-x

35. Miller MJ, Smith TP: Angiographic diagnosis and endovascular management of nonvariceal gastrointestinal hemorrhage. Gastroenterol Clin North Am. 2005, 34:735-52. 10.1016/j.gtc.2005.09.001

36. DelBarros J, Rosas L, Cohen J, Vignati P, Sardella W, Halliney M: The changing paradigm for the treatment of colonic hemorrhage: superselective angiographic embolization. Dis Colon Rectum. 2002, 45:802-8. 10.1007/s10350-004-5201-2

37. Poultisides GA, Kim CJ, Orlando R 3rd, Peros G, Hallisey MJ, Vignati PV: Angiographic embolization for gastroduodenal hemorrhage: safety, efficacy, and predictors of outcome. Arch Surg. 2008, 143:457-61. 10.1001/archsurg.143.5.457

38. Onozato Y, Kakizaki S, Ishihara H, et al.: Endoscopic management of duodenal diverticular bleeding. Gastrointest Endosc. 2007, 66:1042-9. 10.1016/j.gie.2007.07.014
39. Kua JEH, Seah A, So JBY: Periampullary diverticulum: a case of bleeding from a periampullary diverticula. Ann Acad Med Singapore. 2005, 34:656-8.
40. Kobayashi K, Yokote T, Akioka T, et al.: Unique intestinal CT imaging with bleeding from a duodenal diverticulum following myelodysplastic syndrome. Intern Med. 2008, 47:1039-41. 10.2169/internalmedicine.47.0856
41. Lee WS, Cho SB, Park SY, et al.: Successful side-viewing endoscopic hemoclipping for Dieulafoy-like lesion at the brim of a periampullary diverticulum. BMC Gastroenterol. 2010, 10:24. 10.1186/1471-230X-10-24
42. Nishiyama N, Mori H, Rafiq K, Kobara H, Fujihara S, Kobayashi M, Masaki T: Active bleeding from a periampullary duodenal diverticulum that was difficult to diagnose but successfully treated using hemostatic forceps: a case report. J Med Case Rep. 2012, 6:367. 10.1186/1752-1947-6-367
43. Wilhelmsen M, Andersen JF, Lauritsen ML: Severe upper gastrointestinal bleeding in extraluminal diverticula in the third part of the duodenum. BMJ Case Rep. 2014, 2014: 10.1136/bcr-2013-202516
44. Hatt J, Mills S: Unusual cause for overt upper gastrointestinal bleeding. BMJ Case Rep. 2016, 2016:10.1136/bcr-2016-214846
45. Chatila AT, Gou E, Abdulla H, Merwat S: Two cases of bleeding angiodysplasias within duodenal diverticulum. ACG Case Rep J. 2019, 6:e00027. 10.14509/crj.0000000000000027