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ORIGINAL ARTICLE

Retrospective Study

Effectiveness and safety of endoscopic resection for duodenal gastrointestinal stromal tumors: A single center analysis

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Abstract

BACKGROUND

Endoscopic resection for duodenal gastrointestinal stromal tumors (GISTs) is still considered a great challenge with a high risk of complications, including perforation, bleeding, tumor rupture, and residual tumor.

AIM

To assess the effectiveness and safety of endoscopic resection for duodenal GISTs.

METHODS

Between January 2010 and January 2022, 11 patients with duodenal GISTs were treated with endoscopic resection. Data were extracted for the incidence of complete resection, bleeding, perforation, postoperative infection, recurrence, and distant metastasis.

RESULTS

The incidence of successful complete resection of duodenal GISTs was 100%. Three cases (27.3%) had suspected positive margins, and the other 8 cases (72.7%)

had negative vertical and horizontal margins. Perforation occurred in all 11 patients. The success rate of perforation closure was 100%, while 1 patient (9.1%) had suspected delayed perforation. All bleeding during the procedure was managed by endoscopic methods. One case (9.1%) had delayed bleeding. Postoperative infection occurred in 6 patients (54.5%), including 1 who developed septic shock and 1 who developed a right iliac fossa abscess. All 11 patients recovered and were discharged. The mean hospital stay was 15.3 d. During the follow-up period (14-80 mo), duodenal stenosis occurred in 1 case (9.1%), and no local recurrence or distant metastasis were detected.

CONCLUSION
Endoscopic resection for duodenal GISTs appears to be an effective and safe minimally invasive treatment when performed by an experienced endoscopist.

Key Words: Duodenal tumor; Gastrointestinal stromal tumors; Treatment; Endoscopic resection; Effectiveness; Safety

Core Tip: This study presents the findings on endoscopic resection for duodenal gastrointestinal stromal tumors. Endoscopic resection of duodenal gastrointestinal stromal tumors is a great challenge. This study aimed to assess the effectiveness and safety of endoscopic resection for duodenal gastrointestinal stromal tumors. The rate of successful complete resection was 100%. Intraoperative perforation occurred in all 11 patients. The success rate of perforation closure was 100%. All 11 patients recovered. During the follow-up period (14-80 mo), duodenal stenosis occurred in 1 case (9.1%), and no local recurrence or distant metastases were detected.

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INTRODUCTION

Gastrointestinal stromal tumors (GISTs) are rare digestive mesenchymal tumors, characterized by differentiation towards the interstitial cells of Cajal[1]. They can occur in any part of the gastrointestinal tract, most commonly in the stomach (60%) and small intestine (30%), but only 4%-5% occur in the duodenum [2]. GISTs have a variety of clinical behaviors with potentially malignant tendency. Currently, the treatment strategy for GISTs is somewhat controversial[3]. Some studies show that active surveillance was a safe option for GISTs smaller than 20 mm or even 30 mm (excision is only considered when the tumor grows)[4,5]. However, GISTs have inherent potential for malignancy, and the real risk stratification of the lesions is only known after resection[6]. Therefore, several societies recommend resection if a diagnosis of GIST is made, unless a major morbidity is expected[7-9].

In comparison to gastric GISTs, duodenal GISTs have a higher risk of malignancy. In addition, the duodenum has special anatomical features. Once the tumor grows, the difficulty of the operation increases accordingly, increasing the risk of combined organ resection. Therefore, resection should be performed for localized or potentially resectable duodenal GISTs. Traditional surgical treatment methods include pancreaticoduodenectomy and local resection of duodenal lesions. However, these operations are traumatic and prone to serious complications, such as delayed bleeding, pancreatic leakage, bile leakage, or abdominal infection[10,11]. Furthermore, pancreaticoduodenectomy or segmental duodenectomy will inevitably reduce the patient's quality of life. GISTs have unique biological characteristics and rarely have lymph node metastasis[9], which makes endoscopic resection of lesions an alternative. In recent years, the development of endoscopic minimally invasive technologies, such as endoscopic submucosal dissection, endoscopic submucosal excavation, and endoscopic full-thickness resection, has brought attention to endoscopic minimally invasive treatment of duodenal GISTs.

Thus far, there are few studies about endoscopic resection of duodenal GISTs, most of which have been case reports. A few studies have reported small series of cases[12,13]. The aim of this study was to evaluate the effectiveness and safety of endoscopic resection for duodenal GISTs.

MATERIALS AND METHODS

Patients

From January 2010 to January 2022, 11 consecutive patients with pathologically confirmed duodenal GIST underwent endoscopic resection in our center. All patients were examined preoperatively by computed tomography (CT) and endoscopic ultrasonography (EUS). In all cases, there were no signs of lymph node metastasis or distant metastasis, no other malignant tumors, and no coagulation dysfunction, and it was considered that the patient could tolerate endotracheal intubation and general anesthesia. Written informed consent was obtained from all patients. The study was reviewed and approved by the Institutional Ethics Committee of Taizhou Hospital of Zhejiang Province (Approval No. K20210611).

Endoscopic equipment and accessories

A single-accessory channel endoscope (Q260J; Olympus) and/or a dual-channel endoscope (GIF-2T240, Olympus) were used during the procedures. A transparent cap (ND-201-11802; Olympus) was attached to the tip of the endoscope. An insulated-tip knife (KD-611L, IT2; Olympus), hook knife (KD-620LR; Olympus), dual knife (KD-650Q; Olympus), or hybrid knife (ERBE, Tübingen, Germany) was used to dissect the submucosal layer and peel the tumor. A titanium clip (HX-600-135; Olympus and M00522600), an endoloop (Leo Medical Co., Ltd, Changzhou, China), and an over-the-scope clip (OTSC) (12/6 t-type, Ovesco Endoscopy AG) were used for wound closure. Other devices and accessories that were used included a high-frequency electronic cutting device (ICC 200; ERBE), an argon plasma coagulation unit (APC 300; ERBE, Tübingen, Germany), a hot biopsy forceps (FD-410LR; Olympus), a foreign body forceps (FG-B-24, Kangjin, Changzhou, China), a snare (SD-230U-20; Olympus), and a carbon dioxide insufflator (Olympus).

Endoscopic procedures and perioperative management

All operations were performed under general anesthesia with endotracheal intubation by experienced endoscopists. All patients were fasted for ≥ 6-8 h with no water for 2 h before the operation. Antibiotic prophylaxis was administered.

Endoscopic resection was conducted as follows (Figure 1A-K): (1) Several dots were marked around the lesion; (2) A mixture solution (100 mL normal saline +1 mL epinephrine + 2 mL indigo carmine) was then injected to elevate the submucosa; (3) Subsequently, a circumferential incision was made outside the border to expose the pseudo capsule; (4) Next, the submucosa and muscularis propria (MP) around the lesion were circumferentially dissected. After complete excision, the lesion was removed with a snare or foreign body forceps and sent for histopathological examination; and (5) The wound was closed with titanium clips, an OTSC, or an endoloop. If perforation occurred, a 20-gauge needle was used intraoperatively and postoperatively to relieve pneumoperitoneum.

A jejunal nutrition tube with the tip near the duodenal wound and a gastric tube were placed for drainage and detection of any postoperative hemorrhage. After the procedure, all patients were fasted and treated with a proton-pump inhibitor and prophylactic antibiotics. Oral intake was gradually resumed according to wound recovery.

Postoperative specimen management and pathological evaluation

After the operation, the resected specimens were observed and measured, and their size, shape, and envelope integrity were recorded. Then the specimens were immersed in 4% formaldehyde solution and fixed. Hematoxylin and eosin staining and immunohistochemistry were performed routinely. A diagnosis of GIST was confirmed if microscopic spindle cell proliferation was seen in the fasciculate, with staggered arrangement and positivity for CD117 or DOG-1 and CD34 (Figure 1L-R). The risk of recurrence after resection of GISTs was assessed according to the National Institutes of Health risk stratification system (2008 modified)[14].

Definition of terms and outcome assessment

Complete resection was considered if the lesion was resected en bloc with no obvious residual tumor at the resection site and with tumor-free margins according to histopathological examination[15]. Complications included intraoperative perforation, delayed perforation, intraoperative bleeding, delayed bleeding, and perioperative infection. Intraoperative perforation was considered if an extra-duodenal structure was visualized, retroperitoneal pneumatosis occurred, or free gas was detected by CT examination immediately after resection of the lesion[16]. Delayed perforation was considered if the patient experienced sudden abdominal pain after the procedure with a duodenal defect found under endoscopy or surgery. Intraoperative bleeding was regarded as a complication if one of the following criteria was met: (1) During the procedure, bleeding affected the visual field and could not be managed by endoscopic methods; (2) There was a significant reduction in hemoglobin (> 2 mg/dL); or (3) Blood transfusion was required[17]. Delayed bleeding was defined as hemorrhage from a post-procedure ulcer [18]. Local recurrence was defined as the detection of a lesion located on or adjacent to the scar of the previous endoscopic resection, which was then pathologically confirmed by biopsy[15].

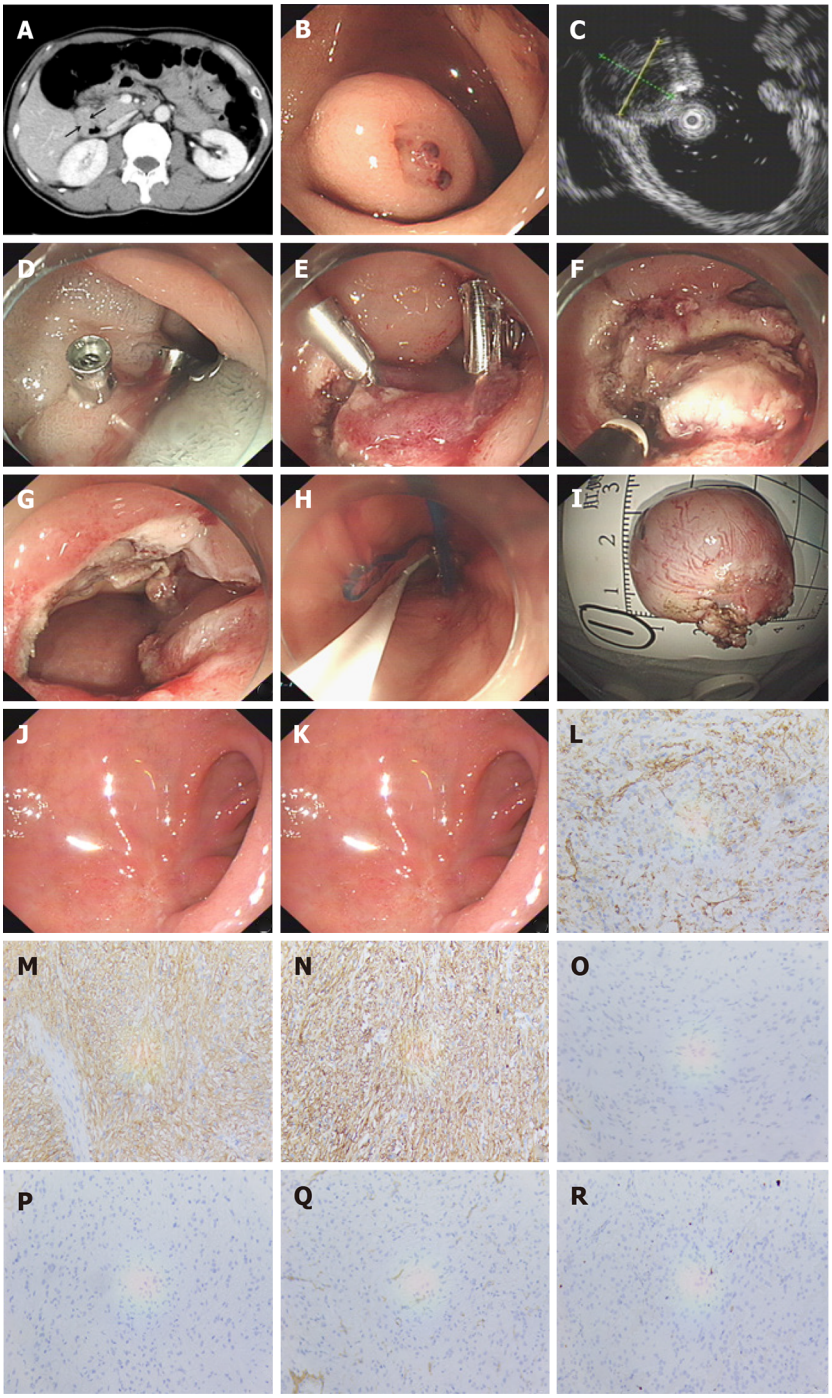

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Figure 1 Endoscopic full-thickness resection for duodenal gastrointestinal stromal tumors in the descending junction of the duodenal bulb. A: Computed tomography revealed a tumor of approximately 3 cm in diameter, with enhancement in the arterial phase; B: A tumor located in the descending junction of the duodenal bulb with ulcer and exposed blood vessels on the surface. Titanium clips were used to stop the bleeding; C: The endoscopic ultrasonography showed that the lesion was a hypoechoic structure originating from the muscularis propria layer, with uniform echo and a clear boundary; D: Submucosal injection after making several marking dots around the lesion; E: A circumferential incision was made outside the border; F: The submucosa and muscularis propria around the lesion were circumferentially dissected; G: The duodenal defect after tumor resection; H: The wound was occluded with several titanium clips + an endoloop + an over-the-scope clip. A jejunal nutrition tube was placed near the wound for drainage; I: The resected tumor with the intact capsule; J: The wound healed well at 3 mo after the procedure; K: Hematoxylin and eosin staining (original magnification × 40); L: Immunohistochemistry showed that the tumor was positive for CD34; M: Immunohistochemistry showed that the tumor was positive for CD117; N: Immunohistochemistry showed that the tumor was positive for Dog-1; O: Immunohistochemistry showed that the tumor was negative for desmin; P: Immunohistochemistry showed that the tumor was negative for S-100; Q: Immunohistochemistry showed that the tumor was negative for SMA; and R: Immunohistochemistry showed that Ki67 was about 2%.

Follow-up

Every patient underwent EUS at 3 mo after the operation to evaluate wound healing and check for residual lesions. The second surveillance endoscopy procedure was performed at 6 mo. Subsequently,

gastroscopy and/or EUS was performed to detect tumor recurrence, and CT and/or abdominal ultrasound was used every 12 mo if any distant metastasis was detected; this was continued indefinitely.

Statistical analysis

Data were presented as the mean, median, number of cases, and percentage. All statistical analyses were performed using the SPSS software program (version 20.0; SPSS Inc, Armonk, NY, United States).

RESULTS

Clinical characteristics

The patient and tumor characteristics are summarized in Table 1. A total of 11 patients (male, n = 9; female, n = 2) with duodenal GISTs underwent endoscopic resection at our center. The median age was 55 years (range: 33–74 years). Eight patients (72.7%) were symptomatic at presentation, with melena in 6 patients (54.5%), abdominal pain in 1 patient (9.1%), and abdominal distension in 1 patient (9.1%). Three tumors (27.3%) were detected incidentally during endoscopy for other reasons. All patients were negative for immunologic series and tumor markers (AFP, CEA, CA199, and CA125). Patients with gastrointestinal hemorrhaging showed fecal occult blood positivity and had anemia, with a minimum hemoglobin level of 36 g/L. All patients showed duodenal mass on abdominal CT before operation, which was enhanced after enhancement.

The lesions were single in all 11 patients. The lesion was detected in the duodenal bulb in 2 cases (18.2%), in the descending junction of the duodenal bulb in 4 cases (36.4%), and in the descending part in 5 cases (45.4%). All lesions originated from the MP layer with intraluminal growth in 6 cases (54.5 %), partially extraluminal growth in 2 cases (18.2%), and mainly extraluminal growth in 3 cases (27.3%). EUS revealed hypoechoic structures in 10 cases (90.9%) and a mixed echoic structure in 1 case (9.1%). The median maximal diameter of these lesions was 3.0 cm (range: 1.5-5.0 cm). Immunohistochemistry of all lesions showed that CD34, CD117, and Dog-1 were positive, and Desmin and S-100 were negative. Nine cases (81.8%) were SMA positive. Four cases (36.4%) were Ki-67 < 1%, 3 cases (27.3%) were Ki-67 1%+, 3 cases (27.3%) were Ki-67 2%+, and 1 case (9.1%) was Ki-67 3%+.

Treatment outcomes

Complete resection was successful in 100% of cases. Four patients (36.4%) were classified as very low risk, and 7 patients (63.6%) were classified as low risk. Among the 11 patients, a positive resection margin was suspected in 3 cases (27.3%) (tumor tissue was found at the electrocautery margin); all cases were pathologically low risk. The remaining 8 cases (72.7%) had negative lateral and basal margins. All 11 patients recovered and were discharged.

Complications

Perforation was detected in all 11 patients during the operation. The duodenal wall defect was occluded with several titanium clips + an endoloop in 1 case (9.1%), an OTSC in 6 cases (54.5%), and an OTSC + several titanium clips + an endoloop in 4 cases (36.4%). Intraoperative perforation closure was successfully performed in 100% of cases. Delayed perforation was suspected in 1 patient (9.1%) (as described below).

All 11 patients had bleeding during the procedure and were treated successfully using argon plasma coagulation and a hot biopsy forceps. A little coffee-colored liquid was drained from the gastrointestinal decompression tube in 1 case (9.1%) on the 1st d after the procedure, which improved after strengthening the acid inhibition and using somatostatin.

Six patients (54.5%) developed postoperative abdominal infection, and their anti-infection treatment was strengthened. Among them, 1 patient developed severe abdominal pain and septic shock on the day after endoscopic resection of a 3.0 cm × 2.5 cm tumor in the descending junction of the duodenal bulb. Emergency surgical exploratory laparotomy was performed immediately for suspected delayed perforation. During the operation, obvious edema was observed on the wound, but no obvious perforation was detected. This patient received peritoneal lavage and distal subtotal gastrectomy with resection of the duodenal bulb. Another patient developed a right iliac fossa abscess, which improved after puncture and drainage. One patient (9.1%) suffered malignant arrhythmia 5 d after the procedure and was transferred to the intensive care unit. All 11 patients recovered and were discharged. The mean time to the recovery of food intake after the operation was 8.1 d (range: 4-14 d). The mean postoperative hospital stay was 15.3 d (range: 8-26 d).

Follow-up

The wound healed well in all patients, and no recurrence or distant metastasis was detected during the follow-up period (median: 36 mo; range: 14-80 mo). Duodenal stenosis occurred in 1 patient (9.1%) whose previous tumor was in the descending junction of the duodenal bulb, and the wound was closed by an OTSC. The OTSC was found to block the lumen, and the endoscope could not pass through at 3

Table 1 Clinical characteristics of 11 duodenal gastrointestinal stromal tumors cases

Patient	Sex	Age, yr	Clinical presentation	Location	Size of maximum diameter, cm	Growth pattern	EUS appearance	Risk assessment	Specimen margin	Postoperative hospital stay, d	Follow-up, mo
1	M	57	Melena	Duodenal bulb	2.2	Mainly extraluminal growth	MP, hypoecho, uniform echo	Low risk	Negative	9	14
2	M	56	No symptoms	Descending junction of duodenal bulb	2.0	Intraluminal growth	MP, hypoecho, uniform echo	Very low risk	Negative	15	19
3	M	68	No symptoms	Descending duodenum	3.0	Partially extraluminal growth	MP, hypoecho, uniform echo	Low risk	Negative	11	22
4	M	63	Melena	Descending duodenum	5.0	Mainly extraluminal growth	MP, hypoecho, uniform echo	Low risk	Suspiciously positive	16	30
5	M	52	Melena	Descending duodenum	1.5	Intraluminal growth	MP, mixed echo, uneven echo	Very low risk	Negative	8	33
6	M	53	Melena	Descending junction of duodenal bulb	3.5	Mainly extraluminal growth	MP, hypoecho, uniform echo	Low risk	Suspiciously positive	15	36
7	M	54	Melena	Descending duodenum	4	Intraluminal growth	MP, hypoecho, uniform echo	Low risk	Suspiciously positive	24	43
8	M	74	Melena	Descending junction of duodenal bulb	3.0	Intraluminal growth	MP, hypoecho, uniform echo	Low risk	Negative	26	50
9	F	33	Abdominal pain	Descending duodenum	3.0	Intraluminal growth	MP, hypoecho, uniform echo	Low risk	Negative	14	51
10	F	42	No symptoms	Descending junction of duodenal bulb	1.5	Intraluminal growth	MP, hypoecho, uniform echo	Very low risk	Negative	13	75
11	M	55	Abdominal distension	Duodenal bulb	2.0	Intraluminal growth	MP, hypoecho, uniform echo	Very low risk	Negative	12	80

EUS: Endoscopic ultrasonography; F: Female; M: Male; MP: Muscularis propria.

mo after the procedure. The patient was followed up, as he had no symptoms of obstruction. During endoscopic surveillance at 12 mo after the procedure, the OTSC detached spontaneously, and the lumen stenosis improved.

DISCUSSION

Endoscopic resection of duodenal lesions, especially subepithelial lesions, is still considered a challenging procedure due to the unique anatomical and endoscopic features of the duodenum. The duodenal lumen is rather narrow, and the initial part (bulbar to descending part) is an anti-c-shaped loop, which makes endoscopic operations difficult. The mucosa is difficult to lift after the injection due to the abundant Brunner's gland and blood vessels in the submucosa of the duodenum, which also increases the difficulty of treatment. Traditionally, the duodenum has been regarded as a forbidden zone for endoscopic excision of duodenal subepithelial lesions, especially for endoscopic full-thickness resection. The rapid de-velopment of endoscopic techniques and endoscopic devices makes endoscopic resection for duodenal GISTs another acceptable alternative to minimize morbidity.

For localized GISTs, complete excision is the standard treatment. R0 resection is the goal in any case. A post hoc observational study showed that among patients with GISTs, when tumor rupture was excluded, there was no significant difference in overall survival of patients who received R0 and R1 resection[19]. Some studies also indicated that the recurrence rate of patients who received R1 resection did not differ from that of patients who received R0 resection[20,21]. Thus, if R0 resection is difficult to achieve, R1 resection (microscopically positive margins) may also be performed for low-risk GISTs in unfavorable locations[7]. If R1 resection was already performed, routine re-excision is not recommended [7], and the microscopic margin status should not be used to dictate adjuvant medical therapy decisions [19]. In our study, there were 3 cases in which microscopic involvement of the resection margins was suspected; all were low risk. No recurrence or distant metastasis was found during follow-up (30 mo, 36 mo, and 43 mo) without re-excision or adjuvant medical therapy.

Tumor rupture is an important adverse prognostic factor for the recurrence of GIST. It is defined by tumor spillage or fracture in the abdominal cavity, piecemeal resection, incisional biopsy, gastric or intestinal perforation to the abdominal cavity, blood-stained ascites at laparotomy, or transperitoneal microscopic infiltration of an adjacent organ[7]. In our study, the maximal diameter of all tumors was ≤ 5 cm and were resected en bloc. When the tumor size is > 5 cm in diameter, it is very difficult to resect it completely and take it out as a whole through the cardia, esophagus, and pharynx. Thus, for tumors larger than 5 cm, especially in intermediate- and high-risk cases, conventional surgery or laparoscopic and endoscopic cooperative surgery may be more appropriate.

In comparison to other parts of the digestive tract, the muscular layer of the duodenum is much thinner, and intraoperative perforation is prone to occur during endoscopic operations. In addition, digestive fluids, such as bile and pancreatic juice, can corrode the wound, and delayed perforation may subsequently occur. Injury to the duodenal muscularis and serosa should be avoided as far as possible in the case of perforation. However, when the lesion is closely associated with the MP or serosal layer of the duodenum, perforation is almost inevitable. Most duodenal GISTs originate from the MP, and the strategy "active perforation" is often adopted, resulting in a well-defined edge and mild edema. In some studies, perforation that could be closed by endoscopic methods during the endoscopic operation was not regarded as a complication[22,23].

With the development of endoscopic suture technology and the invention of OTSC, the OverStitch endoscopic suturing (ES) device and other suture devices, the success rate of wound suturing has been greatly improved. An OTSC has the following advantages: (1) It has great holding strength[24,25]; thus, it can grasp more tissue and clamp the entire wall of the lumen; (2) It is a bear trap-like, large clip with a wingspan of 12 mm, which can close full-thickness perforations of up to 3 cm in diameter[26]; and (3) The gap between the teeth of an OTSC allows blood to pass through to avoid tissue necrosis.

A systematic review showed that the rate of successful closure of the perforation by OTSC closure was 85.3%[27]. In our previous study, OTSC successfully closed the perforation after endoscopic resection of duodenal subepithelial lesions in 100% of cases, without delayed perforation[28]. The OverStitch ES device is designed for tissue approximation and allows the creation of either interrupted or continuous running stitches. Thus, it can reliably close perforations[29]. In a study by Chung *et al* [30], the OverStitch ES device was applied in 7 cases after endoscopic mucosal resection of large duodenal adenomas, and all ES sessions were technically successful.

In addition, purse-string suture technique, which is also widely used in iatrogenic digestive tract perforation, shows a high rate of successful sealing. Our previous study suggested that the closure rate of purse-string suture in endoscopic treatment of duodenal subcutaneous lesions was 100% (including 5 cases of perforation)[31]. In this study, duodenal wall defects were all successfully closed using OTSC, titanium, or purse-string suture according to the size of wound and wall defect. We placed two tubes, one with the tip in the gastric cavity to attract gas and gastric juice, and the other with the tip next to the duodenal wound to attract pancreatic juice and bile. Lessening tension of the wound and reducing the corrosion of digestive juice to the wound could effectively decrease the occurrence of delayed perforation.

Another serious complication of endoscopic resection of duodenal GISTs is perioperative infection followed by perforation. In this study, 6 patients had postoperative abdominal infection, including 1 who developed septic shock and another who developed an abscess in the right iliac fossa. During the procedure, suction should be carried out in a timely manner in order to prevent excessive blood, intestinal contents, and digestive juices flowing into the retroperitoneum. The wound should be closed as soon as possible after the lesion is removed. When a large volume of liquid has overflowed into the retroperitoneum, timely flushing and drainage can also reduce the incidence of infection. Besides, if the lesion is really difficult to remove endoscopically, timely conversion to surgery or laparoscopic-assisted resection may be a wiser option.

In addition, it should be noted that the duodenal lumen is relatively narrow, especially in the descending junction of the duodenal bulb, and postoperative stricture may occur. In this study, 1 patient developed stricture after the wound was closed with an OTSC. When treating the wound, especially when placing the OTSC, attention should be paid to avoid grasping too much tissue in the case of duodenal lumen stenosis.

The present study was associated with some limitations. First, this was a single center retrospective study with a relatively small sample size, and a selection bias may have been present. Second, there was a lack of randomized and controlled samples. Third, the follow-up period of some cases was relatively short.

CONCLUSION

Endoscopic resection for duodenal GISTs appears to be effective and safe in selected cases. The procedure should be performed by a senior endoscopist who has rich experience in the management of complications of endoscopic operations for duodenal lesions. If the lesion is difficult to remove endoscopically or there are severe complications that cannot be managed by conservative treatment or an endoscopic method, surgery should be performed in a timely manner.

ARTICLE HIGHLIGHTS

Research background

Currently, endoscopic resection of duodenal gastrointestinal stromal tumors (GISTs) is a challenging procedure with a high risk of complications.

Research motivation

Traditional surgical treatment methods for duodenal GISTs are traumatic and prone to serious complications. Endoscopic resection of duodenal GISTs is an alternative. However, there are few reports on endoscopic treatment for duodenal GISTs.

Research objectives

We aimed to evaluate the effectiveness and safety of endoscopic resection for duodenal GISTs.

Research methods

This was a retrospective study. We collected data of 11 consecutive patients with duodenal GISTs who were treated with endoscopic resection and analyzed the rate of complete resection, bleeding, perforation, postoperative infection, recurrence, and distant metastasis.

Research results

All lesions were completely resected, while three cases (27.3%) had suspected positive margins. No local recurrence or distant metastasis were detected during the follow-up period in any of the patients.

Research conclusions

Endoscopic resection for duodenal GISTs appears to be an effective and safe treatment by an experienced endoscopist.

Research perspectives

We need to expand the sample size to further confirm the effectiveness and safety of endoscopic resection of duodenal GISTs. In addition, the long-term outcome should be observed by extending the follow-up time.

FOOTNOTES

Author contributions: Wang ZZ, Mao XL, Yan XD, and Yang HD participated in the clinical treatment; Wang ZZ, Fu XY, and Cai Y wrote the original draft; Li SW undertook validation, writing, reviewing, and editing; All authors contributed to the article and approved the submitted version.

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Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: The authors declare that they have no conflicts of interest.

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