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# Feasibility of endoscopic submucosal dissection for upper gastrointestinal submucosal tumors treatment and value of endoscopic ultrasonography in pre-operation assess and post-operation follow-up: a prospective study of 224 cases in a single medical center

**Ganqing He[1] · Jinhui Wang[1] · Baili Chen[1] · Xiangbin Xing[1] · Jinping Wang[1] · Jie Chen[1] · Yao He[1] · Yi Cui[1] · Minhu Chen[1]**

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**Abstract**

*Background and aims* Diagram, diagnosis, and treatment with endoscopic submucosal dissection (ESD) for upper gastrointestinal submucosal tumors (SMTs) remain controversial, although endoscopic ultrasonography (EUS) and ESD have been established in diagnosis and treatment of SMTs in decades, respectively. In this study, we have investigated prospectively the profile of upper gastrointestinal SMTs, assessed the effect and feasibility of ESD in upper gastrointestinal SMTs treatment, as well as value of EUS in pre-ESD diagnosis and post-ESD follow-up for gastrointestinal SMTs.

*Methods* The upper gastrointestinal SMTs patients detected with endoscopy were further checked by EUS, then received series ESD treatment, and fulfilled 3- and 12-month follow-up EUS detection between July 2011 and March 2015. The parameters of SMTs with EUS examination (size, original layer) and treatment with ESD (en bloc resection rate, procedure time, procedure-related complications) were investigated and analyzed.

*Results* A total number of 224 patients with upper gastrointestinal SMTs were enrolled, and 108 (48.2 %) were men. The mean age was 50.4 ± 12.0 years (range 19–77 years). In total, 92 (41.1 %), 14 (6.3 %), 61 (27.2 %), 22 (9.8 %), 25 (11.2 %), and 10 (4.5 %) SMTs were located in esophagus, cardiac, fundus, body and antrum of stomach, duodenum, respectively. Two hundred and eight (92.9 %) patients were successfully treated with an en bloc ESD, while other 16 patients (7.1 %) suffered ESD failure (5.3 %, 12 case) or severe complications (1.8 %, 4 cases). The mean procedure time of ESD was 47.4 ± 27.3 min (range 10–180 min). The mean size of the SMTs measured with ESD samples was 13.6 ± 9.5 mm (range 4–113 mm). In total, 87 (38.8 %), 23 (10.3 %), and 114 (50.9 %) tumors originated from muscularis mucosa, submucosa, and muscularis propria, respectively. The majority of SMTs were leiomyoma (109, 48.7 %) and gastrointestinal stromal tumors (GIST) (77, 34.4 %), while other SMTs were confirmed as ectopic pancreas (21, 9.4 %), adenoid tumor (8, 3.6 %), lipoma (5, 2.2 %), neuroendocrine tumor (3, 1.3 %), and granulosa cell tumor (1, 0.4 %). The accuracy rate of EUS in pathological diagnosis or original layer was 82.6 % (185/224) or 74.6 % (167/224). Residual tumors were detected with EUS in 3 patients (1.3 %) in 3-month follow-up and no recurrence during 12-month follow-up period.

*Conclusions* The predominant SMTs in upper gastrointestinal tract were leiomyoma in esophageal tumors which originated from muscularis mucosae and GIST in stomach which originated from muscularis propria detected satisfactorily with EUS. This study showed that ESD was a safe and effective treatment for upper gastrointestinal SMTs.

**Keywords** Endoscopic · Submucosal tumor · Ultrasonography · Efficacy

Submucosal tumors (SMTs) originated from any of layers of upper gastrointestinal wall are an uncommon, asymptomatic entity and observed accidently during endoscopic

Jinhui Wang and Ganqing He are joint first authors.

Minhu Chen and Yi Cui have contributed equally to the work.

✉ Minhu Chen
minhuch@yeah.net

[1] Department of Endoscopy Center, Gastroenterology and Hepatology, First Affiliated Hospital of Sun Yat-Sen University, Guangzhou 510080, China

examination [1]. Some SMTs originating from the muscularis propria layer [2] may have a potential for malignant transformation, including gastrointestinal stromal tumors (GIST) and ectopic pancreas [3]. The prevalence of subepithelial gastric lesions was more than 0.36 % during routine examination [1].

It is still difficult to get an accurate and differential diagnosis of SMTs with ordinary endoscopy, especially an accurate pathological diagnosis indispensably distinguishing malignant from benign SMTs, which may offer a valuable assessment on treatment strategies. Although endoscopic ultrasonography (EUS) practiced clinically since 1980s has showed an promising diagnosis method on gastrointestinal SMTs with accurate detection of original layer, size, and border of SMTs, which make it possible to predict a histological diagnosis [4]; it is still controversial on diagnosis value of EUS on gastrointestinal SMTs, even if EUS-guided fine-needle aspiration (EUS-FNA) and EUS-guided core needle biopsy have been developed for definitive diagnosis of SMTs [5–8].

Surgical removal is a primary and conventional standard strategy for a local GIST in major cases in the past, and ESD with precise lesion en bloc resection as a successful minimal invasive treatment technique for early digestive tract cancer has become a promising procedure in treatment of gastrointestinal SMTs in decades [9].

However, there is still some hurdles and dilemma in learning diagram of upper gastrointestinal SMTs, or providing accurate diagnostic evaluation with EUS and curative treatment with ESD for SMTs: (1) less information about the profile and nature history of upper gastrointestinal SMTs; (2) most reported studies on upper gastrointestinal SMTs were focused on gastric SMTs (predominantly GIST), few on esophagus or duodenum; (3) less information about assessment of the diagnosis accuracy of EUS on upper gastrointestinal SMTs based on histological diagnosis sampled from surgery or ESD; and (4) few reports about short-term and medium-term efficacy of ESD on gastrointestinal SMTs treatment evaluated with EUS in follow-up.

The aim of this study is to investigate the diagram of upper gastrointestinal SMTs, diagnostic accuracy of EUS, and the effect of ESD.

## Methods

### Patients and study design

This was a prospective study conducted at one center in South China between July 2011 and March 2015. ESD procedures were performed in total 224 consecutive patients with upper gastrointestinal SMTs at the First Affiliated Hospital of Sun Yat-sen University, Guangzhou, China. All of these patients underwent EUS examination to detect the layer of origin and size of SMTs before ESD procedure, and detected with EUS for remains or recurrence in 3- and 12-month follow-ups after ESD.

All patients enrolled in this study had signed informed consent. This study was approved by the institutional review board of first affiliated hospital of Sun Yat-sen University.

### Instruments

EUS examinations with a radial-scanning echo-endoscope (GIF-Q260 J; Olympus, Japan) were performed in all patients to access tumor sizes and layers of origin before ESD and rechecked in follow-up after ESD.

Standard endoscopy (GIT-H260, Olympus, Japan) was used during the ESD procedure. A short, transparent cap (D-2011804, Olympus, Japan) was attached to the tip of the endoscope to provide a constant endoscopic view. Other equipments included insulated-tip knife (KD-611L, Olympus, Japan), hook knife (KD-640-L, Olympus, Japan), injection needle (NM-200L-0425, Olympus, Japan), grasping forceps (FG-8U-1, Olympus, Japan), hot biopsy forceps (FD-410LR, Olympus, Japan), endoclips (HX-610-135, Olympus, Japan), a high-frequency generator (ICC-200, ERBE, Germany), and argon plasma coagulation unit (APC-300, ERBE, Germany).

### ESD procedure

All ESD procedures were performed by experienced endoscopists. The operations were performed with patients under sedative demulcent anesthesia or general endotracheal anesthesia, and vital signs (heart rate, blood pressure, and oxygen saturation) were monitored closely during the procedure.

There were two procedures of ESD performed to remove upper gastrointestinal SMTs: the standard ESD/endoscopic full-thickness resection (EFTR) and submucosal tunneling endoscopic resection (STER). Some gastric (fundus) SMTs originated from muscularia propria were removed by EFTR. Patients with esophagogastric junction SMTs, esophagus SMTs diameter >2 cm, originated from esphagogus muscularis propria were performed STER. The procedures of STER were performed followed as reports by Zhou et al. [10, 11].

The major procedures of ESD/EFTR were as follows. A transparent cap was mounted on the end of the gastroscope before EFTR. Following general endotracheal anesthesia, the edge of the tumor was marked by argon plasma coagulation. Each marked submucosal position was injected with several milliliters of a solution containing 100 mL saline, 2 mL indigo carmine, and 1 mL epinephrine. The

body of the tumor was isolated along the capsule from the muscularis propria to the serosal layer using a IT knife. The serosa was cut along the edge of the tumor. Generally, the serosa was tightly adherent to the tumor body, making it impossible to remove the tumor directly. Therefore, the serosa was penetrated using a needle knife or hook knife, resulting in an artificial perforation. An IT or hook knife was used to cut the serosa along the edge of the tumor and to remove the tumor. The artificial perforation was fully closed with endoclips.

The procedure of STER was as follows. During procedure of STER, patients underwent general endotracheal anesthesia. The confirmed lesion and potential location of the submucosal tunnel were injected with methylene blue or indigo carmine. A fluid cushion was created 2–3 cm proximal to the SMT by injecting several milliliters of a solution containing 100 mL saline, 2 mL indigo carmine, and 1 mL epinephrine. A 2-cm longitudinal mucosal incision was made, and a submucosal tunnel between the submucosal and muscular layers was created. Endoscopic resection of the SMT was then performed through the created tunnel. When the lesion was completely resected, it was removed with a snare or forceps. All visible blood vessels were coagulated with hot biopsy forceps or by argon plasma coagulation. The mucosal incision site was closed with endoclips.

### Pathology evaluation

The removed tissue specimens were analyzed histopathologically with hematoxylin–eosin staining, and immunohistochemically with immunohistochemical staining. Those with immunohistochemical staining of CD117(+) or CD34(+), and smooth muscle actin (SMA) (−) were diagnosed as gastrointestinal stromal (GIST). Those with SMA(+), CD117(−), and CD34(−) were diagnosed as leiomyoma. Those with S-100(+) were diagnosed as neurogenic tumor.

### Follow-up assessment

Patients were rechecked with standard upper GI endoscopy and EUS in 3- and 12-month follow-up after the ESD to monitor any imagined sign of SMTs residual or recurrence.

## Results

### Characteristics of patients and SMTs

The study group included 224 patients, and 108 (48.2 %) were men. The mean age was 50.4 ± 12.0 years (range 19–77 years). The information of SMTs is shown in Table 1. The mean size of these SMTs as measured by ESD samples was 13.6 ± 9.5 mm (range 4–113 mm). The most frequent location of SMTs was esophagus ($n = 92$, 41.1 %), followed by gastric fundus ($n = 61$, 27.2 %), gastric antrum ($n = 25$, 11.2 %), gastric body ($n = 22$, 9.8 %), cardia ($n = 14$, 6.3 %), and duodenum ($n = 10$, 4.5 %). According to the finding of ESD, SMTs originated from muscular mucosae, submucosa, and muscularis propria were 87 (38.8 %), 23 (10.3 %), and 114 (50.9 %), respectively. Most SMTs were histopathologically diagnosed as leiomyoma (109, 48.7 %) and GIST (77, 34.4 %), while few SMTs were ectopic pancreas, adenoid tumor, lipoma, neuroendocrine tumor, and granulosa cell tumor (21, 9.4 %; 8, 3.6 %; 5, 2.2 %; 3, 1.3 %; and 1, 0.4 %, respectively). Most esophageal SMTs (65, 70.7 %) were originated from muscularis mucosae; SMTs located in gastric fundus (45, 73.8 %) or body (11, 50 %) mainly originated from muscularis propria were GIST. SMTs originated from submucosa were histopathologically diagnosed as ectopic pancreas (12, 52.2 %), adenoid tumor

**Table 1** Characteristics and outcomes of ESD for SMTs

| | |
|---|---|
| Tumor location (cases, %) | |
| Esophagus | 92, 41.1 % |
| Cardia | 14, 6.3 % |
| Gastric fundus | 61, 27.2 % |
| Gastric body | 22, 9.8 % |
| Antrum | 25, 11.2 % |
| Duodenum | 10, 4.5 % |
| Layer of origin (cases, %) | |
| Muscularis mucosae | 87, 38.8 % |
| Submucosa | 23, 10.3 % |
| Muscularis propria | 114, 50.9 % |
| Pathology (cases, %) | |
| Leiomyoma | 109, 48.7 % |
| GIST | 77, 34.4 % |
| Ectopic pancreas | 21, 9.4 % |
| Neuroendocrine tumor | 3, 1.3 % |
| Adenoid tumor | 8, 3.6 % |
| Granulosa cell tumor | 1, 0.4 % |
| Lipoma | 5, 2.2 % |
| Outcomes of ESD | |
| En bloc resection | 208, 92.9 % |
| EFTR | 22, 9.8 % |
| STER | 23, 10.3 % |
| ESD time (min) | 47.4 ± 27.3 |
| Tumor diameter (mm) | 13.6 ± 9.5 |
| Length of stay (day) | 4.9 ± 3.4 |
| Massive bleeding | 5, 2.2 % |
| Perforation | 14, 6.25 % |
| Infection | 3, 1.3 % |

(6, 26.1 %), lipoma (4, 17.4 %), and neuroendocrine tumor (1, 4.3 %) (Tables 2, 3).

### Parameter of ESD (STER) en bloc resection rate

Successful curative en bloc resection rate of SMTs with ESD, EFTR, or STER procedure was 208/224 (92.9 %), while 4 patients (1.8 %) were converted to surgery because of ESD complications (uncontrolled bleeding, perforation) and 12 cases (5.3 %) had ESD failure. Of those 208 patients, 22 (10.6 %) and 23 (11.1 %) patients underwent EFTR and STER, respectively. Mean procedure time was 47.4 ± 27.3 min (range 10–180 min), and mean length of stay (LOS) after ESD was 4.9 ± 3.4 days (range 1–31 days).

The severe complications of this procedure were mainly bleeding (defined as >50 mL), perforation (not in EFTR). Perforation occurred in 14 patients (6.25 %) when we performed the ESD procedure, including nine cases arising from muscularis propria, and five from muscularis mucosae, up to 32 mm (range 10–32 mm) in diameter. Thirteen of fourteen cases were conservatively managed by medical therapy after applying endoscopic clips, with emergent operation needed in only one case. Six patients showed signs of abdominal distention, suggesting pneumoperitoneum, and a 20-gauge needle was inserted percutaneously to decompress the pneumoperitoneum. Five patients complained chest tightness or subcutaneous emphysema, and CT/X-ray showed less lung collapse, suggesting pneumothorax; they were relieved after conservative medical therapy. In addition, two cases developed secondary peritonitis. All of the patients with perforation were prohibited from oral intake and given antibiotic therapy. In one of the cases of perforation, the tumor located in cardia was large and tightly adherent to the muscularis propria layer, and perforation occurred during the treatment. An emergent surgery was performed, and the pathological diagnosis was GIST. Minor bleeding occurred in most of cases, but hemostasis was achieved by hot biopsy forceps or argon plasma coagulation. Five patients (2.2 %) had massive bleeding during the procedure or post-operation, and three of them needed to receive emergent operation.

### The diagnostic accuracy of EUS

The diagnostic accuracy of EUS on upper gastrointestinal SMTs, including size and origin of tumor, and even histological speculation, was analyzed and compared to the finding of ESD procedure. The accuracies of EUS detected the layer of tumors originated from muscularis mucosae, submucosa, and muscularis propria was 72.4, 82.6, and 74.6 %, respectively. Additionally, total coincidence rate of EUS speculation and sample histopathological diagnosis was 82.6 % (185/224), and coincidence rates of leiomyoma and GIST were up to 83.5 % (91/109) and 88.3 % (68/77), respectively (Table 4).

### Follow-up

201/208 and 147/208 patients had fulfilled 3- and 12-month follow-ups, respectively, and other 64 patients did not reach the planned follow-up time point. The loss rate of 3- and 12-month follow-ups was, respectively, 3.4 % (7 cases) and 6.3 % (13 cases). Residual tumor was detected in 3 patients (1.4 %) (2 cases esophageal SMTs and 1 case cardiac SMT). No recurrence has been found in 3- and 12-month follow-ups.

## Discussion

The prevalence and diagram of upper gastrointestinal SMTs were still under investigation. Most of reports about upper gastrointestinal SMTs were only on gastric SMTs and few reports about esophageal or duodenal SMTs. The prevalence of gastric SMTs was reportedly 0.36 % [1], and GISTs are considered to be far more common than previously presumed. Little information was learned previously about the profile of upper gastrointestinal SMTs mainly because of less of histopathological information. In this study, according to findings during ESD procedures served as "gold standard", major upper gastrointestinal SMTs (167/224, 74.6 %) were located in esophagus, esophagogastric junction, and gastric fundus. Most SMTs in esophagus (62/92, 67.4 %) and esophagogastic junction (10/14, 71.4 %) originated from muscularis mucosae were histopathologically leiomyoma considered little risk of malignant transformation, while SMTs in gastric fundus (45/61, 73.8 %) originated from muscularis propria were histopathologically GIST in some degree risk of malignant transformation. Gastric antral SMTs commonly originated from submucosa (15/25, 60 %) and diversely histopathological finding were mainly ectopic pancreas (13/25, 44 %). It is far little data to come to conclusion of duodenal SMTs diagram because few cases in this study.

It is important to early detect and presume histopathologically upper gastrointestinal SMTs. Until now, most study of upper gastrointestinal SMTs mainly focused on gastric SMTs which is really different histopathologically from esophageal SMTs, and little information about nature history of esophageal SMTs. EUS is a accurate and useful diagnostic tool for SMTs, significantly more efficient than endoscopy, transparietal ultrasonography, and computed tomography (CT) scan [12, 15–17], which may afford accurately the tumor size, layer of origin, morphologic

**Table 2** The origin and pathology of SMTs in different parts of upper GI

| Layer of origin | Tumor location | | | | | |
|---|---|---|---|---|---|---|
| | Esophagus | Cardia | Gastric fundus | Gastric body | Antrum | Duodenum |
| Muscularis mucosae | 65, 70.7 % | 10, 71.4 % | 3, 4.9 % | 4, 18.2 % | 3, 12 % | 2, 20 % |
| Submucosa | 0 | 1, 7.1 % | 0 | 3, 13.6 % | 15, 60 % | 4, 40 % |
| Muscularis propria | 27, 29.3 % | 3, 21.4 % | 58, 95.1 % | 15, 68.2 % | 7, 28 % | 4, 40 % |
| Pathology | | | | | | |
| Leiomyoma | 84, 91.3 % | 12, 85.7 % | 7, 11.5 % | 4, 18.2 % | 1, 4 % | 1, 10 % |
| GIST | 7, 7.6 % | 1, 7.1 % | 48, 78.7 % | 12, 54.5 % | 7, 28 % | 2, 20 % |
| Ectopic pancreas | 0 | 0 | 6, 9.8 % | 2, 9.1 % | 13, 52 % | 0 |
| Neuroendocrine tumor | 0 | 0 | 0 | 2, 9.1 % | 0 | 1, 10 % |
| Adenoid tumor | 0 | 1, 7.1 % | 0 | 0 | 2, 8 % | 5, 50 % |
| Granulosa cell tumor | 1, 1.1 % | 0 | 0 | 0 | 0 | 0 |
| Lipoma | 0 | 0 | 0 | 2, 9.1 % | 2, 8 % | 1, 10 % |

**Table 3** Pathology of SMTs from different layers of origin

| Pathology | Layer of origin | | |
|---|---|---|---|
| | Muscularis mucosae | Submucosa | Muscularis propria |
| Leiomyoma | 76, 87.4 % | 0 | 33, 28.9 % |
| GIST | 9, 10.3 % | 0 | 68, 59.6 % |
| Ectopic pancreas | 0 | 12, 52.2 % | 9, 7.9 % |
| Neuroendocrine tumor | 0 | 1, 4.3 % | 2, 1.8 % |
| Adenoid tumor | 1, 1.1 % | 6, 26.1 % | 1, 0.9 % |
| Granulosa cell tumor | 0 | 0 | 1, 0.9 % |
| Lipoma | 1, 1.1 % | 4, 17.4 % | 0 |

**Table 4** Accuracy between EUS and ESD for depth determination and diagnosis of upper GI SMTs

| Layer of origin | ESD/pathology | EUS diagnosis accord with ESD/pathology | Accuracy (%) |
|---|---|---|---|
| Muscularis mucosae | 87 | 63 | 72.4 |
| Submucosa | 23 | 19 | 82.6 |
| Muscularis propria | 114 | 85 | 74.6 |
| Tumor types | | | |
| Leiomyoma | 109 | 91 | 83.5 |
| GIST | 77 | 68 | 88.3 |
| Ectopic pancreas | 21 | 13 | 61.9 |
| Neuroendocrine tumor | 3 | 3 | 100 |
| Adenoid tumor | 8 | 5 | 62.5 |
| Granulosa cell tumor | 1 | 1 | 100 |
| Lipoma | 5 | 4 | 80 |

features, and even histopathological information [18]. In two retrospective studies, the presumptive EUS and pathological diagnosis matched in 77–82.9 % of cases [16, 19]. In our prospective study, the presumptive EUS and pathological diagnosis matched in 82.6 % (185/224) of cases totally. Bialek et al. [20] reported that accurate rate of EUS was only 73 % in determining the original layer of tumors. In our series, the accuracy rate of original layer detected with EUS was 72.4, 82.6, and 74.6 % for SMTs originated from muscularis mucosae, submucosa, and muscularis propria, respectively. It is more important to presume pathological diagnosis of SMTs, distinguishing malignant transform GIST from benign leiomyoma. In a prospective multicenter study, the sensitivity and

specificity of EUS examination for predicting malignancy were 64 and 80 %, respectively [21]. In this study, our data showed a histopathological diagnostic accuracy rate of EUS for leiomyoma and GIST were, respectively, up to 83.5 and 88.3 %, according to the histopathological finding of specimens from ESD.

Patients with gastric SMTs < 3 cm were advised to follow up by endoscopic or EUS examinations at regular intervals, according to the position of the American Gastrointestinal Association Institute [12], but it is controversial for potential hazard problems, such as patient compliance, cost-effectiveness, delayed diagnosis of malignancy, and the burden associated with repeated endoscopic procedures [13, 14]. Demetri et al. [13] suggested all GIST larger than 2 cm should be surgically resected, and the treatment options for incidental tumors smaller than 2 cm are surgically resection or surveillance. Surgery is not a comfortable procedure at all and patients prone to accept minimal invasive procedure. With development and clinical appliance of ESD, a novel invasive approach initially developed as a method for endoscopic resection of superficial gastric cancers [22, 23], ESD was considered to be a promising minimal invasive technology to treat upper gastrointestinal SMTs [24]. But there are still a primary and exploratory maneuver of digestive SMTs treated with en bloc ESD and few data about feasibility of digestive SMTs treated with ESD and there is no enough evidence to reach a consensus or guideline. Recently, ESD has been largely developed and applied to resect both of mucous lesions and submucosal gastrointestinal tumors, even those intraluminal growing SMTs originated from muscularis propria [20, 25]. In a large-scale multicenter study, the en bloc resection rate was 95.3 % (953/1000) when ESD was used for all the treated gastric neoplasms [26]. In Li et al. [27] prospectively study, en bloc resection rate with ESD of esophagogastric junction (EGJ) SMTs originating from the muscularis propria layer with ESD was 94.4 %(135/143), including 20 patients with GISTs. However, most reported about ESD on the upper gastrointestinal SMTs treatment were focused on gastric SMTs, little on esophageal or duodenal SMTs, and little information about short- or medium-term effect followed up by EUS. In this prospective series, the overall success rate of en bloc resection with ESD was 92.9 %. SMTs located in gastric fundus commonly originated from muscularis propria, and special tumor size > 2 cm were frequently dissected with EFTR. The success rate of en bloc resection for gastric SMTs originated from different layers was diverse. Hoteya et al. [28] once reported that the complete resection rate of gastric submucosal tumors from submucosal layer or muscularis mucosae origin was 100 %. Recently, a series of studies showed that complete resection rate by ESD was 64–94.4 % for tumors originated from muscularis propria layer [3, 29–31]. In this study, en bloc resection rates with ESD for SMTs originated from muscularis mucosae, submucosa, and muscularis propria were 100, 91.3, and 87.7 %, respectively.

Shi et al. [31] recommended that patients with esophageal submucosal tumors not larger than 3 cm can undergo ESD procedure, because of the volume of the esophageal cavity, the tumor larger than 3 cm is too large to have adequate space to do the ESD procedure, and the perforation rate will increase when the tumor diameter is larger. Bialek et al. [20] reported that ESD is safe for removing gastric SMTs range 1–8 cm in diameter, and tumors larger than 5 cm need to be cut into pieces after ESD to allow for safe retrieval through the cardia and pharyngal sphincter. In our experience from this prospective study, ESD is feasible, safe, and effective treatment for patients with gastrointestinal SMTs size ≤5 cm in diameter, especially ≤2 cm, when lesions adhesive to serosa or tumors from muscularis propria and large than 2 cm were frequently performed with endoscopic full-thickness resection (EFTR) [11].

The common severe complications related to ESD were accident massive bleeding and perforation, but majority (15 cases, 78.9 %) were treated with endoscopy. In this study, fourteen patients (6.25 %) suffered perforation, and only one case was transferred to emergent surgery at initial stage of ESD development, while other thirteen patients were treated by endoscopic clips. In one of the cases of perforation, the tumor located in cardia was large and tightly adherent to the muscularis propria layer, perforation occurred during the treatment, an emergent surgery was performed, and the pathological diagnosis was GIST. When bleeding occurred in the procedure, it is difficult to perform for the disturbed visibility of operating field. Once bleeding happened, APC or hot biopsy forceps would be used to stanch bleeding, so as to make the operation field clear, and avoid residue. In our study, minor bleeding occurred in most of cases, and successful hemostasis was achieved by applying APC or hot biopsy forceps. Five patients (2.2 %) had massive bleeding, APC and hot biopsy forceps were ineffective, endoclips were applied for hemostasis in two cases, and the other three needed to receive emergent operation.

The short-term and medium-term effects on upper gastrointestinal SMTs with ESD was assessed by follow-up with standard endoscopy and EUS 3 months and 12 months after the ESD procedure, and 214/224 (95.5 %) and 147/224 (65.6 %) had been fulfilled 3- and 12-month follow-ups. In addition, 64 patients had not reached the planned follow-up time point. Three cases (0.5 %) (2 cases esophageal SMTs and 1 case cardiac SMT) were found residual tumors in 3-month follow-up, and ESD was successfully performed again. No recurrence during the follow-up has been found so far.

There were some limitations in our study. First, the number of the patients enrolled in this study was limited in one center; secondly, the follow-up period was short or medium term, and a long-term follow-up has not yet been completed.

In conclusion, esophageal SMTs (including cardiac) commonly with leiomyoma from muscularis mucosae and gastric fundus SMTs frequently with GIST from muscularis propria were the major SMTs in upper gastrointestinal SMTs, and EUS had a helpful diagnostic accuracy of tumor size, layer of origin, morphologic features, and even histopathological information. ESD had showed a high rate of successfully en bloc resection with satisfactory short- and medium-term effects. But long-term effects have not been sufficiently explored.

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**Compliance with ethical standards**

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