INTRODUCTION

Submucosal tumors (SMTs) or subepithelial lesions are usually asymptomatic and discovered fortuitously. They appear as smooth intraluminal protrusions with normal covering mucosa. SMTs can arise from any layer of the gastrointestinal (GI) tract wall (intraluminal tumors) or from the external wall (extra-luminal tumors). Endoscopic ultrasound (EUS) is the main procedure for detecting and diagnosing SMTs. The information detailing location, size, echo pattern and originating layer of the SMTs can be provided by EUS.

Therapeutic approaches for SMTs include endoscopic resection, laparoscopic resection and surgical resection, depending on the characteristics of the tumors.

THE ROLE OF EUS IN DIAGNOSIS FOR SMTs

SMTs are usually found fortuitously during the routine endoscopy while conventional endoscopy does not usually provide for a definite, confirmed diagnosis. The use of EUS for diagnosis of SMTs was used more than a decade. Due to its high sensitivity and specificity, EUS is considered to be the most accurate procedure for detecting and diagnosing SMTs, especially for tumors with a size of smaller than 0.5 cm. Information about the malignant potential, originating layer, size and extramural extension of an SMT can be also provided by EUS.

EUS is very accurate in determining whether a submucosal “protrusion” is the result of extrinsic compression and can clearly distinguish solid lesions from cystic structures within the submucosa, differentiate the layers of the GI wall and define the originating layer of the tumor. Electronic radial echoendoscopes with color Doppler or power Doppler can assess the vascular signals from submucosal masses and thus permit the differentiation of vascular structures from cysts. EUS allows for an accurate assessment of SMTs and can provide tissue samples for diagnostic purposes using EUS-guided fine needle aspiration (FNA) technique and EUS-guided trucut biopsy (TCB).

EUS FOR THE DIFFERENTIATION OF SMTs

Extramural compressions mimicking SMTs

Extramural compressions can be caused by normal extramural organs and pathologic extramural lesions. The stomach and duodenum can be compressed by normal extragastric organs, such as: Spleen, splenic vessel, gall bladder, liver, pancreas, intestine and enlarged accessory spleen as well as by pathologic lesions, such as: Liver cyst, hepatic hemangioma, splenic cyst, splenic tuberculosis, pancreatic cyst and pancreatic cystadenoma and also even by abdominal malignant tumors. The compressed esophageal presentation...
can be caused by normal extra-esophageal organs (examples of trachea, left atrium, spine and liver) and by pathologic lesions (such as hyperplastic vertebrae, enlarged heart and dissecting aneurysm), as well as by pulmonary and mediastinal masses.

**Submucosal lesions**

SMTs include a diverse array of benign, potentially malignant and malignant lesions, including: Gastrointestinal stromal tumors (GISTs), leiomyomas, neuroendocrine tumors, lipomas, granular cell tumors, varices, duplication cysts, heterotopic pancreas, Brunner’s gland hamartoma, lymphangiomas, endometriosis, etc.

**GIST**

The term of “GIST” was initially coined in 1983. GISTs are relatively rare neoplasms of the GI tract that may have a potentially lethal clinical outcome. The majority of GISTs present in the stomach (50%-70%) or the small bowel (20%-30%), while they can occur throughout the GI tract. The estimated annual incidence is 10-20 cases per million, of which 20%-30% are malignant. Hirota et al. first described that GISTs are believed to originate from interstitial cells of Cajal or related stem cells and the mutation in KIT seems to play a gatekeeper role in the transformation of interstitial cells of Cajal into a GIST. These Cajal cells constitute a complex cellular network, the likely functions of which are GI tract pacemaking and the regulation of intestinal motility. Histologically, GISTs vary from spindle cell tumors to epithelioid and pleomorphic tumors. Over 90% of GISTs are positive for KIT (CD117), 70% are positive for CD34, 20%-30% are positive for smooth muscle actin (SMA), 10% are positive for S100 protein and <5% are positive for desmin. In contrast, the CD117 is negative for the leiomyoma and sheath tumor.

In EUS, GIST commonly originates from the fourth layer, tending to develop exophytically. Small ones often show a hypoechoic structure with a regular outline (Fig. 1A and B) while larger ones may present with irregular outlines and inhomogenous internal echoes (hyperechoic foci, cystic structures and some other changes). In cases of malignant ones, they even present with metastasized foci. GISTs larger than 5 cm with high mitotic rates are often associated with malignant behavior and display higher rates of recurrence and metastasis.

**Leiomyoma**

Leiomyoma is a benign mesenchymal tumor with an indolent clinical course, which is predominantly found in the esophagus and sometimes in the colon and rectum, but rarely in the stomach and small intestine. Part of the esophageal leiomyoma is derived from the muscularis propria and others arise from the muscularis mucosae, while endoscopic treatment is more suitable for the latter one. Esophageal leiomyoma typically shows a strong positive for both desmin and SMA, while presenting negative for CD34 and KIT (CD117).

In EUS, the esophageal leiomyoma is generally shown as a homogenous hypoechoic mass arising from the fourth layer or the second layer with a regular, well-defined outline (Fig. 2A-D). The small ones may be extremely hypoechoic (even close to anechoic); while larger ones may have internal hyperechoic foci.

**Lipoma**

Gastrointestinal lipomas are benign SMTs, composed of mature adipose tissue. They can occur anywhere in the GI tract. Small lipomas (<2 cm) are usually asymptomatic and are discovered occasionally, while larger ones (>3-4 cm) can cause obstruction or GI bleeding. Most gastric lipomas are situated in the submucosa. Typical endoscopic feature of lipoma is a sharply defined, smooth swelling, often with a yellowish appearance. The typical finding of EUS reveals lipomas as diffused hyperechoic tumors within submucosal layer (Fig. 3A and B).

**Aberrant pancreas**

Aberrant pancreas are also called ectopic or heterotopic pancreas. Aberrant pancreas is defined as the presence of pancreatic tissue lacking anatomical and vascular continuity with the pancreas, which is thought to be a result of separation of pancreatic tissue during the embryonic development of the pancreas. It is commonly located in the digestive tract wall (especially in the areas of gastric antrum proximal to the pylorus). Aberrant pancreas usually is benign.

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Figure 1. A: Endoscopic view showing a protrusion in the gastric fundus; B: Endoscopic ultrasound showing a hypoechoic mass originating from the fourth layer. The immunohistochemical examination after surgical resection confirmed that it was a gastrointestinal stromal tumor.
and asymptomatic. Adenocarcinoma arising from aberrant pancreas is relatively rare.\textsuperscript{22}

The presence of an opening (fluid can trickle from the opening) on the surface is a distinctive endoscopic finding. Although the EUS findings may vary, they are usually shown as heterogeneous hypoechoic mass with a poorly-defined outline, originating from the third and/or fourth layer (actually it could arise from any layer or a combination of several layers) (Fig. 4A and B). The detection of cystic components inside the lesion is helpful, which correspond to the duct-like structures in the aberrant pancreas.

**Cystic lesions**

Cystic lesion (Fig. 5A and B) in the GI tract can be congenital (ex. duplication cyst) or acquired (ex. retention cysts and neoplastic cystic formation). Endosonographically, cystic tumors were classified into simple cystic, multicystic and solid cystic tumor types.\textsuperscript{23}

Cystic lesions of the gastric wall include retention cysts, gastric duplication cysts, heterotopic gastric mucosa (simple cystic or multicystic) and some neoplasia-associated cysts (presenting solid cystic, such as heterotopic pancreas,
gastric stromal tumors with cystic degeneration,24 multiple submucosal cysts accompanied with gastric carcinoma). Brunner’s gland hamartomas (heterogeneous solid and/or cystic) are uncommon duodenal SMTs.25 Lymphangioma is a common multiple cystic tumor in the GI tract, mostly located in the duodenum. Endoscopically, it exhibits a cream-colored appearance and exudation of yellowish chylous liquid will be seen if a biopsy is performed. Without histological confirmation, it is difficult to yield a confident differential diagnosis of them (particularly for the solid cystic lesions). EUS and EUS-guided needle aspiration not only can be used for diagnosis, but also for treating foregut cysts that are located in the upper GI tract.26 However, an aspiration of cystic lesions may on occasions cause infection.27

**Hemangiomas**

Hemangiomas of the GI tract are infrequently encountered entities. Histologically, cavernous vascular malformation is composed of blood-filled sinus-like spaces with prominent vascular channels in the submucosa.28 They are usually present as intraluminal lesions; though, diffuse cavernous hemangioma can extend into adjacent structures by infiltrating the submucosa and beyond.28 They range from solitary lesions to clusters.

Endoscopy is regarded as the first choice to diagnose hemangiomas, EUS could be used in some instances. In EUS, the typical finding of cavernous hemangioma is shown as multiple cystic mass arising within the submucosa (Fig. 6A and B); diffuse cavernous hemangioma can extend into adjacent structures by infiltrating the submucosa and beyond (Fig. 6C and D).

Table 1 summarizes the characteristic clinical and endosonographic features of submucosal lesions.

**TISSUE DIAGNOSIS FOR SMTs**

Pre-operative pathologic diagnosis of SMTs may be helpful in clinical decision making. Although EUS can assist in the diagnosis of an SMT, endosonography cannot replace histopathologic classification.29 Many techniques have been used in attempts to obtain adequate samples for tissue diagnosis of the SMTs, including endoscopic boring biopsy, biopsy after mucosal incision to expose the tumor, endoscopic submucosal tumorectomy and biopsy after resection of the mucosa. EUS-guided FNA and EUS-guided TCB are also alternative procedures obtaining tissue samples for tissue diagnosis of SMTs.

EUS-FNA has been proved to be a sensitive and safe method for histological diagnosis of submucosal lesions. Hoda et al.30 reported EUS-FNA sampling of submucosal lesions was diagnostic in 61.6% and showed a spindle cell neoplasm (“suspicious”) in another 22.3% (diagnostic

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**Figure 5.** A: Endoscopic view showing a smooth protrusion in the duodenum; B: Endoscopic ultrasound showing an anechoic structure in the third layer, without internal color Doppler signal detected.

**Figure 6.** A: Endoscopic view showing a solitary lesion in the esophagus; B: Endoscopic ultrasound (EUS) showing a multiple cystic mass arising within the submucosa; C: Endoscopic view showing a cluster in the esophagus; D: EUS showing diffuse cavernous hemangioma extending into adjacent structures by infiltrating the submucosa and beyond.
Table 1. Characteristics of common gastrointestinal submucosal lesions at EUS

| Submucosal tumor          | Most common sites of occurrence                                      | EUS layer | EUS appearance                                                                 |
|---------------------------|-----------------------------------------------------------------------|-----------|--------------------------------------------------------------------------------|
| Leiomyoma                 | Esophagus, cardia                                                     | 2nd, 3rd, 4th | Homogenous hypochoic, well-defined outline; larger ones might present with internal hyperechoic foci |
| GIST                      | Commonly seen at the border between the fundus and body of the stomach, can also be seen in the fundus, cardia, antrum, duodenum, small intestine, colon and etc. | 4th       | Hypoechoic or slightly lower than iso-echoic; larger ones might have internal anechoic areas or hyperechoic patterns |
| Aberrant pancreas         | Gastric antrum proximal to the pylorus                                | 2nd, 3rd, 4th | Heterogenous hypochoic, poorly-defined outline; might include cystic components |
| Lipoma                    | Gastric antrum, duodenum                                             | 3rd       | Diffuse hyperechoic                                                            |
| Duplication cyst           | anywhere throughout the GI-tract                                      | Any or extradural | Anechoic, 3-5-layer wall, round or oval, absent Doppler signal                |
| Varices                   | Esophagus, stomach                                                   | 3rd       | Anechoic, serpiginous, Doppler positive                                         |

GIST: gastrointestinal stromal tumor; EUS: endoscopic ultrasound.

yield 83.9%). Sepe et al.31 reported the sensitivity of EUS-FNA cytology for the diagnosis of GIST was 78.4% and was influenced by size, location, shape and layer of origin whereas, sometimes the amount of tissue samples obtained by FNA is small, which would increase the number of needle passes.

Compared with EUS-FNA, the application of EUS-TCB may reduce the number of needle passes and increase the success rate. Levy et al.32 suggested EUS-TCB can be safely used to obtain biopsy specimens of intraintestinal and extraintestinal mass lesions. Ribeiro et al.33 respectively reported one case of GIST diagnosed by TCB, while failed by FNA. However, EUS-TCB may be technically difficult to perform when the echo-endoscope is not in a straight form.

Immunohistochemical staining analysis may sometimes be necessary for reliably differentiating the type of mesenchymal lesions. When sufficient cell block and tissue fragment are obtained, EUS-FNA with immunohistochemical staining is a reliable method for histological diagnosis.34

ENDOSCOPIC RESECTION TECHNIQUES FOR SMTs

Recent technical advances in EUS as well as new devices designed for endoscopic resection have opened up the field to many therapeutic possibilities. Several endoscopic techniques, including endoscopic mucosal resection (EMR), endoscopic band ligation, endoscopic submucosal dissection (ESD), endoscopic submucosal enucleation (ESE), endoscopic full-thickness resection (EFR), endoscopic submucosal tunneling dissection (ESTD) have been proven useful in the management of SMTs.

For tumors arising from mucosal and submucosal layer, EMR, ligation device assisted- endoscopic mucosal resection (EMR-L),35-40 transparent cap-assisted endoscopic mucosal resection (EMR-C)41-45 as well as ESD can be performed.

EMR technique has become a promising therapeutic option for removal of GI tumors arising from mucosal and submucosal layer. Several techniques of EMR can be used to make the lesion into a polypoid shape, such as the “strip biopsy” technique, which uses a grasping forceps with double-channel endoscope, the “suck and cut” technique that implements a cap on the endoscope (EMR-C) and the “suck-and -ligate” technique, which employs a ligation device (EMR-L). Inoue et al.35,36 firstly reported that EMR-C could be a simplified technique for resection of GI mucosal lesions. Rectal carcinoid tumors,37-39 esophageal leiomyoma derived from the muscularis mucosa and granular cell tumor40 could also successfully resected by endoscopic submucosal tumor resection with a transparent cap. Akahoshi et al.41 and Ono et al.42 reported successful results using endoscopic submucosal tumor resection performed with a ligation device (ESMRL) for the resection of rectal carcinoid tumors less than 1 cm in diameter. Niimi et al.43 and Kim et al.44 also reported that EMR-L (or ESMR-L) is a simple and effective procedure for the complete removal of small rectal carcinoid tumors. Lee et al.45 reported that ESMR-L was successfully performed in all 25 small esophageal SMTs localized within the muscularis mucosae or submucosa, the en bloc resection rate was 100% (25/25) and histologically complete resection was achieved in 24 lesions (24/25, 96%). Minor immediate bleeding occurred in four cases after resection of the lesion by snare, but there was no delayed bleeding or perforation. Nevertheless, resection with EMR technique (including EMR-L and EMR-C) is limited by the size of the SMTs. A larger lesion might be resected in piecemeal (not en bloc) by EMR technique. ESD using insulated-tip electrosurgical knife could improves the completeness of resection of a larger lesion, although ESD technique usually requires highly skillful manipulation by experienced specialists and relatively longer procedure times.

For tumors originating from muscularis propria, although endoscopic resection may carry a relatively high risk of hemorrhage and perforation, several endoscopic resection techniques have been proven feasible and useful, including: ESE,46-47 ESD,48-53 EFR,54,55 ESTD56-59 and

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endoscopic ligation.\textsuperscript{60-62} Park \textit{et al.}\textsuperscript{63} firstly reported that endoscopic enucleation using with an insulated-tip electrosurgical knife could be performed for en bloc enucleation of SMTs arose from the muscularis propria. Jeong \textit{et al.}\textsuperscript{64} also reported that en bloc enucleation using an insulated-tip knife and snare was a safe and effective method for the histological diagnosis and removal of small gastric SMTs in the muscularis propria, especially those located in the cardia and the high body of the stomach.

The ESD technique appears to be an effective and relatively safe method in the complete resection of selected cases of gastric SMTs arose from the muscularis propria layer.\textsuperscript{48,53} Lee \textit{et al.}\textsuperscript{48} reported that ESD could be used for the resection of intraluminal gastric tumors. Hwang \textit{et al.}\textsuperscript{49} reported endoscopic resection for the treatment of SMTs arose from the muscularis propria seems to be feasible and effective only in the well-marginated tumors, which showed underlying muscle layer under EUS. Complete endoscopic resection of SMTs was successful in 64\% (16/25 tumors). The successful resection rate of tumors which had underlying muscle layer was 93.8\% (15/16), but that of tumors which didn't show any underlying muscle layer on EUS was 11.1\% (1/9). All three perforations occurred in the cases of tumors, which did not show underlying muscle layer on EUS during dissection of the tumor base from surrounding tissue. Bialek \textit{et al.}\textsuperscript{50} reported that EUS findings can predict complete tumor resections: Successful R0 resections were predicted by the observation of no, or only narrow, tumor connections with the underlying muscle layer during EUS. Chun \textit{et al.}\textsuperscript{51} concluded that small tumor size (≤20 mm) and a positive rolling sign are appropriate indications for ESD.

EFR used to treat non-intracavitary gastric stromal tumors was firstly reported by Wang \textit{et al.}\textsuperscript{52} Zhou \textit{et al.}\textsuperscript{53} also reported the results of EFR for 26 patients without laparoscopic assistance, the complete resection rate was 100\% and the mean operation time was 105 (range, 60-145) min. The mean resected lesion size was 2.8 (range: 1.2-4.5) cm. No gastric bleeding, peritonitis sign or abdominal abscess occurred after EFR.

In the research of Xu \textit{et al.},\textsuperscript{54} ESTD is a promising new procedure. The EFR for Gastrointestinal Submucosal Tumors was also reported band ligation was also effective and safe for small duodenal GISTs.\textsuperscript{55} However, for the gastric GISTs located in the gastric fundus; endoscopic band ligation treatment might carry a risk of post-ligation perforation.\textsuperscript{65} In order to prevent post-

Although endoscopic enucleation techniques or ESD technique has proven promising feasible and useful, they usually require highly skillful manipulation by experienced specialists and relatively longer procedure times. For the small tumors, especially those smaller than 1 cm, the complete resection rate was lower than for the larger tumors.\textsuperscript{56} It was more difficult to strip the covering mucosa and dissect the submucosal layer in the small tumors.\textsuperscript{57} For those tumors less than 1 cm in diameter, endoscopic band ligation without electrosurgery could be an alternative, effective and safe treatment (Fig. 7A-C).

Procedures for endoscopic band ligation: A standard esophagogastroduodenoscopy is introduced with a transparent cap attached at the tip of scope; after the tumor is fully aspirated into the cap, the band is released to ligate the tumor by injecting 2 ml of air into the tube.

Sun \textit{et al.}\textsuperscript{58} reported the results of endoscopic band ligation for 50 esophageal leiomyomas and showed a 100\% resection rate (50/50) and no perforation occurred. After the complete ligation of SMT and few of adherent normal tissues of the digestive wall, the SMT would naturally slough after several weeks because of ischemia. In another study of Sun \textit{et al.}\textsuperscript{59}, 29 patients with small gastric stromal tumors arising in the gastric muscularis propria were treated by ligation. The 28 GISTs sloughed completely. One lesion did not slough because it was not completely ligated. Sun \textit{et al.}\textsuperscript{60} also reported band ligation was also effective and safe for small duodenal GISTs.

In the esophagus and cardia up to a size of 4 cm. Linghu \textit{et al.}\textsuperscript{61} reported that ESTD could be used to remove large esophageal SMTs. The average length of the resected five lesions was 5.7 cm. Operative times ranged from 50 to 120 min (mean, 77 min). En bloc resection with negative lateral and basal margins was achieved in all lesions without complications. In addition, during the ESTD procedure, tumors sometimes can be hard to identify and differentiate from other physiological protrusions (e.g: Aorta compression) by endoscopic view in the tunnel. EUS could be performed to identify the tumor during the endoscopic dissection procedure. EUS could also be used to evaluate the healing quality of submucosal tunnel after the ESTD procedure.\textsuperscript{59}

**Figure 7. Schematic diagram of endoscopic band ligation of gastrointestinal (GI) muscularis propria tumors.** When suction and elastic band ligation are performed, all layers of the GI tract together with the tumor will be ligated (A and B). The goal of ligation is to cause the lesion to assume a polypoid form with a pseudostalk; C: Several days after ligation, because of the resultant ischemia and an ulcer will form. At the same time, the serosa outside of the band will gradually adhere in response to the local inflammatory reaction, therefore, avoiding perforation.
Contraindications

Advantages

Complications

Disadvantages

2011; 45: Guo et al. EUS can characterize lesions by providing information delineating the separate histologic layers of the GI wall. EUS is the optimal imaging technique capable of treatment of SMTs are summarized in (Tab. 2).

EUS can be a simple, safe and effective treatment technique. Therefore, for those small GISTs in the gastric fundus, surfaces of the clips and lesions to secure the clips firmly. In particular, for tumors in the muscularis propria layer, it is even more important to ligate perforation; Nan et al. placed 4-5 hemoclips on the folds around the ligation band to reduce tension of the ligation site. Then, a medical adhesive was sprayed onto the surfaces of the clips and lesions to secure the clips firmly. Therefore, for those small GISTs in the gastric fundus, hemoclip-reinforced endoscopic band ligation appeared to be a simple, safe and effective treatment technique. The disadvantage of endoscopic band ligation is that it is impossible to make a complete pathological examination because tumor masses slough directly into the lumen and are excreted.

Various endoscopic therapeutic procedures for the treatment of SMTs are summarized in (Tab. 2).

CONCLUSION

EUS is the optimal imaging technique capable of delineating the separate histologic layers of the GI wall. EUS can characterize lesions by providing information on echogenic origin, size, outline, homogeneity and the presence of echogenic or anechoic foci. EUS-FNA, EUSTCB, EUS-FNB can provide samples for cytologic or histologic analysis and discrimination between benign and malignant SMTs.

SMTs of the GI tract can be treated with various endoscopic techniques. EUS is a very useful evaluation tool for the selection of the appropriate treatment method for each case. EUS could also be performed for systematic follow-up after tumors resection.

REFERENCES

1. Alkhatib AA, Faigel DO. Endoscopic ultrasonography-guided diagnosis of subepithelial tumors. Gastrointest Endosc Clin N Am 2012; 22: 187-205, vii.
2. Kongkam P, Devereaux BM, Ponrudurai R, et al. Endoscopic ultrasound forum summary from the Asian Pacific Digestive Week endoscopic ultrasound 2012. Endosc Ultrasound 2013; 2: 43-60. 3. Nagler AK, Aslanian HR, Siddiqui UD, et al. Endoscopic ultrasound and gastric lesions. J Clin Gastroenterol 2011; 45: 215-21.
4. Sakamoto H, Kitano M, Kudo M, et al. Diagnosis of subepithelial tumors in the upper gastrointestinal tract by endoscopic ultrasonography. World J Radiol 2010; 2: 289-97.
5. Ponsaing LG, Kiss K, Loft A, et al. Diagnostic procedures for submucosal tumors in the gastrointestinal tract. World J Gastroenterol 2007; 13: 3301-10.

6. Rana SS, Bhasin DK, Rao C, et al. Splenic tuberculosis diagnosed by endoscopic ultrasound-guided fine needle aspiration. Endosc Ultrasound 2012; 1: 167-8.

7. Sivu S. Electronic Endoscopic Ultrasonography: Diagnostic Imaging and Interventional Techniques [M]. Beijing: People’s Medical Publishing House; 2008. p. 71-2.

8. Rossini LG, Ribeiro PA, Rodrigues FC, et al. Transrectal ultrasound-techniques and outcomes in the management of intestinal endometriosis. Endosc Ultrasound 2012; 1: 23-35.

9. Mazur MT, Clark HB. Gastric stromal tumors. Reappraisal of histogenesis. Am J Surg Pathol 1983; 7: 507-19.

10. Badalamenti G, Rodolico V, Fufaro F, et al. Gastrointestinal stromal tumors (GISTs): Focus on histopathological diagnosis and biomolecular features. Ann Oncol 2007; 18 Suppl 6: vi136-40.

11. Miettinen M, Lasota J. Gastrointestinal stromal tumors — Definition, clinical, histological, immunohistochemical, and molecular genetic features and differential diagnosis. Virchows Arch 2001; 438: 1-12.

12. Steigen SE, Eide TJ. Gastrointestinal stromal tumors (GISTs): A review. APMIS 2009; 117: 73-86.

13. Hirota S, Isozaki K, Moriyama Y, et al. Gain-of-function mutations of c-kit in human gastrointestinal stromal tumors. Science 1998; 279: 577-80.

14. Joensuu H. Gastrointestinal stromal tumor (GIST). Ann Oncol 2006; 17 Suppl 10: x280-6.

15. Abraham SC. Distinguishing gastrointestinal stromal tumors from their mimics: An update. Adv Anat Pathol 2007; 14: 178-88.

16. Punpale A, Rangole A, Bhambhani N, et al. Leiomyoma of esophagus. Ann Thorac Cardiovasc Surg 2007; 13: 78-81.

17. Lee SJ, Paik YH, Lee DK, et al. The diagnostic value of endprobe for small esophageal leiomyomas derived from the muscularis mucosae. Yonsei Med J 2005; 46: 61-5.

18. Zhu X, Zhang XQ, Li BM, et al. Esophageal mesenchymal tumors: Endoscopy, pathology and immunohistochemistry. World J Gastroenterol 2007; 13: 768-73.

19. Thompson WM. Imaging and findings of lipomas of the gastrointestinal tract. AJR Am J Roentgenol 2005; 184: 1163-71.

20. Kibria R, Butt S, Ali SA, et al. An unusual case of giant gastric lipoma with hemorrhage. J Gastrointest Cancer 2009; 40: 144-5.

21. Christodoulidis G, Zacharoulis D, Barbanis S, et al. Endoscopic ultrasound-guided fine needle aspiration for the diagnosis of upper gastrointestinal endometriosis. J Gastroenterol Cancer 2009; 40: 652-6.

22. Matsuki M, Gouda Y, Ando T, et al. Adenocarcinoma arising from aberrant pancreas in the stomach. J Gastroenterol 2005; 40: 652-6.

23. Hizawa K, Matsumoto T, Kouzuki T, et al. Cystic submucosal tumors in the gastrointestinal tract: Endosonographic findings and endoscopic removal. Endoscopy 2000; 32: 712-4.

24. Stelzner S, Freitag M, Justus J, et al. Cystic gastric stromal tumors: A diagnostic dilemma? Chirurg 2000; 71: 696-701.

25. Hizawa K, Iwai K, Esaki M, et al. Endosonographic features of Brunner’s gland hamartomas which were subsequently resected endoscopically. Endoscopy 2002; 34: 956-8.

26. Van Dam J, Rice TW, Sivak MV Jr. Endoscopic ultrasonography and endoscopically guided needle aspiration for the diagnosis of upper gastrointestinal tract foregut cysts. Am J Gastroenterol 1992; 87: 762-5.

27. Grandval P, Picon M, Coste P, et al. Infection of submucosal tumor after endosonography-guided needle biopsy. Gastroenterol Clin Biol 1999; 23: 566-8.

28. Yoo S. GI-associated hemangiomas and vascular malformations. Clin Colon Rectal Surg 2011; 24: 193-200.

29. Giovannini M. Report of EUS presentations during the 20th UEGW meeting in Amsterdam. Endosc Ultrasound 2012; 1: 169-72.

30. Hoda KM, Rodriguez SA, Faigel DO. EUS-guided sampling of suspected GI stromal tumors. Gastrointest Endosc 2009; 69: 1218-23.

31. Sepe PS, Moparty B, Pitman MB, et al. EUS-guided FNA for the diagnosis of GI stromal cell tumors: Sensitivity and cytologic yield. Gastrointest Endosc 2009; 70: 254-61.

32. Levy MJ, Jondal ML, Clain J, et al. Preliminary experience with an EUS-guided trucut biopsy needle compared with EUS-guided FNA. Gastrointest Endosc 2003; 57: 101-6.

33. Ribeiro A, Vernon S, Quintela P. EUS-guided trucut biopsy with immunohistochemical analysis of a gastric stromal tumor. Gastrointest Endosc 2004; 60: 645-8.

34. Murad FM, Debol SM, Lai R, et al. EUS-guided FNA with immunocytochemical staining is an accurate method of diagnosing GI mesenchymal neoplasms without requiring core biopsy: A comparison study of EUS-guided FNA cytologic diagnosis to histologic diagnosis of resected specimens. Gastrointest Endosc 2007; 65: A198.

35. Inoue H, Endo M, Takeshita K, et al. A new simplified technique of endoscopic esophageal mucosal resection using a cap-fitted panendoscope (EMRC). Surg Endosc 1992; 6: 264-5.

36. Inoue H, Takeshita K, Hori H, et al. Endoscopic mucosal resection with a cap-fitted panendoscope for esophagus, stomach, and colon mucosal lesions. Gastrointest Endosc 1993; 39: 58-62.

37. Imada-Shirakata Y, Sakai M, Kajiyama T, et al. Endoscopic resection of rectal carcinoid tumors using aspiration lumbectomy. Endoscopy 1997; 29: 34-8.

38. Oshitani N, Hamaaki N, Sawa Y, et al. Endoscopic resection of small rectal carcinoid tumours using an aspiration method with a transparent overcap. J Int Med Res 2000; 28: 241-6.

39. Kajiyama T, Sakai M, Torii A, et al. Endoscopic aspiration lumbectomy of esophageal leiomyomas derived from the muscularis mucosae. Ann J Gastroenterol 1995; 90: 417-22.

40. Endo S, Hirasaki S, Doi T, et al. Granular cell tumor occurring in the sigmoid colon treated by endoscopic mucosal resection using a transparent cap (EMR-C). J Gastroenterol 2003; 38: 385-9.

41. Akahoshi K, Fujimaru T, Nakanishi K, et al. Endosonography probe-guided endoscopic resection of small flat rectal carcinoid tumor using band ligation technique. Endoscopy 2001; 33: 471.

42. Ono A, Fujii T, Saito Y, et al. Endoscopic submucosal resection of rectal carcinoid tumors with a ligation device. Gastrointest Endosc 2003; 57: 583-7.

43. Niimi K, Goto O, Fujishiro M, et al. Endoscopic mucosal resection with a ligation device or endoscopic submucosal dissection for rectal carcinoid tumors: An analysis of 24 consecutive cases. Dig Endosc 2012; 24: 443-7.

44. Kim HH, Park SJ, Lee SH, et al. Efficacy of endoscopic submucosal resection with a ligation device for removing small rectal carcinoid tumor compared with endoscopic mucosal resection: Analysis of 100 cases. Dig Endosc 2012; 24: 159-63.

45. Lee DG, Kim GH, Park DY, et al. Endoscopic submucosal resection of esophageal subepithelial lesions using band ligation. Endoscopy 2011; 43: 822-5.

46. Park YS, Park SW, Kim TI, et al. Endoscopic enucleation of upper GI submucosal tumors by using an insulated-tip electrosurgical knife. Gastrointest Endosc 2004; 59: 409-15.

47. Jeong ID, Jung SW, Bang SJ, et al. Endoscopic enucleation for gastric subepithelial tumors originating in the muscularis propria layer. Surg Endosc 2011; 25: 468-74.

48. Lee IL, Lin PY, Tung SY, et al. Endoscopic submucosal resection of submucosal lesions with band ligation. Endoscopy 2011; 43: 806-10.

49. Hwang JC, Kim JH, Kim JH, et al. Endoscopic resection for the treatment of intraluminal gastric subepithelial tumors originating from the muscularis propria layer. Endoscopy 2006; 38: 1024-8.

50. Bialek A, Wiechowska-Kozłowska A, Pftikiewicz J, et al. Endoscopic submucosal dissection for treatment of gastric subepithelial tumors (with video). Gastrointest Endosc 2012; 75: 276-86.
51. Chun SY, Kim KO, Park DS, et al. Endoscopic submucosal dissection as a treatment for gastric subepithelial tumors that originate from the muscularis propria layer: A preliminary analysis of appropriate indications. Surg Endosc 2013.
52. Białek A, Wiechowska-Kozłowska A, Huk J. Endoscopic submucosal dissection of large gastric stromal tumor arising from muscularis propria. Clin Gastroenterol Hepatol 2010; 8: e119-20.
53. Liu BR, Song JT, Qu B, et al. Endoscopic muscularis dissection for upper gastrointestinal subepithelial tumors originating from the muscularis propria. Surg Endosc 2012; 26: 3141-8.
54. Wang L, Ren W, Fan CQ, et al. Full-thickness endoscopic resection of nonintracavitary gastric stromal tumors: A novel approach. Surg Endosc 2011; 25: 641-7.
55. Zhou PH, Yao LQ, Qin XY, et al. Endoscopic full-thickness resection without laparoscopic assistance for gastric submucosal tumors originated from the muscularis propria. Surg Endosc 2011; 25: 2926-31.
56. Xu MD, Cai MY, Zhou PH, et al. Submucosal tunneling endoscopic resection: A new technique for treating upper GI submucosal tumors originating from the muscularis propria layer (with videos). Gastrointest Endosc 2012; 75: 195-9.
57. Linghu E, Feng X, Wang X, et al. Endoscopic submucosal tunnel dissection for large esophageal neoplastic lesions. Endoscopy 2013; 45: 60-2.
58. Khashab MA, Saxena P, Valeshabad AK, et al. Novel technique for submucosal tunneling and endoscopic resection of submucosal tumors (with video). Gastrointest Endosc 2013; 77: 646-8.
59. Ge N, Sun S, Wang S, et al. Endoscopic ultrasound-assisted tunnel-type endoscopic submucosal dissection for the treatment of esophageal tumors arising in the muscularis propria (with video). Endosc Ultrasound 2013; 2: 11-5.
60. Sun S, Jin Y, Chang G, et al. Endoscopic band ligation without electrosurgery: A new technique for excision of small upper-GI leiomyoma. Gastrointest Endosc 2004; 60: 218-22.
61. Sun S, Ge N, Wang C, et al. Endoscopic band ligation of small gastric stromal tumors and follow-up by endoscopic ultrasonography. Surg Endosc 2007; 21: 574-8.
62. Sun S, Ge N, Wang S, et al. EUS-assisted band ligation of small duodenal stromal tumors and follow-up by EUS. Gastrointest Endosc 2009; 69: 492-6.
63. Siyu S, Sheng W, Guoxin W, et al. Gastric perforations after ligation of GI stromal tumors in the gastric fundus. Gastrointest Endosc 2010; 72: 615-6.
64. Nan G, Siyu S, Shiwei S, et al. Hemoclip-reinforced and EUS-assisted band ligation as an effective and safe technique to treat small GISTs in the gastric fundus. Am J Gastroenterol 2011; 106: 1560-1.