Review

Endosonography-Assisted Diagnosis and Therapy of Gastrointestinal Submucosal Tumors

Jintao Guo[1], Zhijun Liu[2], Siyu Sun[1*], Sheng Wang[1], Nan Ge[1], Xiang Liu[1], Guoxin Wang[1], Wen Liu[1]

[1]*Endoscopic Center,* [2]*Department of Ultrasound, The Shengjing Hospital of China Medical University, Shenyang, Liaoning Province, China*

Abstract

Submucosal tumors (SMTs) are usually discovered fortuitously during routine endoscopy, including various non-neoplastic and neoplastic conditions. Endoscopic ultrasound (EUS) is considered to be the best imaging procedure to characterize SMTs and to determine the need for further treatment. In this review, the following issues will be addressed: The role of EUS in diagnosis for SMTs, tissue diagnosis for SMTs and the influence of EUS on endoscopic resection techniques for SMTs.

Keywords: Endoscopic ultrasound; submucosal tumor, gastrointestinal; diagnosis; therapy

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,[1-5]

especially for tumors with a size of smaller than 0.5 cm.[5] 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 extra-gastric 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,[6] pancreatic cyst and pancreatic cystadenoma and also even by abdominal malignant tumors.[7] The compressed esophageal presentation

*To whom correspondence should be addressed.
E-mail: sunsiyu@hotmail.com

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,[8] etc.

GIST

The term of "GIST" was initially coined in 1983.[9] GISTs are relatively rare neoplasms of the GI tract that may have a potentially lethal clinical outcome.[10] The majority of GISTs present in the stomach (50%-70%) or the small bowel (20%-30%), while they can occur throughout the GI tract.[11,12] The estimated annual incidence is 10-20 cases per million, of which 20%-30% are malignant.[10-12]

Hirota *et al.*[13] 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.[13] Histologically, GISTs vary from spindle cell tumors to epithelioid and pleomorphic tumors.[10,14,15] 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.[10,14,15] In contrast, the CD117 is negative for the leiomyoma and sheath tumor.[15]

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 in homogenous 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.[16] Part of the esophageal leiomyoma is derived from the muscularis propria and others arise from the muscularis mucosae,[17] while endoscopic treatment is more suitable for the latter one.[18] Esophageal leiomyoma typically shows a strong positive for both desmin and SMA, while presenting negative for CD34 and KIT (CD117).[15,18]

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, but most frequently in the colon and sometimes in the stomach.[19] Small lipomas (<2 cm) are usually asymptomatic and are discovered occasionally, while larger ones (>3-4 cm) can cause obstruction or GI bleeding.[20]

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.[21] 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
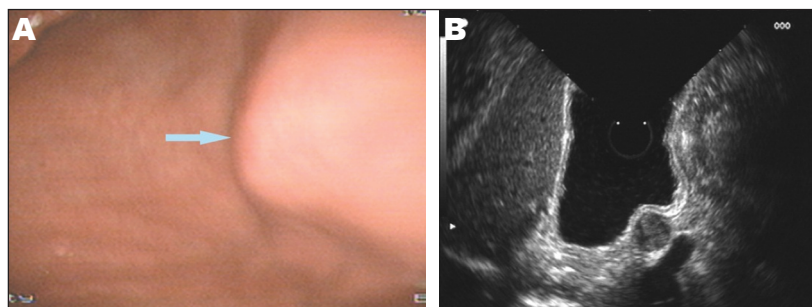

Figure 1. A: Endoscopic view showing a protrusion in the gastric fundus; **B:** Endoscopic ultrasound showing a hypoechoic mass originating from the fourth layer. The immunohistochemical examination after surgical resection confirmed that it was a gastrointestinal stromal tumor.
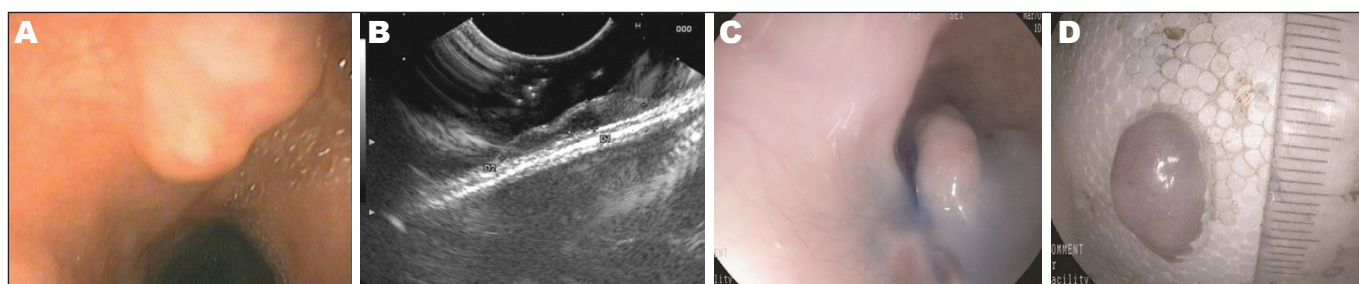
Figure 2. A: Endoscopic view showing a protrusion in the esophagus; **B:** Endoscopic ultrasound showing a homogeneous hypoechoic mass originating from the second layer; **C:** Endoscopic view showing that the lesion was lifted by submucosal injection; **D:** The lesion was resected by endoscopic mucosal resection. The immunohistochemical examination confirmed that it was a leiomyoma.
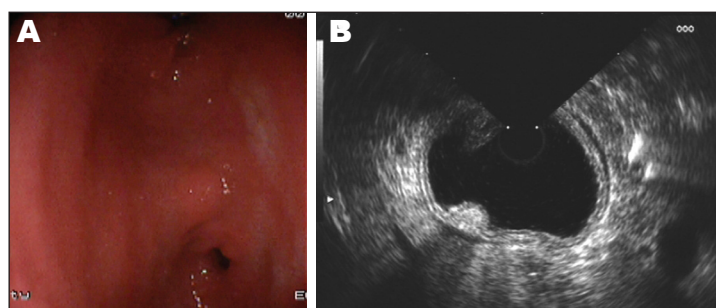

Figure 3. A: Endoscopic view showing a smooth protrusion in the gastric antrum; **B:** Endoscopic ultrasound showing a hyperechoic mass originating from the third layer with posterior echo distinctly attenuated. Pathology after endoscopic resection confirmed that the lesion was a lipoma.
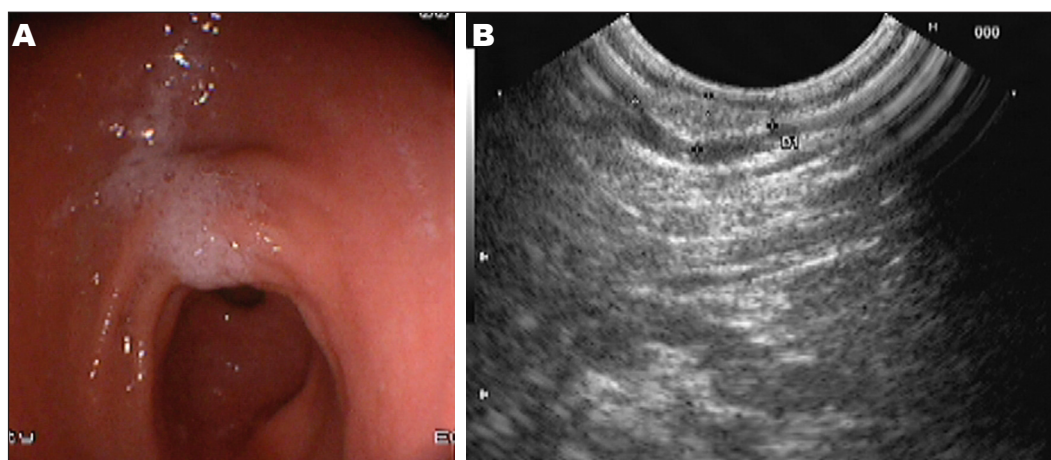

Figure 4. A: Endoscopic view showing a smooth protrusion in the gastric antrum; **B:** Endoscopic ultrasound showing a heterogeneous hypoechoic mass with poorly-defined borderline, origination from the third layer. Pathology after endoscopic resection confirmed that the lesion was an aberrant pancreas.

and asymptomatic. Adenocarcinoma arising from aberrant pancreas is relatively rare.[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.[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,
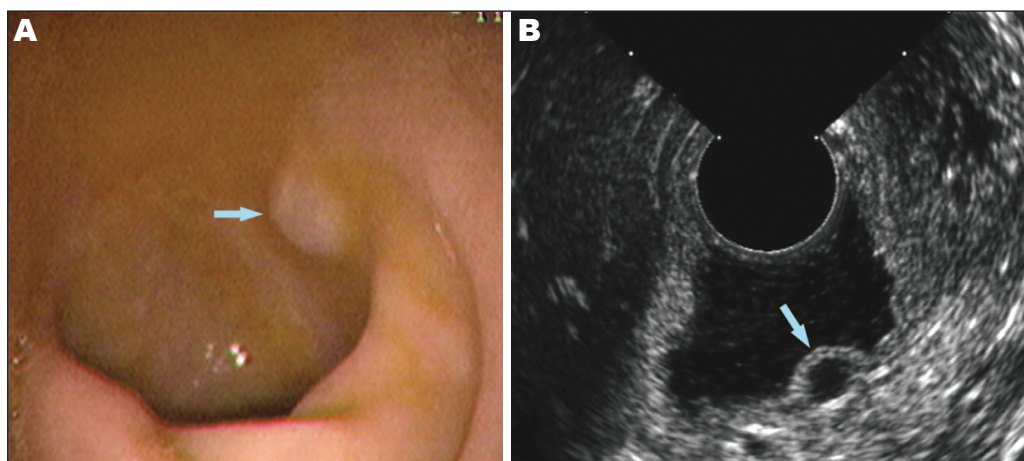
Figure 5. A: Endoscopic view showing a smooth protrusion in the duodenum; B: Endoscopic ultrasound showing an anechoic structure in the third layer, without internal color Doppler signal detected.
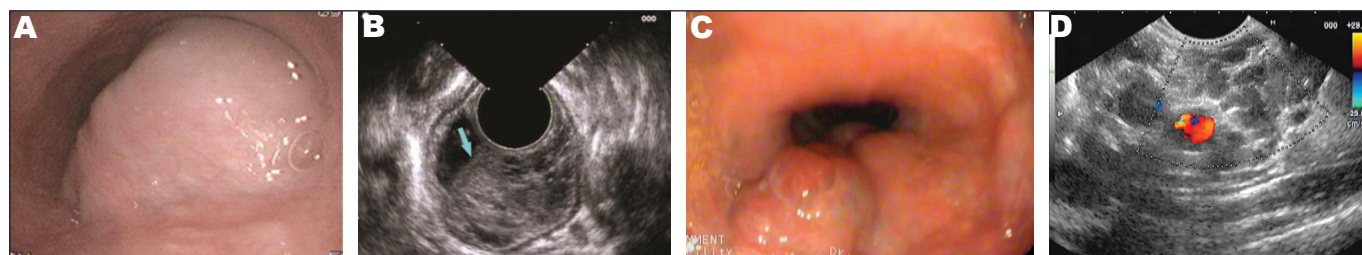

Figure 6. A: Endoscopic view showing a solitary lesion in the esophagus; B: Endoscopic ultrasound (EUS) showing a multiple cystic mass arising within the submucosa; C: Endoscopic view showing a cluster in the esophagus; D: EUS showing diffuse cavernous hemangioma extending into adjacent structures by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

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

Table 1. Characteristics of common gastrointestinal submucosal lesions at EUS

Characteristics of submucosal lesions at EUS			
Submucosal tumor	Most common sites of occurrence	EUS layer	EUS appearance
Leiomyoma	Esophagus, cardia	2nd, 3rd, 4th	Homogenous hypoechoic, 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	Heterogeneous hypoechoic, poorly-defined outline; might include cystic components
Lipoma	Gastric antrum, duodenum	3rd	Diffuse hyperechoic
Duplication cyst	anywhere throughout the GI-tract	Any or extramural	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 submucoal 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 submucoal 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,[37,38] esophageal leiomyoma derived from the muscularis mucosa[39] and granular cell tumor[40] 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 (ESMR-L) 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] ESTD[56-59] and

endoscopic ligation.[60-62]

Park *et al.*[46] 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 *et al.*[47] 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.[48-53] Lee *et al.*[48] reported that ESD could be used for the resection of intraluminal gastric tumors. Hwang *et al.*[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 *et al.*[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 *et al.*[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 *et al.*[54] Zhou *et al.*[55] 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 *et al.*,[56] ESTD is a promising new technique for selected SMTs in the esophagus and cardia up to a size of 4 cm. Linghu *et al.*[57] 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.[59]

BAND LIGATION FOR SMTs

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.[47] It was more difficult to strip the covering mucosa and dissect the submucosal layer in the small tumors.[47] 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 *et al.*[60] 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 *et al.*[61], 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 *et al.*[62] also reported band ligation was also effective and safe for small duodenal GISTs.

However, for the gastric GISTs located in the gastric fundus; endoscopic band ligation treatment might carry a risk of post-ligation perforation.[63] In order to prevent post-
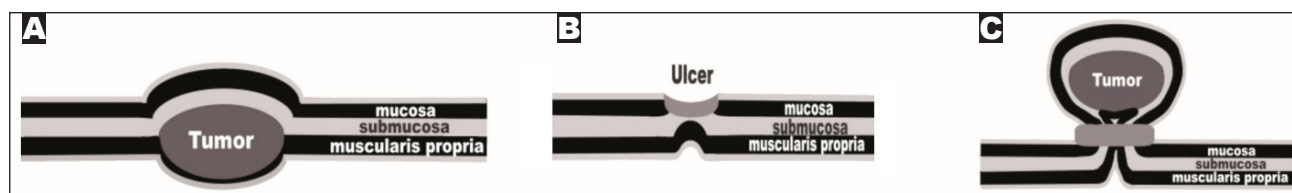

Figure 7. Schematic diagram of endoscopic band ligation of gastrointestinal (GI) muscularis propria tumors. When suction and elastic band ligation are performed, all layers of the GI tract together with the tumor will be ligated (A and B). The goal of ligation is to cause the lesion to assume a polypoid 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

Table 2. Various endoscopic therapeutic procedures for the treatment of SMTs

	Indication	Contraindications	Complications	Advantages	Disadvantages
ESMR-C[35-40]	SMTs <2 cm in the non-muscularis propria layer	SMTs >2 cm; SMTs origination from the muscularis propria	Minor hemorrhage, though rare	Simpler and easier than conventional EMR; high success rate	This technique can only be applied to small SMTs
ESMR-L[41-45]	SMTs <1 cm in the non-muscularis propria layer	SMTs >1 cm; SMTs origination from the muscularis propria	No serious complications have been reported	Not restricted by the location of the SMTs; achieves deeper resection than conventional EMR and thus a higher rate of curative resection	This technique can only be applied to small SMTs
ESE[46,47]	Gastric SMTs in the muscularis propria	SMTs did not meet the indication	Perforation, minor hemorrhage	This technique is not limited by the size, sessile form or association with the muscularis propria	Difficult to perform; the purpose of this treatment usually are macroscopic complete resection rather than microscopic complete resection
ESD[48-53]	SMTs in the non-muscularis propria and selected gastric SMTs in the muscularis propria	Tumors which did not show underlying muscle layer under EUS	Perforation, hemorrhage	It makes the resection of whole lesions possible and provides precise histologic information	This technique usually requires highly skillful manipulation by experienced specialists and relatively longer procedure times
EFR[54,55]	Large gastric SMTs in the muscularis propria	SMTs did not meet the indication	Perforation, hemorrhage	It makes the resection of whole lesions possible and provides precise histologic information	This technique usually requires highly skillful manipulation by experienced specialists and relatively longer procedure times
ESTD[56-59]	SMTs arising from muscularis propria of the esophagus and cardia	SMTs did not meet the indication	Minor hemorrhage	The advantage of this new method is the maintenance of GI tract mucosal integrity while achieving an en bloc resection of tumors	This technique usually requires highly skillful manipulation by experienced specialists and relatively longer procedure times
Endoscopic ligation[60-64]	SMTs <1 cm and arising from muscularis propria	SMTs did not meet the indication	Perforation, minor hemorrhage	Simple and easy to perform; the procedure time is short	This technique can only be applied to small SMTs and it is impossible to make a complete pathological examination

ESMR-C: endoscopic submucosal tumor resection with a transparent cap; ESMR-L: endoscopic submucosal tumor resection performed with a ligation device; ESE: endoscopic submusocal enucleation; ESD: endoscopic submucosal dissection, EFR: endoscopic full-thickness resection; ESTD: endoscopic submucosal tunneling dissection, SMTs: submucosal tumors.

ligation perforation; Nan *et al.*[64] 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, EUS-

TCB, 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 following-up after tumors resection.

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