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Imaging and Clinicopathologic Features of Esophageal Gastrointestinal Stromal Tumors

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Abstract

OBJECTIVE—The purpose of this article is to describe the imaging and clinicopathologic characteristics of esophageal gastrointestinal stromal tumors (GISTs) and to emphasize the features that differentiate esophageal GISTs from esophageal leiomyomas.

MATERIALS AND METHODS—A pathology database search identified all surgically resected or biopsied esophageal GISTs, esophageal leiomyomas, and esophageal leiomyosarcomas from 1994 to 2012. Esophageal GISTs were included only if imaging studies (including CT, fluoroscopic, or ¹⁸F-FDG PET/CT scans) and clinical data were available.

RESULTS—Nineteen esophageal mesenchymal tumors were identified, including eight esophageal GISTs (42%), 10 esophageal leiomyomas (53%), and one esophageal leiomyosarcoma (5%). Four patients (50%) with esophageal GIST had symptoms, including dysphagia in three (38%), cough in one (13%), and chest pain in one (13%). One esophageal GIST appeared on barium study as a smooth submucosal mass. All esophageal GISTs appeared on CT as well-marginated predominantly distal lesions, isoattenuating to muscle, that moderately enhanced after IV contrast agent administration. Compared with esophageal leiomyomas, esophageal GISTs tended to be more distal, larger, and more heterogeneous and showed greater IV enhancement on CT. All esophageal GISTs showed marked avidity (mean maximum standardized uptake value, 16) on PET scans. All esophageal GISTs were positive for c-KIT (a cell-surface transmembrane tyrosine kinase also known as CD117) and CD34. On histopathology, six esophageal GISTs (75%) were of the spindle pattern and two (25%) were of a mixed spindle and epithelioid pattern. Five esophageal GISTs had exon 11 mutations (with imatinib sensitivity). Clinical outcome correlated with treatment strategy (resection plus adjuvant therapy or resection alone) rather than risk stratification.

CONCLUSION—Esophageal GISTs are unusual but clinically important mesenchymal neoplasms. Although esophageal GISTs and esophageal leiomyomas had overlapping imaging features, esophageal GISTs tended to be more distal, larger, more heterogeneous, and more enhancing on CT and were markedly FDG avid on PET. Given their malignant potential, esophageal GISTs should be included in the differential diagnosis of intramural esophageal neoplasms.

Keywords

barium esophagogram; CT; esophageal neoplasms; esophagus; gastrointestinal stromal tumor; PET

Gastrointestinal stromal tumors (GISTs) are the most common mesenchymal tumors in the gastrointestinal tract [1, 2]. GISTs can arise anywhere from the esophagus to the anus [1–3]. Although GISTs most often occur in the stomach or small intestine, 1–3% are thought to arise in the esophagus [2–4]. Originating from gut pacemaker cells, the interstitial cells of Cajal, GISTs are characterized by their unique immunohistochemical expression of CD117, also known as c-KIT, a cell-surface transmembrane tyrosine kinase [5–7].

Diagnostic imaging and pathologic characterization are critical for proper detection and staging of GISTs [8]. The imaging and clinicopathologic features of GISTs in the stomach and small intestine have been reviewed extensively [8–11]. In contrast, the largest series of esophageal GISTs in the pathology literature consists of only 17 cases [12], and the diagnosis of esophageal GIST has only recently been introduced in the radiology literature [13]. In fact, because of its apparent rarity, esophageal GIST is notably absent from the discussion of mesenchymal tumors of the esophagus in the latest edition of a well-known gastrointestinal radiology textbook [4].

There are apparent similarities in the imaging features of esophageal GISTs and esophageal leiomyomas. However, differentiation of esophageal GISTs from esophageal leiomyomas is clinically important because of the known malignant potential of GISTs [8] and the possible need for aggressive treatment when this tumor is detected [7]. In contrast, esophageal leiomyomas are benign neoplasms that have virtually no risk of malignant degeneration [4]. Given the paucity of information about esophageal GISTs and their clinical ramifications in the radiology literature, the purpose of our study is to familiarize radiologists with this relatively new pathologic entity by describing the imaging and clinicopathologic features of esophageal GISTs in eight patients, emphasizing the imaging features that differentiate potentially malignant esophageal GISTs from benign esophageal leiomyomas.

Materials and Methods

We performed a computerized search of the pathology database at our institution from 1992 to 2012, using the keywords “esophagus,” “gastrointestinal stromal tumor,” and “GIST.” Inclusion criteria for our study population were tumor size greater than 1.0 cm, one or more preoperative imaging tests showing the lesions, and adequate clinical data about the presentation, treatment, and patient course. Eight patients with esophageal GISTs fulfilled our study criteria. Seven (88%) of the esophageal GISTs were surgically resected and one

(12%) was confirmed by the histopathologic findings on endoscopic biopsy specimens. Preoperative imaging tests included three chest radiographs, one barium esophagogram, eight chest CT scans (seven with administration of IV contrast material), and five ^{18}F -FDG PET/CT scans. One attending gastrointestinal radiologist and one radiology resident retrospectively reviewed the imaging studies by consensus without knowledge of the clinical or pathologic findings other than the presence of an esophageal GIST in the esophagus.

Chest radiographs were evaluated for the presence of a mediastinal mass and any relevant lung pathologic abnormality, such as pleural or parenchymal metastases. Barium esophagograms were evaluated for the size, location, and morphologic features of the lesions, and the presence of ulceration or luminal narrowing. Chest CT scans, all with 5.0- to 7.5-mm slice thicknesses, were evaluated for lesion size, location, and density (measured in Hounsfield units) before and after administration of IV contrast material; the presence of hemorrhagic, cystic, or necrotic changes; the presence of esophageal obstruction; and any nodal, mediastinal, or distant metastases. PET scans were evaluated for FDG avidity compared with background, measured as maximum standardized uptake values (SUV_{max}), when available.

Medical records were subsequently reviewed to determine the clinical presentation, treatment, and patient course. Pathology records were also reviewed to determine the histologic and immunohistochemical characteristics of these lesions, including CD117 and CD34 expression and *KIT* and *PDGFRA* mutation status, when available.

To obtain an estimate of the prevalence of esophageal GISTs at our institution, we performed an additional search of the same pathology database during the same period, using the keywords “esophagus,” “leiomyoma,” and “leiomyosarcoma,” and calculated the relative proportions of esophageal GISTs, esophageal leiomyomas, and esophageal leiomyosarcomas identified by this search. Using the same inclusion criteria and methods described previously, 10 esophageal leiomyomas were available for review. Only one esophageal leiomyosarcoma was identified, and this case was excluded because of inadequate clinical and pathologic data.

Results

Clinical Presentation

The demographic features of eight patients with esophageal GISTs are summarized in Table 1. Four patients (50%) were asymptomatic; their esophageal GISTs were discovered incidentally during endoscopy for gastroesophageal reflux ($n = 2$), surveillance chest CT for emphysema ($n = 1$), and preoperative chest radiograph for elective surgery ($n = 1$). The remaining four patients (50%) were symptomatic, including two with dysphagia, one with cough and dysphagia, and one with chest pain. Both patients (100%) with tumors involving the left side of the esophagus were symptomatic versus two of six (33%) with tumors involving the right side.

Radiologic Findings

Chest radiograph—All three preoperative chest radiographs revealed a posterior mediastinal mass (Figs. 1A and 2A).

Barium esophagogram—One preoperative barium esophagogram revealed a smooth submucosal mass that compromised the lumen by more than 50% without causing obstruction (Fig. 1B).

CT—All eight CT scans revealed well-margined posterior mediastinal masses that were inseparable from the adjacent esophagus, and all seven contrast-enhanced CT scans revealed enhancement of these lesions (Figs. 2B and 3–6). Six esophageal GISTs (75%) were located in the distal third of the thoracic esophagus (Fig. 1) and two (25%) were located in the middle third (Figs. 2 and 3). Two esophageal GISTs involved the left side of the esophagus (Figs. 2 and 6), and six involved the right (Figs. 1, 4, and 5). One of the right-sided tumors was so large that it crossed the midline without causing obstruction (Fig. 4). All eight esophageal GISTs caused some degree of luminal narrowing (Figs. 1B, 4, 5A, and 6A), but only three revealed signs of esophageal obstruction (all mild). The solid portions of all esophageal GIST tumors were enhancing. The mean un-enhanced value was 34 HU (range, 22–46 HU; $n = 5$), and the mean contrast-enhanced value was 64 HU (range, 30–100 HU; $n = 6$). In the five patients who had both unenhanced and contrast-enhanced attenuation values, the calculated mean enhancement of the solid portions of these esophageal GISTs was 23 HU. Numeric Hounsfield unit measurements were not available for the remaining two patients, whose digitized cases were originally analog. These esophageal GISTs were variably heterogeneous, with smaller tumors appearing more homogeneous. Tumors larger than 4.5 cm invariably contained avascular cystic regions (Figs. 2B and 6A). One esophageal GIST (largest in size) contained scattered coarse calcifications (Fig. 4). No mediastinal lymphadenopathy or other evidence of mediastinal, pulmonary, pleural, or distant metastases was identified in any case.

PET—All five esophageal GISTs (100%) showed marked FDG avidity (Figs. 2C and 6B). In three cases in which a numeric SUV was available, the mean SUV_{max} 16 (range, 10–20). In the remaining two cases, the FDG avidity was qualitatively described as “marked.”

Histopathology

The mean greatest diameter of these esophageal GISTs was 6.2 cm (range, 3–11.6 cm), according to the size of the pathologic specimen in seven cases and the size at imaging in one case. All resected lymph nodes were negative for metastatic tumor. Six of eight (75%) esophageal GISTs had a spindle cell pattern without cystic changes on histology, and two (25%) had a mixed spindle and epithelioid cellular pattern with necrosis and cystic changes (Fig. 2B and 6A).

Histopathologic examination revealed mitotic rates ranging from 0 to 10 mitoses per 10 high-power fields. Six of eight (75%) esophageal GISTs were thought to have greater malignant potential because of a size greater than 5 cm ($n = 2$) or frequent mitoses ($n = 4$).

Immunohistochemistry showed CD117 (c-KIT) and CD34 positivity in all eight patients (100%). Six esophageal GIST tumors were tested and all were negative for S100 (calcium-binding protein A1). Three esophageal GISTs (38%) showed faint focal smooth-muscle actin positivity, but the remaining five (62%) were SMA negative. Five of the resected specimens underwent molecular genotyping: all five (100%) had *KIT* exon 11 mutations. No *PDGFRA* mutations were identified.

Esophagoscopy

In all eight patients (100%), endoscopy revealed intramural esophageal masses encroaching on the lumen, with ulceration of the overlying mucosa in three (38%), one with frank tumor visualized in the esophageal lumen (Table 1). Endoscopic biopsy specimens were obtained in seven of eight (88%) patients with esophageal GIST, including five fine-needle aspirations (FNAs) and two core needle biopsies. Six of seven (86%) esophageal GIST endoscopic biopsy specimens showed CD117 positivity. One esophageal GIST FNA specimen (13%) yielded nondiagnostic material.

Surgery

Four patients (50%) with esophageal GISTs underwent primary surgical treatment with Ivor Lewis esophagogastrectomy, and three (38%) underwent thoracotomy with tumor enucleation. One of the enucleation patients later required Ivor Lewis esophagogastrectomy because of positive surgical margins. In all other patients, the resected specimens had negative surgical margins. One patient with a core biopsy-proven esophageal GIST was not an operative candidate because of other health issues. His tumor increased in size despite escalating doses of imatinib and showed minimal response to sunitinib. This patient subsequently died of other causes.

Adjuvant Treatment and Follow-Up

Four patients (50%) underwent surgery and adjuvant treatment with imatinib ($n = 3$) or radiation ($n = 1$), three (38%) underwent surgery alone, and one (13%) underwent treatment only with imatinib (Table 1). Patients were followed up for a mean period of 3.9 years. The three patients treated with surgery and adjuvant imatinib had no evidence of recurrent tumor during the follow-up period. The one patient treated with surgery and adjuvant radiation therapy had no evidence of recurrent tumor 5 years after surgery. Two of the three patients treated with surgery alone had esophageal GISTs that were thought to have increased malignant potential; both of these patients developed recurrent tumor in the pleural space ($n = 1$) or mediastinum and liver ($n = 1$) at 4.5 and 9 years after surgery, respectively. The third patient treated with surgery alone had no evidence of recurrent tumor 3 years after surgery.

Comparison With Other Esophageal Submucosal Tumors

Of the 19 pathologically proven esophageal mesenchymal tumors identified during the study period, 10 (53%) were esophageal leiomyomas, eight (42%) were esophageal GIST, and one (5%) was an esophageal leiomyosarcoma.

Barium esophagogram in one patient with an esophageal leiomyoma revealed a smooth submucosal mass that was fluoroscopically indistinguishable from an esophageal GIST (Fig.

7A). Nine of 10 (90%) patients with esophageal leiomyoma underwent endoscopy, and all nine esophageal leiomyomas (100%) showed normal intact esophageal mucosa overlying a submucosal mass. In addition, all nine (100%) esophageal leiomyomas underwent simultaneous endoscopic FNA, which was negative for malignant cells in all cases (100%), so immunohistochemical stains were not pursued in these patients. Additional imaging studies in 10 patients with esophageal leiomyomas (including 10 chest CT scans and six PET scans) are summarized in Table 2. Comparative imaging findings for esophageal GISTs and for esophageal leiomyomas are summarized in Table 3.

Discussion

There are scant data in the radiology literature about esophageal GISTs and their imaging and clinicopathologic features. Until recently, almost all mesenchymal neoplasms arising from the esophagus were thought to be benign esophageal leiomyomas that could be followed conservatively in the absence of dysphagia or other major symptoms [4]. It has been documented, however, that GISTs also occur in the esophagus [12, 13]. Unlike esophageal leiomyomas, esophageal GISTs have a known malignant potential (similar to that of GISTs elsewhere in the gastrointestinal tract) that warrants serious consideration for surgical resection, treatment with tyrosine kinase inhibitors, or both, even in the absence of symptoms. Thus, it is important for radiologists to be aware of esophageal GISTs as a potential cause of intramural masses of the esophagus.

It has previously been estimated that esophageal leiomyomas are three times more common than esophageal GISTs [12]. In our study, however, esophageal GISTs were only slightly less common than esophageal leiomyomas, constituting 42% of all pathologically proven mesenchymal tumors of the esophagus at our institution over a 20-year period. Given that larger mesenchymal tumors in the esophagus are more likely to undergo resection, the relative proportion of esophageal stromal tumors that are esophageal GISTs was probably exaggerated in our series. On the other hand, the total number of both esophageal GISTs and esophageal leiomyomas in our patient population is probably higher, because smaller lesions that were not resected during this period were likely overlooked. Regardless of the actual numbers, our experience suggests that esophageal GISTs are more common mesenchymal tumors of the esophagus than previously recognized.

As in another recent study [13], the esophageal GISTs in our series had a strong distal predilection, with six of eight (75%) occurring in the lower thoracic esophagus and the remaining two (25%) occurring in the mid-thoracic esophagus. This finding likely reflects the intrinsic distribution of purported GIST progenitor cells—namely, the interstitial cells of Cajal—which are most abundant in the distal esophagus [14].

Our study data revealed notable differences in the demographic features between patients with esophageal GISTs and those with GISTs elsewhere in the gastrointestinal tract. Seven of our eight patients (88%) with esophageal GISTs were white and six (75%) were women, whereas GISTs elsewhere in the gastrointestinal tract are more common in African American patients and in men [15]. Although GISTs elsewhere in the gastrointestinal tract are often considered to be neoplasms of the elderly, with a mean age of 63 years reported in

the literature [15], two of our eight patients (25%) were younger than 40 years. Given that esophageal leiomyomas usually develop in a younger population than GISTs, with a mean age of 35 years [12, 16], the occurrence of esophageal GISTs in younger patients underscores the importance of radiologic imaging as a tool for differentiating esophageal GISTs from esophageal leiomyomas.

In our series, esophageal GISTs were large mesenchymal neoplasms that had a mean maximal diameter of 6.2 cm (range, 3–11.6 cm). Though patients with larger esophageal GISTs were more likely to have symptoms, four of our eight patients (50%) were asymptomatic, including one patient whose tumor had a diameter of 11.6 cm. Our experience suggests that esophageal GISTs can be surprisingly large without causing symptoms—an observation previously reported for GISTs elsewhere in the gastrointestinal tract [9, 11, 17]. When symptoms do occur, these patients most commonly present with dysphagia caused by encroachment of the tumor on the lumen. Other common symptoms, such as chest pain and cough, may result from mass effect exerted by the tumor on adjacent mediastinal structures. Regardless of size, both esophageal GISTs (100%) involving the left side of the esophagus caused symptoms, versus only two of six (33%) involving the right side, so our findings suggest that patients with left-sided esophageal GISTs are more likely to experience symptoms, possibly due to mass effect or crowding of left-sided mediastinal structures. Though three of the eight (38%) esophageal GISTs were ulcerated at endoscopy, no patients presented with signs or symptoms of gastrointestinal bleeding. Similarly, esophageal leiomyomas are a rare cause of ulceration or gastrointestinal bleeding [4].

The imaging features of esophageal GISTs are similar to those of GISTs elsewhere in the gastrointestinal tract [9–11, 17, 18]. In our series, esophageal GISTs appeared as bulky enhancing heterogeneous FDG-avid intramural masses with a predominantly exoenteric growth pattern and caused luminal narrowing without obstruction or frank invasion of adjacent mediastinal structures. Esophageal GISTs appeared on CT as intramural soft-tissue masses that were isoattenuating to muscle and moderately enhancing after IV administration of contrast material; internal avascular cystic regions were common in tumors larger than 4.5 cm. Calcifications were infrequent and, when present, of coarse quality [9–11, 17, 18]. Cross-sectional imaging studies revealed no evidence of mediastinal lymphadenopathy or other metastatic disease in our eight patients with esophageal GISTs at the time of diagnosis [9–11, 17, 18].

Imaging features may facilitate preoperative differentiation of esophageal GISTs and esophageal leiomyomas. Specifically, on contrast-enhanced CT, esophageal GISTs were larger than esophageal leiomyomas, were more consistently distal in location, were more heterogeneous in density, and had greater enhancement (Table 3). Calcifications were rare for both lesions, occurring in two of 10 (20%) patients with esophageal leiomyomas and in one of eight (13%) with esophageal GISTs. When present, calcifications had a diffuse popcorn-type appearance in the two esophageal leiomyomas, versus a focal eccentric coarse appearance in the one esophageal GIST.

Barium study or endoscopy is essential for mucosal characterization of esophageal lesions. In addition to differentiating mucosal lesions (e.g., esophageal carcinomas) from

submucosal lesions (including esophageal GIST and esophageal leiomyoma), barium study or endoscopy can detect the presence of ulceration, which may help differentiate esophageal GIST from esophageal leiomyoma. For example, esophageal carcinomas are typically mucosal lesions that can be polypoid, ulcerated, or circumferentially infiltrating with irregular luminal narrowing and abrupt shelflike margins [4]. In contrast, esophageal leiomyomas typically appear as discrete submucosal masses with smooth overlying mucosa [4]. In our study, esophageal GISTs and esophageal leiomyoma were indistinguishable on barium esophagogram (both appearing as smooth submucosal masses); however, this was limited by the very small number of barium studies performed (one esophageal GIST and one esophageal leiomyoma).

Endoscopy was performed in almost all patients (86% of esophageal GISTs and 90% of esophageal leiomyomas). Three of the eight (38%) esophageal GISTs were ulcerated at endoscopy, whereas no esophageal leiomyoma showed mucosal ulceration. Indeed, multiple other sources have found that ulceration is exceedingly rare in esophageal leiomyoma [4, 19]. Mucosal ulceration was common in esophageal GISTs larger than 4.5 cm and also in left-sided esophageal GISTs with mixed spindle-epithelioid histopathology. In view of these findings, the presence of an ulcerated submucosal esophageal mass on endoscopy or barium esophagogram should raise clinical suspicion for esophageal GIST; however, the lack of mucosal ulceration should not exclude GIST as a potential cause.

Another potentially helpful feature for differentiating esophageal GISTs from esophageal leiomyomas was the uniform marked FDG avidity (mean SUV_{max} , 16; range, 10–20) that was observed for all five patients (100%) with esophageal GISTs who underwent PET; this feature has also been reported in the radiology literature for GISTs in general [9, 11, 13, 20]. In contrast, esophageal leiomyomas were infrequently FDG avid, with only two of seven (29%) esophageal leiomyomas in our series showing mild FDG uptake (mean SUV_{max} , 2.3; range, 0–7.1). Our retrospective study suggests that small bland-appearing nonenhancing non-FDG-avid esophageal lesions are more likely to be esophageal leiomyomas, which have little or no malignant potential. Large, heterogeneous, moderately enhancing, or FDG-avid esophageal lesions are more worrisome for esophageal GISTs. Given our small sample size, however, endoscopic biopsy specimens are required for a definitive diagnosis before decisions are made about surgical resection versus conservative management of these lesions.

None of the esophageal GISTs in our series had associated mediastinal adenopathy or other evidence of metastatic disease at presentation. Definitive treatment of these esophageal GISTs entailed surgical resection and adjuvant therapy with a tyrosine kinase inhibitor (imatinib) or, in one patient, radiation therapy. It is not possible from this small series to make strong recommendations regarding treatment, other than to note that recurrent tumor developed only in patients not treated with adjuvant imatinib or radiation therapy. All five patients (100%) with esophageal GISTs who underwent molecular genotyping had *KIT* exon 11 mutations, which are known to identify tumors with high in vitro sensitivity to imatinib. As in a previous study, both patients with *KIT* exon 11 mutations who received adjuvant imatinib had an excellent response to therapy without evidence of recurrent tumor [21] (Table 1).

Our investigation is restricted by a small sample size as well as the inherent limitations of a retrospective study, including interpretation and selection bias. This selection bias likely exaggerated the frequency of esophageal GISTs in our patient population because of the inclusion of predominantly larger lesions that were surgically resected. In the future, a larger prospective study may be helpful to better assess the prevalence of esophageal GISTs and to further delineate the imaging and clinicopathologic features of this newly recognized entity.

In summary, we have presented the imaging and clinicopathologic findings in eight patients with esophageal GISTs, which are intramural mesenchymal tumors of the esophagus that have features similar to those of GISTs in other parts of the gastrointestinal tract. Despite the long-standing perception that esophageal GISTs are rare and that nearly all mesenchymal tumors of the esophagus are esophageal leiomyomas, our experience suggests that esophageal GISTs are more common than has previously been recognized and that these lesions may be encountered in modern radiology practice. Given their known malignant potential, differentiation of esophageal GISTs from esophageal leiomyomas is important for clinical management of these patients. Imaging features that differentiate esophageal GISTs from esophageal leiomyomas include larger size, more frequent location in the distal third of the esophagus, greater IV contrast enhancement and greater heterogeneity on CT, and uniformly marked FDG avidity on PET. Although esophageal GISTs are less common than esophageal leiomyomas, radiologists should be familiar with the imaging and clinicopathologic features of these tumors as well as their malignant potential and appropriate patient management.

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Fig. 1. Asymptomatic 69-year-old woman with incidental esophageal gastrointestinal stromal tumor on imaging studies

A, Chest radiograph shows right retrocardiac opacity (*arrow*) silhouetting right hemidiaphragm.

B, Left posterior oblique spot image from double-contrast barium esophagogram shows 4-cm smooth submucosal mass (*arrow*) compressing lumen of distal right esophagus by more than 75%, without obstruction.

C, Unenhanced chest CT shows rounded well-circumscribed mass (*arrow*), isoattenuating to muscle, inseparable from wall of distal esophagus.

Fig. 2. 64-year-old woman with esophageal gastrointestinal stromal tumor causing dysphagia and cough

A, Chest radiograph reveals large mass (*arrow*) in left lower mediastinum.

B, Axial contrast-enhanced chest CT shows distal large well-circumscribed mass inseparable from left lateral wall of distal esophagus, with peripheral enhancing solid components (*short arrows*) and large internal cystic areas (*long arrows*).

C, Coronal FDG PET maximum intensity projection shows marked FDG avidity (maximum standard uptake value, 20) of large left paraesophageal mass (*arrows*).

Fig. 3. 62-year-old woman with chest pain. Coronal image from IV contrast-enhanced CT shows large heterogeneous mass (*arrows*) in mid esophagus with luminal narrowing.

Fig. 4.

Asymptomatic 78-year-old man with incidental esophageal gastrointestinal stromal tumor (GIST) seen on CT. Contrast-enhanced axial CT image shows large well-circumscribed mildly heterogeneous predominantly right-sided mass (*long arrows*) crossing midline to encase esophagus, without obstruction. Note coarse calcifications (*short arrows*) within lesion, a rare finding in patients with esophageal GISTs.

Fig. 5. 53-year-old woman with esophageal gastrointestinal stromal tumor causing dysphagia
A, Axial image from contrast-enhanced CT shows round well-circumscribed homogeneously enhancing mass (*black arrow*) inseparable from right side of esophagus, with thin rim of oral contrast material (*white arrow*) in compressed lumen. Note how lesion abuts right lower lobe bronchus.
B, Axial image from contrast-enhanced CT scan 9 years after Ivor Lewis esophagogastrectomy with gastric pull-through shows recurrent tumor in posterior right pleural space (*arrow*). This lesion showed marked FDG avidity on PET.

Fig. 6. 71-year-old man with esophageal gastrointestinal stromal tumor causing dysphagia
A, Axial image from contrast-enhanced CT shows well-marginated heterogeneous mass (*large arrows*) involving left lateral aspect of distal esophagus. Note crescent-shaped rim of oral contrast material (*small arrows*) outlining compressed esophageal lumen.
B, Coronal FDG PET maximum-intensity-projection image shows marked FDG avidity of well-marginated mass in distal esophagus.

Fig. 7. Esophageal leiomyoma causing dysphagia

A, Left posterior oblique spot image from double-contrast barium esophagogram of 54-year-old woman shows smooth submucosal mass (*arrows*) in distal esophagus, with associated luminal narrowing. Note how findings are indistinguishable from those in esophageal gastrointestinal stromal tumor (GIST) shown in Figure 1B.

B, Axial image from contrast-enhanced CT of 70-year old man shows small midline minimally enhancing mass (*arrow*) in esophagus.

C, Sagittal image from FDG PET maximum intensity projection in 70-year old man shows that this mass has no FDG avidity, enabling differentiation from esophageal GIST.

TABLE 1

Imaging and Clinicopathologic Features of Esophageal Gastrointestinal Stromal Tumors (GISTs)

Patient No.									
Feature	1	2	3	4	5	6	7	8	Mean
Age (y)/sex/ethnicity	64 F/Asian	71 M/white	69 F/white	38 F/white	38 F/white	53 F/white	62 F/white	78 M/white	59
Tobacco use/alcohol use/BMI	Smoking spouse/rare/22	30 pack-years/rare/23	65 pack-years/never/27	4 pack-years/never/24	Smoking spouse/rare/27	30 pack-years/rare/31.5	30 pack-years/never/19	40 pack-years/never/32	
Symptoms	Cough, dysphagia	Dysphagia	None	None	None	Dysphagia	Chest pain	None	
Site	Distal left	Distal left	Distal right	Distal right	Distal right	Mid distal, right	Mid, right	Distal, right	
Attenuation (HU), contrast-enhanced/unenhanced	23/71	34/40	Iso- and hyperattenuation to muscle	Isotenuation to muscle/NA	22/30	43/85	NA/100	46/57	34/64
CT attenuation	Heterogeneous, cystic areas, no calcification	Heterogeneous, cystic areas, no calcification	Homogeneous, no calcification	Homogeneous, no calcification	Homogeneous, no calcification	Homogeneous, no calcification	Heterogeneous, cystic areas, no calcification	Heterogeneous, cystic areas, few coarse calcifications	
PDG α /dty (SUV)	20	Marked	NA	Marked	16	NA	NA	10	16
Esophagogastroduodenoscopy	Focal mucosal ulceration	Focal mucosal ulceration	Normal mucosa	Normal mucosa	Erythema, no ulceration	Normal mucosa	2.5-cm mucosal defect, intra-luminal tumor	Normal mucosa	
Size (cm)	7.8 $\times$ 7.5 $\times$ 6.5	5.7 $\times$ 6.2 $\times$ 5.6	3.0 $\times$ 2.8 $\times$ 3.0	2.0 $\times$ 1.8 $\times$ 3.8	2.9 $\times$ 2.7 $\times$ 2.5	4.3 $\times$ 3.4 $\times$ 3.6	4.5 $\times$ 2.6 $\times$ 3.5	11.6 $\times$ 8.7 $\times$ 6.2	
Histology	Mixed spindle-epithelioid	Mixed spindle-epithelioid	Spindle	Spindle	Spindle	Spindle	Spindle	Spindle	
Mitoses per 10 high-power field, necrosis	3, cystic necrosis	> 10, cystic necrosis	10, no necrosis	1, no necrosis	2, no necrosis	Frequent, no necrosis	> 10, no necrosis	0, no necrosis	
S 100 protein/SMA	Negative/negative	Negative/negative	Negative/faint focal positivity	Negative/negative	Negative/negative	Negative/negative	Negative/faint focal positivity	Negative/faint focal positivity	Negative
Risk	High (size)	High (mitotic rate)	High (mitotic rate)	Low	Low	High (mitotic rate)	High (mitotic rate)	High (size)	
<i>KIT</i> or <i>PDGFR</i> mutation	<i>KIT</i> exon 11, V560D point mutation	<i>KIT</i> exon 11 mutation	NA	<i>KIT</i> exon 11, WK557-8 deletion	<i>KIT</i> exon 11 mutation, 2-aa deletion	<i>KIT</i> exon 11 mutation, 1-aa insertion 558 K	NA	NA	<i>KIT</i> exon 11
Surgical margins/nodes	Negative/5 nodes negative	Negative	Negative	Negative	Negative/12 nodes negative	Negative/19 nodes negative	Negative/9 nodes negative	Negative	Negative
Surgery	Esophagegastrectomy	Esophagegastrectomy	Tumor enucleation	Tumor enucleation	Esophagegastrectomy	Esophagegastrectomy	Esophagegastrectomy	Not surgical candidate	
Adjuvant therapy	None	Imatinib for 3 y	6000 cGy	None	Imatinib for 3 y	None	Imatinib for 3 y	Imatinib for 1 y, sunitinib for 6 mo	
Time to recurrence/site	4.5 y/local pleura	NED	NED	NED	NED	9 y/surgical margin and liver	NED	NA	6.8 y
Outcome	Deceased	Well, NED	NED 5 y postoperative, then lost to follow-up	NED 3 y postoperative then lost to follow-up	Well, NED	Deceased	Well, NED	Deceased	

Note—All esophageal GISTs were positive for CD117 (c-KIT) and CD34. BMI = body mass index (kg/m²), SUV = standardized uptake value, SMA = smooth-muscle actin, NED = no evidence of disease, NA = not applicable, aa = amino acid.

TABLE 2

Esophageal Leiomyoma Imaging Characteristics

Case No.	Size (cm)	Location	Laterality	Unenhanced Attenuation (HU)	Contrast-Enhanced Attenuation (HU)	CT Attenuation	Calcifications	PET/CT Maximum SUV
1	1.9 × 1.4 × 1.4	Upper	Midline	NA	27	Homogeneous	None	NA
2	4.7 × 3.0 × 1.9	Mid	Midline	41 HU	45	Homogeneous	None	NA
3	2.9 × 2.5 × 3.0	Mid	Midline	NA	39	Homogeneous	None	No avidity
4	2.1 × 2.0 × 3.0	Mid	Midline	NA	36	Homogeneous	None	No avidity
5	3.0 × 2.0 × 1.5	Mid	Left	Hypodense to muscle	NA	Homogeneous	None	No avidity
6	4.5 × 3.3 × 3.2	Distal	Right	Hypodense to muscle	NA	Homogeneous	None	NA
7	2.4 × 1.5 × 2.8	Distal	Right	NA	47	Homogeneous	None	7.1
8	2.4 × 2.3 × 1.2	Distal	Left	Hypodense to muscle	NA	Homogeneous	None	4.4
9	2.0 × 1.5 × 2.5	Distal	Left	Hypodense to muscle	NA	Homogeneous	Diffuse popcorn	No avidity
10	2.8 × 1.1 × 2.8	Distal	Right	Hypodense to muscle	NA	Homogeneous	Diffuse popcorn	No avidity
Mean	2.6 (<i>n</i> = 10); range, 2.0–4.7			41 (<i>n</i> = 1)	39 (<i>n</i> = 5); range, 27–47			2.3 (<i>n</i> = 6); range, 0–7.1

Note—SUV = standardized uptake value, NA = not applicable.

TABLE 3

Comparative Imaging Features of Esophageal Gastrointestinal Stromal Tumor (GIST) Versus Esophageal Leiomyoma

Imaging Feature	Esophageal GIST	Esophageal Leiomyoma
Tumor size, mean (range) diameter (cm)	5.6 (3.8–10.0)	2.6 (2.4–4.7)
Location (craniocaudal)	Predominantly distal (75%)	Mid third (40%) and distal third (50%)
Laterality	Predominantly right (75%); almost never midline	Predominantly midline (60%) or left (30%)
Esophagoscopy	Mucosal ulceration (38%); submucosal lesion	Normal mucosa (100%); submucosal lesion
Chest radiograph	Posterior mediastinal mass	Posterior mediastinal mass
Esophagogram	Smooth, nonobstructive submucosal filling defect	Smooth, nonobstructive submucosal filling defect
Mean unenhanced CT attenuation, numeric or qualitative (HU)	34 (range, 23–43) (<i>n</i> = 5)	41 (<i>n</i> = 1)
Mean contrast-enhanced CT attenuation, numeric or qualitative (HU)	64 (range, 30–100) (<i>n</i> = 6)	39 (range, 27–47) (<i>n</i> = 5)
Mean enhancement (HU) ^a	23 (<i>n</i> = 5); moderate enhancing	4 (<i>n</i> = 1); minimal to no enhancement
Calcifications	Rare (<i>n</i> = 1); eccentric, coarse	Uncommon (20%); diffuse popcorn
FDG avidity	Uniform marked FDG avidity; mean SUV _{max} , 16 (range, 10–20)	Usually not FDG avid (66%); mild FDG avidity possible; mean SUV _{max} , 2.3 (range, 0–7.1)

Note—SUV_{max} = maximum standardized uptake value.

^aMean enhancement based only on studies with both unenhanced and contrast-enhanced values.