PICTORIAL ESSAY

Imaging Features of Gastrointestinal Stromal Tumour: Diagnosis and Evaluation of Treatment Response

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INTRODUCTION

Gastrointestinal stromal tumours (GISTs) are the most common mesenchymal neoplasms of the gastrointestinal tract and more commonly found in middle-aged patients. They arise from the interstitial cells of Cajal in the myenteric plexus and are potential malignancies that can occur anywhere along the gastrointestinal tract, most commonly in the stomach (50-60%), followed by the small intestine (30-35%), colon and rectum (5%), and oesophagus (<1%).1 GISTs can also be extraintestinal and originate in the mesentery, omentum or retroperitoneum. In the Chinese population, the incidence among those aged ≥50 years is higher than in those under 50 years old with a mean age at diagnosis of 55.2 years.2 Most GISTs have a KIT or platelet-derived growth factor receptor alpha (PDGFRA) mutation. Neoadjuvant therapy with imatinib acts by blocking the signalling via KIT and PDGFRA. Nonetheless, 10% to 15% of GISTs do not have a detectable KIT or PDGFRA mutation and have a poor response to imatinib. Some are associated with neurofibromatosis type 1, Carney–Stratakis syndrome and Carney triad.3 Biopsy is preferred to confirm the diagnosis for large resectable tumours or metastatic GISTs. This article evaluates the radiological images of pathologically proven GISTs.

RISK STRATIFICATION OF GASTROINTESTINAL STROMAL TUMOURS

There are several guidelines for assessing the malignant potential of GISTs; the most common are the modified National Institutes of Health criteria and the Armed Forces Institute of Pathology criteria. In both guidelines, risk of recurrence varies with tumour size and mitotic rate. The presence of tumour rupture is an additional prognostic indicator. Intermediate tumours, i.e., large tumours with a low mitotic rate or small tumours with a high mitotic rate, that arise from the stomach have a more favourable prognosis than those in other parts of the gastrointestinal tract.4

IMAGING FEATURES OF GASTROINTESTINAL STROMAL TUMOURS AT THE TIME OF DIAGNOSIS

General Features

The radiological appearance of GISTs varies depending on their anatomical location and size. Most GISTs are submucosal and located in the muscularis propria so have a propensity for exophytic growth and manifest as masses outside the organ of origin.5 GISTs have...
near-universal expression of CD117 antigen compared with other submucosal gastrointestinal tract tumours that are typically CD117 negative. Small GISTs usually show homogeneous enhancement; larger GISTs can be heterogeneous with central necrosis or cystic degeneration. The incidence of GIST rupture is about 7%. Extensive calcification of GISTs is rare with only a few cases reported in the literature.

**Oesophagus**

GISTs account for only about 25% of oesophageal mesenchymal neoplasms, and the oesophagus is the only site where leiomyomas predominate. GISTs and oesophageal leiomyomas have overlapping imaging features although oesophageal GISTs tend to be more distal in location, larger, and more heterogeneous with a higher degree of enhancement on computed tomography (Figures 1 and 2).

The radiological differential diagnoses of oesophageal GISTs depend on the size and origin of the lesion. For small mucosal lesions, papilloma and fibrovascular polyp should be considered. For small submucosal lesions, leiomyoma and granular cell tumour are the differential diagnoses. If a tumour is large and aggressive-looking, carcinoma and leiomyosarcoma need to be considered.

**Stomach**

The stomach is the most common location of a GIST. In contrast to small gastric GISTs that are confined to the organ of origin (Figures 3 and 4a), large gastric GISTs may extend into the gastrohepatic ligament, gastrosplenic ligament or lesser sac (Figure 5a). Endoscopic ultrasonography is useful to identify the layer of origin of the mass (Figures 4b, 5b and 5c). Gastric GISTs may also be complicated by perforation or bleeding (Figure 6).
Common differential diagnoses of gastric masses include carcinoma and lymphoma. Advanced gastric carcinoma is commonly associated with perigastric lymphadenopathy (Figure 7). Lymphoma causes significant circumferential mural thickening of the stomach with lymphadenopathy (Figure 8). Absence of lymphadenopathy is a radiological feature favouring a diagnosis of GIST.

Small Intestine
The small intestine is the second most common site of GISTs. There can be extraintestinal extension of the neoplasm into the pelvic cavity mimicking a pelvic mass (Figure 9), rendering it radiologically difficult to assess the origin of the tumour. Tumour bleeding and perforation are also complications of small bowel GISTs.
(Figure 10). Intestinal obstruction is an uncommon complication due to the exophytic nature of GISTs.

Apart from GISTs, other common primary small bowel tumours include adenocarcinoma, lymphoma and carcinoid tumour. Adenocarcinoma usually presents with a circumferential mass with shouldered border (Figure 11). Both lymphoma and GISTs may show aneurysmal dilatation of the bowel but the absence of lymphadenopathy favours the diagnosis of GIST. Carcinoid tumour usually shows avid homogeneous enhancement with desmoplastic reaction that can be a distinguishing imaging feature.
Colon and Rectum

Colonic GISTs are rarer than rectal GISTs and were not found in our case series. Colonic GISTs are typically transmural tumours with frequent intraluminal and extraserosal components. Circumferential growth with aneurysmal dilatation of the affected colonic segment is also common.

Rectal GIST is usually seen as a well-defined eccentric mural mass with extraserosal extension that may involve the ischiorectal fossa, prostate or vagina (Figure 12). On magnetic resonance imaging, GISTs are usually T1 hypointense to isointense and T2 hyperintense relative to muscle (Figure 12).

Adenocarcinoma is the most common colorectal neoplasm. Compared with rectal GISTs that usually have a smooth margin, rectal adenocarcinoma tends to have an irregular margin (Figure 13) and may have soft tissue stranding extending into the ischiorectal fossa or suprapelvic space. Perirectal lymphadenopathy is common in rectal adenocarcinomas (Figure 13) but not in GISTs. In addition, the presence of haemorrhage on magnetic resonance imaging is a feature that favours GISTs.

Mesentery and Omentum

Primary GISTs can occur in the mesentery and omentum. Similar to GISTs in the gastrointestinal tract, mesenteric and omental GISTs are usually heterogeneous with central necrosis or cystic degeneration (Figure 14). Nonetheless, they are commonly larger in size and most exceed 10 cm.

GISTs in the gastrointestinal tract may metastasise to the mesentery and omentum, usually manifesting as multiple masses, whereas primary mesenteric or omental GISTs are more often solitary. The imaging appearance of mesenteric and omental GISTs can be indistinguishable from that of other primary peritoneal tumours.

Figure 12. Rectal gastrointestinal stromal tumour in a 48-year-old man. (a) Contrast-enhanced computed tomography showing a heterogeneously enhancing mass with smooth margin arising from the right mesorectum with possible invasion into the mesorectal fascia and right pelvic floor (arrow). (b) T1-weighted and (c) T2-weighted magnetic resonance imaging showing a well-defined eccentric mural mass at right mesorectum. The mass is heterogeneous, T1 isointense and T2 hyperintense relative to muscle.

Figure 13. Rectal adenocarcinoma in a 69-year-old woman. (a) Contrast-enhanced computed tomography showing eccentric mural thickening with irregular margin involving the mid rectum (white arrow). (b) T1-weighted and (c) T2-weighted magnetic resonance imaging showing an irregular eccentric mural mass (white arrow) that is T1 isointense and mildly T2 hyperintense relative to muscle. Perirectal lymphadenopathy is present (black arrow).
Metastasis
The most common sites of metastases are the liver and peritoneum; less commonly, GISTs may metastasise to lung and bone. They rarely metastasise to lymph nodes; in the Surveillance, Epidemiology, and End Results Program database study of the United States, nodal involvement was identified in only 5% of cases and was associated with decreased cancer-specific and overall survival.\textsuperscript{13}

EVALUATION OF TREATMENT RESPONSE
In the early post-treatment period with imatinib, tumour size reduction may not be significant and there can even be a paradoxical increase in tumour size due to tumoural haemorrhage, necrosis or myxoid degeneration. The first radiographic response to imatinib is usually reduction in tumour attenuation, followed by a gradual decrease in size (Figures 15 and 16). This response pattern is
not well suited to the standard RECIST (Response Evaluation Criteria in Solid Tumours) that is based on tumour size. An alternative way to evaluate treatment response is therefore proposed — the Choi response criteria (Table).14

18F-fluorodeoxyglucose positron emission tomography is more sensitive for the assessment of early therapy response than morphological imaging modalities.14 Studies show that a ≥50% reduction in maximum standardised uptake value and/or a maximum

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Table. The Choi response criteria for GISTs.

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<th>Response</th>
<th>Definition</th>
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<tr>
<td>Complete response (CR)</td>
<td>Disappearance of all target lesions AND no new lesions</td>
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<tr>
<td>Partial response (PR)</td>
<td>≥10% decrease in tumour size OR ≥15% decrease in tumour attenuation without any new lesions</td>
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<tr>
<td>Progressive disease (PD)</td>
<td>≥10% increase in tumour size and does not meet the criteria for partial response by virtue of tumour attenuation OR new intratumoural nodules OR increase in size of the existing intratumoural nodules OR new lesions</td>
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<tr>
<td>Stable disease</td>
<td>Does not meet the criteria of CR, PR or PD</td>
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Figure 16. Gastric gastrointestinal stromal tumour in a 53-year-old man. (a) Contrast-enhanced computed tomography (CT) before treatment showing a large heterogeneously enhancing gastric mass (arrow). (b) 18F-fluorodeoxyglucose (18F-FDG) positron emission tomography (PET) before treatment showing a large FDG-avid gastric mass (arrow). (c) Contrast-enhanced CT 5 months after treatment showing reduction in size and attenuation of the tumour (arrow). (d) 18F-FDG-PET 7 weeks after treatment showing that the tumour has become non-FDG-avid (arrow).
The role of other advanced imaging for treatment response assessment of GISTs remains under investigation. Dual-energy computed tomography scan is reported to enable visualisation and quantification of iodine-related attenuation and has the potential for accurate response assessment in GISTs. Nonetheless, further studies are required to prove the efficacy of new imaging techniques.

**SURVEILLANCE**

Recurrence of disease is common and usually occurs first in the liver or peritoneum (Figures 17 and 18). Disease progression and recurrence may fail to be detected by RECIST since there may not be significant increase in tumour size initially. Instead, recurrence commonly first manifests as a new enhancing intratumoural solid lesion within the previous hypodense lesion (Figure 19), and some may show a hyperdense ‘nodule-within-a-mass’ pattern (Figure 17).

The side-effects of imatinib include fluid retention, muscle cramps and vomiting. Fluid retention with peripheral oedema, pleural effusion and ascites are common, especially in elderly patients. New onset of
ascites on follow-up computed tomography should not be mistaken for peritoneal metastasis or disease progression.

CONCLUSION
GISTs are the most common mesenchymal neoplasms of the gastrointestinal tract. Although there is no pathognomonic imaging feature of GIST, it is useful to narrow the differential diagnoses of a gastrointestinal tract neoplasm based on imaging findings. The Choi criteria can effectively assess response in patients treated with targeted therapies.

REFERENCES