Hong Kong J Radiol. 2022;25:311-9 | https://doi.org/10.12809/hkjr2217461

PICTORIAL ESSAY

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

YT Wong, KY Kwok, OL Chan, SH Lee, ML Tsang

Department of Radiology, Tuen Mun Hospital, Hong Kong

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

Correspondence: *Dr YT Wong, Department of Radiology, Tuen Mun Hospital, Hong Kong*
Email: wyt521@ha.org.hk

Submitted: 28 Aug 2021; Accepted: 4 Feb 2022.

Contributors: YTW designed the study. YTW, OLC, SHL and MLT acquired the data. YTW and KYK analysed the data. YTW drafted the manuscript. All authors critically revised the manuscript for important intellectual content. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of Interest: All authors have disclosed no conflicts of interest.

Funding/Support: This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data Availability: All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics Approval: The study was approved by the New Territories West Cluster Research Ethics Committee of the Hospital Authority (Ref: NTWC/REC/21076). A waiver for written informed consent of patients was granted by the Committee as this manuscript is for pictorial review only and does not involve patient's treatment/procedure.

near-universal expression of CD117 antigen compared with other submucosal gastrointestinal tract tumours that are typically CD117 negative.[6] 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%.[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.[8] 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).[9]

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).

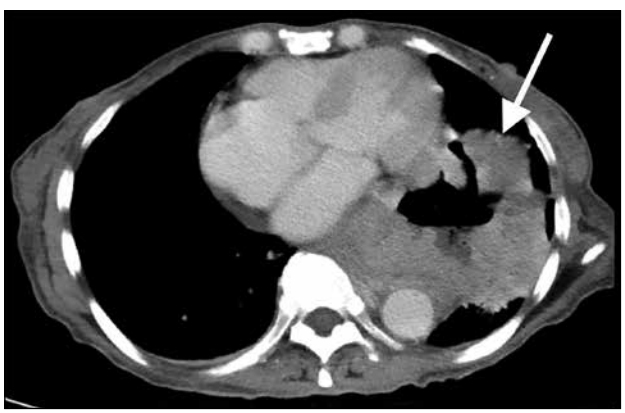

Figure 1. Oesophageal gastrointestinal stromal tumour in a 65-year-old woman. Contrast-enhanced computed tomography showing a large heterogeneously enhancing mass at the distal oesophagus (arrow). Internal air-fluid level may represent necrotic component communicating with the oesophageal lumen.

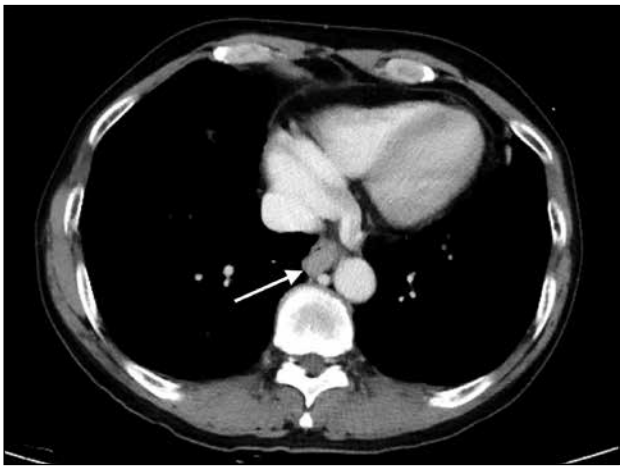

Figure 2. Suspected oesophageal leiomyoma in a 73-year-old man. Contrast-enhanced computed tomography showing a small homogeneously enhancing mass at the lower oesophagus (arrow).

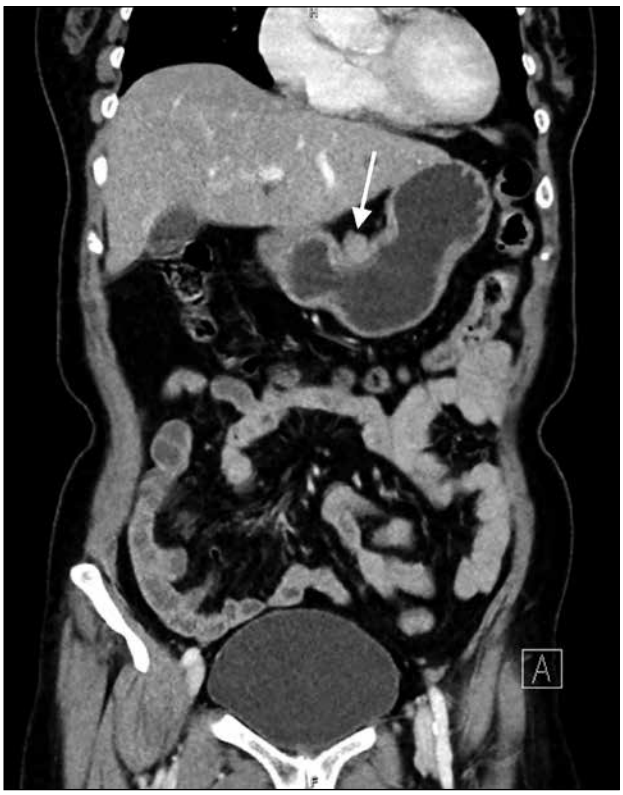

Figure 3. Gastric gastrointestinal stromal tumour in a 67-year-old woman. Contrast-enhanced computed tomography showing an exophytic homogeneously enhancing mass at the lesser curvature of the stomach (arrow).

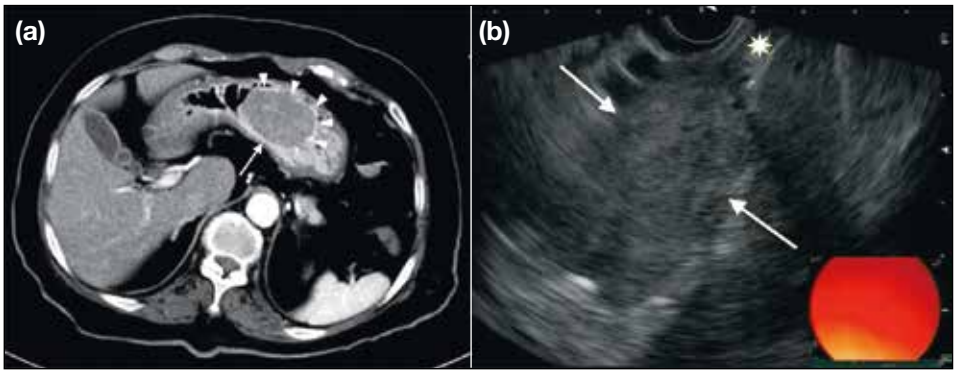

Figure 4. Gastric gastrointestinal stromal tumour in an 86-year-old woman. (a) Contrast-enhanced computed tomography showing a well-defined submucosal gastric mass (arrow) with smooth overlying mucosa (arrowheads). (b) On endoscopic ultrasound, the tumour (arrows) originates from the muscularis propria (asterisk).

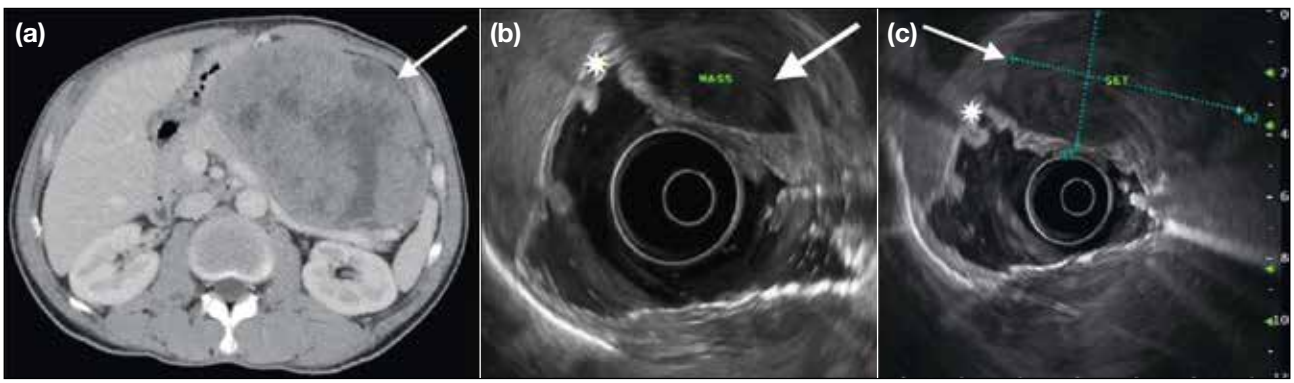

Figure 5. Gastric gastrointestinal stromal tumour in a 53-year-old man. (a) Contrast-enhanced computed tomography showing a heterogeneously enhancing mass arising from the gastric body (arrow) with extension into the lesser sac. (b, c) On endoscopic ultrasound, the tumour (arrow) arises from the muscularis propria (asterisk).

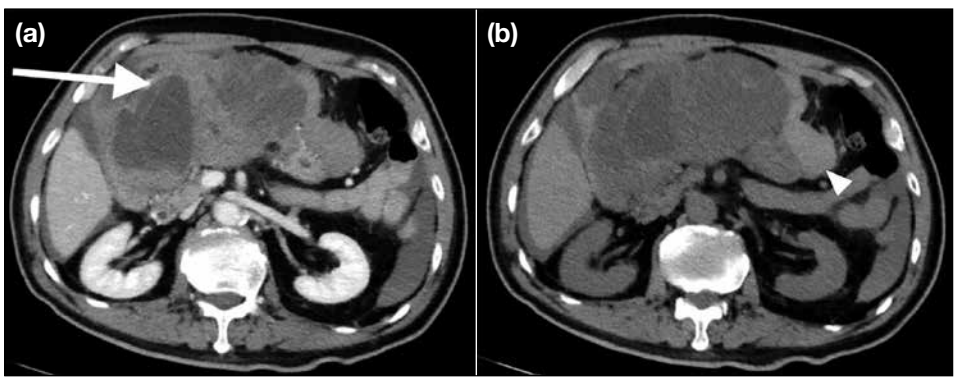

Figure 6. Gastric gastrointestinal stromal tumour in a 78-year-old man. (a) Contrast-enhanced computed tomography (CT) showing a large heterogeneous mass in the upper abdomen (arrow). (b) On plain CT, hyperdensities close to the tumour represent tumour bleeding (arrowhead).

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

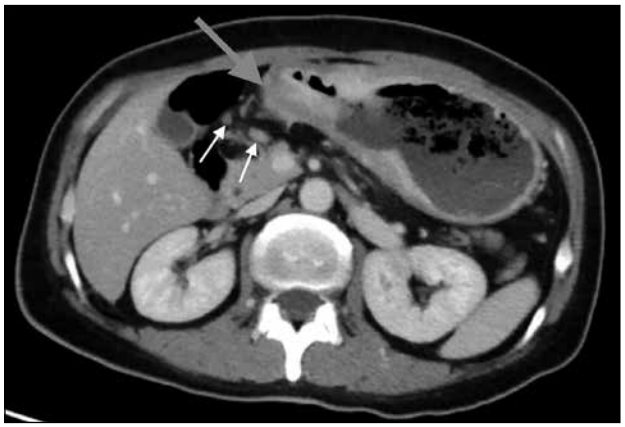

Figure 7. Gastric carcinoma in a 56-year-old woman. Contrast-enhanced computed tomography showing eccentric mural thickening of the gastric antrum (grey arrow). Perigastric nodal metastases are noted (white arrows).

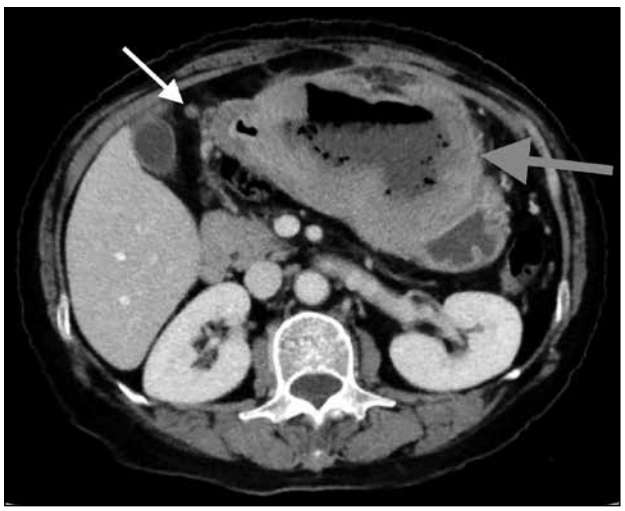

Figure 8. Gastric lymphoma in a 59-year-old woman. Contrast-enhanced computed tomography showing marked diffuse mural thickening of the stomach (grey arrow). Prominent lymph node adjacent to the gastric pylorus (white arrow) is suspicious of disease involvement.

(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.

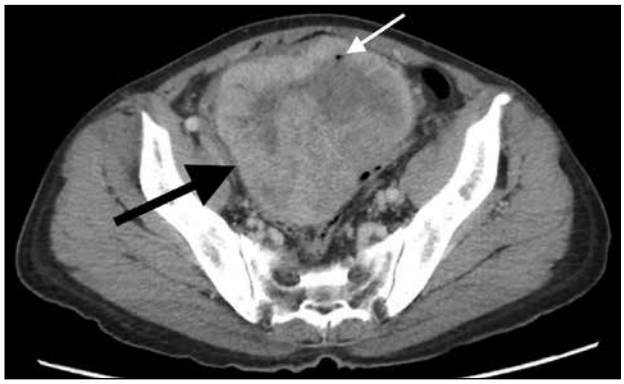

Figure 9. Small bowel gastrointestinal stromal tumour in a 64-year-old man. Contrast-enhanced computed tomography showing a heterogeneously enhancing mass in the lower abdomen and pelvis (black arrow). Small gas pockets (white arrow) within the tumour could be necrotic components communicating with the small bowel lumen. No intestinal obstruction is noted.

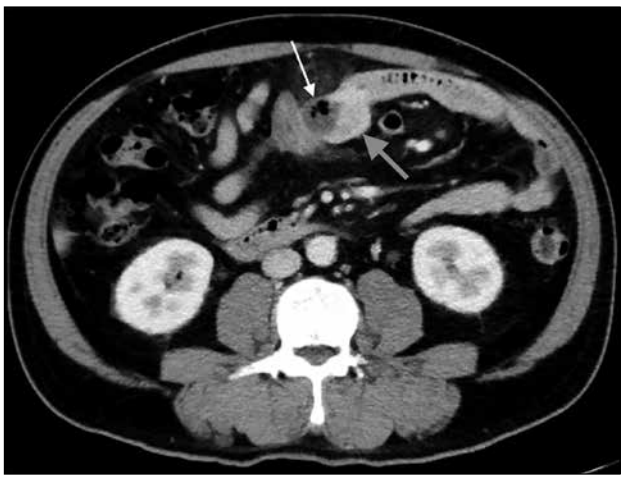

Figure 10. Small bowel gastrointestinal stromal tumour (GIST) in a 61-year-old man. A well-defined homogeneously enhancing lesion (grey arrow) abutting the small bowel is compatible with GIST. A gas-containing collection (white arrow) is in close proximity to the enhancing mass. Findings are suggestive of small bowel GIST with perforation.

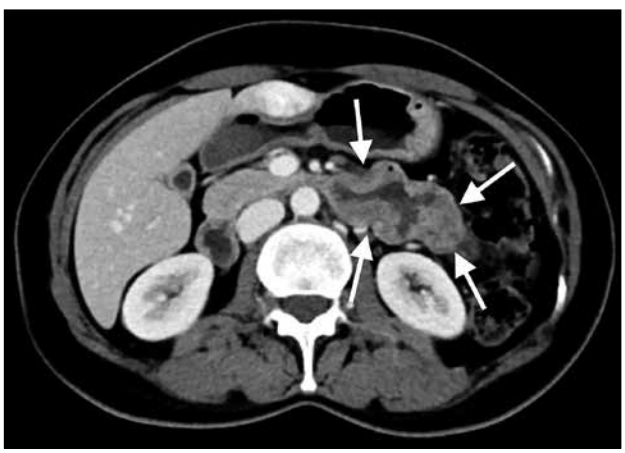

Figure 11. Small bowel adenocarcinoma in a 61-year-old woman. An irregular circumferential mass with shouldered edge (arrows) involves the third and fourth parts of the duodenum.

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.[10] Circumferential growth with aneurysmal dilatation of the affected colonic segment is also common.[10]

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).[11]

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 supralevator space.[11] Perirectal lymphadenopathy is common in rectal adenocarcinomas (Figure 13) but not in GISTs.[11] In addition, the presence of haemorrhage on magnetic resonance imaging is a feature that favours GISTs.[11]

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.[12]

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.

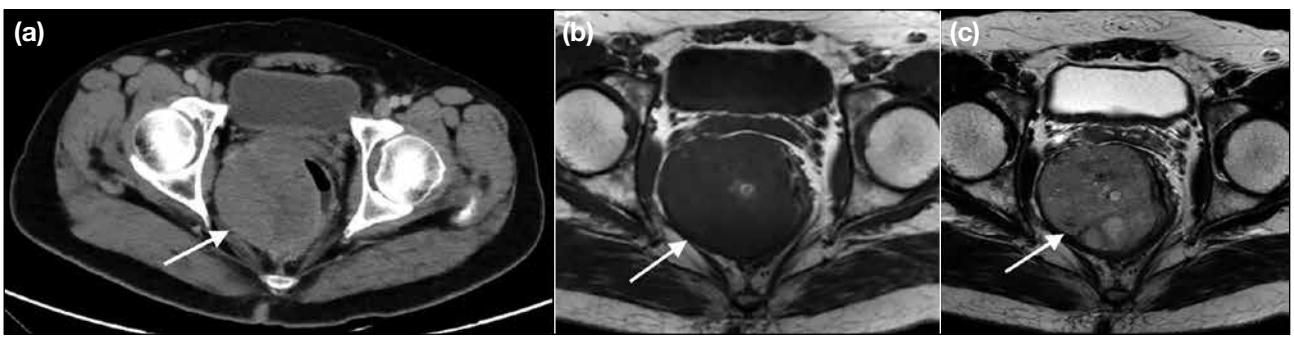

Figure 12. Rectal gastrointestinal stromal tumour in a 48-year-old man. (a) Contrast-enhanced computed tomography showing a heterogeneously enhancing mass with smooth margin arising from the right mesorectum with possible invasion into the mesorectal fascia and right pelvic floor (arrow). (b) T1-weighted 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.

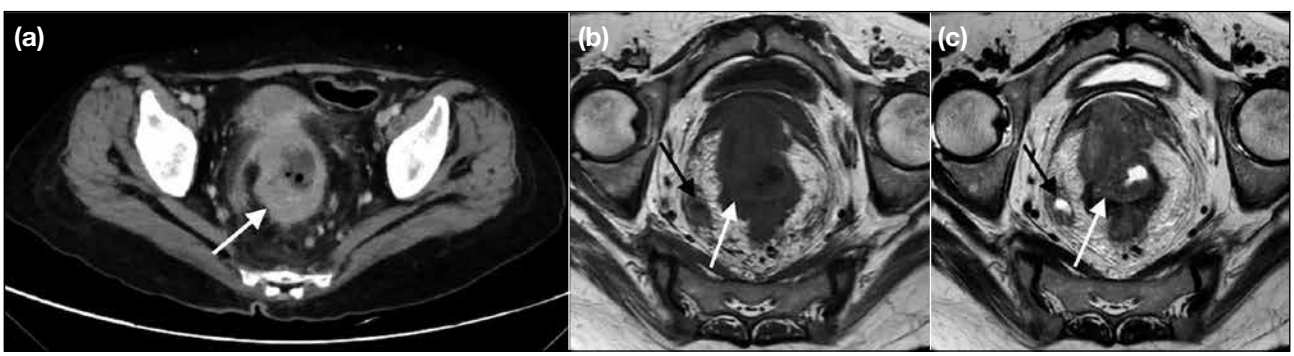

Figure 13. Rectal adenocarcinoma in a 69-year-old woman. (a) Contrast-enhanced computed tomography showing eccentric mural thickening with irregular margin involving the mid rectum (white arrow). (b) T1-weighted and (c) T2-weighted magnetic resonance imaging showing an irregular eccentric mural mass (white arrow) that is T1 isointense and mildly T2 hyperintense relative to muscle. Perirectal lymphadenopathy is present (black arrow).

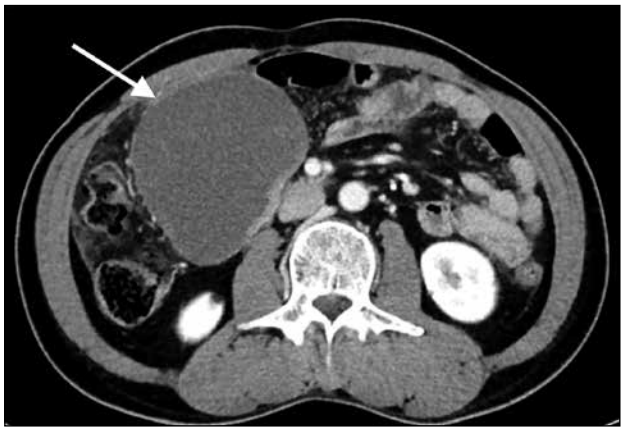

Figure 14. Mesenteric gastrointestinal stromal tumour in a 69-year-old man. Contrast-enhanced computed tomography showing a large well-defined mesenteric mass with central low attenuation (arrow) that does not have obvious connection with the bowel.

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.[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

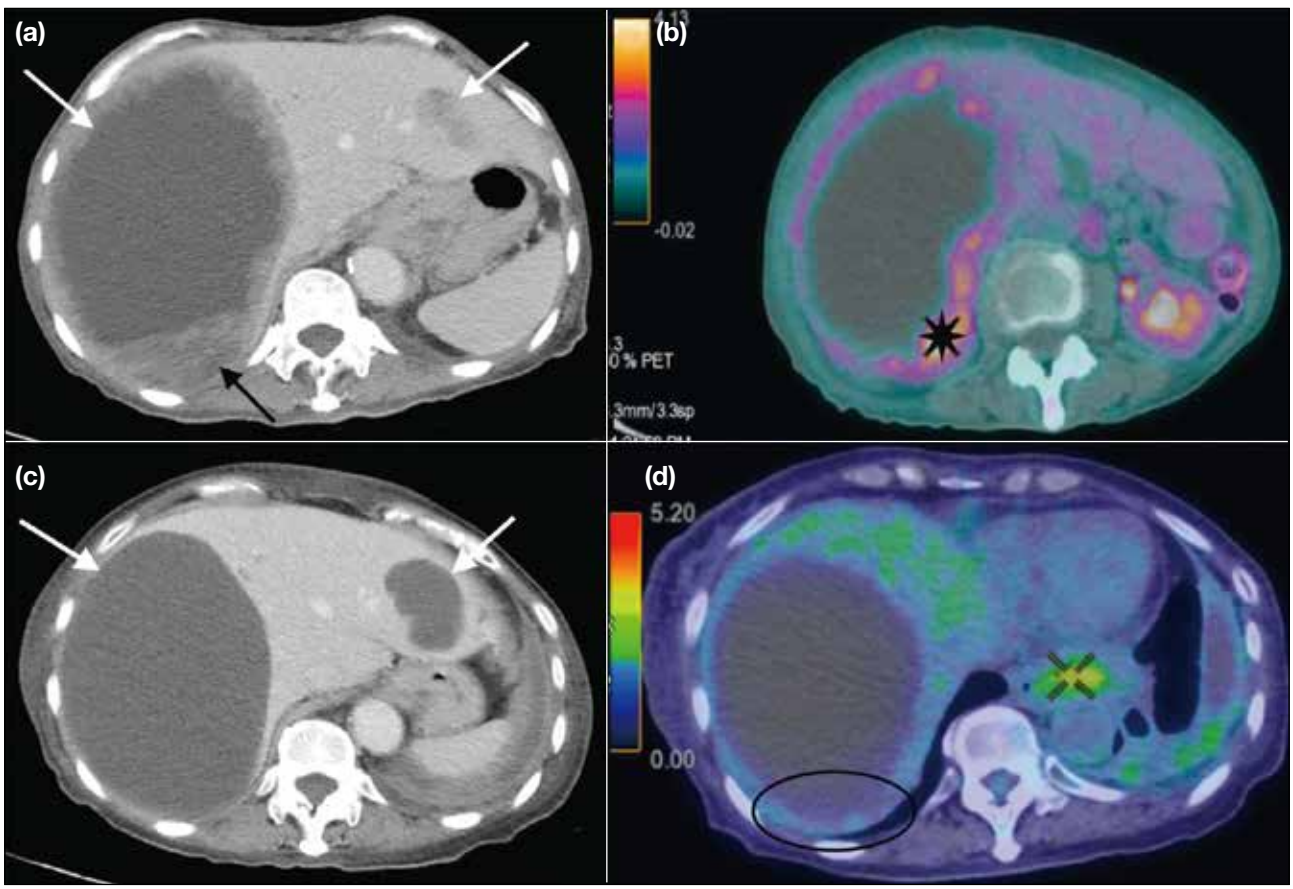

Figure 15. Oesophageal gastrointestinal stromal tumour in a 65-year-old woman with liver metastases. (a) Contrast-enhanced computed tomography (CT) before treatment showing predominantly low-attenuation liver metastases (white arrows); the largest lesion at the right lobe of liver shows internal solid component (black arrow). (b) ^{18}F-fluorodeoxyglucose (^{18}F-FDG) positron emission tomography (PET) before treatment shows the metastasis at the right lobe of liver is FDG-avid (asterisk). (c) Contrast-enhanced CT 7 months after treatment showing cystic change in the liver metastases (white arrows). (d) ^{18}F-FDG PET 8 months after treatment showing that the metastasis at the right lobe of liver has become non-FDG-avid (circle).

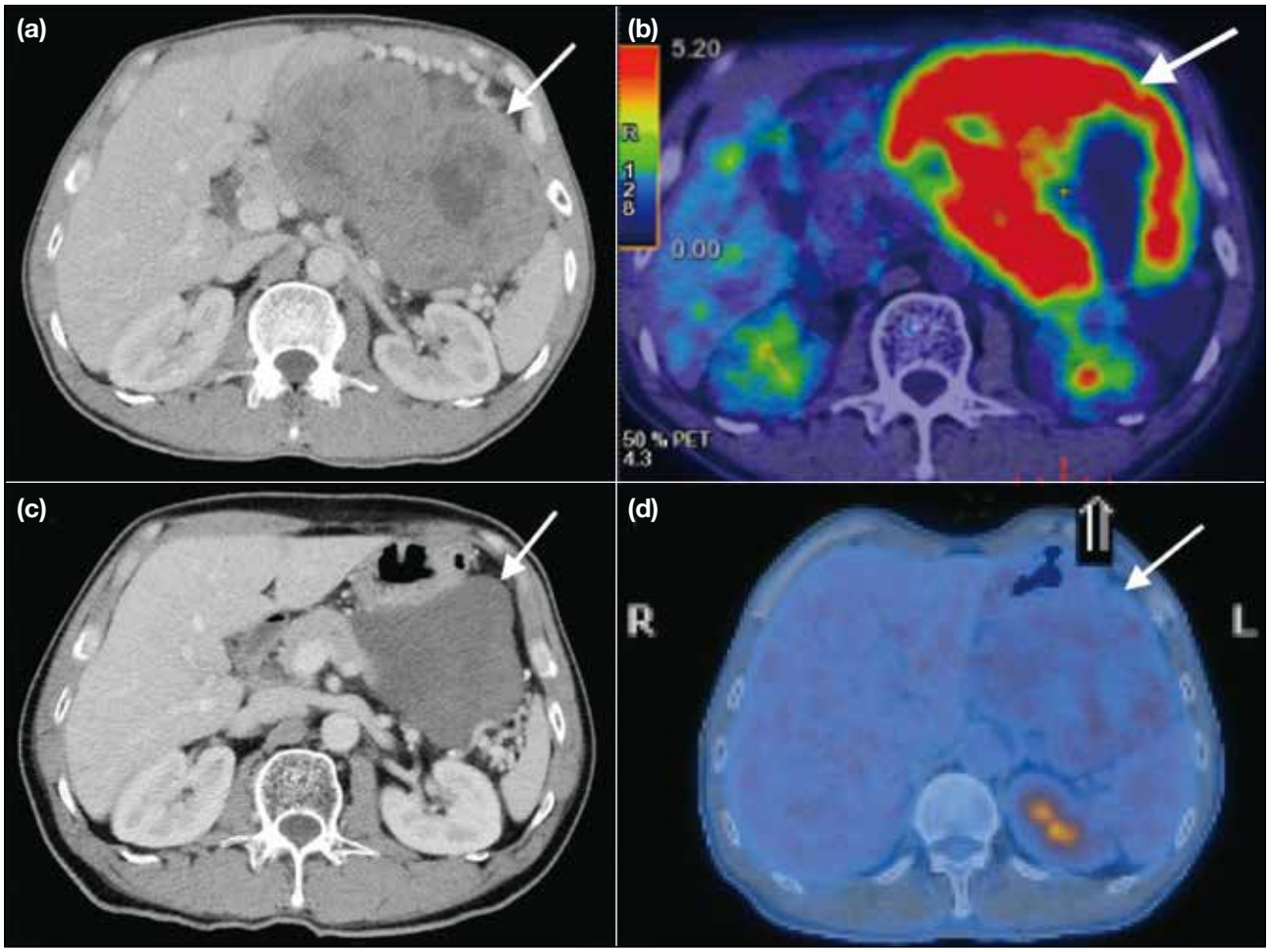

Figure 16. Gastric gastrointestinal stromal tumour in a 53-year-old man. (a) Contrast-enhanced computed tomography (CT) before treatment showing a large heterogeneously enhancing gastric mass (arrow). (b) ^{18}F-fluorodeoxyglucose (^{18}F-FDG) positron emission tomography (PET) before treatment showing 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) ^{18}F-FDG-PET 7 weeks after treatment showing that the tumour has become non-FDG-avid (arrow).

Table. The Choi response criteria for GISTs.

Response	Definition
Complete response (CR)	Disappearance of all target lesions AND no new lesions
Partial response (PR)	≥10% decrease in tumour size OR ≥15% decrease in tumour attenuation without any new lesions
Progressive disease (PD)	≥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
Stable disease	Does not meet the criteria of CR, PR or PD

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]

^{18}F-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

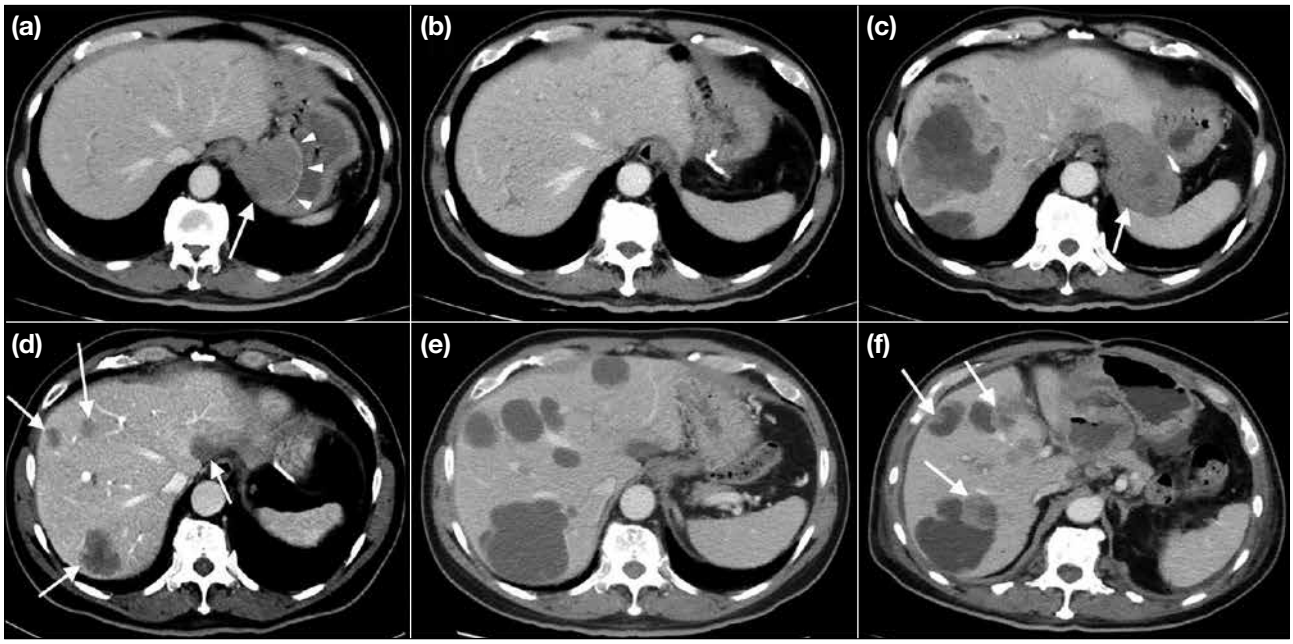

Figure 17. Metastatic gastric gastrointestinal stromal tumour in a 67-year-old man with liver metastases. Partial gastrectomy was performed and the patient was treated with imatinib. (a) Preoperative computed tomography (CT) scan showing a well-defined submucosal gastric mass (arrow) with smooth overlying intact mucosa (arrowheads). (b) Postoperative CT scan showing curvilinear hyperdense suture material at the stomach wall, compatible with partial gastrectomy. Fat strandings in the surgical bed suggest postoperative changes. (c) Follow-up CT scan 4 years later showing a new heterogeneously enhancing mass in the surgical bed (arrow), suggestive of local recurrence. (d) Preoperative CT scan showing multiple hypodense solid liver masses (arrows), suggestive of liver metastases. (e) Follow-up CT scan 2 years after surgery showing multiple predominantly cystic lesions in the liver, in keeping with partial treatment response. (f) Follow-up CT scan 4 years after surgery showing new intratumoural solid lesions (arrows) within the previous cystic liver metastases, suggestive of disease progression.

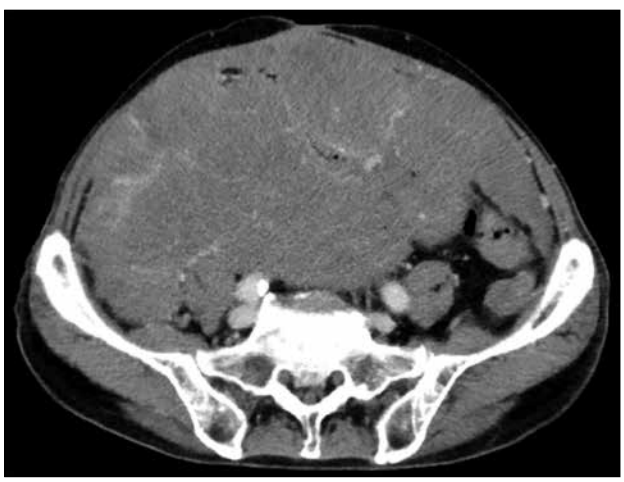

Figure 18. Small bowel gastrointestinal stromal tumour in an 84-year-old man with small bowel partial resection. Follow-up computed tomography scan 11 months after surgery showing multiple solid peritoneal masses, suggestive of metastases.

standardised uptake value <2.5 in the follow-up scan can be used to assess a sustained response.[14] Nonetheless, ^{18}F-fluorodeoxyglucose positron emission tomography cannot be used to assess treatment response in GISTs that are initially non-FDG-avid.

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.[15] 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

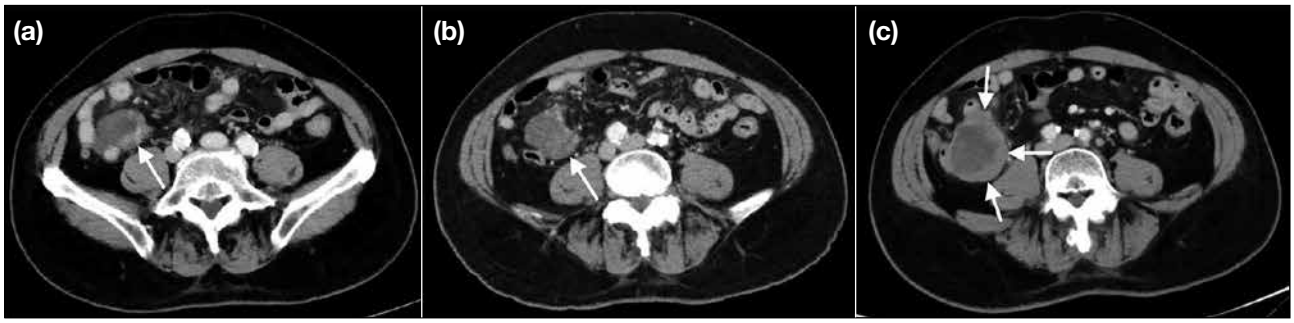

Figure 19. Small bowel gastrointestinal stromal tumour in a 75-year-old man with imatinib treatment. (a) Pretreatment computed tomography (CT) scan showing solid component (arrow) within the small bowel tumour. (b) Follow-up CT scan shortly after starting imatinib showing that the intratumoural solid component has reduced attenuation (arrow), in keeping with partial treatment response. (c) Follow-up CT scan 2 years later showing new solid lesion within the tumour (arrows), suggestive of disease progression.

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

1. Joensuu H, Vehtari A, Riihimäki J, Nishida T, Steigen SE, Brabec P, et al. Risk of recurrence of gastrointestinal stromal tumour after surgery: an analysis of pooled population-based cohorts. Lancet Oncol. 2012;13:265-74.
2. Xu L, Ma Y, Wang S, Feng J, Liu L, Wang J, et al. Incidence of gastrointestinal stromal tumor in Chinese urban population: a national population-based study. Cancer Med. 2021;10:737-44.
3. Tirumani SH, Baheti AD, Tirumani H, O'Neill A, Jagannathan JP. Update on gastrointestinal stromal tumors for radiologists. Korean J Radiol. 2017;18:84-93.
4. Khoo CY, Chai X, Quek R, Teo MC, Goh BK. Systematic review of current prognostication systems for primary gastrointestinal stromal tumors. Eur J Surg Oncol. 2018;44:388-94.
5. Levy AD, Remotti HE, Thompson WM, Sobin LH, Miettinen M. Gastrointestinal stromal tumours: radiologic features with pathologic correlation. Radiographics. 2003;23:283-304.
6. Sarlomo-Rikala M, Kovatich AJ, Barusevicius A, Miettinen M. CD117: a sensitive marker for gastrointestinal stromal tumors that is more specific than CD34. Mod Pathol. 1998;11:728-34.
7. Nishida T, Cho H, Hirota S, Masuzawa T, Chiguchi G, Tsujinaka T, et al. Clinicopathological features and prognosis of primary GISTs with tumor rupture in the real world. Ann Surg Oncol. 2018;25:1961-9.
8. Miettinen M, Sarlomo-Rikala M, Sobin LH, Lasota J. Esophageal stromal tumors: a clinicopathologic, immunohistochemical, and molecular genetic study of 17 cases and comparison with esophageal leiomyomas and leiomyosarcomas. Am J Surg Pathol. 2000;24:211-22.
9. Winant AJ, Gollub MJ, Shia J, Antonescu C, Bains MS, Levine MS. Imaging and clinicopathologic features of esophageal gastrointestinal stromal tumors. AJR Am J Roentgenol. 2014;203:306-14.
10. Miettinen M, Sarlomo-Rikala M, Sobin LH, Lasota J. Gastrointestinal stromal tumors and leiomyosarcomas in the colon: a clinicopathologic, immunohistochemical, and molecular genetic study of 44 cases. Am J Surg Pathol. 2000;24:1339-52.
11. Levy AD, Remotti HE, Thompson WM, Sobin LH, Miettinen M. Anorectal gastrointestinal stromal tumors: CT and MR imaging features with clinical and pathologic correlation. AJR Am J Roentgenol. 2003;180:1607-12.
12. Feng F, Feng B, Liu S, Liu Z, Xu G, Guo M, et al. Clinicopathological features and prognosis of mesenteric gastrointestinal stromal tumor: evaluation of a pooled case series. Oncotarget. 2017;8:46514-22.
13. Güller U, Tarantino I, Cerny T, Schmied BM, Warschkow R. Population-based SEER trend analysis of overall and cancer-specific survival in 5138 patients with gastrointestinal stromal tumor. BMC Cancer. 2015;15:557.
14. Dimitrakopoulou-Strauss A, Ronellenfitsch U, Cheng C, Pan L, Sachpekidis C, Hohenberger P, et al. Imaging therapy response of gastrointestinal stromal tumors (GIST) with FDG PET, CT and MRI: a systematic review. Clin Transl Imaging. 2017;5:183-97.
15. Meyer M, Hohenberger P, Apfaltrer P, Henzler T, Dinter DJ, Schoenberg SO, et al. CT-based response assessment of advanced gastrointestinal stromal tumor: dual energy CT provides a more predictive imaging biomarker of clinical benefit than RECIST or Choi criteria. Eur J Radiol. 2013;82:923-8.