**Name of Journal:** *World Journal of Gastroenterology*

**Manuscript NO:** 56758

**Manuscript Type:** MINIREVIEWS

**Prevalence, diagnosis, and treatment of primary hepatic gastrointestinal stromal tumors**

Qian XH *et al*. Review of PHGIST

Xiao-Hui Qian, Ying-Cai Yan, Bing-Qiang Gao, Wei-Lin Wang

**Xiao-Hui Qian, Ying-Cai Yan, Bing-Qiang Gao, Wei-Lin Wang,** Department of Hepatobiliary and Pancreatic Surgery, The Second Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou 310009, Zhejiang Province, China

**Xiao-Hui Qian, Bing-Qiang Gao, Wei-Lin Wang,** Key Laboratory of Precision Diagnosis and Treatment for Hepatobiliary and Pancreatic Tumor of Zhejiang Province, Hangzhou 310009, Zhejiang Province, China

**Xiao-Hui Qian, Bing-Qiang Gao, Wei-Lin Wang,** Research Center of Diagnosis and Treatment Technology for Hepatocellular Carcinoma of Zhejiang Province, Hangzhou 310009, Zhejiang Province, China

**Xiao-Hui Qian, Bing-Qiang Gao, Wei-Lin Wang,** Clinical Medicine Innovation Center of Precision Diagnosis and Treatment for Hepatobiliary and Pancreatic Disease of Zhejiang University, Hangzhou 310009, Zhejiang Province, China

**Xiao-Hui Qian, Bing-Qiang Gao, Wei-Lin Wang,** Clinical Research Center of Hepatobiliary and Pancreatic Diseases of Zhejiang Province, Hangzhou 310009, Zhejiang Province, China

**Author contributions:** Qian XH designed the study, prepared the table, and wrote the paper; Yan YC and Gao BQ performed the research and analyzed and interpreted the data; Wang WL critically reviewed and drafted the manuscript, supervised, and finally approved the article.

**Supported by** National Natural Science Foundation of China, No. 81572307 and 81773096.

**Corresponding author: Wei-Lin Wang, MD, PhD, Doctor, Professor, Surgeon,** Department of Hepatobiliary and Pancreatic Surgery, The Second Affiliated Hospital, Zhejiang University School of Medicine, No. 88 Jiefang Road, Hangzhou 310009, Zhejiang Province, China. wam@zju.edu.cn

**Received:** May 13, 2020

**Revised:** May 27, 2020

**Accepted:** September 22, 2020

**Published online:**

**Abstract**

Gastrointestinal stromal tumors (GIST), which is the most common mesenchymal tumor of the digestive tract, account for 1%-3% of gastrointestinal tumors. Primary stromal tumors outside the gastrointestinal tract are collectively referred to as extra GISTs, and stromal tumors in different regions often have different prognoses. A primary hepatic GIST is a rare tumor with an unknown origin, which may be related to interstitial Cajal-like cells. Although primary hepatic GIST has certain characteristics on imaging, it lacks specific symptoms and signs; thus, the final diagnosis depends on pathological and genetic evidence. This review summarizes all cases of primary hepatic GIST described in the literature and comprehensively analyzes the detailed clinical data of all patients. In terms of treatment, local resection alone or with adjuvant therapy was the prioritized choice to obtain better disease-free survival and longer survival time. For advanced unresectable cases, imatinib mesylate was applied as the first-line chemotherapy agent. Moreover, transcatheter arterial chemoembolization, radiofrequency ablation, and microwave ablation were shown to improve overall survival for selected patients. Liver transplantation was a final treatment option after resistance to chemotherapy developed.

**Key Words:** Extra gastrointestinal stromal tumor; Treatment; Liver transplant; Review

Qian XH, Yan YC, Gao BQ, Wang WL. Prevalence, diagnosis, and treatment of primary hepatic gastrointestinal stromal tumors. *World J Gastroenterol* 2020; In press

**Core Tip:** A primary hepatic gastrointestinal stromal tumor(PHGIST) is a rare tumor with an unknown origin and bad prognosis, which has always been misdiagnosed. The majority of studies of PHGIST are case reports, and clinical evaluation of different treatment methods has never been established. This review, including 35 cases from different nations, summarizes the etiology, clinical characteristics, diagnosis, treatment, and prognosis of PHGIST in order to clarify the treatment options for this rare disease.

**INTRODUCTION**

Gastrointestinal stromal tumors (GISTs) are the most common gastrointestinal mesenchymal tumor with an incidence of approximately 1/100000 to 1.6/100000 per year[1-3]. They are a sophisticated mesenchymal tumor, mainly including immature spindle-shaped and/or epithelial-like cell proliferations. Studies have shown that tumorigenesis originates from the interstitial cell of Cajal (ICC) in the gastrointestinal tract, which is the cell responsible for triggering gastrointestinal mobility[4]. The diagnosis of GIST is based on the pathology of the lesion, including cell morphology and immunohistochemistry. According to previous research, CD117 (c-KIT) is expressed in approximately 94%-98% of GIST cases, while CD34 is expressed in 70% of cases[5,6]. GIST occurs in the digestive tract, including the stomach (60%-70%), the small intestine (20%-25%), the colon and rectum (5%), and the esophagus (< 5%)[7].

An extra GIST (EGIST) refers to a type of tumor similar to GIST in tissue morphology and immunophenotype but that originates in the abdominal cavity or retroperitoneum and does not involve the intestinal wall or visceral serosa[8]. Presently, there is no unified understanding of the origin of EGIST due to its low incidence. According to the study by Du *et al*[9], the incidence of EGIST is < 10% of all GISTs with a definite source. The malignant risk of the tumor, defined as its ability to invade and metastasize, is varied. GISTs are classified into four levels according to their size, mitotic image, and location of the lesion using the National Institutes of Health (NIH) classification guideline, which corresponds to different prognoses and preferred treatment methods. According to previous reports, the risk classification and prognosis of EGISTs are significantly worse than those of gastrointestinal tumors[10,11].

Both GIST and EGIST commonly metastasize to the liver[12-14], but the liver is a rare primary metastatic site of GIST. The majority of studies of primary hepatic GIST (PHGIST) are case reports, and clinical evaluation of different treatment methods has never been established. However, an overall impression of the clinical features, imaging, pathology, and treatment prognosis of PHGIST can be obtained from the limited literature. This review summarizes the etiology, clinical characteristics, diagnosis, and treatment of PHGIST, including cases from the earliest reports found to December 2019. Moreover, this review attempts to clarify the survival and treatment options for this rare disease.

**SEARCH FOR CASE REPORTS OF PHGIST PATIENTS**

Online databases, including PubMed and China National Knowledge Internet, were used to find relevant studies and further analyze the characteristics of PHGIST without restrictions on publication dates until December 1, 2019. The search terms used were as follows: “extra-gastrointestinal stromal tumors,” “gastrointestinal stromal tumor and liver,” “primary hepatic gastrointestinal stromal tumors,” and “stromal tumors of the liver.” The references for initial studies found were scanned carefully to identify more studies. Eligible documents were selected according to the abstract, and the entire report was subsequently reviewed cautiously. We collected and recorded all reports containing detailed patient information including medical history, laboratory and imaging data, pathological information, treatment records, and prognostic methods (Table 1).

**ETIOLOGY OF PHGIST**

ICCs are interstitial cells found in the gastrointestinal tract that function as pacemakers for gastrointestinal peristalsis[4]. Current research suggests that GISTs originate from this cell[15]. Moreover, ICC-like cells with a similar structure and function to ICC were observed in organs outside the digestive tract as well as in the vasculature, including the portal vein and mesenteric artery space, using immunohistochemistry in human and animal specimens[16,17]. Rusu *et al*[18] and Ilie *et al*[19] demonstrated that ICC-like cells were also present in the human embryonic liver as a single precursor/progenitor cell. Therefore, it is reasonable to speculate that PHGISTs originate from this typical ICC-like precursor cell. Some authors also believe that PHGISTs originate from undifferentiated pluripotent mesenchymal stem cells located outside the gastrointestinal tract that then differentiate into ICC[10]. The occurrence of PHGIST on all liver lobes indicates that the distribution of ICC cells in the liver is widespread, and the presence of ICC-like cells in liver tissue may contribute to the development of PHGIST.

The mechanism underlying how ICC develops into a tumor remains largely unknown. Several studies have shown that the function-acquired mutation stem cell factor receptor (*KIT*) of the receptor tyrosine kinase gene in ICC plays a crucial role in the occurrence of most GIST cases[20]. In previous studies, 65%-80% of GISTs had mutations in the *KIT* gene, and approximately 10% of KIT-negative GISTs had activation mutations in the platelet-derived growth factor receptor alpha (*PDGFRA*) gene[21,22]. In our review, nine patients with gene analysis were included, and the mutation rate was 66% (6/9; *n* = 4 for *KIT* gene, *n* = 2 for *PDGFRA* gene). *KIT* and *PDGFRA* mutations may also promote the occurrence and development of PHGIST *via* activation and autophosphorylation of downstream signaling pathways.

**CLINICAL FEATURES AND LABORATORY TESTS FOR PHGIST**

PHGIST patients may have no obvious symptoms with a liver mass accidentally found during routine physical examination or imaging with subsequent confirmatory diagnostic testing. Symptomatic patients show symptoms similar to chronic liver disease, and abdominal pain and a palpable abdominal mass are the most common presentations. Other presenting gastrointestinal symptoms include abdominal discomfort, indigestion, and distension. It is worth noting that two patients presented with significant, acute weight loss in the late stage[23,24]. Some patients may have difficulty breathing because of a large tumor resulting in mechanical obstruction[25,26]. In the later stage of tumor growth, tumor rupture and bleeding can occur, and patients present to the hospital due to sudden onset abdominal pain[27]. Although the incidence is rare, the possibility of GIST should be considered clinically for large space-occupying lesions of the liver. PHGIST is currently not associated with any specific tumor marker, except for a few cases that presented with slightly elevated but within normal range alpha-fetoprotein, CA19-9, and CA125 levels[11].

**IMAGING AND PATHOLOGICAL DIAGNOSIS**

Given that there are no specific radiological features for PHGIST, it is challenging to distinguish PHGIST from other hepatic tumors preoperatively. Thus, these types of tumors are often misdiagnosed. From a morphological point of view, most PHGISTs appear as single round cyst-like solid masses that are occasionally lobulated with bright or fuzzy borders and thick pseudo capsules in some parts with central necrosis and cysts. Tumors may be accompanied by intratumor bleeding, and calcification is rare. It is worth mentioning that magnetic resonance imaging is useful in showing the complex components of tumor tissues[28]. Specifically, diffusion-weighted imaging for solid components shows a significantly high signal, which may be related to malignant tumors[29].

Two types of enhancement imaging patterns for most contrasted scans were seen. First, during the arterial, portal, and delay phases, there was continuous uneven enhancement. If the tumor was a solid mass, it was often difficult to distinguish from hepatic hemangioma[30]. Second, on the fast-forward and fast-reverse phases, the arterial phase was significantly strengthened to a level higher than the normal liver parenchyma. Identification was challenging when equal or low density signals were similar to those for hepatocellular carcinoma, especially when the lesion had a false capsule[11]. In one case, an entirely cystic tumor was seen, which was difficult to distinguish from a hepatic cyst during the early stage. Its size increased during the follow-up course, and PHGIST was finally confirmed[31]. Follow-up imaging studies should be performed, and a diagnosis of PHGIST should be suspected if there is rapid tumor enlargement.

In GIST, positron emission tomography-computed tomography (PET-CT) is considered to be the most sensitive method for diagnosis as well as for evaluating the efficacy of molecularly targeted drugs. Because PET-CT has essential value in diagnosis and staging, prediction of malignant potential, treatment decision, efficacy assessment, and follow-up monitoring, it has been clinically recognized and included in the 2010 National Comprehensive Cancer Network Guide Guidelines Medium[6]. In the literature, PET-CT was used to exclude liver GIST from extrahepatic lesions with a maximum standardized uptake value of 6.30-6.85[28,32]. Importantly, even if patients have a characteristic image without a history of hepatitis and alpha-fetoprotein levels are not elevated, the possibility of PHGIST should be considered in the differential diagnosis. However, the final diagnosis should still be based on pathology and immunohistochemistry.

EGISTs have the same morphology, immunohistochemistry, and molecular characteristics as conventional GISTs, including metastatic GISTs. The histopathological diagnostic criteria for GISTs have been firmly established. Histologically, there are three main PHGIST types. The spindle cell type predominates, while epithelioid cell and mixed cell types account for only a small portion of cases (11.4%, 4/35). The tumor cells of most patients who underwent immunohistochemistry expressed CD117 and CD34, which showed a positive envelope and/or diffuse cytoplasm. Only one case of GIST was found not to express CD117, but it was CD34 positive[33]. The diagnosis of GIST cannot be ruled out in a patient with a tumor morphologically consistent with GIST but without CD117 expression. In this case, further detection of mutations in the *c-KIT* and *PDGFRA-α* genes is required for diagnosis. Moreover, GISTs can also express DOG1, especially in cases with a *PDGFR-α* gene mutation without a *c-KIT* mutation with an overall sensitivity similar to that of CD117[34]. The combination of DOG1 and CD117 expression for the diagnosis of GIST has functional complementarity[35].

We believe that a precise diagnosis requires immunohistochemistry and molecular examination, which may exclude other rare types of hepatic mesenchymal epithelioid tumors, such as epithelioid vascular leiomyomata, leiomyosarcoma, and malignant melanin tumors. It should be emphasized that the liver is the most likely place for GIST metastasis and that primary GIST of the liver is rare. Therefore, to ensure an accurate diagnosis, it is necessary to exclude tumors in other common locations of the gastrointestinal tract by using methods such as barium radiography, digestive endoscopy, and PET-CT. In addition, CT or ultrasound-guided fine-needle aspiration biopsy is commonly used to diagnose unresectable hepatic tumors[23,36]. Puncture biopsy can also be used to definitively diagnose patients with inoperable PHGIST.

**OVERALL CONDITION OF THE CASE REPORTS**

There were 34 reports of PHGIST in the literature, with a total of 35 cases as follows: twenty-three in China, one in South Korea, two in France, two in India, three in Japan, and four in other countries (Table 1). Patients ranged in age from 17-79 years with an average age of 56 years. Seventeen cases were male, seventeen cases were female, and one case had no reported gender. Of all cases, 26.6% (15/35) were asymptomatic and found on routine physical examination. The presenting symptom was abdominal pain of varying intensity in 11 patients. One case presented with acute rupture due to tumor rupture, and the other presenting manifestations included loss of appetite (*n* = 2), indigestion (*n* = 1), abdominal discomfort (*n* = 2), weight loss (*n* = 2), and shortness of breath (*n* = 2). Tumors were located in all lobes of the liver with the majority being in the right lobe (*n* = 22). Most patients presented with a single hepatic mass (*n* = 30); however, two patients had more than two masses. The tumors ranged in diameter from 2.3 cm to 44.0 cm (median, 15.0 cm; mean, 13.8 cm). On imaging, there were three, eight, and twenty-four cases of cystic masses, solid masses, and mixed masses, respectively.

Of the thirty-five patients, twenty-five underwent local hepatectomy alone or in combination with adjuvant therapy, two underwent transcatheter arterial chemoembolization (TACE), and two underwent liver transplantation. Three patients received different interventions for various reasons: one patient (tumor size 5.1 cm) underwent radiofrequency ablation, one patient (tumor size 2.4 cm) was treated with microwave ablation, and one patient with large cystic masses (largest tumor > 20 cm) underwent repeated cystic drainage. The remaining five cases were not treated surgically, including one patient who was discharged without any treatment. Follow-up data were obtained from 24 patients, and recurrence usually occurred within 1 year of the operation. The metastatic sites included the liver, lymph nodes, bones, and brain. Most patients were categorized as high risk according to the risk stratification criteria of the 2008 version of the NIH guidelines, and 16 patients received adjuvant therapy or chemotherapy alone. Nineteen of twenty-five patients (76.0%) had a mitotic index ≥ 5/50 high-power fields.

Ki-67 expression was detected in ten patients, and eight patients had a ratio more than 5%. Among thirty liver GIST specimens, spindle cell morphology was observed in twenty-five (83.3%), epithelioid cell morphology was observed in one (3.3%), and mixed cell morphology was observed in four (13.3%). Of the 35 (97.1%) specimens, 34 were positive for CD117, and 18 (51.4%) were positive for CD3. Five of six cases (83.3%) were positive for DOG-1. Genomic mutations were examined in four specimens. *KIT* mutations in exon 11 were found in three of nine specimens, *KIT* mutations in exon 9 were found in one specimen, *PDGFE 12* mutations were found in two specimens, and the remaining three specimens had no apparent genetic mutations. The 2008 version of NIH risk classified thirty-three patients as high risk (94%), and the other two patients could not be classified because of incomplete data. Seventeen studies reported prognostic results. During follow-up, five patients were diagnosed with recurrent or metastatic tumors. Metastases were found in the following organs: hilar and pulmonary lymph nodes (*n* = 1), stomach (*n* = 1), lungs (*n* = 1), brain (*n* = 1), and bone (*n* = 1). Two patients who did not undergo surgery died of primary liver EGIST at 13 mo.

**PHGIST TREATMENT**

As there are few cases of PHGIST, the main treatment methods follow the treatment protocol of GIST, which reflects the concept of comprehensive therapy as a whole. Based on a review of all cases, we believe that lesion resection with or without combined chemotherapy is the best choice. Of the 30 patients with PHGIST who received local hepatectomy alone or in combination with chemotherapy, 23 (76.7%) patients had a survival > 6 mo. For locally advanced tumors, after an evaluation is performed, obtaining R0 resection should be attempted followed by adjuvant treatment. In one case, a liver mass was located in the right posterior lobe of the liver, which spread to the right adrenal gland[11]. Because conventional methods could not be used for resection, external hepatectomy and autotransplantation were performed[37]. Interestingly, the majority of reported cases of PHGIST were detected at a resectable stage with < 15% of patients not being treated with surgery.

According to the recommendations of the NIH, almost all PHGISTs are high risk and thus require adjuvant treatment. Among chemotherapeutic agents, imatinib is recommended as a first-line treatment[38,39], although less common drugs such as sunitinib and regorafenib are sometimes used[40,41]. GIST is caused by *c-KIT* or *PDGFR* mutations in precursor cells, leading to the continuous activation of tyrosine kinase and uncontrolled cell proliferation and differentiation. Therefore, the use of imatinib, a tyrosine kinase inhibitor, has completely changed the concept of surgical treatment and comprehensive treatment of GIST[38]. For PHGIST, almost half of the patients studied received imatinib as a basic or adjuvant treatment with satisfactory results. Although no patient received imatinib as a preoperative adjuvant treatment, we believe that after the evaluation of certain advanced tumors, it can be used as neoadjuvant therapy to minimize the lesion and obtain possible R0 resection.

Imatinib is also the first-line therapy recommended for patients with unresectable tumors or who have obvious contraindications to surgery. A needle biopsy is required to confirm the diagnosis for nonsurgical treatment; however, it is necessary to ensure that the biopsy is performed well. It is worth noting that in patients treated with imatinib, even if the lesion does not shrink significantly during follow-up, this may indicate stable cancer with a prolonged survival time. Joyon *et al*[23] reported a patient who had only minimal response at 6 mo follow-up (< 10% reduction in diameter), but who survived 18 mo following diagnosis. For patients who can undergo resection after relapse, the tumor should be resected, and imatinib should be added or continued. In GIST cases, the 2 years of progression-free survival for patients treated with imatinib was 77%, which may be similar for PHGIST[36,42,43]. Conventional chemotherapeutics such as doxorubicin combined with cisplatin were seldom used in PHGIST cases; however, they may contribute to the maintenance of tumor stability. In one report[36], systemic chemotherapy consisting of 50 mg/m2 doxorubicin and 50 mg/m2 cisplatin every 3 wk resulted in improved symptoms with reductions in dull upper abdominal pain and tumor size on palpation after the first treatment cycle.

PHGIST may be asymptomatic early, but the tumors grow quickly, and rupture and bleeding may occur. Indeed, several cases of intratumor bleeding have been reported. Transarterial embolization can be performed to stanch bleeding. Other treatment strategies are used in specific clinical situations. In two patients with small tumors, local treatment was attempted with radiofrequency[44] and microwave[45] ablation resulting in a satisfying prognosis. TACE is a palliative treatment for patients with unresectable primary hepatic angiosarcoma. Liao *et al*[43] reported a case who accepted TACE to slow tumor progression and reduce lesions, ultimately achieving R0 resection of the tumor.

Resistance to chemotherapy treatment may eventually occur with the prolongation of imatinib treatment time. For GIST, it has been reported that 15% of patients are primarily resistant to the drug[46], In general, 88% of patients suffer from recurrence about 2 years after imatinib treatment due to the secondary resistance mutations in additional *KIT* exons[47,48]. Given the poor results of palliative treatment including chemotherapy, ablation, and TACE in patients with tyrosine kinase inhibitor drug resistance, liver transplantation may be the only treatment that may improve prognosis and prolong the overall survival time[49]. In a case reported by Joyon *et al*[23], a patient received a first course of lipiodol chemoembolization, but a second intrahepatic lesion was discovered in the left lobe 3 mo later. After evaluating the transplantation indications, liver transplantation was proposed. The patient eventually died 22 years after the initial diagnosis, 21 years after liver transplantation, and 9 years after tumor recurrence. According to the study by Frilling *et al*[50], adjuvant treatment with imatinib initially given before transplantation for a period > 2 years may yield better results. Mao *et al*[37] performed extracorporeal hepatic resection and autotransplantation for PHGIST. The patient then received imatinib adjuvant therapy and had no evidence of recurrence on CT or ultrasound after 12 mo.

**LIMITATIONS OF THE ANALYSIS**

Our study is a retrospective analysis based on previous literature, and it inevitably has some limitations. First, the sample size was relatively small. Only Chinese and English language literature was searched, which may have led to uneven regional sampling. Second, this review included case reports from East and South Asia, North and South America, and western and southern Europe; therefore, the demographic heterogeneity across different studies is inevitable. Third, combined case report analyses are somewhat limited and inaccurate due to the difference in the quality of care between hospitals and institutions. We tried to minimize the analysis of data from case reports and preferred to focus on the essential characteristics of the patients in these reports.

**CONCLUSION**

PHGISTs are sporadic. It remains challenging to accurately determine the liver as the primary site of GISTs to obtain an accurate diagnosis. The first-line treatment of PHGIST is surgical intervention. Additionally, imatinib can be used as adjuvant therapy for locally advanced tumors and as the first-line treatment for unresectable tumors, recurrence, and metastases. Overall, existing studies have shown that PHGISTs are high-risk tumors compared with common GISTs, meaning that the prognosis of PHGIST is worse than that of gastric and small intestine GIST. Therefore, involvement of a multidisciplinary team is needed for the diagnosis and treatment of patients with PHGIST.

**REFERENCES**

1 **Labgaa I**, Stueck A, Ward SC. Lymphoepithelioma-Like Carcinoma in Liver. *Am J Pathol* 2017; **187**: 1438-1444 [PMID: 28500863 DOI: 10.1016/j.ajpath.2017.02.022]

2 **Corless CL**, Barnett CM, Heinrich MC. Gastrointestinal stromal tumours: origin and molecular oncology. *Nat Rev Cancer* 2011; **11**:865-878 [PMID: 22089421 DOI: 10.1038/nrc3143]

3 **Nilsson B,** Bümming P, Meis-Kindblom JM, Odén A, Dortok A, Gustavsson B, Sablinska K, Kindblom LG. Gastrointestinal stromal tumors: the incidence, prevalence, clinical course, and prognostication in the preimatinib mesylate era--a population-based study in western Sweden. *Cancer* 2005; **103**:821-829 [PMID: 15648083 DOI: 10.1002/cncr.20862]

4 **Kindblom LG**, Remotti HE, Aldenborg F, Meis-Kindblom JM. Gastrointestinal pacemaker cell tumor (GIPACT): gastrointestinal stromal tumors show phenotypic characteristics of the interstitial cells of Cajal. *Am J Pathol* 1998; **152**: 1259-1269 [PMID: 9588894]

5 **Blay JY,** Bonvalot S, Casali P, Choi H, Debiec-Richter M, Dei Tos AP, Emile JF, Gronchi A, Hogendoorn PC, Joensuu H, Le Cesne A, McClure J, Maurel J, Nupponen N, Ray-Coquard I, Reichardt P, Sciot R, Stroobants S, van Glabbeke M, van Oosterom A, Demetri GD; GIST consensus meeting panelists. Consensus meeting for the management of gastrointestinal stromal tumors. Report of the GIST Consensus Conference of 20-21 March 2004, under the auspices of ESMO. *Ann Oncol* 2005; **16**: 566-578 [PMID: 15781488 DOI: 10.1093/annonc/mdi127]

6 **Demetri GD**, von Mehren M, Antonescu CR, DeMatteo RP, Ganjoo KN, Maki RG, Pisters PW, Raut CP, Riedel RF, Schuetze S, Sundar HM, Trent JC, Wayne JD. NCCN Task Force report: update on the management of patients with gastrointestinal stromal tumors. *J Natl Compr Canc Netw* 2010; **8** Suppl 2: S1-41; quiz S42-44 [PMID: 20457867 DOI: 10.6004/jnccn.2010.0116]

7 **Miettinen M**, Lasota J. Gastrointestinal stromal tumors--definition, clinical, histological, immunohistochemical, and molecular genetic features and differential diagnosis. *Virchows Arch* 2001; **438**:1-12 [PMID: 11213830 DOI: 10.1007/s004280000338]

8 **Reith JD**, Goldblum JR, Lyles RH, Weiss SW. Extragastrointestinal (soft tissue) stromal tumors: an analysis of 48 cases with emphasis on histologic predictors of outcome. *Mod Pathol* 2000; **13**: 577-585 [PMID: 10824931 DOI: 10.1038/modpathol.3880099]

9 **Du CY**, Shi YQ, Zhou Y, Fu H, Zhao G. The analysis of status and clinical implication of KIT and PDGFRA mutations in gastrointestinal stromal tumor (GIST). *J Surg Oncol* 2008; **98**:175-178 [PMID: 18618605 DOI: 10.1002/jso.21104]

10 **Yi JH**, Park BB, Kang JH, Hwang IG, Shin DB, Sym SJ, Ahn HK, Lee SI, Lim DH, Park KW, Won YW, Lim SH, Park SH. Retrospective analysis of extra-gastrointestinal stromal tumors. *World J Gastroenterol* 2015; **21**: 1845-1850 [PMID: 25684950 DOI: 10.3748/wjg.v21.i6.1845]

11 **Xu L**, Zhang M, Xu M. Primary hepatic gastrointestinal stromal tumor with right adrenal gland invasion: A case report and systematic literature review. *Medicine (Baltimore)* 2019; **98**:e15482 [PMID: 31096446 DOI: 10.1097/MD.0000000000015482]

12 **Wardelmann E**, Thomas N, Merkelbach-Bruse S, Pauls K, Speidel N, Büttner R, Bihl H, Leutner CC, Heinicke T, Hohenberger P. Acquired resistance to imatinib in gastrointestinal stromal tumours caused by multiple KIT mutations. *Lancet Oncol* 2005; **6**: 249-251 [PMID: 15811621 DOI: 10.1016/S1470-2045(05)70097-8]

13 **Bauer S**, Hartmann JT, de Wit M, Lang H, Grabellus F, Antoch G, Niebel W, Erhard J, Ebeling P, Zeth M, Taeger G, Seeber S, Flasshove M, Schütte J. Resection of residual disease in patients with metastatic gastrointestinal stromal tumors responding to treatment with imatinib. *Int J Cancer* 2005; **117**: 316-325 [PMID: 15900603 DOI: 10.1002/ijc.21164]

14 **DeMatteo RP**, Lewis JJ, Leung D, Mudan SS, Woodruff JM, Brennan MF. Two hundred gastrointestinal stromal tumors: recurrence patterns and prognostic factors for survival. *Ann Surg* 2000; **231**: 51-58 [PMID: 10636102 DOI: 10.1097/00000658-200001000-00008]

15 **Taşkın OÇ**, Armutlu A, Adsay V, Aslan F, Kapran Y. Clinicopathologic and immunohistochemical characteristics of upper gastrointestinal leiomyomas harboring interstitial cells of Cajal: A potential mimicker of gastrointestinal stromal tumor. *Ann Diagn Pathol* 2020; **45**:151476 [PMID: 32062475 DOI: 10.1016/j.anndiagpath.2020.151476]

16 **Harhun MI**, Pucovský V, Povstyan OV, Gordienko DV, Bolton TB. Interstitial cells in the vasculature. *J Cell Mol Med* 2005; **9**:232-243 [PMID: 15963246 DOI: 10.1111/j.1582-4934.2005.tb00352.x]

17 **Rusu MC**, Pop F, Hostiuc S, Curcă GC, Streinu-Cercel A. Extrahepatic and intrahepatic human portal interstitial Cajal cells. *Anat Rec (Hoboken)* 2011; **294**: 1382-1392 [PMID: 21714117 DOI: 10.1002/ar.21441]

18 **Rusu MC,** Dută I, Didilescu AC, Vrapciu AD, Hostiuc S, Anton E. Precursor and interstitial Cajal cells in the human embryo liver. *Rom J Morphol Embryol* 2014; **55**: 291-296 [PMID: 24969977 DOI: 10.1039/c4pp00073k]

19 **Ilie CA**, Rusu MC, Didilescu AC, Motoc AG, Mogoantă L. Embryonic hematopoietic stem cells and interstitial Cajal cells in the hindgut of late stage human embryos: evidence and hypotheses. *Ann Anat* 2015; **200**: 24-29 [PMID: 25723517 DOI: 10.1016/j.aanat.2015.01.001]

20 **Corless CL**, Schroeder A, Griffith D, Town A, McGreevey L, Harrell P, Shiraga S, Bainbridge T, Morich J, Heinrich MC. PDGFRA mutations in gastrointestinal stromal tumors: frequency, spectrum and *in vitro* sensitivity to imatinib. *J Clin Oncol* 2005; **23**:5357-5364 [PMID: 15928335 DOI: 10.1200/JCO.2005.14.068]

21 **Heinrich MC**, Corless CL, Duensing A, McGreevey L, Chen CJ, Joseph N, Singer S, Griffith DJ, Haley A, Town A, Demetri GD, Fletcher CD, Fletcher JA. PDGFRA activating mutations in gastrointestinal stromal tumors. *Science* 2003; **299**: 708-710 [PMID: 12522257 DOI: 10.1126/science.1079666]

22 **Lasota J**, Miettinen M. Clinical significance of oncogenic KIT and PDGFRA mutations in gastrointestinal stromal tumours. *Histopathology* 2008; **53**: 245-266 [PMID: 18312355 DOI: 10.1111/j.1365-2559.2008.02977.x]

23 **Joyon N**, Dumortier J, Aline-Fardin A, Caramella C, Valette PJ, Blay JY, Scoazec JY, Dartigues P. Gastrointestinal stromal tumors (GIST) presenting in the liver: Diagnostic, prognostic and therapeutic issues. *Clin Res Hepatol Gastroenterol* 2018; **42**: e23-e28 [PMID: 28645742 DOI: 10.1016/j.clinre.2017.05.010]

24 **Bhoy T**, Lalwani S, Mistry J, Varma V, Kumaran V, Nundy S, Mehta N. Primary hepatic gastrointestinal stromal tumor. *Trop Gastroenterol* 2014; **35**: 252-253 [PMID: 26349171 DOI: 10.7869/tg.225]

25 **Hu X**, Forster J, Damjanov I. Primary malignant gastrointestinal stromal tumor of the liver. *Arch Pathol Lab Med* 2003; **127**: 1606-1608 [PMID: 14632569]

26 **Hu Z**, Wei Y, Zhu H, Yang X, Deng ZZ, Yong M, Xiang L. Huge malignant liver mesenchymal tumor: one case report. *Zhongguo Shiyong Waike Zazhi* 2007; **27**: 417 [DOI: 10.3321/j.issn:1005-2208.2007.05.029]

27 **Lok HT**, Chong CN, Chan AW, Fong KW, Cheung YS, Wong J, Lee KF, Lai PB. Primary hepatic gastrointestinal stromal tumor presented with rupture. *Hepatobiliary Surg Nutr* 2017; **6**: 65-66 [PMID: 28261601 DOI: 10.21037/hbsn.2017.01.11]

28 **Kim HO**, Kim JE, Bae KS, Choi BH, Jeong CY, Lee JS. Imaging findings of primary malignant gastrointestinal stromal tumor of the liver. *Jpn J Radiol* 2014; **32**:365-370 [PMID: 24682930 DOI: 10.1007/s11604-014-0307-z]

29 **Zhao Y**, Yang B. Imaging findings of primary hepatic gastrointestinal stromal tumors. *Zhongguo zhongxiyi Jiehe Yingxiangxue Zazhi* 2018; **16**: 625-627

30 **Carrillo Colmenero AM**, Serradilla Martín M, Redondo Olmedilla MD, Ramos Pleguezuelos FM, López Leiva P. Giant primary extra gastrointestinal stromal tumor of the liver. *Cir Esp* 2017; **95**:547-550 [PMID: 28153448 DOI: 10.1016/j.ciresp.2016.12.005]

31 **Zhou B**, Zhang M, Yan S, Zheng S. Primary gastrointestinal stromal tumor of the liver: report of a case. *Surg Today* 2014; **44**: 1142-1146 [PMID: 23681598 DOI: 10.1007/s00595-013-0521-9]

32 **Nagai T**, Ueda K, Hakoda H, Okata S, Nakata S, Taira T, Aoki S, Mishima H, Sako A, Maruyama T, Okumura M. Primary gastrointestinal stromal tumor of the liver: a case report and review of the literature. *Surg Case Rep* 2016; **2**: 87 [PMID: 27586264 DOI: 10.1186/s40792-016-0218-6]

33 **Yamamoto H**, Miyamoto Y, Nishihara Y, Kojima A, Imamura M, Kishikawa K, Takase Y, Ario K, Oda Y, Tsuneyoshi M. Primary gastrointestinal stromal tumor of the liver with PDGFRA gene mutation. *Hum Pathol* 2010; **41**: 605-609 [PMID: 20096441 DOI: 10.1016/j.humpath.2009.09.016]

34 **Sui XL**, Wang H, Sun XW. Expression of DOG1, CD117 and PDGFRA in gastrointestinal stromal tumors and correlations with clinicopathology. *Asian Pac J Cancer Prev* 2012; **13**:1389-1393 [PMID: 22799337 DOI: 10.7314/apjcp.2012.13.4.1389]

35 **Wada T**, Tanabe S, Ishido K, Higuchi K, Sasaki T, Katada C, Azuma M, Naruke A, Kim M, Koizumi W, Mikami T. DOG1 is useful for diagnosis of KIT-negative gastrointestinal stromal tumor of stomach. *World J Gastroenterol* 2013; **19**: 9133-9136 [PMID: 24379641 DOI: 10.3748/wjg.v19.i47.9133]

36 **Su YY**, Chiang NJ, Wu CC, Chen LT. Primary gastrointestinal stromal tumor of the liver in an anorectal melanoma survivor: A case report. *Oncol Lett* 2015; **10**: 2366-2370 [PMID: 26622853 DOI: 10.3892/ol.2015.3561]

37 **Mao L**, Chen J, Liu Z, Liu CJ, Tang M, Qiu YD. Extracorporeal hepatic resection and autotransplantation for primary gastrointestinal stromal tumor of the liver. *Transplant Proc* 2015; **47**: 174-178 [PMID: 25645799 DOI: 10.1016/j.transproceed.2014.09.111]

38 **Jones RL**, Judson IR. The development and application of imatinib. *Expert Opin Drug Saf* 2005; **4**:183-191 [PMID: 15794712 DOI: 10.1517/14740338.4.2.183]

39 **Zakaria GY**, Allahloubi N, Bahnasy A, Khorshid O. Clinical correlation between different CKIT exon mutations and clinical outcome imatinibmesylate treatment in gastrointestinal stromal tumor (GIST) patients. *Ann Oncol* 2019; **30** Suppl 1: i13 [DOI: 10.1093/annonc/mdz026.003]

40 **Serrano C**, Leal A, Kuang Y, Morgan JA, Barysauskas CM, Phallen J, Triplett O, Mariño-Enríquez A, Wagner AJ, Demetri GD, Velculescu VE, Paweletz CP, Fletcher JA, George S. Phase I Study of Rapid Alternation of Sunitinib and Regorafenib for the Treatment of Tyrosine Kinase Inhibitor Refractory Gastrointestinal Stromal Tumors. *Clin Cancer Res* 2019; **25**: 7287-7293 [PMID: 31471313 DOI: 10.1158/1078-0432.CCR-19-2150]

41 **Kim JJ**, Ryu MH, Yoo C, Beck MY, Ma JE, Kang YK. Phase II Trial of Continuous Regorafenib Dosing in Patients with Gastrointestinal Stromal Tumors After Failure of Imatinib and Sunitinib. *Oncologist* 2019; **24**: e1212-e1218 [PMID: 31036770 DOI: 10.1634/theoncologist.2019-0033]

42 **De Chiara A**, De Rosa V, Lastoria S, Franco R, Botti G, Iaffaioli VR, Apice G. Primary gastrointestinal stromal tumor of the liver with lung metastases successfully treated with STI-571 (imatinib mesylate). *Front Biosci* 2006; **11**:498-501 [PMID: 16146747 DOI: 10.2741/1813]

43 **Liao HJ**, Lie JH, Wu XJ. Primary hepatic stromal tumor with metastasis to cervical lymph nodes: a case report and literature review. *Zhongguo Putong Waike Zazhi* 2017, **26**:116-120 [DOI: 10.3978/j.issn.1005-6947.2017.01.019]

44 **Luo XL**, Liu D, Yang JJ, Zheng MW, Zhang J, Zhou XD. Primary gastrointestinal stromal tumor of the liver: a case report. *World J Gastroenterol* 2009; **15**: 3704-3707 [PMID: 19653356 DOI: 10.3748/wjg.15.3704]

45 **Liu L**, Zhu Y, Wang D, Yang C, Zhang QI, Li X, Bai Y. Coexisting and possible primary extra-gastrointestinal stromal tumors of the pancreas and liver: A single case report. *Oncol Lett* 2016; **11**:3303-3307 [PMID: 27123107 DOI: 10.3892/ol.2016.4420]

46 **Caram MV**, Schuetze SM. Advanced or metastatic gastrointestinal stromal tumors: systemic treatment options. *J Surg Oncol* 2011; **104**:888-895 [PMID: 22069173 DOI: 10.1002/jso.21930]

47 **Antonescu CR**, Besmer P, Guo T, Arkun K, Hom G, Koryotowski B, Leversha MA, Jeffrey PD, Desantis D, Singer S, Brennan MF, Maki RG, DeMatteo RP. Acquired resistance to imatinib in gastrointestinal stromal tumor occurs through secondary gene mutation. *Clin Cancer Res* 2005; **11**:4182-4190 [PMID: 15930355 DOI: 10.1158/1078-0432.CCR-04-2245]

48 **Liegl B**, Kepten I, Le C, Zhu M, Demetri GD, Heinrich MC, Fletcher CD, Corless CL, Fletcher JA. Heterogeneity of kinase inhibitor resistance mechanisms in GIST. *J Pathol* 2008; **216**: 64-74 [PMID: 18623623 DOI: 10.1002/path.2382]

49 **Machairas N**, Prodromidou A, Molmenti E, Kostakis ID, Sotiropoulos GC. Management of liver metastases from gastrointestinal stromal tumors: where do we stand? *J Gastrointest Oncol* 2017; **8**: 1100-1108 [PMID: 29299371 DOI: 10.21037/jgo.2017.08.08]

50 **Frilling A**, Malago M, Testa G, Schleyer E, Grabellus F, Kronenberger R, Li J, Broelsch CE. Liver transplantation for metastasized extragastrointestinal stromal tumor: a case report and an overview of literature. *Transplant Proc* 2010; **42**: 3843-3848 [PMID: 21094867 DOI: 10.1016/j.transproceed.2010.06.016]

51 **Xiao DW**, Zhao HT. CT misdiagnosis of hepatic gastrointestinal stromal tumor: a case report. *Zhongguo Wuzhenxue Zazhi* 2006; **6**:2140-2141 [DOI: 10.3969/j.issn.1009-6647.2006.11.094]

52 **Ren SY**, Huang ZQ, Dong BW. Primary gastrointestinal stromal tumor of the liver: a case report. *Zhonghua Yixue Zazhi* 2006; **86**:3311 [DOI: 10.3760/j:issn:0376-2491.2006.46.019]

53 **Hu X**. Primary hepatic gastrointestinal stromal tumor: a case report. *Zhonghua Xiaohua Waike Zazhi* 2008; **7**: 77 [DOI: 10.3760/cma.j.issn.1673-9752.2008.01.026]

54 **Ochiai T**, Sonoyama T, Kikuchi S, Ikoma H, Kubota T, Nakanishi M, Ichikawa D, Kikuchi S, Fujiwara H, Okamoto K, Sakakura C, Kokuba Y, Taniguchi H, Otsuji E. Primary large gastrointestinal stromal tumor of the liver: report of a case. *Surg Today* 2009; **39**: 633-636 [PMID: 19562456 DOI: 10.1007/s00595-008-3885-5]

55 **Yang YL**, Xing CP, Liu B, Su QJ, Dong L. Primary stromal tumor of the liver: A case report and review of the literature. *Modern Oncology* 2010; **18**: 2432-2434 [DOI: 10.3969/j.issn.1672-4992.2010.12.50]

56 **Li ZY**, Liang QL, Chen GQ, Zhou Y, Liu QL. Extra-gastrointestinal stromal tumor of the liver diagnosed by ultrasound-guided fine needle aspiration cytology: a case report and review of the literature. *Arch Med Sci* 2012; **8**: 392-397 [PMID: 22662017 DOI: 10.5114/aoms.2012.28572]

57 **Wu PP**. Huge hepatic stromal tumor: one case report. *Xinan Guofang Yiyao* 2012; **22**: 197

58 **Xue YJ**, He XJ. Primary Gastrointestinal Stromal Tumor of the Liver: One Case Report. *Zhongliuxue Zazhi* 2013; **19**:159-160

59 **Lu Y**, Guo S. One case: primary malignant stromal tumor of the liver. *Shiyong Fangshexue Zazhi* 2013; **29**:1368-1369

60 **Louis AR**, Singh S, Gupta SK, Sharma A. Primary GIST of the liver masquerading as primary intra-abdominal tumour: a rare extra-gastrointestinal stromal tumour (EGIST) of the liver. *J Gastrointest Cancer* 2014; **45**: 392-394 [PMID: 23749608 DOI: 10.1007/s12029-013-9514-6]

61 **Lin XK**, Zhang Q, Yang WL, Shou CH, Liu XS, Sun JY, Yu JR. Primary gastrointestinal stromal tumor of the liver treated with sequential therapy. *World J Gastroenterol* 2015; **21**:2573-2576 [PMID: 25741171 DOI: 10.3748/wjg.v21.i8.2573]

62 **Tan Y**, Deng D. Hepatic huge stromal tumor: a case report. *Xian Dai Yang Sheng* 2015; **4**:138

63 **Losada H**, Villaseca M, Vivallo C, López M. Gastrointestinal stromal tumor as cause of hepatic mass. *Hepatobiliary Surg Nutr* 2016; **5**: 388-389 [PMID: 27500151 DOI: 10.21037/hbsn.2016.05.04]

64 **Wang Y**, Liu Y, Zhong Y, Ji B. Malignant extra-gastrointestinal stromal tumor of the liver: A case report. *Oncol Lett* 2016; **11**: 3929-3932 [PMID: 27313719 DOI: 10.3892/ol.2016.4531]

65 **Cheng X**, Chen D, Chen W, Sheng Q. Primary gastrointestinal stromal tumor of the liver: A case report and review of the literature. *Oncol Lett* 2016; **12**: 2772-2776 [PMID: 27698856 DOI: 10.3892/ol.2016.4981]

66 **Zhong J**, Sun YM, Li L. Ultrasound presentation of primary gastrointestinal stromal tumor of the liver: a case report. *Zhongguo Chaosheng Yixue Zazhi* 2017; **33**: 270-271

67 **Wang YK**, Li Q, Liu H, et la. Primary gastrointestinal stromal tumor of the liver: a case report. *Zhongguo Zhongliu Linchuang* 2018; **45**: 539-540 [DOI: 10.3969/j.issn.1000-8179.2018.10.365]

**Footnotes**

**Conflict-of-interest statement:** The authors have no conflicts of interest to declare.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/Licenses/by-nc/4.0/

**Manuscript source:** Unsolicited manuscript

**Peer-review started:** May 13, 2020

**First decision:** May 21, 2020

**Article in press:**

**Specialty type:** Gastroenterology and hepatology

**Country/Territory of origin:** China

**Peer-review report’s scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): B, B

Grade C (Good): 0

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Xu X **S-Editor:** Huang P **L-Editor:** Filipodia **P-Editor:**

**Table 1 Case reports of primary hepatic gastrointestinal stromal tumors**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ref.** | **Year** | **Nation** | **Age/sex** | **Symptom** | **Location/*n*** | **Size in cm** | **Tumor presentation** | **Rupture** | **Treatment** | **Cell morphology** | **Mitotic, / 50 HPFs** | **IH (+)** | ***Ki67,* %** | **Test for gene mutation** | **Risk** | **Recurrence** | **OS** |
| [25] | 2003 | United States | 79/F | Short of breath | R/1 | 15 | Solid + cyst | No | HR | S | 20 | CD117, CD34 | 15 | No | High | 16/Met | 20/A |
| [42] | 2006 | Italy | 37/M | No symptom | R/1 | 18 | Solid + cyst | No | HR | S | 20 | CD117 | NA | No | High | 14/Met | 39/A |
| [51] | 2006 | China | 62/M | AP | R + L/2 | 14.5 | Solid + cyst | No | HR | S | NA | CD117, CD34 | NA | No | High | NA | NA |
| [52] | 2006 | China | 45/M | AP | R/> 3 | 20 | Cyst | No | Drainage | S | 35 | CD117, CD34 | 50 | No | High | 3/DFS | NA |
| [26] | 2007 | China | 67/M | Short of breath, distention | L/1 | 44 | Solid + cyst | No | HR | NA | > 3 | CD117, CD34 | NA | No | High | 4/DFS | 4/A |
| [53] | 2008 | China | 48/F | No symptom | L/1 | 4.3 | Solid + cyst | No | Chemo | NA | NA | CD117 | NA | No | NA | NA | NA |
| [44] | 2009 | China | 17/M | No symptom | R/1 | 5.1 | Solid | No | RFA | S | 0 | CD117, CD34 | NA | No | High | 3/DFS | 3/A |
| [54] | 2009 | Japan | 30/M | Abdominal fullness | R + L/1 | 20 | Solid + cyst | No | HR | S + E | 75 | CD117, CD34 | NA | Yes, negative | High | 24/Rec + Met | 108/A |
| [33] | 2010 | Japan | 70/M | Appetite reduced | L/1 | 20 | Solid | No | HR | E | 1 | CD34 | NA | Yes, *PDGFRA 12* | High | NA | NA |
| [55] | 2010 | China | 40/F | No symptom | L/1 | 18 | Cyst | No | HR | S | > 5 | CD117 | > 5 | No | High | 12/DFS | 12/A |
| [56] | 2012 | China | 53/M | Abdominal discomfort | R/1 | 20 | Solid + cyst | No | No treatment | NA | NA | CD117, CD34, DOG-1 | NA | No | High | NA | NA |
| [57] | 2012 | China | 65/F | No symptom | R/1 | NA | Solid + cyst | No | Chemo | S | NA | CD117, CD34 | NA | No | High | NA | NA |
| [58] | 2013 | China | 66/F | Distention | L/1 | 8.6 | Solid + cyst | No | HR | S | 35 | CD117 | NA | No | High | 12/Rec + Met | 13/D |
| [59] | 2013 | China | 71/M | No symptom | R / 1 | 10 | Solid | No | HR | S | NA | CD117, CD34, DOG-1 | NA | No | High | NA | NA |
| [60] | 2014 | India | 55/F | AP, Appetite reduced | R + L/3 | 18 | Solid | No | HR | S | 10 | CD117 | NA | No | High | 7/DFS | 7/A |
| [28] | 2014 | Korea | 71/M | Nausea, indigestion | L/1 | 7 | Solid + cyst | No | HR | S | 30-32 | CD117, DOG-1 | NA | No | High | 19/DFS | 19/A |
| [31] | 2014 | China | 56/M | No symptom | R + L/1 | 10 | Cyst | No | HR | S | < 5 | CD117 | NA | No | High | 12/DFS | 12/A |
| [24] | 2014 | India | 41/F | AP, weight loss | R/2 | 15 | Solid + cyst | No | HR | S | NA | CD117 | NA | No | High | 5/DFS | 5/A |
| [37] | 2015 | China | 60/F | No symptom | R + C/1 | 19 | Solid + cyst | No | HR + AT | S | 10 | CD117, DOG-1 | NA | Yes, *KIT* exon 11 | High | 12/DFS | 12/A |
| [61] | 2015 | China | 65/M | AP, appetite reduced | L/1 | 12 | Solid + cyst | No | Chemo | S | 25 | CD117 | NA | Yes, negative | High | 13/Met | 13/D |
| [36] | 2015 | China | 67/F | No symptom | R/1 | 7.4 | Solid + cyst | No | HR | S + E | 8 | CD117, CD34 | NA | Yes, *KIT* exon 11 | High | 14/Rec | 50/A |
| [62] | 2015 | China | 48/F | AP | L/1 | 17.6 | Solid + cyst | No | HR | NA | NA | CD117, CD34, DOG-1 | NA | No | High | NA | NA |
| [45] | 2016 | China | 56/F | No symptom | L/1 | 2.4 | Solid | No | MWA | S | 1-2 | CD117 | 60 | No | High | 17/Met | 17/A |
| [63] | 2016 | Chile | 61/M | AP | L/1 | 15 | Solid + cyst | No | HR | NA | NA | CD117, CD34 | NA | No | High | NA | NA |
| [64] | 2016 | China | 61/M | No symptom | C/1 | 7.3 | Solid + cyst | No | HR | S | NA | CD117, CD34, DOG-1 | 2 | No | High | 11/DFS | 11/A |
| [32] | 2016 | Japan | 70/F | No symptom | L/1 | 6.8 | Solid + cyst | No | HR | S | 35-40 | CD117, CD34 | NA | No | High | 10/DFS | 10/A |
| [65] | 2016 | China | 63/M | No symptom | R/1 | 13 | Solid + cyst | No | HR | S | > 5 | CD117, CD34 | NA | No | High | 60/DFS | 60/A |
| [11] | 2019 | China | 64/F | AP | R/1 | 15 | Solid + cyst | No | HR | S | > 5 | CD117 | NA | Yes, *PDGFRA 12* | High | 5/DFS | 5/A | |
| [27] | 2017 | China | 50/F | Onset AP | R/1 | 15 | Solid + cyst | Yes | HR | S | 70 | CD117, CD34 | NA | No | High | 6/Met | 6/A | |
| [66] | 2017 | China | 57/F | No symptom | L/1 | 4 | Solid + cyst | No | HR | S | NA | CD117, DOG-1 | 10 | No | NA | 6/DFS | 6/A | |
| [43] | 2017 | China | 45/F | No symptom | R + L/> 3 | 11.5 | Solid | No | TACE + HR | S | 5 | CD117, CD34, DOG-1 | 3 | Yes, negative | High | 1/Met | 18/A | |
| [30] | 2017 | Spanish | 41/M | Abdominal discomfort | R + L/1 | 20 | Solid | No | HR | S | 5 | CD117, DOG-1 | 10 | Yes, *KIT* exon 11 | High | 18/DFS | 18/A | |
| [23] | 2018 | France | 56/M | AP | R/1 | 10 | Solid | No | TACE + HR + T + Chemo | S | 8 | CD117, CD34 | NA | No | High | 12/Rec | 264/D | |
|  | France | 59/F | AP, weight loss | R + L/1 | 23 | Solid + cyst | No | Chemo | S + E | 42 | CD117, DOG-1 | 30 | Yes, *KIT* exon 9 | High | 18/DFS | 18/A | |
| [67] | 2018 | China | 74/M | Abdominal discomfort | R/1 | 5.5 | Solid + cyst | No | HR | S | < 5 | CD117, DOG-1 | 15 | No | High | NA | NA | |

AP: Abdominal pain; AT: Autotransplantation; C: Caudate lobe of liver; Chemo: Chemotherapy; DFS: Disease-free survival; E: Epithelioid; F: Female; HPF: High-power field; HR: Hepatic resection; IH: Immunohistochemistry; L: Left lobe of liver; M: Male (sex), and median lobe of liver (location); Met: Metastasis; MWA: Microwave ablation; NA: Not available; OS: Overall survival; R: Right lobe of liver; Rec: Recurrence; RFA: Radiofrequency ablation; S: Spindle; TACE: Transcatheter arterial chemoembolization; T: Transplantation.