*Review*

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# Comments and illustrations of the WFUMB CEUS liver guidelines: Rare benign focal liver lesion, part II

**Yi Dong[1], Elisa Guggisberg[2], Wen-Ping Wang[3], Ehsan Safai Zadeh[4], Christian Görg[5], Kathleen Möller[6], Annalisa Berzigotti[7], Nitin Chaubal[8], Xin Wu Cui[9], Chiara De Molo[10], Klaus Dirks[11], Nathally Espinosa Montagut[12], Odd Helge Gilja[13], Alois Hollerweger[14], Christian Jenssen[15], Ernst-Michael Jung[16], Christoph Klinger[17], Adrian Lim[18], Vito Sansone[19], Andreas Schuler[20], Carla Serra[10], Zeno Sparchez[21], David Srivastava[2,22], Christoph Frank Dietrich[2]**

[1]Department of Ultrasound, Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China, [2]Department Allgemeine Innere Medizin, Kliniken Hirslanden, Beau Site, Salem und Permanence, Bern, Switzerland, [3]Department of Ultrasound, Zhongshan Hospital, Fudan University, Shanghai, China, [4]Department of Biomedical Imaging and Image-Guided Therapy, Medical University of Vienna, Vienna, Austria, [5]Interdisciplinary Center of Ultrasound Diagnostics, University Hospital Giessen and Marburg, Philipps University Marburg, Marburg, Germany, [6]Medical Department I/Gastroenterology; SANA Hospital Lichtenberg, Berlin, Germany, [7]Department of Visceral Surgery and Medicine, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland, [8]Thane Ultrasound Centre: Jaslok Hospital and Research Centre, Mumbai, India, [9]Department of Medical Ultrasound, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China, [10]Interventional, Diagnostic and Therapeutic Ultrasound Unit, Department of Medical and Surgical Sciences, IRCCS, Azienda Ospedaliero-Universitaria Sant'Orsola Malpighi Hospital, Bologna, Italy, [11]Rems-Murr-Klinikum, Winnenden, Germany, [12]School of Medicine, Universidad de los Andes, Bogotá, Colombia, [13]National Centre for Ultrasound in Gastroenterology, Haukeland University Hospital, Bergen, and Department of Clinical Medicine, University of Bergen, Norway, [14]Department of Radiology and Nuclear Medicine, Barmherzige Brüder Hospital Salzburg, Austria, [15]Medical Department, Krankenhaus Maerkisch-Oderland Strausberg, Germany, and Brandenburg Institute of Clinical Ultrasound at Medical University Brandenburg, Neuruppin, Germany, [16]Department of Radiology, University Medical Center Regensburg, Germany, [17]Vaisana Ärztehaus GmbH, Vaihingen/Enz, Germany, [18]Imperial College London and Healthcare NHS Trust, London, UK, [19]Unit of Internal Medicine, Department of Medical and Surgical Sciences, University of Bologna S. Orsola-Malpighi Hospital, Bologna, Italy, [20]Zentrum für Innere Medizin, Alb Fils Kliniken, Helfenstein Klinik, Goeppingen, Germany, [21]Department of Internal Medicine-Gastroenterology, University of Medicine and Pharmacy, Cluj-Napoca, Romania, [22]Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

**Abstract**

It is important to be familiar with the typical imaging features of the uncommon or even extremely rare focal liver lesions (FLL). Current guidelines of the World Federation for Ultrasound in Medicine and Biology (WFUMB) is aimed at assessing the usefulness of contrast enhanced ultrasound (CEUS) in the management of various FLL. In this review, we aim to summarize the ultrasound and CEUS characteristics with literature review of some extremely rare benign FLL, which might be helpful for improving diagnostic efficiency clinically.

**Keywords:** Contrast enhanced ultrasound (CEUS); hepatic adenomatosis; leiomyoma; perivascular epithelioid cell neoplasms (PEComas); solitary fibrous tumor

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Corresponding author: Christoph F Dietrich
Department Allgemeine Innere Medizin (DAIM),
Kliniken Hirslanden Beau Site,
Salem und Permancence, Bern, Switzerland
Phone: +41764408150
E-mail: ChristophFrank.Dietrich@hirslanden.ch
ORCID: http://orcid.org/0000-0001-6015-6347

## Introduction

Currently, according to recommendations of contrast-enhanced ultrasound (CEUS) for the evaluation of focal liver lesions (FLL) by the World Federation for Ultrasound in Medicine and Biology (WFUMB) [1-5], CEUS is helpful for improving both detection and characterization of various focal liver lesions (FLL) [6-12].

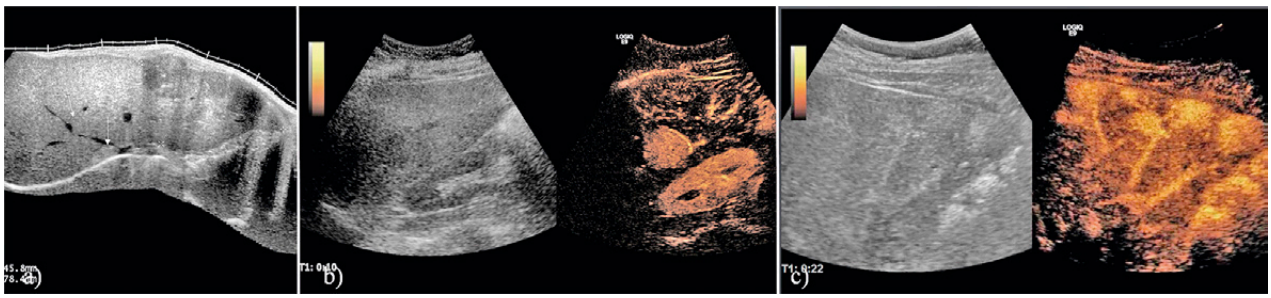

**Fig 1.** Hepatic adenomatosis. Multiple hepatocellular adenomas in von Gierke´s disease (histological proven) in a 30-year-old female, previously on contraceptives. She had no symptoms, but hepatic steatosis. B-mode image of the liver and kidney using panoramic imaging (a), with hardly any liver tumor visible. CEUS in the early arterial phase shows early enhancement of two liver adenomas as well as the right kidney, long before enhancement of the rest of the liver parenchyma. Note also the feeding artery and the subcapsular artery at the right edge of the tumor, classically observed with high-resolution ultrasound in adenomas of the liver (b). CEUS of another young female patient with hepatic adenomatosis. The arterial phase image shows three feeding arteries and five hyperenhancing tumors in a small section of the liver. This patient also had numerous hyperenhancing lesions in other parts of the liver (c).

Current WFUMB recommendations based on the international literature and the findings of the WFUMB experts are established as answers to common questions. Among all FLL, beside hepatocellular carcinoma (HCC), liver metastasis, and cholangiocarcinoma (ICC), the imaging findings of other relatively rare FLLs are less discussed in the literature. Imaging diagnosis of these rare or extremely rare FLL with atypical imaging characteristics is a real clinical diagnostic challenge [6-20].

Published papers with gold-standard histology cover cholangiocellular adenoma [21], peliosis [22-24], cystadenoma and cystadenocarcinoma [25], hemangioendothelioma [26,27], and hepatocellular carcinoma (HCC) in the non-cirrhotic liver and how to deal with incidental findings in general [8,14,28,29] and we also refer on how to deal with incidental findings in general [30]. There are also several papers and reports on the uncommon and more esoteric hepatic lesions. These include characterization of fibrolamellar hepatocellular carcinoma [16,31], very small HCC (<10 mm) [32], mixed HCC and cholangiocellular carcinoma [33], nodular regenerative hyperplasia [34], sarcoma [35], inflammatory pseudotumour [36], sarcoidosis [37-40], tuberculosis [41,42], hydatid cysts [43-46], alveolar echinococcosis [44], schistosomiasis [47,48], ascariasis [49,50], fasciolosis [51], clonorchis and opisthorchis [52], toxocariasis [53], bacillary angiomatosis [54], amyloidosis with spontaneous hemorrhage [55], and portal venous gas accumulation [20] as well as rare FLLs in pediatric patients [56,57].

In a series of papers, particular attention is paid to the US and CEUS features of rare FLL where there are limited reports and images published, in order to create a library of these rare lesions.

**Hepatic adenomatosis**

Hepatic adenomatosis (HA) is a rare disease defined by the presence of multiple adenomas in the liver. It was first described by Flejou in 1985, and the number of adenomatous lesions needed for diagnosis was arbitrarily set to 10 [58]. In a later paper, the presence of 4 or more lesions was considered sufficient [59]. HA most often occurs in young women aged 20–40 years, and increased prevalence is observed in women with a history of prolonged oral contraceptive (OC) intake. The estimated incidence of HA is 3 per million per year and increases to 30–40 per million among long-term OC users [60]. Patients usually display no symptoms and have normal liver blood analyses, although elevated liver enzymes are sometimes detected, indicating cholestasis [58,61,62]. However, HA is associated with a risk of rupture, hemorrhage, and malignant transformation into HCC [60].

***Imaging of hepatic adenomatosis***

HA is not associated with any specific subtypes, and its imaging features are similar to those of solitary adenoma [60]. Adenomas are typically well-defined and may have a partial or complete capsule. The differential diagnosis should include multifocal HCC, metastatic disease, and multiple focal nodular hyperplasia (FNH) [60]. HA should also be considered when confronted with multiple hypervascular liver lesions. Standard imaging is most often conducted with computed tomography (CT) and magnetic resonance imaging (MRI) to obtain an optimal overview of all the lesions. However, US and CEUS can also be performed, particularly to study the details of tumor perfusion with respect to the initial direction of enhancement (i.e., centrifugal or centripetal) in the arterial phase.

The clinical symptoms and potential risk of malignant transformation and bleeding in patients with multiple

HA do not much differ from those in patients with a single HA, being driven by the underlying etiology and by the size of the largest nodule, rather than the number of nodules [63]. A higher bleeding risk of patients with HA compared to single and multiple HAs was described in one large United States cohort (2,8 fold increase of risk) [64] (fig 1).

**Lipoma**

Hepatic lipoma (HL) is a very rare benign neoplasm of mesenchymal origin, consists of mature adipose tissue and has a strong association with fatty involution of the liver parenchyma [65,66]. The first HL case was described in 1970 as an incidental finding during autopsy. In an almost complete review of scientific literatures, fewer than 30 HL have been reported up to 2007. The pathogenesis of HL is unclear, while a statistically significant association between non-alcoholic liver steatosis and lipomas has been reported [67]. Increased levels of insulin in portal blood due to insulin resistance is a potential key factor that results in a greater supply of fatty acids in the liver [68]. HL proved to have no potential of malignant transformation. As most patients are asymptomatic, lipomas appear as incidental findings, and large lipomas can even be discovered during physical examination. Others may present with acute or chronic epigastric pain [69].

***Imaging***

On US, HL lesions usually appear as well-defined, large, round, and homogeneously hyperechoic masses with posterior acoustic shadowing [70]. They can also have mixed echogenicity due to heterogeneity. Perilesional vascularization can be detected in the color Doppler modality [65,71,72]. On CEUS, HL was reported to be inhomogeneously hyperenhanced in the arterial phase and showed sustained hyperenhancement in the portal venous and late phases [73,74] (fig 2 and 3).

An important differential diagnosis on US is hemangioma. On CT scan, hepatic lipoma lesions present as round, non-infiltrating, lobulated homogeneously

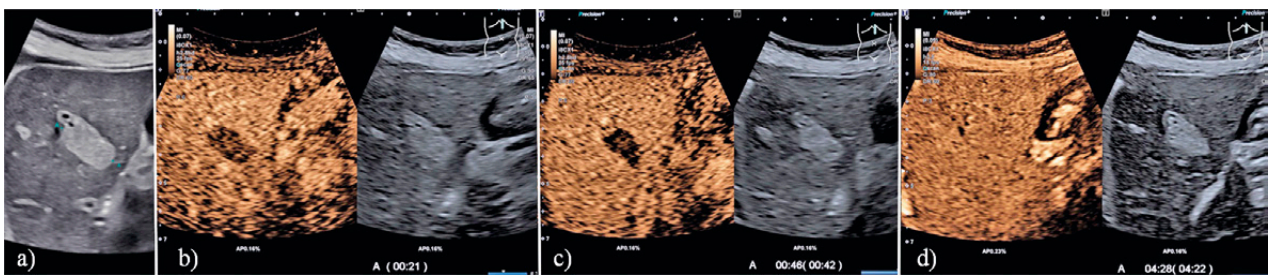


**Fig 2.** Lipoma in the left liver lobe as an incidental finding in a 57-year-old woman: The liver enzymes were normal, B-mode and 2D-elastography did not indicate cirrhosis. The benign character was proven by clinical course and MRI which confirmed a lipoma. Ultrasound-guided biopsy for definite diagnosis was rejected by the patient. B-mode displays a hyperechoic homogenous lesion with a clear border (a). After injection of 1,2 ml Sonovue in the arterial and portal phase, showed hypoenhancement compared to the surrounding liver parenchyma (b, c). In the very late phase (> 4 minutes) the lesion develops nearly isoechoic (d).

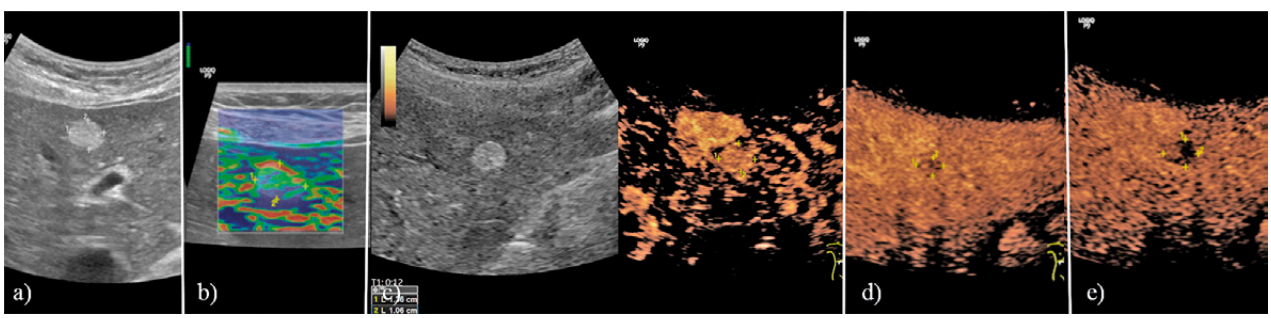


**Fig 3.** Lipoma of the liver (proven benign by an indolent clinical course). 51 y/o asymptomatic female presenting in 05/2021 with an incidentally detected focal liver lesion during follow-up of malignant melanoma in 2013. The focal liver lesion was first detected in 03/2020 by computed tomography. MRI 06/2020 and CT 04/2021 revealed stable size. Both CT- and MRI-findings were suspicious of hepatic lipoma. B-mode ultrasound 05/2021 showed a homogeneous hyperechoic lesion in liver segment IV (a) with a diameter of 12 x 11 x 14 mm. On ultrasound elastography, the lesion appeared to be soft (b). Contrast enhanced ultrasound in 11/2021 revealed homogeneous hyperenhancement during the arterial phase (c) with slight wash-out during the portal venous (d) and late phases (e). Ultrasound-guided biopsy for definite diagnosis was rejected by the patient. During follow-up with ultrasound 05/2022, the focal liver lesion remained stable, and the patient was still asymptomatic. It is important to comment that lipoma typically do not show arterial phase hyperenhancement.

hypoattenuating masses with fat attenuation. No increased attenuation can be observed after administration of the contrast medium in the early and delayed phases [65,71,72]. It may be difficult to differentiate hepatic lipomas from hepatic angiomyolipomas, especially when there is a density increase in post-contrast images over 30 HU. Attenuation values must be less than 20 HU to identify a lipoma.

On MRI scans, there may be multiple hepatic lipomas, where these lesions are hyperintense on both T1- and T2- weighted images with no signal drop-out in out-of-phase sequences and is hypo-intense on T2-weighted fat saturated images [75]. There is no significant contrast enhancement following the administration of the contrast medium [71,72]. MRI is the most predictive imaging method. Owing to the absent risk of malignancy, hepatic lipoma has a good prognosis [72], and most cases do not require resection [72].

**Leiomyoma**

Primary hepatic leiomyoma is a rare benign mesenchymal tumor that is secondary to benign smooth muscle proliferation [76]. Its complex pathogenesis remains largely unknown. Several cases have been reported in which primary liver leiomyoma occurred in immunosuppressed patients [77,78]. The mean age of patients with leiomyoma is 43 years, and the prevalence is slightly more common in females. In this study, the average size of the tumors was 8.7 cm, and 34% of the cases were incidental findings with a mean follow-up time of 33 months without any symptoms reported in most patients. Cases of leiomyomas originating from vascular smooth muscle have been described, including from the hepatic veins [79]. The prognosis of this condition is encouraging, and no adverse events have been observed during the follow-up to the reported cases [76]. Surgical resection is recommended in primary hepatic leiomyoma not only for diagnostic but also for curative purposes [76].

***Imaging***

On US images, primary leiomyoma of the liver appears as hypoechoic solid lesions with varying degrees of heterogeneity [80-83]. Previously, it was reported as a heterogeneous mass the inferior vena cava (IVC) and the right kidney medially across the midline [84]. Primary hepatic leiomyomas present on CT scans as heterogeneously hypodense lesions with strong hyperenhancement in the arterial phase and sustained homogeneous enhancement in the hepatic venous and equilibrium phases [76,85]. Furthermore, peripheral rim enhancement has also been reported [86]. Various studies report that primary hepatic leiomyoma lesions display hypointense or isointense masses T1-weighted sequences and hyperintense masses T2-weighted sequences [80,85]. However, hypointense lesions have also been reported T2-weighted sequences [85,86]. After injection of contrast medium, the lesions exhibit intense enhancement during the arterial phase, persistent and homogeneous enhancement during the hepatic venous and equilibrium phases [85]. However, on liver-specific contrast-enhanced MRI, the absence of contrast retention may lead to the misdiagnosis of primary liver leiomyoma [85,86]. Since the imaging features of the tumor do not allow for a tissue-specific diagnosis, histological results of the tissue specimen and immunohistochemical stains are important for diagnosis. In addition, a metastatic workup to exclude occult leiomyoma elsewhere should be undertaken. Up till now, CEUS findings have not been reported in the literature. The differential diagnosis of primary liver leiomyoma should be considered in the management of liver tumors.

**Perivascular epithelioid cell neoplasms (PEComas)**

Perivascular epithelioid cell tumors (PEComa) are rare mesenchymal liver tumors [87]. Histopathologically, polygonal epithelioid and spindle-shaped mesenchymal cells are present. Immunohistochemically, the tumor shows dual expression of melanocytic (HMB 45 and/or Melan-A) and smooth muscle markers (actin and/or desmin) [87,88]. In 1944 Aitz et al first described the characteristic of perivascular epithelioid cells [87]. The term "PEComa" was first introduced by Bonetti in 1992 and was defined in the World Health Classification of Tumors in 2002 [87, 89]. According to the WHO classification (2013) for soft tissue tumors, PEComa include epithelioid angiomyolipoma, clear cell tumor, clear-cell myomelanocytic tumors of the falciform ligament/ligamentum teres, clear-cell ''sugar'' tumors, lymphangioleiomyoma/lymphangiomyomatosis of the lung, and other PEComa of uncertain differentiation, so-called "PEComa-NOS" (perivascular epithelioid cell tumor not otherwise specified) [87,90]. They are mostly considered benign, but on occasions can develop malignant characteristics with metastases.

According to clinical, radiologic, and morphologic diagnostic features, PEComa of the liver may appear different from angiomyolipoma of the liver [87,90,91]. In contrast to a "classic angiomyolipoma," a PEComa does not have adipocytes or abnormal vessels [87,88]. Furthermore, PEComa of the liver is very rare. Only 25 cases of hepatic PEComa were described worldwide between 1999 and 2014 [87].

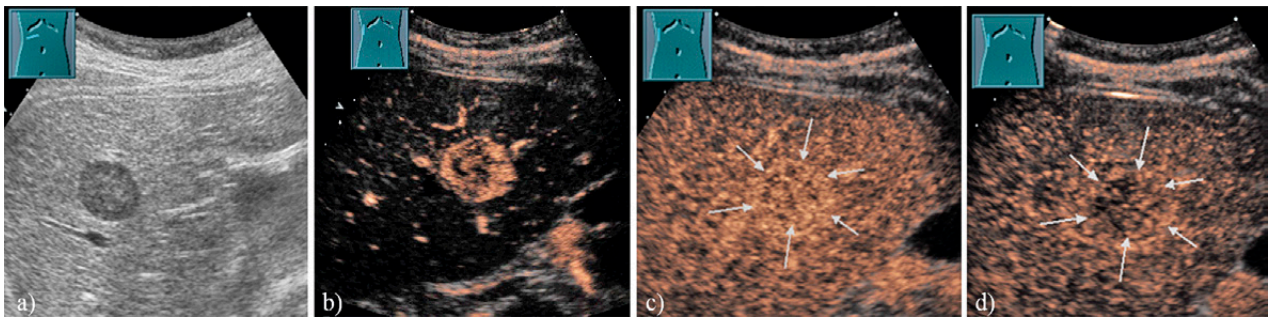


**Fig 4.** PEComa. A 49-year-old female patient with a hypoechoic hepatic mass as an incidental finding (a). On contrast-enhanced ultrasound, the lesion showed homogeneous marked hyperenhancement after 20 s (b). The lesion is still mildly hyperenhanced (arrows) after 4 min (c) and shows mild hypoenhancement (arrows) after 6 min (d). An ultrasound-guided biopsy was performed, and the diagnosis of PEComa was confirmed histologically.

***Imaging***

No standardized specific imaging morphological characteristics exist at this time [87]. On the basis of casuistic data, the mostly hypoechoic tumor shows early arterial adenoma-like hyperenhancement with an inhomogeneous slight parenchymal washout [87]. The diagnosis is always made histologically. Although the tumor is often classified as benign, aggressive courses with the occurrence of metastases have also been described [87,92]. Folpe et al [87,93] established a classification to assess malignancy. Based on this classification, tumors with a size of >5 cm, a vascular infiltration and proliferation index of >1/50 HPF (high power fields), and tumor necrosis have a higher risk of malignancy and should be resected [87,92] (fig 4).

**Solitary fibrous tumor**

Solitary fibrous tumors of the liver (SFTLs) are uncommon neoplasms of mesenchymal origin histologically characterized by spindle cells and collagen. They are most frequently found in the pleura [94] and secondarily in other serous cavities such as the pericardium and the peritoneum [95], as well as non-serous cavities, soft tissues, and solid organs [96,97]. The vast majority of SFTs are benign neoplasms, with a higher frequency of malignity in the pleura [98]. In 1959, solitary fibrous tumors of the liver (SFTLs) were first reported [99] in a case series that encompassed three different tumors; one was a SFTL with hypoglycemia as a manifesting symptom. SFTLs are extremely rare, and fewer than 100 cases have been reported in the literature. Prognosis is uncertain due to their erratic behavior: although the vast majority of the reported cases are benign neoplasms [100], malignant progression was reported, occurring with the loss of CD34 positivity [101]. Primary malignant SFTLs have been described in rare cases [102] and can recur even 10 years after surgery.

England's criteria [103] are used to identify malignant SFTLs based on pathology; these include mass diameter, mitotic rate, metastasis, and nuclear pleomorphism [104]. A certain diagnosis is possible only with a histopathological analysis on the resected lesion; the role of fine-needle biopsy is debated [105]. Therefore, pathology plays a pivotal role in diagnosing SFTLs. The macroscopical appearance is of a solid mass, firmly elastic at the edge with a smooth, thick white-yellow capsule [104]; in the context of the lesion necrosis, hemorrhage as well as areas of cystic necrosis and myxoid degeneration [106] can be observed. Initially, STFLs were described as hemangiopericytomas (HPCs), soft tissue neoplasms with a characteristically branched vascular pattern, a feature later understood to be non-specific and shared among many neoplasms [107]. These lesions do not have a microscopical unequivocal appearance, ranging from more to less fibrous tumors.

Gengler et al proposed a classification system that account for this difference; they further identified a cellular and a fibrous type of solitary fibrous tumor [107]. Cells with a spindle-like appearance and ovoid, banded, or fusiform nuclei are interspersed in a "pattern-less" pattern in a hyaline-radiated area [104, 108]. Other notable features include a myxoid stroma and branching vessels with thick walls, leading to its previous classification as an HPC [104,107]. Known malignancy predictors are nuclear atypia, areas of necrosis, and a high rate of mitotic figures [109]. Immunohistochemistry is a tool of utmost importance in correctly diagnosing an SFTL, and stains are positive for the following proteins: CD34, expressed in endothelial and mesenchymal cells [108]; CD99; BCL-2; and vimentin [110]. They are negative for epithelial membrane antigen (EMA), smooth muscle actin (SMA), CD117, S-100, IgG4, cytokeratin AE1/AE3, and desmin [107,110]. Clinical features are nonspecific: this neoplasm is usually detected incidentally while investigating other conditions. Mass effect-relat-

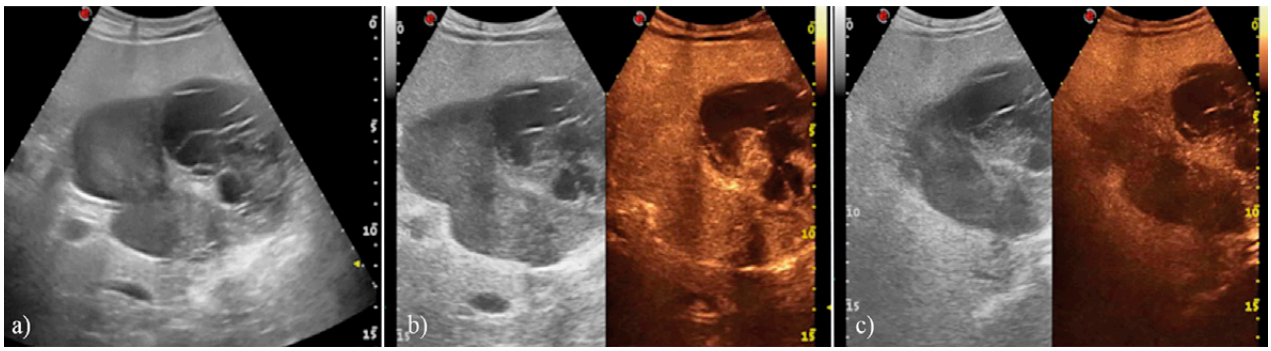


**Fig 5.** Solitary fibrous tumor (histological proven). 69 y/o male with a hepatic lesion in segment 3, discovered while undergoing surveillance for an IPMN. B-mode ultrasound showed a large heterogeneous lesion with a mixed pattern both hypo- and anechoic, compatible with a solid and fluid component (a). Upon injection of contrast (2.4 ml, Sonovue©) the solid portion appeared isoechoic in the arterial phase, with a well visible vascular pattern, with protrusion into the fluid segments. (b) Washout started at 50 seconds and increased in intensity (c – 90 seconds).

ed symptoms such as epigastric fullness are common, although the mass may remain largely asymptomatic [111]. Hypoglycemia may occur due to the ectopic production of insulin-like growth factor 2 (IGF-2) by the tumor. High circulating serum levels was demonstrated in such cases [112].

***Imaging***

Imaging is paramount for diagnosing this neoplasm. Contrast-enhanced CT detects SFTL as a hypodense and hypervascularized mass that has a thick capsule with strong hyperenhancement in both the arterial and portal phases, becoming even more hyperenhanced in the late venous phase [108,111]. The MRI appearance of this neoplasm is iso-hypo-intense in T1-w and T2-w sequences with respect to the normal parenchyma, given the high fiber content of the lesion [110]. Following contrast administration, a heterogeneous enhancement is observed in the arterial, portal, and late phases [95,100,110], while the contrast biliary excretion phase demonstrates hypointensity [113]. In PET/CT scans, mass uptake is heterogeneous [113], the higher the uptake, the more likely the mass displays malignant behavior [110,113]. US reports a solid and well-defined heterogenous mass, while CEUS reveals heterogeneously isoenhanced lesions in the arterial phase that progressively become hypoenhanced during the venous and late phases. The lesion often presents as a solitary large heterogeneous lesion, with marked peripheric enhancement mimicking sclerosing hemangioma, cholangiocarcinoma and fibrolamellar hepatocellular carcinoma [66].

Surgical resection is the main option currently available for malignant tumors [100], and it has proven to be curative in most cases [114]. Other options reported in literature include transarterial chemoembolisation (TACE) [115] and chemotherapy [116], although neither has strong evidence to support its use (fig 5).

## Conclusion

Owing to its unique advantages of a non-invasive technique without ionizing radiation and real time scanning capability, CEUS has become an established complementary imaging modality which can be very helpful for non-invasive assessment of rare liver tumors, particularly when CT/MRI results are inconclusive. “Washout” as a sign of malignancy using CEUS is regarded a marker of cases which need biopsy. Also, if imaging findings are not typical or diagnostic, biopsy is required.

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## References

1. Dietrich CF, Averkiou M, Nielsen MB, et al. How to perform Contrast-Enhanced Ultrasound (CEUS). Ultrasound Int Open 2018;4:E2-E15.
2. Claudon M, Dietrich CF, Choi BI, et al. Guidelines and good clinical practice recommendations for contrast enhanced ultrasound (CEUS) in the liver--update 2012: a WFUMB-EFSUMB initiative in cooperation with representatives of AFSUMB, AIUM, ASUM, FLAUS and ICUS. Ultraschall Med 2013;34:11-29.
3. Claudon M, Dietrich CF, Choi BI, et al. Guidelines and good clinical practice recommendations for Contrast Enhanced Ultrasound (CEUS) in the liver - update 2012: A WFUMB-EFSUMB initiative in cooperation with representatives of AFSUMB, AIUM, ASUM, FLAUS and ICUS. Ultrasound Med Biol 2013;39:187-210.
4. Dietrich CF, Nolsoe CP, Barr RG, et al. Guidelines and Good Clinical Practice Recommendations for Contrast-Enhanced Ultrasound (CEUS) in the Liver-Update 2020 WFUMB in Cooperation with EFSUMB, AFSUMB, AIUM, and FLAUS. Ultrasound Med Biol 2020;46:2579-2604.

5. Dietrich CF, Nolsoe CP, Barr RG, et al. Guidelines and Good Clinical Practice Recommendations for Contrast Enhanced Ultrasound (CEUS) in the Liver - Update 2020 - WFUMB in Cooperation with EFSUMB, AFSUMB, AIUM, and FLAUS. Ultraschall Med 2020;41:562-585.
6. Möller K, Tscheu T, De Molo C, et al. Comments and illustrations of the WFUMB CEUS liver guidelines: rare congenital vascular pathology. Med Ultrason 2022;24:461-472.
7. Möller K, Braden B, Culver EL, et al. Secondary sclerosing cholangitis and IgG4-sclerosing cholangitis - A review of cholangiographic and ultrasound imaging. Endosc Ultrasound 2022, doi: 10.4103/EUS-D-22-00208.
8. Möller K, Safai Zadeh E, Gorg C, et al. Prevalence of benign focal liver lesions and non-hepatocellular carcinoma malignant lesions in liver cirrhosis. Z Gastroenterol 2022, doi: 10.1055/a-1890-5818.
9. Ignee A, Möller K, Thees-Laurenz R, et al. Comments and illustrations of the WFUMB CEUS liver guidelines: Rare focal liver lesions - infectious, bacterial. Med Ultrason 2023, doi: 10.11152/mu-4065.
10. Möller K, Stock B, Ignee A, et al. Comments and illustrations of the WFUMB CEUS liver guidelines. Rare focal liver lesion – non infectious, non-neoplastic. Med Ultrason 2023, doi: 10.11152/mu-4192.
11. Zander T, Safai Zadeh E, Möller K, et al. Comments and illustrations of the WFUMB CEUS liver guidelines: Infectious FLL parasitic and fungi. Med Ultrason 2023, doi: 10.11152/mu-4091.
12. Möller K, Safai Zadeh E, Goerg C, et al. Focal liver lesions other than hepatocellular carcinoma in cirrhosis: Diagnostic challenges. J Transl Int Med 2022;10:308-327.
13. Dong Y, Koch J, Alhyari A, et al. Ultrasound Elastography for Characterization of Focal Liver Lesions. Z Gastroenterol 2023;61:399-410.
14. Alhyari A, Gorg C, Alakhras R, Dietrich CF, Trenker C, Safai Zadeh E. HCC or Something Else? Frequency of Various Benign and Malignant Etiologies in Cirrhotic Patients with Newly Detected Focal Liver Lesions in Relation to Different Clinical and Sonographic Parameters. Diagnostics (Basel) 2022;12.
15. Dong Y, Qiu Y, Zhang Q, et al. Preliminary Clinical Experience with Shear Wave Dispersion Imaging for Liver Viscosity in Preoperative Diagnosis of Focal Liver Lesions. Z Gastroenterol 2020;58:847-854.
16. Dong Y, Wang WP, Mao F, et al. Imaging Features of Fibrolamellar Hepatocellular Carcinoma with Contrast-Enhanced Ultrasound. Ultraschall Med 2020;42:306-313.
17. Safai Zadeh E, Baumgarten MA, Dietrich CF, et al. Frequency of synchronous malignant liver lesions initially detected by ultrasound in patients with newly diagnosed underlying non-hematologic malignant disease: a retrospective study in 434 patients. Z Gastroenterol 2022;60:586-592.
18. Chaubal N, Thomsen T, Kabaalioglu A, Srivastava D, Rosch SS, Dietrich CF. Ultrasound and contrast-enhanced ultrasound (CEUS) in infective liver lesions. Z Gastroenterol 2021;59:1309-1321.
19. Dong Y, Wang WP, Ignee A, et al. The Diagnostic Value of Doppler Resistive Index in the differential diagnosis of focal liver lesions. J Ultrason 2023, doi: 10.15557/JoU.2023.0010
20. Trenker C, Gorg C, Dong Y, et al. Portal venous gas detection in different clinical situations. Med Ultrason 2023, doi: 10.11152/mu-4010.
21. Ignee A, Piscaglia F, Ott M, Salvatore V, Dietrich CF. A benign tumour of the liver mimicking malignant liver disease--cholangiocellular adenoma. Scand.J.Gastroenterol. 2009;44:633-636.
22. Gronlykke L, Tarp B, Dutoit SH, Wilkens R. Peliosis hepatis: a complicating finding in a case of biliary colic. BMJ Case Rep 2013;2013.
23. Loizides A, Glodny B, Zoller H, et al. Contrast enhanced ultrasound of a rare case of Peliosis hepatis. Med Ultrason 2017;19:114-116.
24. Dong Y, Wang WP, Lim A, et al. Ultrasound findings in peliosis hepatis. Ultrasonography 2021;40:546-554.
25. Dong Y, Wang WP, Mao F, et al. Contrast enhanced ultrasound features of hepatic cystadenoma and hepatic cystadenocarcinoma. Scand J Gastroenterol 2017;52:365-372.
26. Klinger C, Stuckmann G, Dietrich CF, et al. Contrast-enhanced imaging in hepatic epithelioid hemangioendothelioma: retrospective study of 10 patients. Z Gastroenterol 2019;57:753-766.
27. Dong Y, Wang WP, Cantisani V, et al. Contrast-enhanced ultrasound of histologically proven hepatic epithelioid hemangioendothelioma. World J Gastroenterol 2016;22:4741-4749.
28. Dong Y, Wang WP, Lee WJ, et al. Hepatocellular carcinoma in the non-cirrhotic liver. Clin Hemorheol Microcirc 2022;80:423-436.
29. Dong Y, Wang WP, Lee WJ, et al. Contrast-Enhanced Ultrasound Features of Histopathologically Proven Hepatocellular Carcinoma in the Non-cirrhotic Liver: A Multicenter Study. Ultrasound Med Biol 2022;48:1797-1805.
30. MDietrich CF, Fraser AG, Dong Y, Guth S, Hari R, Hoffmann B, Prosch H, et al. Managing Incidental Findings Reported by Medical, Sonography and Other Students Performing Educational Ultrasound Examinations. Ultrasound Med Biol 2022;48:180-187.
31. Fu T, Ding H, Xu C, Zhu Y, Xue L, Lin F. Imaging findings of fibrolamellar hepatocellular carcinomas on ultrasonography: A comparison with conventional hepatocellular carcinomas. Clin Hemorheol Microcirc 2021;77:49-60.
32. Dong Y, Teufel A, Wang WP, Dietrich CF. Current Opinion about Hepatocellular Carcinoma <10 mm. Digestion 2020:1-7.
33. Dong Y, Teufel A, Trojan J, Berzigotti A, Cui XW, Dietrich CF. Contrast enhanced ultrasound in mixed hepatocellular cholangiocarcinoma: Case series and review of the literature. Dig Liver Dis 2018;50:401-407.
34. Faust D, Fellbaum C, Zeuzem S, Dietrich CF. Nodular regenerative hyperplasia of the liver: a rare differential diagnosis of cholestasis with response to ursodeoxycholic acid. Z.Gastroenterol 2003;41:255-258.

35. Trojan J, Hammerstingl R, Engels K, Schneider AR, Zeuzem S, Dietrich CF. Contrast-enhanced ultrasound in the diagnosis of malignant mesenchymal liver tumors. J.Clin.Ultrasound 2010;38:227-231.
36. Schuessler G, Fellbaum C, Fauth F, et al. [The infammatory pseudotumour -- an unusual liver tumour]. Ultraschall Med. 2006;27:273-279.
37. Tana C, Schiavone C, Ticinesi A, et al. Ultrasound imaging of abdominal sarcoidosis: State of the art. World J Clin Cases 2019;7:809-818.
38. Tana C, Silingardi M, Dietrich CF. New trends in ultrasound of hepatosplenic sarcoidosis. Z Gastroenterol 2015;53:283-284.
39. Hirche TO, Hirche H, Cui XW, Wagner TO, Dietrich CF. Ultrasound evaluation of mediastinal lymphadenopathy in patients with sarcoidosis. Med Ultrason 2014;16:194-200.
40. Tana C, Dietrich CF, Schiavone C. Hepatosplenic sarcoidosis: contrast-enhanced ultrasound findings and implications for clinical practice. Biomed Res Int 2014;2014:926203.
41. Dong Y, Jurgensen C, Puri R, et al. Ultrasound imaging features of isolated pancreatic tuberculosis. Endosc Ultrasound 2018;7:119-127.
42. Barreiros AP, Braden B, Schieferstein-Knauer C, Ignee A, Dietrich CF. Characteristics of intestinal tuberculosis in ultrasonographic techniques. Scand.J.Gastroenterol 2008;43:1224-1231.
43. Dietrich CF, Douira-Khomsi W, Gharbi H, et al. Cystic echinococcosis, review and illustration of non-hepatic manifestations. Med Ultrason 2020;22:319-324.
44. Dietrich CF, Douira-Khomsi W, Gharbi H, et al. Cystic and alveolar echinococcosis of the hepatobiliary tract - the role of new imaging techniques for improved diagnosis. Med Ultrason 2020;22:75-84.
45. Brunetti E, Tamarozzi F, Macpherson C, et al. Ultrasound and Cystic Echinococcosis. Ultrasound Int Open 2018;4:E70-E78.
46. Dietrich CF, Mueller G, Beyer-Enke S. Cysts in the cyst pattern. Z.Gastroenterol. 2009;47:1203-1207.
47. Richter J, Botelho MC, Holtfreter MC, et al. Ultrasound assessment of schistosomiasis. Z Gastroenterol 2016;54:653-660.
48. Richter J, Azoulay D, Dong Y, et al. Ultrasonography of gallbladder abnormalities due to schistosomiasis. Parasitol Res 2016;115:2917-2924.
49. Dong Y, Mao F, Cao J, et al. Differential diagnosis of gallbladder ascariasis debris: the added value of contrast enhanced ultrasound with high frequency transducer. Med Ultrason 2018;20:413-419.
50. Dietrich CF, Sharma M, Chaubal N, et al. Ascariasis imaging: pictorial essay. Z Gastroenterol 2017;55:479-489.
51. Dietrich CF, Kabaalioglu A, Brunetti E, Richter J. Fasciolosis. Z Gastroenterol 2015;53:285-290.
52. Dietrich CF, Atkinson NSS, Lee WJ, Kling K, Neumayr A, Braden B, Richter J, et al. Never seen before? Opisthorchiasis and Clonorchiasis. Z Gastroenterol 2018;56:1513-1520.
53. Dietrich CF, Cretu C, Dong Y. Imaging of toxocariasis. Adv Parasitol 2020;109:165-187.
54. Braden B, Helm B, Fabian T, Dietrich CF. [Bacillary angiomatosis of the liver, a suspected ultrasound diagnosis?]. Z.Gastroenterol. 2000;38:785-789.
55. Barreiros AP, Otto G, Ignee A, Galle P, Dietrich CF. Sonographic signs of amyloidosis. Z.Gastroenterol 2009;47:731-739.
56. Chiorean L, Cui XW, Tannapfel A, et al. Benign liver tumors in pediatric patients - Review with emphasis on imaging features. World J Gastroenterol 2015;21:8541-8561.
57. Schreiber-Dietrich DG, Leuschner I, Tannapfel A, et al. [Primary liver tumours in childhood]. Z Gastroenterol 2015;53:1267-1275.
58. Flejou JF, Barge J, Menu Y, et al. Liver adenomatosis. An entity distinct from liver adenoma? Gastroenterology 1985;89:1132-1138.
59. Ribeiro A, Burgart LJ, Nagorney DM, Gores GJ. Management of liver adenomatosis: results with a conservative surgical approach. Liver Transpl Surg 1998;4:388-398.
60. Shao N, Pandey A, Ghasabeh MA, et al. Long-term follow-up of hepatic adenoma and adenomatosis: analysis of size change on imaging with histopathological correlation. Clin Radiol 2018;73:958-965.
61. Grazioli L, Federle MP, Ichikawa T, Balzano E, Nalesnik M, Madariaga J. Liver adenomatosis: clinical, histopathologic, and imaging findings in 15 patients. Radiology 2000;216:395-402.
62. Chiche L, Dao T, Salame E, et al. Liver adenomatosis: reappraisal, diagnosis, and surgical management: eight new cases and review of the literature. Ann Surg 2000;231:74-81.
63. Gossmann J, Scheuermann EH, Frilling A, Geiger H, Dietrich CF. Multiple adenomas and hepatocellular carcinoma in a renal transplant patient with glycogen storage disease type 1a (von Gierke disease). Transplantation 2001;72:343-344.
64. McDermott C, Ertreo M, Jha R, et al. Risk factors for bleeding hepatocellular adenoma in a United States cohort. Liver Int 2022;42:224-232.
65. Roberts JL, Fishman EK, Hartman DS, Sanders R, Goodman Z, Siegelman SS. Lipomatous tumors of the liver: evaluation with CT and US. Radiology 1986;158:613-617.
66. Thampy R, Elsayes KM, Menias CO, et al. Imaging features of rare mesenychmal liver tumours: beyond haemangiomas. Br J Radiol 2017;90:20170373.
67. Martin-Benitez G, Marti-Bonmati L, Barber C, Vila R. Hepatic lipomas and steatosis: an association beyond chance. Eur J Radiol 2012;81:e491-494.
68. Sohn J, Siegelman E, Osiason A. Unusual patterns of hepatic steatosis caused by the local effect of insulin revealed on chemical shift MR imaging. AJR Am J Roentgenol 2001;176:471-474.
69. Bangeas P, Bitzika S, Loufopoulos P, Drevelegkas K, Papadopoulos VN. Infarcted ligamentum teres hepatis lipoma mimicking acute abdomen in a female patient: a case report and mini-review of the literature. J Surg Case Rep 2020;2020:rjaa391.
70. Bruneton JN, Kerboul P, Drouillard J, Menu Y, Normand F, Santini N. Hepatic lipomas: ultrasound and computed tomographic findings. Gastrointest Radiol 1987;12:299-303.

71. Nakamura N, Kudo A, Ito K, Tanaka S, Arii S. A hepatic lipoma mimicking angiomyolipoma of the liver: report of a case. Surg Today 2009;39:825-828.
72. Manenti G, Picchi E, Castrignano A, Muto M, Nezzo M, Floris R. Liver lipoma: a case report. BJR Case Rep 2017;3:20150467.
73. Xu HX, Xie XY, Lu MD, et al. Unusual benign focal liver lesions: findings on real-time contrast-enhanced sonography. J Ultrasound Med 2008;27:243-254.
74. Xu HX, Liu GJ, Lu MD, et al. Characterization of focal liver lesions using contrast-enhanced sonography with a low mechanical index mode and a sulfur hexafluoride-filled microbubble contrast agent. J Clin Ultrasound 2006;34:261-272.
75. Basaran C, Karcaaltincaba M, Akata D, et al. Fat-containing lesions of the liver: cross-sectional imaging findings with emphasis on MRI. AJR Am J Roentgenol 2005;184:1103-1110.
76. Luo XZ, Ming CS, Chen XP, Gong NQ. Epstein-Barr virus negative primary hepatic leiomyoma: case report and literature review. World J Gastroenterol 2013;19:4094-4098.
77. Sclabas GM, Maurer CA, Wente MN, Zimmermann A, Buchler MW. Case report: hepatic leiomyoma in a renal transplant recipient. Transplant Proc 2002;34:3200-3202.
78. Sadler M, Mays WL, Albert P, Javors B. Hepatic leiomyomas in two adult patients with AIDS: intravenous contrast-enhanced CT and MR imaging. Emerg Radiol 2002;9:175-177.
79. Dunlap HJ, Udjus K. Atypical leiomyoma arising in an hepatic vein with extension into the inferior vena cava and right atrium. Report of a case in a child. Pediatr Radiol 1990;20:202-203.
80. Vyas S, Psica A, Watkins J, Yu D, Davidson B. Primary hepatic leiomyoma: unusual cause of an intrahepatic mass. Ann Transl Med 2015;3:73.
81. Coletta D, Parrino C, Nicosia S, et al. Primary leiomyoma of the liver in an immunocompetent patient. Intractable Rare Dis Res 2020;9:251-255.
82. Jia B, Jin Z, Gao P, Liu Y. Primary hepatic leiomyoma in a Chinese female patient without underlying disease: a case report. BMC Surg 2019;19:140.
83. Urizono Y, Ko S, Kanehiro H, et al. Primary leiomyoma of the liver: report of a case. Surg Today 2006;36:629-632.
84. Perini MV, Fink MA, Yeo DA, et al. Primary liver leiomyoma: a review of this unusual tumour. ANZ J Surg 2013;83:230-233.
85. Marin D, Catalano C, Rossi M, et al. Gadobenate dimeglumine-enhanced magnetic resonance imaging of primary leiomyoma of the liver. J Magn Reson Imaging 2008;28:755-758.
86. Omiyale AO. Primary leiomyoma of the liver: a review of a rare tumour. HPB Surg 2014;2014:959202.
87. Panahova S, Rempp H, Sipos B, Malek N, Boozari B. Das PECom der Leber–eine neue Entität der Lebertumoren? Zeitschrift für Gastroenterologie 2015;53:399-408.
88. Liu D, Shi D, Xu Y, Cao L. Management of perivascular epithelioid cell tumor of the liver: A case report and review of the literature. Oncology Letters 2014;7:148-152.
89. Fletcher CD, Unni KK, Mertens F. World Health Organization Classification of Tumors of Pathology and Genetics: Tumors of Soft Tissue and Bone. Lyon, France: IARC Press, 2002.
90. Petersen J. Die neue WHO-Klassifikation und aktuelle Ergebnisse in der Weichteiltumorpathologie. Pathologe 2013;34:436-448.
91. Jia J, Luo J, Pan CG, et al. Single-center Experience in the Diagnosis and Treatment of Hepatic Perivascular Epithelioid Cell Neoplasm. J Clin Transl Hepatol 2022;10:72-79.
92. Bleeker JS, Quevedo JF, Folpe AL. "Malignant" perivascular epithelioid cell neoplasm: risk stratification and treatment strategies. Sarcoma 2012;2012:541626.
93. Folpe AL, Kwiatkowski DJ. Perivascular epithelioid cell neoplasms: pathology and pathogenesis. Hum Pathol 2010;41:1-15.
94. Cardillo G, Carbone L, Carleo F, et al. Solitary fibrous tumors of the pleura: an analysis of 110 patients treated in a single institution. Ann Thorac Surg 2009;88:1632-1637.
95. Debs T, Kassir R, Amor IB, Martini F, Iannelli A, Gugenheim J. Solitary fibrous tumor of the liver: report of two cases and review of the literature. Int J Surg 2014;12:1291-1294.
96. Cincu R, Rodriguez R, Perez A, Blanco T, Arrotegui I, Barcia C. Solitary fibrous tumor of the thoracic spine. J Neurosci Rural Pract 2010;1:118-119.
97. Hong JP, Chung YK, Kim SW, Kim TH, Lee KG. Solitary fibrous tumour of the face: a rare case report. Br J Plast Surg 2002;55:75-77.
98. Fletcher C, Unni KK, Mertens F. World Health Organization Classification of Tumours. Pathology and Genetics of Tumours of Soft Tissue and Bone. J Bone Joint Surg 2004;177:1365–1376.
99. Nevius DB, Friedman NB. Mesotheliomas and extraovarin thecomas with hypoglycemic and nephrotic syndromes. Cancer 1959;12:1263-1269.
100. Chen N, Slater K. Solitary fibrous tumour of the liver-report on metastasis and local recurrence of a malignant case and review of literature. World J Surg Oncol 2017;15:27.
101. Mosquera JM, Fletcher CD. Expanding the spectrum of malignant progression in solitary fibrous tumors: a study of 8 cases with a discrete anaplastic component--is this dedifferentiated SFT? Am J Surg Pathol 2009;33:1314-1321.
102. Jakob M, Schneider M, Hoeller I, Laffer U, Kaderli R. Malignant solitary fibrous tumor involving the liver. World J Gastroenterol 2013;19:3354-3357.
103. Korkolis DP, Apostolaki K, Aggeli C, et al. Solitary fibrous tumor of the liver expressing CD34 and vimentin: a case report. World J Gastroenterol 2008;14:6261-6264.
104. Beltran MA. Solitary Fibrous Tumor of the Liver: a Review of the Current Knowledge and Report of a New Case. J Gastrointest Cancer 2015;46:333-342.
105. Silvanto A, Karanjia ND, Bagwan IN. Primary hepatic solitary fibrous tumor with histologically benign and ma-

lignant areas. Hepatobiliary Pancreat Dis Int 2015;14:665-668.
106. Ali SZ, Hoon V, Hoda S, Heelan R, Zakowski MF. Solitary fibrous tumor. A cytologic-histologic study with clinical, radiologic, and immunohistochemical correlations. Cancer 1997;81:116-121.
107. Gengler C, Guillou L. Solitary fibrous tumour and haemangiopericytoma: evolution of a concept. Histopathology 2006;48:63-74.
108. Feng LH, Dong H, Zhu YY, Cong WM. An update on primary hepatic solitary fibrous tumor: An examination of the clinical and pathological features of four case studies and a literature review. Pathol Res Pract 2015;211:911-917.
109. Chan G, Horton PJ, Thyssen S, et al. Malignant transformation of a solitary fibrous tumor of the liver and intractable hypoglycemia. J Hepatobiliary Pancreat Surg 2007;14:595-599.
110. Bejarano-Gonzalez N, Garcia-Borobia FJ, Romaguera-Monzonis A, et al. Solitary fibrous tumor of the liver. Case report and review of the literature. Rev Esp Enferm Dig 2015;107:633-639.
111. Dey B, Gochhait D, Kaushal G, Barwad A, Pottakkat B. Solitary Fibrous Tumor of the Liver: A Rare Tumor in a Rarer Location. Rare Tumors 2016;8:6403.
112. Fama F, Le Bouc Y, Barrande G, et al. Solitary fibrous tumour of the liver with IGF-II-related hypoglycaemia. A case report. Langenbecks Arch Surg 2008;393:611-616.
113. Makino Y, Miyazaki M, Shigekawa M, et al. Solitary fibrous tumor of the liver from development to resection. Intern Med 2015;54:765-770.
114. Wilky BA, Montgomery EA, Guzzetta AA, Ahuja N, Meyer CF. Extrathoracic location and "borderline" histology are associated with recurrence of solitary fibrous tumors after surgical resection. Ann Surg Oncol 2013;20:4080-4089.
115. El-Khouli RH, Geschwind JF, Bluemke DA, Kamel IR. Solitary fibrous tumor of the liver: magnetic resonance imaging evaluation and treatment with transarterial chemoembolization. J Comput Assist Tomogr 2008;32:769-771.
116. Maccio L, Bonetti LR, Siopis E, Palmiere C. Malignant metastasizing solitary fibrous tumors of the liver: a report of three cases. Pol J Pathol 2015;66:72-76.