Contrast-enhanced ultrasound of the liver: basics and interpretation of common focal lesions

Kontrastmittelunterstützte Sonografie der Leber: Grundlagen und Interpretation häufiger fokaler Läsionen

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ABSTRACT

Background Over the past 20 years, contrast-enhanced ultrasound (CEUS) has become established as a procedure that is complementary to B-mode ultrasound and color Doppler sonography.

Method The aim of this review is to provide the fundamental knowledge required for examining the liver with CEUS. Additionally, the characteristic CEUS patterns of frequent focal liver lesions are described.

Results and Conclusion Considering the limitations of ultrasound, CEUS offers an equivalent alternative to other imaging modalities, such as computed tomography and magnetic resonance imaging, for evaluating focal liver lesions. It should be utilized as a primary modality due to its lack of radiation exposure and rapid availability.

Key Points:

- CEUS plays an important role particularly in the detection and evaluation of incidentally detected liver lesions.
- Considering the limitations of ultrasound, CEUS offers an equivalent alternative to other imaging modalities, such as CT and MRI, for evaluating focal liver lesions.

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ZUSAMMENFASSUNG

Hintergrund Die kontrastunterstützte Sonografie (CEUS) hat sich innerhalb der letzten 20 Jahren als ergänzendes Verfahren zur B-Bild-Sonografie und Farb-Doppler-Sonografie etabliert.

Methode Ziel der vorliegenden Übersicht ist, das notwendige Grundwissen zur Untersuchung der Leber mit Ultraschallkontrastmittel zu ermitteln. Darüber hinaus werden die klassischen CEUS-Muster häufiger fokaler Leberläsionen beschrieben.

Ergebnisse und Schlussfolgerung Unter Berücksichtigung der Limitationen des Ultraschalls ist die CEUS bei Beurteilung der fokalen Leberläsionen eine gleichwertige Alternative zu anderen bildgebenden Verfahren wie Computertomografie und Magnetresonanztomografie und sollte bei fehlender Strahlenbelastung und rascher Verfügbarkeit primär eingesetzt werden.

1 Introduction

Contrast-enhanced ultrasound (CEUS) has become established in the last 20 years as a supplementary method to B-mode ultrasound (B-US) and color Doppler sonography (FDS) and is now routinely performed in corresponding medical issues. The European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) is continuously updating the possible uses and indications for CEUS and the corresponding procedures [1]. Particularly in the case of the detection and characterization of incidentally discovered focal liver lesions, CEUS has a high recommendation rate (evidence level 1) in the region of the liver [1]. An important characteristic of ultrasound contrast agent is that it remains strictly intravasal, allowing precise visualization of the vascular network in the arterial phase and reliable differentiation between perfused and non-perfused tissue [1].

The present study provides the necessary basic information for examining the liver with ultrasound contrast agent. Moreover, the classic CEUS patterns of common liver lesions are described.

1.1 Basic principles of CEUS

The use and interpretation of CEUS are to be performed under consideration of the patient's clinical background. Therefore, it is decisive for determining the tumor status, e. g., of a focal liver lesion, whether the lesion is observed as an incidental finding during tumor staging or in known liver cirrhosis [2]. The examiner should have a basic understanding of B-mode US and FDS [1]. CEUS is only indicated when the lesion cannot be sufficiently clinically classified on B-mode US and FDS. If there are still uncertainties after CEUS examination, the diagnosis can be determined in consideration of the clinical background by supplementary magnetic resonance imaging (MRI) and if the finding is still unclear with ultrasound-guided biopsy [3].

The contrast agent SonoVue is currently the most commonly used ultrasound contrast agent [1]. It is a second generation contrast agent. The CEUS examination is performed with a low mechanical index (MI) to avoid destruction of the bubbles. SonoVue is a microbubble-based contrast agent comprised of a suspension of microscopic gas bubbles filled with sulfur hexafluoride gas and a phospholipid layer in an aqueous solution [4]. The bubbles are a size of approx. 1–10 μm and resonance vibration occurs during scanning [4]. The bubbles thus act as effective scattering bodies, increase the reflection of ultrasound waves by approximately 1000 fold, and therefore provide better visualization of tissue and tumor perfusion [4]. The contrast agent is eliminated by the lungs [4]. There are no contraindications for the use of CEUS in patients with impaired renal function, cardiac insufficiency, or impaired thyroid function [1, 5]. Its use is contraindicated by known allergic reactions to the contrast agent, acute respiratory distress syndrome (ARDS), severe pulmonary hypertension, uncontrolled systemic hypertension, and a known right-left shunt [5, 6]. Severe anaphylactic reaction to SonoVue is observed in approximately 1 out of 10,000 applications (0.01 %) [1]. In Europe, CEUS is used off label in pediatric patients like many other medications [6]. Initial clinical data indicates that CEUS is safe for use during pregnancy [1]. However, the data regarding the safety of this examination in pregnancy is currently insufficient. The first prospective multicenter study is planned [7].

The requirements for performing CEUS are as follows: 1 – The ultrasound device must have a contrast mode, 2 – the patient must be informed of possible risks and complications and have provided informed written consent, 3 – there should be no contraindications for the examination.

1.2 Performing CEUS of the liver

The best patient position and the best acoustic window for CEUS should be determined on B-mode US. In general, every peripheral or central vein access can be used for contrast administration. The left arm, usually the antecubital vein, is preferably used for access to avoid contact between the injector and a right-handed examiner. The contrast agent is usually administered as a bolus injection followed by a 10-ml sodium chaser [8]. The dose depends decisively on the type of US device and is usually 1.2–2.4 ml [8].

CEUS of the liver has 3 phases [1]:

- In the ***arterial phase***, the contrast enters the liver through the hepatic artery after administration (▶ **Fig. 1A**). The arterial phase begins with perfusion of the hepatic artery and approx. 10–20 s after administration of the contrast agent and lasts approx. 30–45 s [1].
- In the ***portal venous phase*** (liver-specific phase), the contrast agent is initially visible in the portal vein on the image of the hepatic hilum (▶ **Fig. 1B**). The portal venous phase begins with perfusion of the portal vein and approx. 25–45 s after administration of the contrast agent and lasts approx. 120 s [1, 9].
- In the late phase (parenchymal phase), the contrast distributes homogeneously and in a long-lasting manner in the liver after approx. 120 s (▶ **Fig. 1C**) [1, 10].

It must be taken into consideration that in patients with central access and impaired cardiac function there can be mild to moderate deviations in the times of contrast wash-in and washout [1].

1.3 Significance of liver vascularization and liver perfusion patterns for CEUS

The liver parenchyma is supplied by a dual vascular system with the majority of the blood flow (approx. 70–75 %) coming from the portal vein and the remaining portion (approx. 25–30 %)
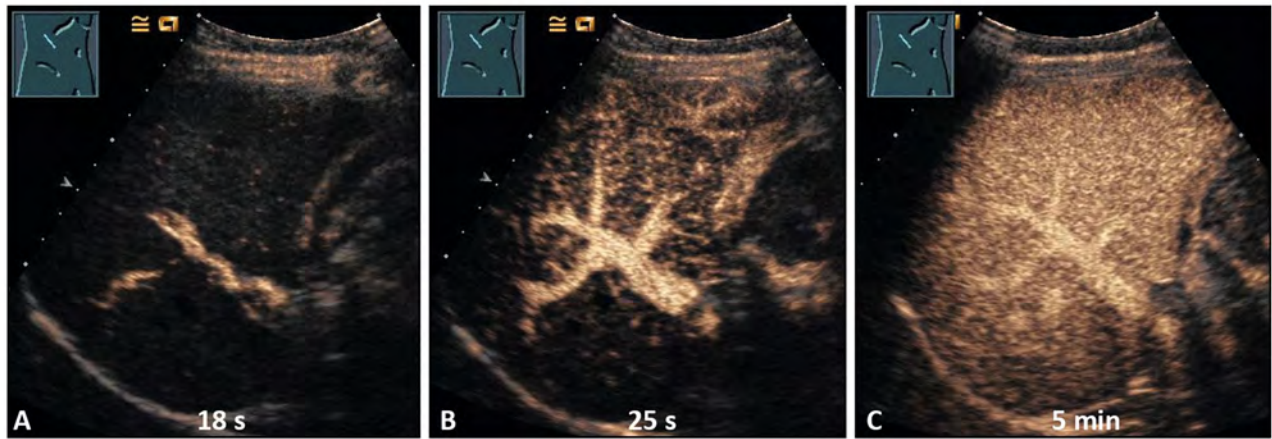
► **Fig. 1** Arterial phase (**A**), portal venous phase (**B**), and late phase (**C**) on contrast-enhanced ultrasound (CEUS).
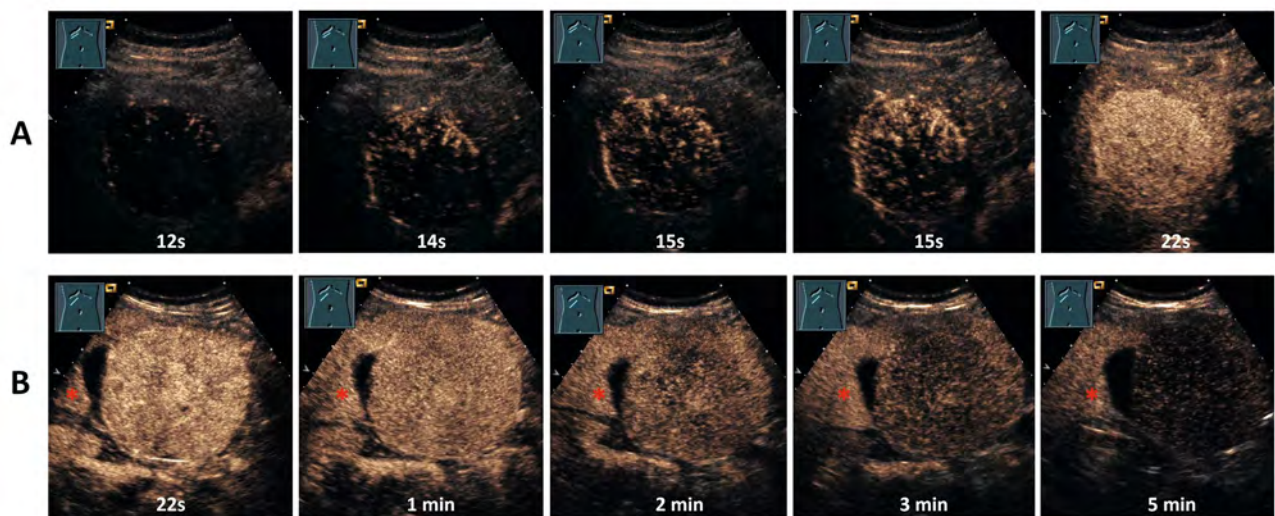
► **Fig. 2 A** Example of the early arterial angiogenesis phenomenon on CEUS in a patient with histologically confirmed hepatocellular carcinoma. The lesion shows increasing enhancement beginning in the early arterial phase due to the perfusion of many small chaotic vessels. **B**: Example of the parenchymal washout phenomenon in a patient with histologically confirmed metastasis of a malignant melanoma: The lesion shows hyperenhancement in the arterial phase (22 s), a decrease in enhancement in the portal venous phase (1 min), and hypoenhancement in the late phase (2–5 min) compared to healthy liver tissue (*).

being provided by the hepatic artery [1]. In contrast to the provision of nutrition to the liver's own tissue, blood is supplied to pathological liver processes like primary malignant liver tumors, metastases, granulomatous lesions, and inflammatory processes almost exclusively via angiogenesis from branches of the hepatic artery [11]. The vascularization pattern of lesions with neoangiogenesis is characterized by a secondary chaotic vascular pattern often of small vessels [12]. Thus, chaotic perfusion usually in the early arterial phase on CEUS (angiogenesis pattern, ► **Fig. 2A**) and/or a lack of portal venous, liver-specific perfusion with parenchymal hypoenhancement (washout phenomenon, ► **Fig. 2B**) indicates non-liver tissue among other things.

2 Focal fat distribution disorder

As a rule, sonographic findings are to be evaluated in consideration of the clinical background.

2.1 Cystic liver lesions

In 5.8 % of sonographic liver examinations, liver cysts are observed as incidental findings (incidentalomas) [13]. B-mode US is considered the US gold standard for the diagnosis of simple liver cysts [14]. However, CEUS can be used as a diagnostic method for further differentiation in septated cysts or cysts with echogenic content (complicated cysts) [1]. In echogenic cysts, CEUS is used to differentiate between non-perfused content (e. g., hemorrhagic
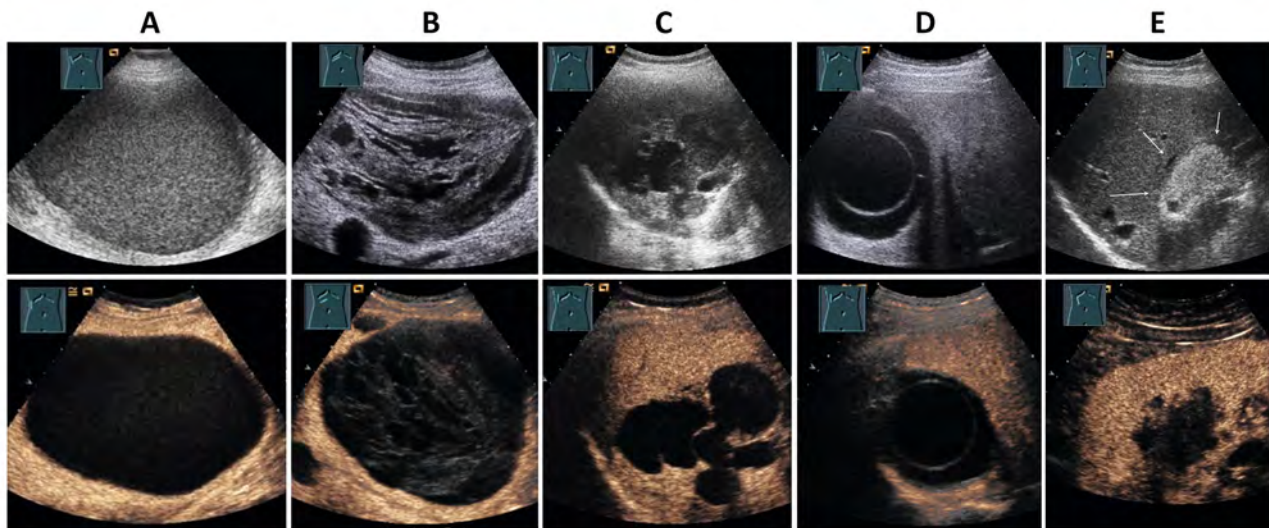
▶ **Fig. 3** Various liver cysts on B-mode US and CEUS. **A**: Echogenic lesion with smooth margins on B-mode US with a lack of enhancement on CEUS as in the case of a cyst; **B**: Complex lesion with smooth margins on B-mode US with a lack of enhancement on CEUS as in the case of a hemorrhagic cyst with echogenic prior hematoma; **C**: Multi-septated complex mass on B-mode US with a lack of enhancement on CEUS as in the case of multi-septated cysts; **D**: Anechoic lesion with intralesional cyst on B-mode US, the intralesional structure does not show any wall enhancement on CEUS in confirmed cystic echinococcosis; **E**: Echogenic lesion (arrows) on B-mode US with irregular margins and a lack of enhancement on CEUS in verified alveolar echinococcosis.

cysts, ▶ **Fig. 3A–C**) and perfused content (e. g., metastases with a "cystic" appearance) [1, 15]. Simultaneous peripheral enhancement of the lesion with corresponding clinical symptoms can be an indication of a liver abscess. Hepatobiliary cystadenoma is extremely rare and is potentially precancerous [1, 15].

In the case of clinical suspicion of cystic echinococcosis of the liver, the outer wall (laminar layer) shows significant enhancement while the inner layer (germinal layer) and the intralesional walls, corresponding to inward pointing daughter cysts, show no enhancement (▶ **Fig. 3D**) [16]. Depending on the stage and the underlying parasites, focal lesions with a solid appearance can also occur. Corresponding to the recommendation of the World Health Organization (WHO), cystic echinococcosis can be classified in five sonomorphological groups [17, 18]. In alveolar echinococcosis the lesions can have an irregular hyperechoic solid margin on B-mode US due to daughter cysts with outward infiltrating growth, with a lack of enhancement in all phases on CEUS (▶ **Fig. 3E**) [19].

2.2 Focal fat distribution disorder

Focal fat distribution disorders are usually observed as an incidental finding, can be hyperechoic or hypoechoic, and usually have map-like margins on B-mode US. Fat distribution disorders typically manifest along the portal vein or in the immediate vicinity of the gallbladder. If the fat is distributed in a wedge shape or the vessels run normally through the lesion on FDS, CEUS is not necessary [3]. In the case of the morphology of a nodule with simultaneous presence of a malignant primary disease, CEUS is indicated [1]. The enhancement of focal fat distribution disorders is the same as the liver in all phases and they cannot be differenti-

ated from normal liver tissue (▶ **Fig. 4A–C**) [1]. They are rarely an indication of a primary focal lesion ("observation tumor") [20].

2.3 Hemangioma

As an incidental finding in a liver that is otherwise morphologically unremarkable on B-mode US, circumscribed, round, usually hyperechoic lesions less than 3 cm in size without a halo sign and without intralesional vessels on FDS are diagnosed as hemangioma [1]. CEUS is indicated when the lesion is greater than 3 cm [1], B-mode US and FDS are not definitive, or a malignant primary disease (e. g., neuroendocrine tumor) is present or possible. The characteristic CEUS feature of a hemangioma is peripheral, iris diaphragm-like (▶ **Fig. 5A**) or tongue-shaped nodular peripheral enhancement (▶ **Fig. 5B**) in the early arterial phase followed by progressive centripetal partial or complete filling in the portal venous and parenchymal phase [1]. The perfusion pattern is described as an iris diaphragm phenomenon similar to computed tomography (CT) and MRI [3]. Lesions with rapid complete wash-in within 30 s are referred to as "high flow" hemangiomas (▶ **Fig. 5C**) [21]. "High flow" hemangiomas comprise approx. 20 % of all hemangiomas [22].

2.4 Focal nodular hyperplasia (FNH)

Focal nodular hyperplasia (FNH) is usually diagnosed as an incidental finding and has a spoke wheel parenchymal pattern with a central artery visible on FDS in 40 % of cases on B-mode US and FDS [23, 24]. In the case of an atypical pattern and the presence of a primary disease, CEUS is recommended [1]. On CEUS, FNH is typically perfused by a large artery in a central or peripheral location and hyperenhancement is seen on CEUS within several sec-
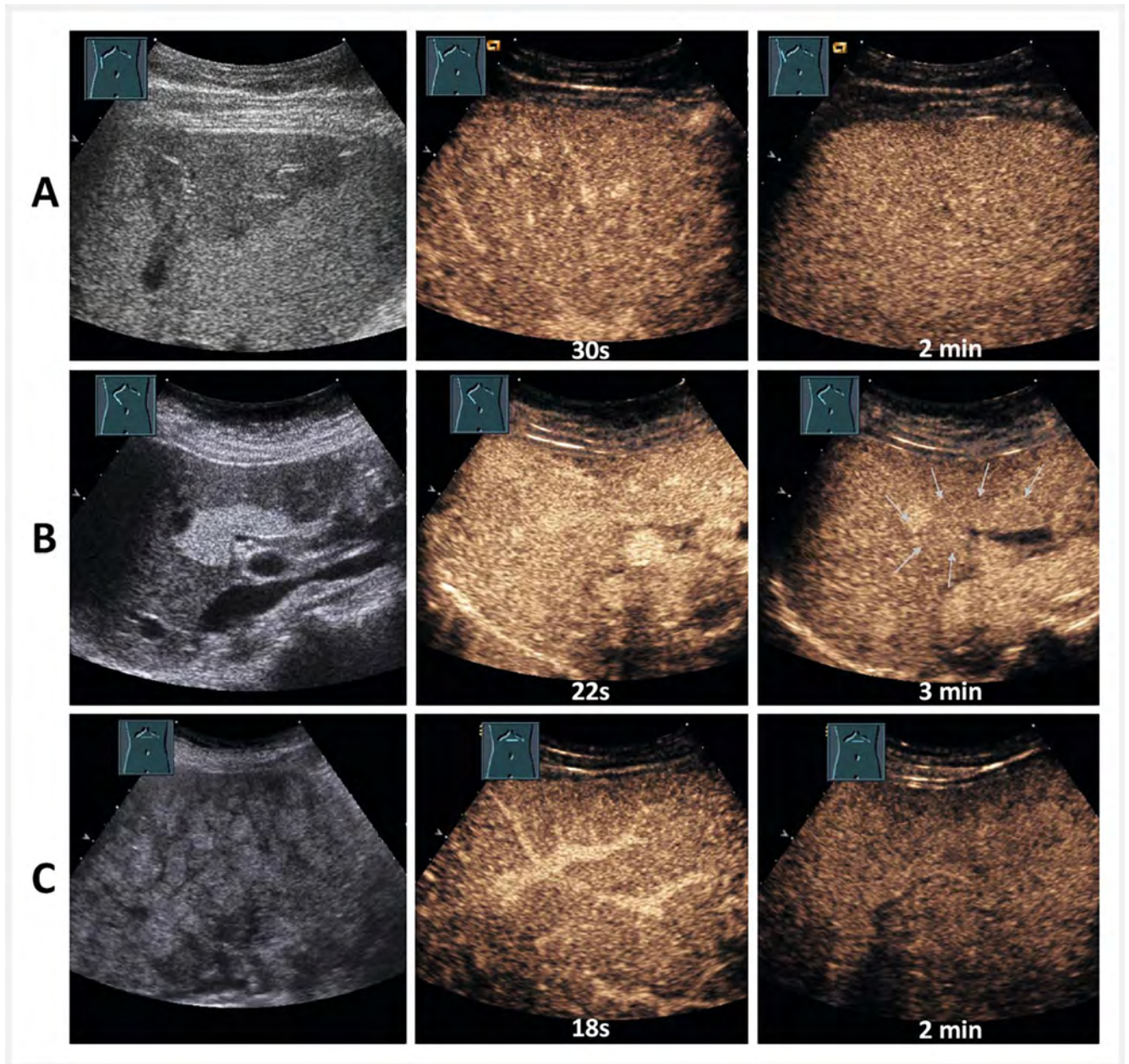
▶ **Fig. 4** Various focal fat distribution disorders on B-mode US and CEUS. **A**: Hypoechoic wedge-shaped liver lesion, **B**: hyperechoic periportal lesion, and **C**: multiple hyperechoic nodules penetrating the liver as an incidental finding. All lesions show homogeneous enhancement that is the same as the liver both in the arterial and the portal venous phases as in the case of focal fat distribution disorders.

onds, i. e., the "light bulb phenomenon" [1] (▶ **Fig. 6A–B**). Another common characteristic of FNH in the arterial phase is centrifugal contrast enhancement of the lesions [1]. In the portal venous and late phases, FNH is characterized by homogeneous, usually pronounced enhancement (lack of parenchymal washout phenomenon) [1]. In the late phase, central hypoenhancement or a lack of central enhancement of the central scar can be observed. Together with the centrifugal contrast enhancement in the arterial phase (if visible), this is an important characteristic in the differentiation of high flow hemangiomas [1].

In the case of an atypical CEUS pattern, supplementary MRI can be helpful. MRI has high specificity of 98 % in the diagnosis of

FNH [25]. "High flow" metastases [3] must be considered in the differential diagnosis, particularly when washout is observed in the late parenchymal phase (5–7 minutes), which is always an indication for histological diagnostic confirmation.

2.5 Hepatocellular adenoma

Hepatocellular adenomas (HCAs) are rare, usually incidental findings, occur at a ratio of 1:5 compared to FNH, and have a nonspecific pattern on B-mode US [3, 13, 21]. Since an HCA does not have any portal vein branches and bile ducts on histopathology and is supplied solely by the hepatic artery, the tumor is com-
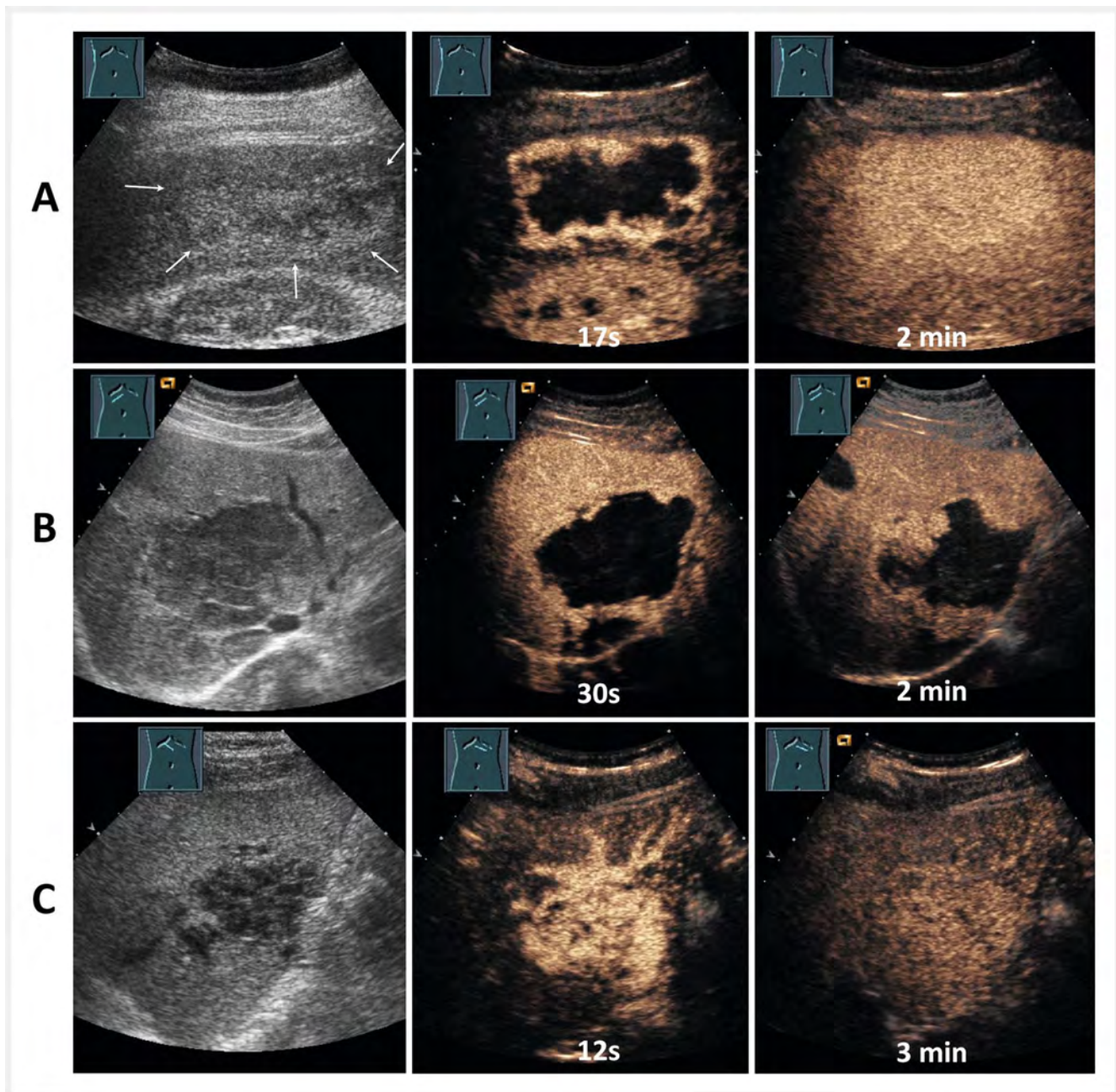
► **Fig. 5** Perfusion pattern of various hemangiomas on CEUS; **A:** Hyperechoic hemangioma on B-mode US as an incidental finding with peripheral enhancement with the iris diaphragm sign in the early arterial phase of CEUS, followed by progressive centripetal complete filling in the portal venous phase, **B:** Hypoechoic hemangioma on B-mode US as an incidental finding with a tongue-shaped nodular peripheral enhancement in the early arterial phase of CEUS, followed by progressive centripetal incomplete filling in the portal venous phase; **C:** Hypoechoic histologically confirmed hemangioma on B-mode US with quick, complete wash-in within 12 s on CEUS followed by persistent hyperenhancement in the portal venous phase and late phase.

prised of non-liver tissue [21]. On CEUS, an HCA is typically perfused by numerous small peripheral vessels (angiogenesis pattern) and achieves hyperenhancement more slowly compared to an FNH (► **Fig. 7A**). During the portal venous phase, a liver adenoma has homogeneous, usually isoechogenic enhancement with typically low parenchymal hypoenhancement (► **Fig. 7B**) [1].

HCAs can be classified as inflammatory adenomas (40–50 % of all adenomas), fatty nuclear factor-positive adenomas (30–40 %),

and β-catenin-mutated adenomas (approx. 10 %) [21]. In the case of β-catenin-mutated adenomas, there is a risk (4–8 %) of a malignant transformation to a hepatocellular carcinoma [26]. Reliable differentiation between the different types of adenoma can only be achieved by immunohistochemical examination [21, 27]. Therefore, in the case of every incidental liver lesion with an arterial "angiogenesis pattern" and/or more or less parenchymal hypoenhancement, the presence of non-liver tissue (e. g., adenoma)
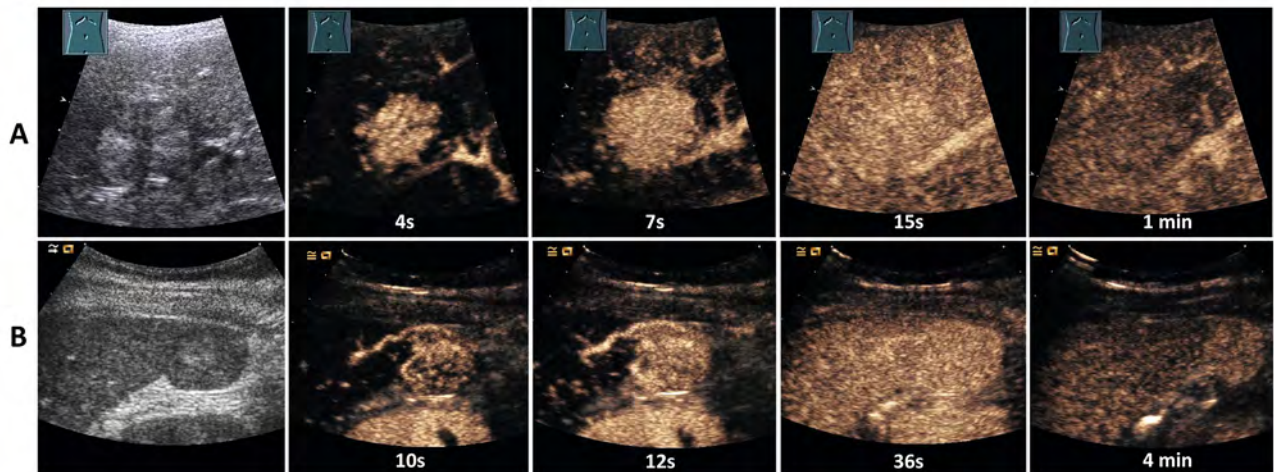
▶ **Fig. 6** Perfusion pattern of various FNHs on CEUS, **A**: Isoechogenic lesion on B-mode US as an incidental finding with spoke wheel pattern. On CEUS, the lesion shows rapid hyperenhancement through a central vessel in the early arterial phase, followed by isoenhancement in the portal venous phase, **B**: Isoechogenic lesion on B-mode US as an incidental finding. On CEUS, the lesion shows rapid hyperenhancement through a peripheral vessel in the early arterial phase, followed by persistent hyperenhancement in the portal venous phase and late phase.
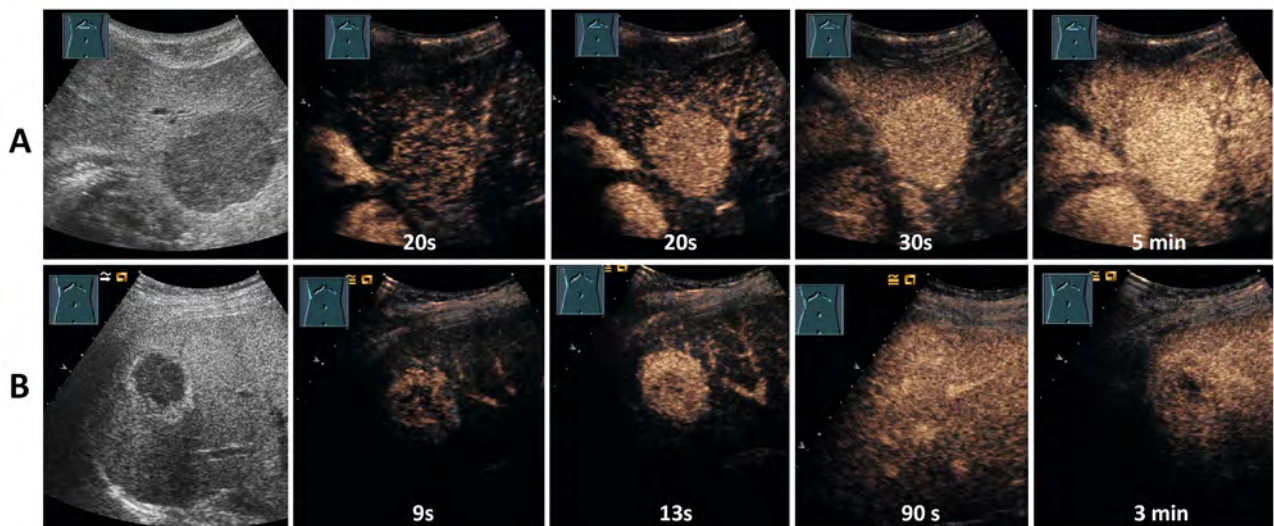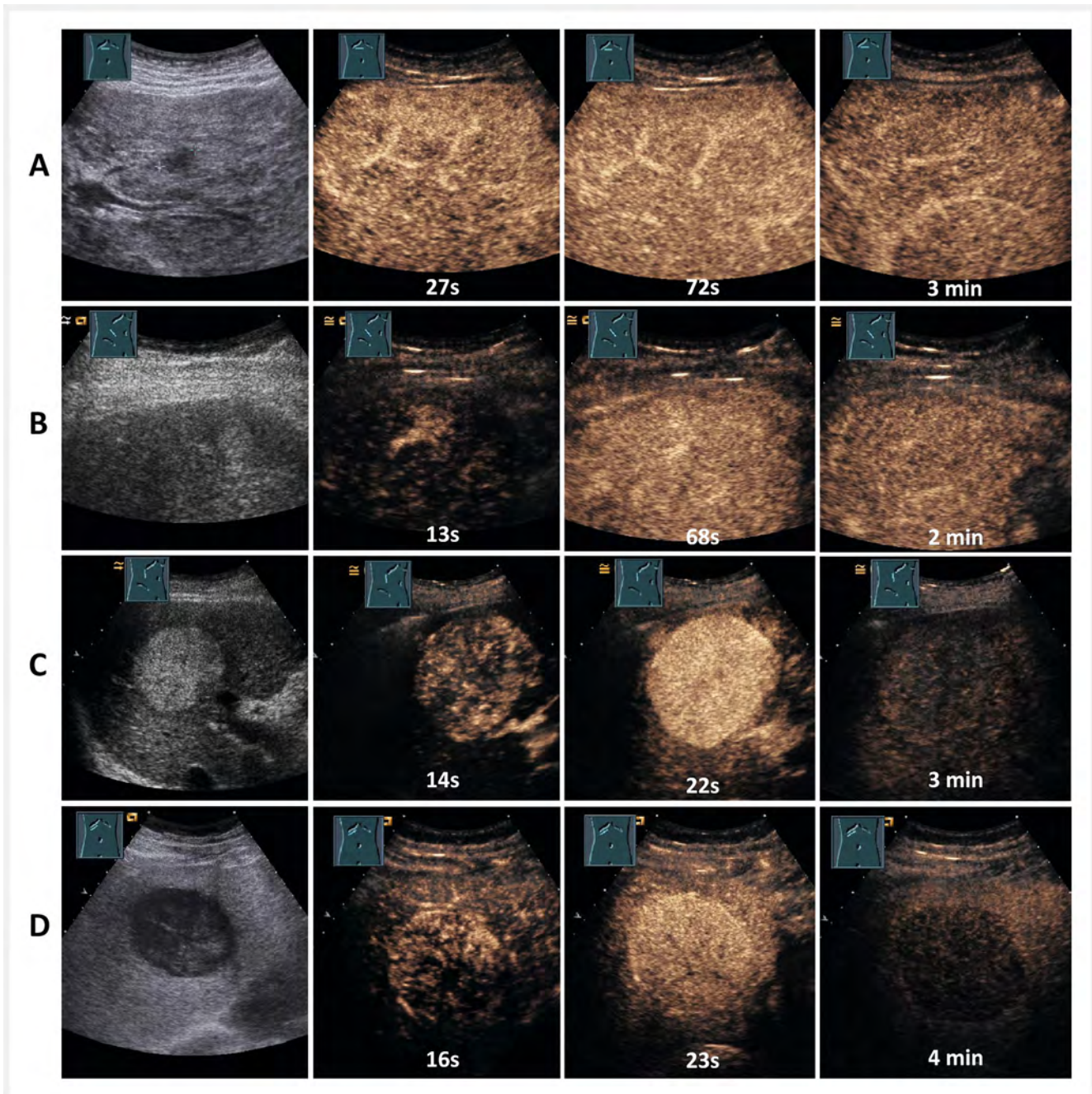

▶ **Fig. 7** Perfusion pattern of various HCAs on CEUS, **A**: Hypoechoic lesion on B-mode US as an incidental finding. On CEUS, the lesion shows delayed hyperenhancement through numerous small peripheral vessels (angiogenesis pattern) in the early arterial phase, followed by persistent hyperenhancement in the portal venous phase and late phase. An β-catenin-mutated adenoma was able to be histologically confirmed. **B**: Hypoechoic lesion on B-mode US as an incidental finding. On CEUS, the lesion shows delayed hyperenhancement through numerous small peripheral vessels (angiogenesis pattern) in the early arterial phase, followed by isoenhancement in the portal venous phase and hypoenhancement in the late phase (washout phenomenon). A primary bile duct adenoma could be histologically confirmed.

must be suspected with an indication for supplementary MRI followed by histological confirmation if the finding is still unclear [3, 28]. MRI has high diagnostic accuracy with a sensitivity of 87 % and a specificity of 100 % particularly for steatotic adenomas [28].

2.6 Regenerative nodules

Lesions in a cirrhotic liver are a diagnostic challenge. While a hepatocellular carcinoma (HCC) can be seen in approximately 60 % of all focal lesions in cirrhotic livers, a regenerative nodule can be diagnosed in 11 % of sonographically detected lesions in a cirrhotic liver [29]. Regenerative nodules are bordered by strands of fibrosis and are comprised of hepatocytes, bile ducts, and Kupffer cells [30]. On B-mode US, regenerative nodules have a nonspecific echo pattern (40 % hypoechoic, 30 % hyperechoic, 30 % echo complex) [31]. A regenerative nodule is characterized by isoechogenic

▶ **Fig. 8** Perfusion patterns of various regenerative nodules and HCCs on CEUS, **A**: Hypoechoic lesion on B-mode US in a patient with liver cirrhosis. On CEUS the lesion's enhancement is the same as the liver (isoenhancement) in the early arterial phase, portal venous phase, and late phase compatible with a regenerative nodule; **B**: Hyperechoic lesion on B-mode US in a patient with liver cirrhosis. On CEUS, the lesion shows moderate hyperenhancement in the early arterial phase, followed by isoenhancement in the portal venous phase and late phase. The finding indicates increasing arterial perfusion and potential transformation to an HCC. A regenerative nodule was diagnosed on histology. **C**: Hyperechoic lesion on B-mode US in a patient with liver cirrhosis. On CEUS, the lesion shows delayed hyperenhancement through numerous small peripheral vessels (angiogenesis pattern) in the early arterial phase, followed by isoenhancement in the portal venous phase and late phase. An HCC was diagnosed on histology, **D**: Hypoechoic lesion on B-mode US in a patient with a fatty liver. On CEUS, the lesion shows slower hyperenhancement through numerous small peripheral vessels (angiogenesis pattern) in the early arterial phase, followed by hypoenhancement in the late phase. An HCC was diagnosed on histology.

enhancement in all phases compared to the surrounding liver tissue on CEUS (▶ **Fig. 8A**) [32].
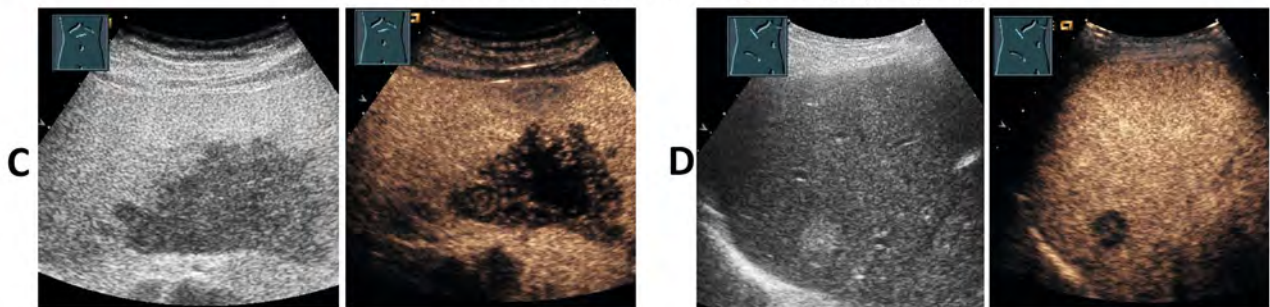
The hepatocytes within the regenerative nodule can transform into an HCC [33]. The transformation to an HCC is a dynamic and slow process associated with a decrease in portal venous perfusion and an increase in arterial perfusion due to tumor neoangiogenesis through the hepatic artery (▶ **Fig. 8B**) [3].
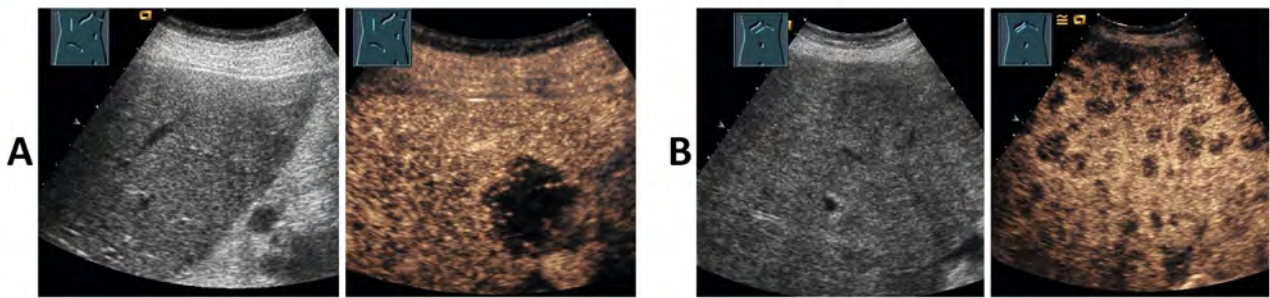
▶ **Fig. 9 A** 44-year-old patient with known cervical cancer and suspicion of liver metastasis on MRI. No lesions can be delimited on B-mode US. CEUS shows one lesion with washout phenomenon consistent with non-liver tissue in the case of histologically confirmed liver metastasis. **B**: 63-year-old patient with known prostate cancer and elevated bilirubin. No lesions can be delimited on B-mode US. Multiple lesions with hypoenhancement consistent with non-liver tissue in the case of histologically confirmed liver metastasis can be seen on CEUS; **C**: 84-year-old patient with known breast cancer and a hypoechoic map-like lesion on B-mode US consistent with abnormal fat distribution. CEUS shows a lesion with a washout phenomenon in the case of histologically confirmed liver metastasis, **D**: 44-year-old patient with known rectal cancer and a hyperechoic lesion on B-mode US suspicious for the presence of hemangioma. On CEUS, the lesion shows a washout phenomenon after 2 minutes in the case of histologically confirmed liver metastasis.

2.7 Hepatocellular carcinoma (HCC)

In patients with liver cirrhosis or chronic liver diseases like hepatitis B, hepatitis C, non-alcoholic and alcoholic steatohepatitis (NASH, ASH), autoimmune hepatitis, hereditary hemochromatosis, or Wilson's disease must be suspected or ruled out in the case of every solid liver lesion. However, it must be taken into consideration that approximately 20 percent of HCCs occur in patients with a non-cirrhotic liver [34]. HCCs typically show hyperenhancement with an angiogenesis pattern in the arterial phase of CEUS [35]. In the portal venous phase and late phase, HCCs have isoechogenic enhancement lasting up to 6 minutes (lack of washout phenomenon, ▶ **Fig. 8C**) due to the pronounced tumor angiogenesis and invasion of the portal venous fields with consecutive shunt formation in 13 % of cases [35]. In 10 % of HCCs, a mild washout phenomenon can occur in the late parenchymal phase (4–6 minutes) (▶ **Fig. 8D**) [35]. According to the current S3 guidelines of the Association of the Scientific Medical Societies in Germany, contrast-enhanced MRI should be used primarily to diagnose an HCC in liver cirrhosis. The use of CEUS or contrast-enhanced CT is only indicated in the case of an unclear MRI finding [36]. A biopsy is recommended in a palliative situation, primarily in the case of suspicion of an HCC in a non-cirrhotic liver, and in the case of unclear contrast behavior in 2 independent imaging methods in a curative treatment approach [36].

2.8 Liver metastasis

In patients with a malignant primary disease and synchronous or metachronous evidence of a liver lesion, a malignancy should be ruled out. CEUS significantly increases the diagnostic sensitivity and specificity of B-mode US in this case (▶ **Fig. 9**).

In the arterial phase, these lesions show variable contrast enhancement in terms of chaotic perfusion (angiogenesis pattern) [16]. In the portal venous phase, a washout phenomenon is typically seen in the lesions as an indication of non-liver tissue (▶ **Fig. 10**) [1]. In the case of metastases with arterial hyperenhancement, washout can also occur first in the late parenchymal phase (5–7 minutes). Primary malignant carcinomatous liver lesions (▶ **Fig. 10A**) or also focal lesions in other malignant hematological diseases including infiltrates in malignant lymphoma, Hodgkin lymphoma (▶ **Fig. 10B**), and stem cell diseases (chloroma), have an arterial angiogenesis pattern with parenchymal washout on CEUS like metastases [37].

In this connection it must be mentioned that benign granulomatous lesions (e. g., sarcoidosis) and also localized chronic inflammation have parenchymal washout (▶ **Fig. 10C**) [3]. In the
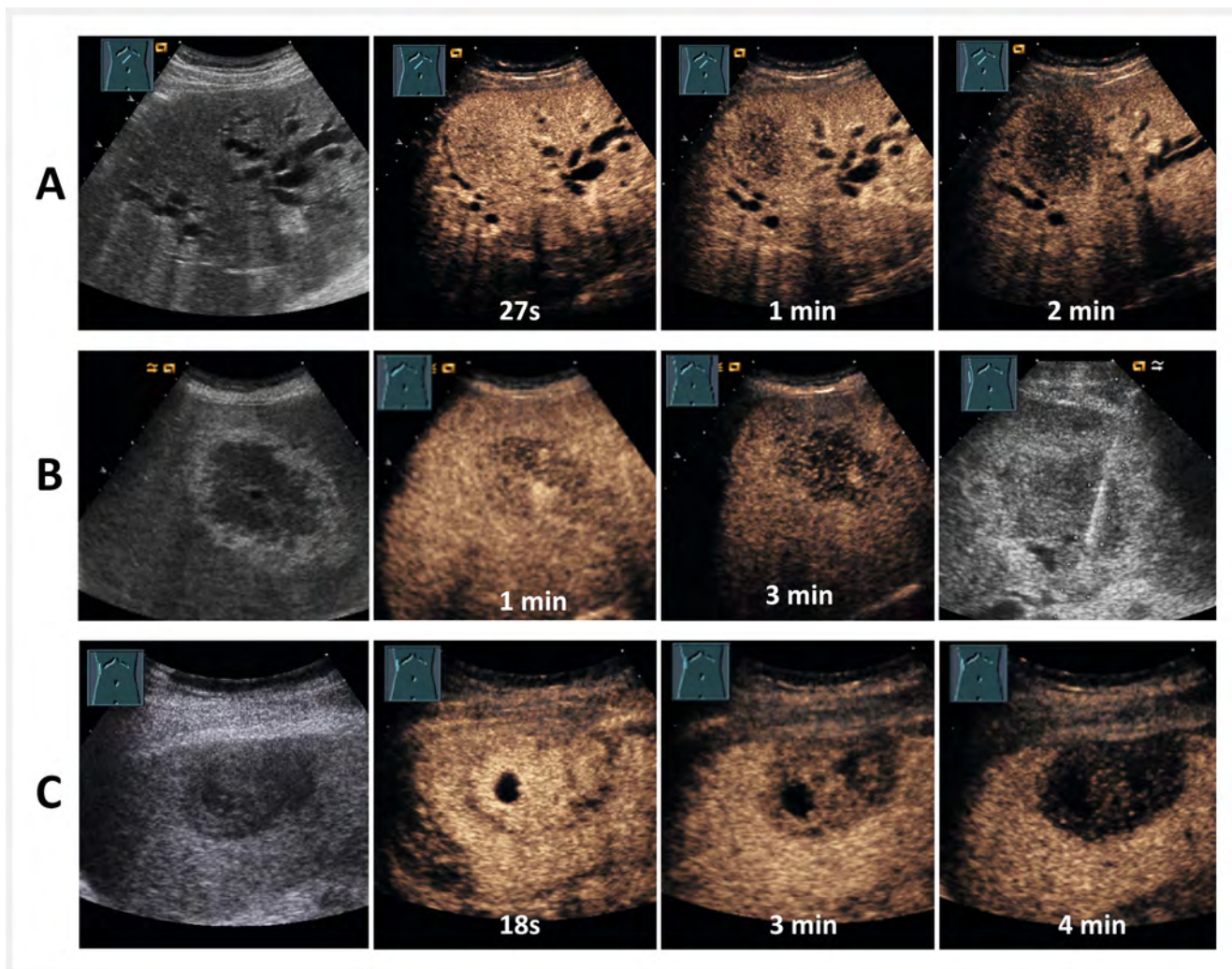
▶ **Fig. 10 A** 70-year-old patient with dilated bile ducts on B-mode US. CEUS shows a lesion with washout phenomenon consistent with non-liver tissue. Histology yielded a diagnosis of cholangiocellular carcinoma, **B**: 74-year-old patient with B-symptoms. B-mode US shows a hypoechoic space-occupying lesion with a hyperechoic outer wall. On CEUS the lesion shows a washout phenomenon consistent with non-liver tissue. Histology yielded the diagnosis of primary Hodgkin lymphoma of the liver, **C**: 44-year-old patient with elevated inflammatory parameters. B-mode US shows a hypoechoic lesion with an unclear etiology. On CEUS the lesion shows a washout phenomenon consistent with non-liver tissue. Histology yielded the diagnosis of chronic sclerotic granulomatous inflammation.

case of the latter pathology, the parenchymal washout phenomenon on CEUS may be due to localized inflammatory pylephlebitis of the smallest portal veins [38].

[40]. A further challenge when using CEUS is the fact that multiple lesions in the liver cannot be evaluated at the same time if the lesions do not appear in the same acoustic window [39].

3 Limitations

In general, CEUS as an examiner-dependent method compared to CT and MRI. Therefore, the diagnostic value depends on the experience and expertise of the examiner [39]. Moreover, ultrasound is characterized by a lack of overview compared to other cross-sectional imaging methods. As in B-mode US, deep regions sometimes cannot be visualized on CEUS due to significant sound absorption and regions of the liver and diaphragm cannot be imaged due to overlying gas in patients that are difficult to examine

4 Conclusion

CEUS is an established method for evaluating the status of focal liver lesions and should be used in the case of unclear lesions under consideration of the clinical background and the B-mode US and FDS findings. Under consideration of the limitations of ultrasound, CEUS is an equivalent alternative to imaging methods like CT and MRI in the evaluation of focal liver lesions and should be used as the primary imaging method given the lack of radiation and availability. The examiner must have sufficient competence to perform and interpret CEUS and be familiar with the indications,

limitations, contraindications, artifacts, and emergency treatment in the case of complications.

Conflict of Interest

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