Diagnostic approach to splenic lesions

Differenzialdiagnostik von Milzläsionen

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ABSTRACT

Background Splenic lesions are rare and mostly incidental findings on cross-sectional imaging. Most lesions are of benign nature and can be correctly identified based on imaging characteristics. Further, invasive evaluation is only necessary in cases of splenic lesions with uncertain or potentially malignant etiology.

Method While in most cases a correct diagnosis can be made from computed tomography (CT), (additional) magnetic resonance imaging (MRI) can aid in the identification of lesions. As these lesions are rare, only a few of the differential diagnoses are regularly diagnosed in the clinical routine.

Result and Conclusion This review presents the differential diagnoses of splenic lesions, including imaging characteristics and a flowchart to determine the right diagnosis. In conjunction with laboratory results and clinical symptoms, histological workup is necessary only in a few cases, especially in incidental findings. In these cases, image-guided biopsies should be preferred over splenectomy, if possible.

Key Points

- Splenic lesions are rare and are usually incidental findings on abdominal imaging
- CT imaging and MRI imaging are the diagnostic tools of choice for the further workup of splenic lesions
- Based on their image morphological characteristics, a large number of splenic lesions can be assigned to one entity and do not need histological analysis

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ZUSAMMENFASSUNG

Hintergrund Milzläsionen sind seltene und zumeist inzidentelle Befunde in der Schnittbildgebung. Der Großteil dieser Läsionen sind benignen Ursprungs und können korrekt anhand der Charakteristika in der Bildgebung identifiziert werden, nur in Fällen unsicherer oder potenziell maligner Ätiologie ist eine invasive weitere Abklärung notwendig.

Methode Während in den meisten Fällen die korrekte Diagnose anhand einer Computertomographie (CT) gestellt werden kann, kann eine (zusätzliche) Magnet-Resonanz-Tomographie helfen, die Läsion richtig zu identifizieren. Da diese Läsionen selten sind, werden nur einige der Differenzialdiagnosen regelmäßig im klinischen Alltag diagnostiziert.

Ergebnisse und Schlussfolgerung In diesem Übersichtsartikel werden die Differenzialdiagnosen von Milzläsionen erörtert, basierend auf den Charakteristika in der Bildgebung; ein Fließschema unterstützt in der Diagnosestellung. In Verbindung mit laborchemischen Ergebnissen und etwaigen Symptomen ist nur in wenigen Fällen eine histologische Sicherung notwendig, insbesondere bei Zufallsbefunden. In diesen Fällen sollte die bildgestützte Biopsie vor der Splenektomie bevorzugt werden.

Kernaussagen

- Milzläsionen sind selten und zumeist inzidentelle Nebenbefunde abdominaler Bildgebung.
- CT-und MR-Bildgebung sind die diagnostischen Mittel der Wahl zur weiteren Abklärung von Milzläsionen.
- Anhand ihrer bildmorphologischen Charakteristika lässt sich eine Vielzahl von Milzläsionen einer Entität zuordnen und benötigen keine histologische Abklärung.

Introduction

The incidence of splenic lesions is low, with 0.1–0.2 % [1] overall, especially in comparison to the incidence of liver lesions, with 15.1 % of patients having benign hepatic lesions [2]. Most are incidentally discovered and if needed, multimodality imaging is generally the first approach to characterize these lesions, with a spectrum of possible disease entities. In many of these cases, lesions are secondary to hematological, oncological, infectious, immunological, or vascular diseases. Therefore, knowledge of the patient's medical history is essential [3]. In the case of splenic lesions or splenomegaly, symptoms, if present, are nonspecific with abdominal pain, sometimes of colicky nature, fever or secondary symptoms due to anemia or thrombocytopenia.

While the majority of splenic lesions are benign in nature, undetermined or possibly malignant lesions might require histological workup after image-guided biopsy [4]. Image-guided biopsy should be preferred over splenectomy because it avoids long-term immunologic dysfunction related to complete removal of the spleen [5]. While complications especially hemorrhage are often feared, image-guided percutaneous biopsy has high diagnostic accuracy and complication rates similar to the regularly performed biopsies of the liver and kidneys [6, 7]. However, characteristic lesion patterns and imaging features should be recognized by radiologists. Integrated with clinical and laboratory findings these often enable diagnostic classification without the need for an invasive biopsy [8]. As primary malignant splenic tumors are highly aggressive, with a subsequently bad prognosis, the features indicative of malignant disease should be identified by the radiologist and guide decision for biopsies [4]. The aim of this review is to present the most common entities in splenic lesions and aid in their identification, with a systematic overview of differential diagnoses and their typical imaging features. While (contrast-enhanced) ultrasound can aid in the differentiation of splenic lesions, this review focuses on CT and MR imaging features.

The spleen

The spleen is a lymphatic organ of mesodermal origin and is divided into two histological compartments: red and white pulp, with the latter made up of T- and B-lymphocytes and the red pulp composed of tortuous venous sinuses [9]. Notches, clefts and accessory spleens (spleniculi) are normal variants and can be easily identified due to their identical signal intensity to splenic parenchyma in all sequences [4]. The absence of the spleen (asplenia) and the presence of more than one spleen (polysplenia) are rare and usually associated with other congenital abnormalities [10]. Focal splenic disease, however, has always been a challenge for radiologists and these lesions are often overlooked due to its low frequency [10].

Imaging of the spleen

Most often, splenic lesions are incidental findings on abdominal imaging, which only need a further workup in some cases. In our tertiary care university hospitals, an imaging protocol similar to the one used for the evaluation of hepatic lesions is used. For CT imaging, it comprises an arterial phase CT examination of the upper abdomen (triggered in the abdominal aorta), followed by a portal-venous CT scan of the entire abdomen including the pelvis after 80 s. For MR imaging, the protocol comprises an axial T2-weighted sequence, as well as a dual FFE, diffusion-weighted imaging with 3 b-values (50, 500 and 1000), an mDIXON with 4 time points (without contrast, arterial phase, venous phase, late phase), a coronal T2 with fat suppression, and an axial and coronal mDIXON after the application of contrast medium.

Cystic lesions

Exemplary cases of cystic lesions can be found in ▶ **Fig. 1**.

Cysts

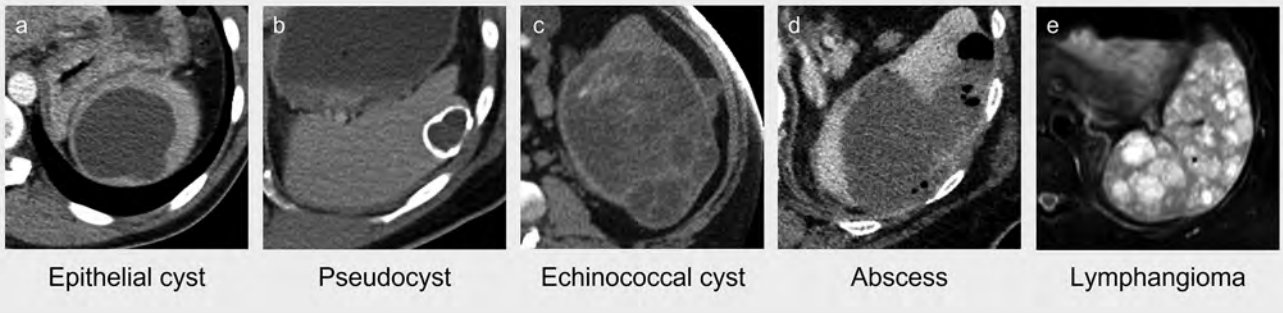
Cysts are the most common benign focal splenic masses [10]. Congenital cysts are lined with epithelial cells. They usually do not cause symptoms and are a typical incidental finding. On CT, an epidermoid cyst can be difficult to differentiate from pseudocysts [9]. The latter typically occur after a splenic trauma and are thought to be sequelae of prior hematoma. Pancreatic pseudocysts of the tail may also extend into the spleen. They can be differentiated from true cysts as they do not have an epithelial lining, but this can be difficult to depict on CT and MRI. In cases of a fibrous wall with possible calcifications, the diagnosis of a pseudocyst is easily made [9], while cyst wall trabeculation or peripheral septations are much more commonly found in true cysts [11]. The attenuation of both types of cysts is similar to water. They are thus hypointense on T1-weighted imaging and hyperintense on T2-weighted imaging. Cystic lesions are well-defined, round masses without enhancement on post-contrast images [12].

Echinococcus cyst

Splenic involvement in hydatid disease, which usually affects the liver or lungs, is rare, with fewer than 2 % of patients being affected [13]. It usually arises from systemic dissemination or intraperitoneal spread from a ruptured liver cyst. Therefore, most patients also have typical findings of hydatid disease in the liver. The appearance depends on the age of the cyst. They can be homogeneous, with attenuation equal to water, simulating a normal cyst. High attenuation occurs in cases of internal calcification or due to intracystic debris, hydatid sand, or inflammation. They often have small daughter peripheral cysts, giving it a wheel-like structure [13]. The water lily sign, occurring through the presence of collapsed membranes, is considered pathognomonic [14].

Lymphangioma

Lymphangiomas are most often found in soft tissues but can also occur in abdominal organs such as the liver, spleen, or gastrointestinal tract. They are benign, slow-growing tumors filled with lymphatic fluid [15] that can be divided into three histologic subtypes: simple lymphangiomas, cavernous lymphangiomas, and



▶ **Fig. 1** Exemplary cases of cystic lesions of the spleen. **a** CT in the portal venous phase with an epithelial cyst that presents as a homogeneous, sharply defined water-isodense lesion. **b** Contrast-enhanced CT in a late phase with a typical pseudocyst, easily identifiable through the calcified rim. **c** Non-contrast-enhanced CT of a hydatid cyst, with peripheral daughter cysts. The pathognomonic detached, irregular membrane (forming the water lily sign) can be faintly seen in the ventral part of the cyst. **d** CT in the portal venous phase with a large hypodense lesion that contains trapped air, typical for a focal abscess. **e** Fat-suppressed T2w MRI (STIR) with the typical appearance of a lymphangioma. Multiple hyperintense, coalescing lesions can be seen, giving it the typical "Swiss cheese" appearance.

▶ **Abb. 1** Beispielfälle von zystischen Läsionen der Milz. **a** CT in portalvenöser Phase mit einer Epithelzyste, die sich als eine homogene, scharf begrenzte, wasserisodene Läsion präsentiert. **b** Kontrastverstärktes CT in einer späten Phase zeigt eine typische Pseudozyste, die gut durch die randständige Kalzifikation identifiziert werden kann. **c** Natives CT mit einer Hydatidenzyste und den typischen Tochterzysten. Die pathognomonische abgelöste Membran (welche das Wasserlilienzeichen bildet) kann im ventralen Anteil angedeutet abgegrenzt werden.
d CT in portalvenöser Phase mit einer großen hypodensen Läsion und sichtbaren Lufteinschlüssen, typisch für einen fokalen Abszess. **e** Fettsupprimiertes T2w MRT (STIR) mit der typischen Erscheinung eines Lymphangioms. Multiple hyperintense, konfluierende Läsionen sind sichtbar, welche den Eindruck eines Schweizer Käses ergeben (Swiss cheese Sign).

cystic hygromas. Histologically, their structure is similar to hemangiomas [3]. Splenic lymphangiomas can be seen with lymphangiomatosis (rare) or systemic cystic angiomatosis (lymphangiomas and hemangiomas). They are usually subcapsular in location and on CT imaging, multiple non-enhancing large and small thin-walled cysts containing lymph-like clear fluid are present [10]. On MRI, well-circumscribed fluid-signal-intensity lesions are present on T2-weighted images. High signal intensity can be seen on T1-weighted imaging if there has been internal bleeding or if there is a large amount of intra-cystic proteinaceous material [9]. They are avascular and can give the spleen a "*Swiss cheese*" appearance [9].

Infectious lesions

Abscess

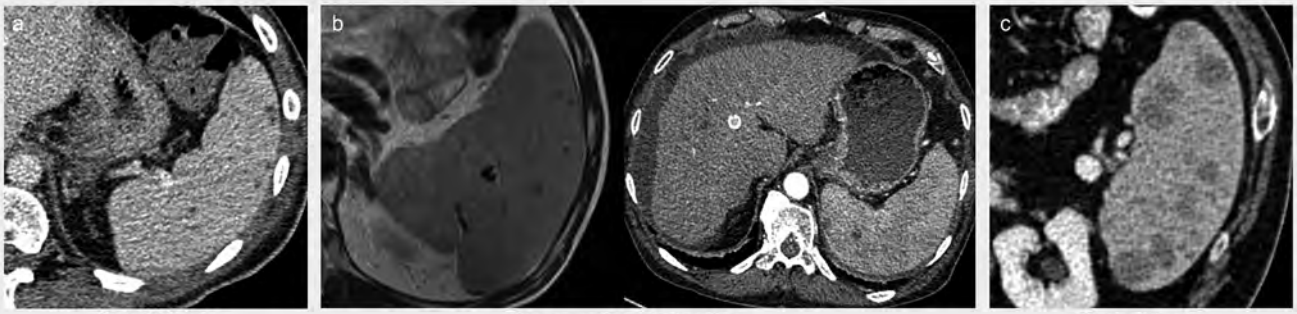
Splenic abscesses are a rather uncommon finding and have high mortality rates in cases of delayed detection [10]. Pyogenic abscesses are most commonly caused by hematogenous spread of infection, followed by penetrating trauma, and prior splenic infarction. They often occur as multiple lesions, often only 5–10 mm in diameter [9]. On MRI, they are typically hypointense on T1-weighted images and have a moderate to high signal intensity on T2-weighted images. On CT images, they are hypodense in all contrast phases. The margins are typically irregular and undefined, similar to abscesses in the liver parenchyma. Intralesional gas might be visible, which is easily depicted on CT images and can be identified as susceptibility artifacts on T1-weighted in- and out-of-phase sequences on MRI. The typical peripheral enhancement of abscesses is often only fairly visible due to the intense enhancement of the splenic parenchyma [16].

Tuberculosis

Splenic manifestations of tuberculosis are mostly caused by *Mycobacterium tuberculosis*, while atypical mycobacteria such as *Mycobacterium avium intracellulare* are much less common. Splenic involvement is typically found in widespread miliary tuberculosis [9]. Two different types of splenic tuberculosis are found – macronodular and micronodular, the latter is found in patients with miliary tuberculosis of the lungs. Splenic manifestations of this disease are very heterogeneous and nonspecific on CT and MRI. If very small calcifications are present, this leads to a typical *"starry sky"* appearance [3]. The macronodular subtype is rare, with singular or multiple splenic lesions, which are hypodense on CT [17].

Candidiasis

Candidiasis is an opportunistic infection that is found in immunocompromised patients and most frequently affects both the liver and the spleen. In critical patients, CT is the imaging method of choice, but MRI is superior to CT for the detection and characterization of splenic micro-abscesses that appear as multiple hyperintense lesions on T2-weighted images with peripheral ring enhancement [11, 18]. On either CT or MR images, occasionally tiny central foci of increased attenuation may be seen within, likely reflecting pseudo hyphae [19]. Other pathogens such as *Aspergillus* and *Kryptococcus* can cause similar splenic lesions [3]. Focal abscesses, however, are also possible (see above) [20]. An exemplary case of candidiasis can be found in ▶ **Fig. 2a**.



▶ **Fig. 2** Exemplary cases of solid splenic lesions that typically present with multiple lesions. **a** Candidiasis presents with multiple tiny lesions on portal venous CT. These occur in immunocompromised patients and they often also affect the liver. **b** T2w MRI without fat suppression and contrast-enhanced CT show tiny nodular lesions (smaller than 1 cm) that are hypointense on MRI and hypodense on CT scans that are typical of Gamna-Gandy bodies. They typically occur in patients with portal hypertension, which can be seen on the CT scan, with signs of liver cirrhosis and a TIPS in place. **c** Splenic manifestations of sarcoidosis on CT in the portal venous phase presenting with multiple hypodense lesions. The usually tiny nodular lesions coalesce and thus form larger lesions.

▶ **Abb. 2** Beispielfälle von soliden Milzläsionen die typischerweise mit multiplen Läsionen auftreten. **a** Die Candidose präsentiert sich mit kleinen hypodensen Läsionen in der portalvenösen CT-Bildgebung. Diese betrifft immunkomprimierte Patienten und es finden sich oftmals ebenso Manifestationen in der Leber. **b** T2w MRT ohne Fettsuppression und kontrastverstärktes CT zeigen winzige noduläre Läsionen (kleiner als 1 cm), die hypointens in der MRT und hypodens in der CT sind, typisch für Gamna-Gandy Körperchen. Diese treten vorrangig in Patienten mit portaler Hypertension auf, in der CT-Bildgebung zeigen sich typische Zeichen einer Leberzirrhose, mit einliegendem TIPS. **c** Sarkoidosiemanifestationen in der Milz in einem CT in portalvenöser Phase mit multiplen hypodensen Läsionen. Die typischerweise sehr kleinen nodulären Läsionen konfluieren und bilden damit größere Läsionen.

Solid lesions

Gamna-Gandy bodies

These siderotic nodules are foci of iron deposits that result from splenic microhemorrhages. They are seen in 9–12 % of patients with portal hypertension, which aids in differential diagnosis [9]. These nodules are usually smaller than 1 cm in size and hypointense on all sequences. A *"blooming"* artifact in T2*-weighted sequences is a typical finding [21, 22]. An exemplary case of Gamna-Gandy bodies can be found in ▶ **Fig. 2b**.

Sarcoidosis

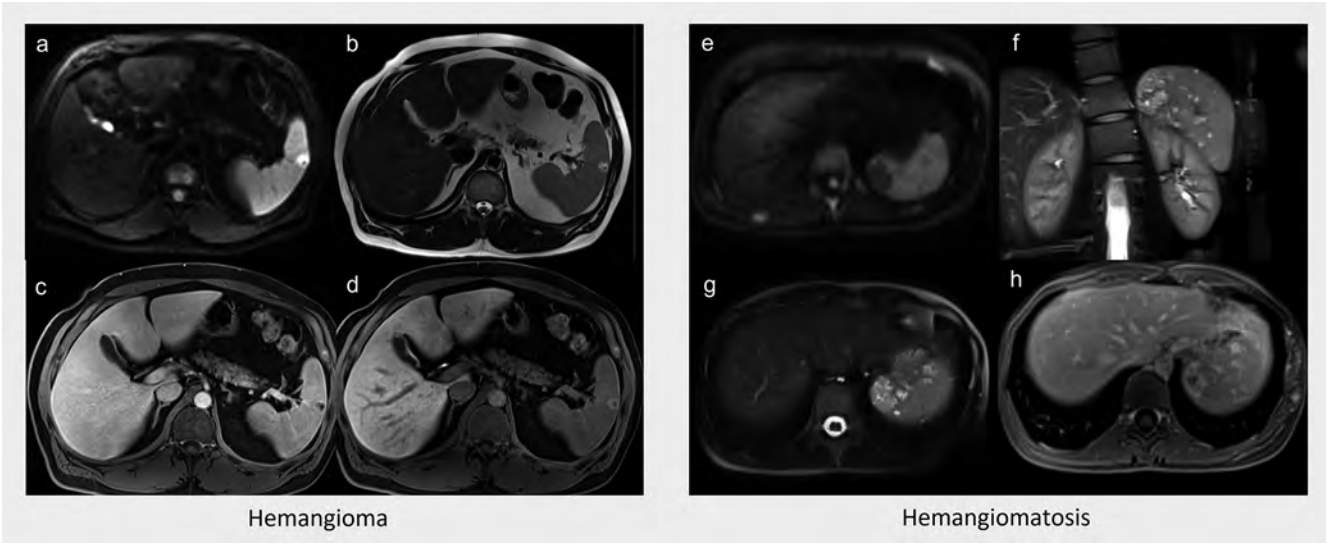
Sarcoidosis is a granulomatous systemic disease of largely unknown etiology, with the spleen being involved in 24–59 % of cases [23]. Nodular sarcoidosis appears as multiple, tiny hypovascular lesions with low signal intensity on all MRI sequences and with minimal enhancement on delayed contrast-enhanced images [10]. Sarcoid granulomas typically occur in the white pulp in association with the arterial circulation. They are often small but can coalesce to produce macroscopically visible nodules. On contrast-enhanced CT images, they are hypodense with respect to the splenic parenchyma, while they are most easily depicted on T2-weighted fat-suppressed images or early postcontrast images [24]. Radiologists must keep in mind that in 25–33 % of cases, chest X-ray does not show any abnormalities [16]. An exemplary case of splenic sarcoidosis can be found in ▶ **Fig. 2c**.

Peliosis

This entity is an infrequent benign disorder characterized by the presence of irregular cystic blood-filled cavities. The term originates from the Greek *pelios*, which means dusky or purple, referring to the macroscopic appearance of the lesion. Different causal associations have been identified including oral contraceptives, anabolic steroids, and chronic hematological disorders [25]. Most commonly, the liver and spleen are affected. Complications include spontaneous rupture of the hemorrhagic cysts, leading to life-threatening intraperitoneal hemorrhage [26]. It can be differentiated from hemangioma by blood-filled spaces that are randomly scattered in the red pulp, with preferential involvement of the parafollicular areas of the spleen. On non-contrast CT, they appear as hypoattenuating, possibly multiloculated lesions, often with well-defined septa [27]. After injection of contrast medium, the lesions demonstrate significant enhancement. Lobules and septa are often masked [26]. Fluid-fluid levels can also be visible and are thought to represent hematocrit levels that demonstrate enhancement in their dependent portions. MRI findings include a mixed signal on T1- and T2-weighted images attributed to the presence of deoxyhemoglobin and methemoglobin [26].

Extramedullary hematopoiesis

This occurs on a secondary basis as a compensatory response to deficient bone marrow cells and arises from pluripotential stem cells distributed throughout the body. It can occur in congenital hemolytic disorders, where it is mostly found adjacent to hematopoietically active bones. In patients with acquired marrow replacement disorders such as myeloproliferative diseases, the marrow space is nonfunctional and extramedullary hematopoiesis can



▶ **Fig. 3** Exemplary cases of splenic hemangiomas. MR imaging of a hemangioma (**a**–**d**, **a** diffusion-weighted imaging **b** T2w **c** contrast-enhanced T1w with fat suppression in an early venous phase, **d** contrast-enhanced T1w with fat suppression in a delayed phase) and multiple hemangiomas in a case of splenic hemangiomatosis (**e**–**h**, **e** diffusion-weighted imaging, **f** T2w with fat suppression in the coronal plane, **g** T2w with fat suppression in the axial plane, **h** contrast-enhanced T1 with fat suppression in delayed phase) show the typical appearance of a hemangioma, which is hyperintense on T2w and diffusion-weighted imaging, with centripetal fill-in of larger lesions and homogeneous enhancement of smaller lesions.

▶ **Abb. 3** Beispielfälle von Hämangiomen der Milz. MR-Bildgebung von Hämangiomen (**a**–**d**, **a** Diffusionswichtung **b** T2w **c** kontrastverstärkte T1w mit Fettsuppression in einer frühen venösen Phase **d** kontrastverstärkte T1w mit Fettsuppression in einer späten Phase) und multiple Hämangiome in einem Fall von Hämangiomatose der Milz (**e**–**h**, **e** Diffusionswichtung **f** koronale T2w mit Fettsuppression **g** axiale T2w mit Fettsuppression **h** kontrastverstärkte T1w mit Fettsuppression in einer späten Phase) zeigt das typische Erscheinungsbild von Hämangiomen, welche hyperintens in der T2w und in der Diffusionswichtung sind, mit zentripetaler Kontrastmittelanreicherung größerer Läsionen und homogenem Enhancement kleinerer Läsionen.

occur in organs such as the spleen or liver. It usually presents as a diffusely infiltrative mass but can also present as a focal mass-like lesion [28]. It is hypodense on CT imaging. On MRI, active lesions are isointense on T1-weighted images and hyperintense on T2-weighted images. They show variable enhancement on contrast-enhanced images [9], while in some reports, progressive enhancement in dynamic contrast-enhanced MRI was described [29]. Older, inactive lesions may be of low signal intensity on T1- and T2-weighted images without contrast enhancement, probably due to iron deposition [28].

Hemangioma

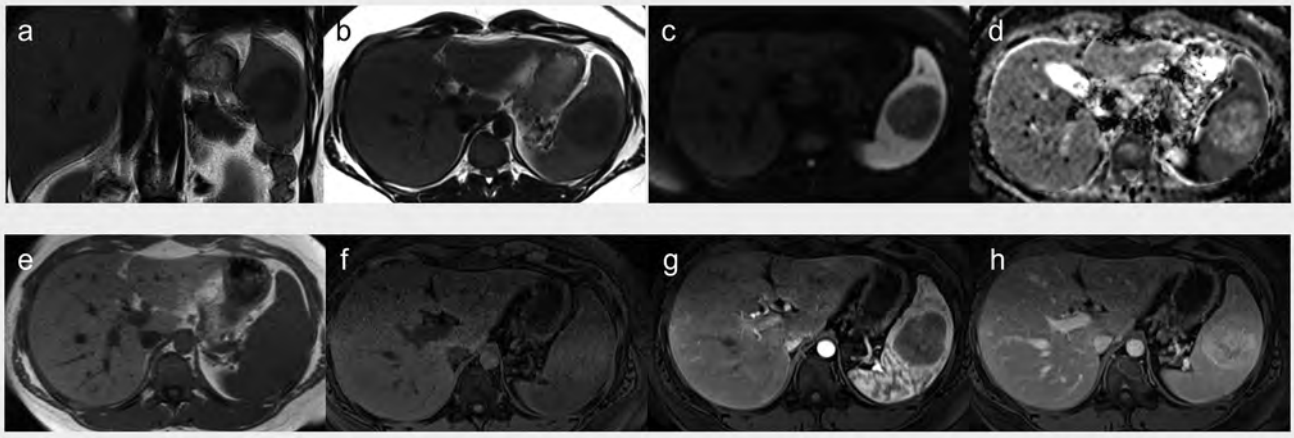
Although infrequent, hemangiomas are the most common benign neoplasm of the spleen. They are most often incidental findings and can occur as multiple lesions (also referred to as "splenic hemangiomatosis") [30]. Their imaging features are similar to hepatic hemangiomas, but in the spleen, they are often small in size and show calcifications. On CT imaging, they have a low attenuation on non-enhanced scans. After the administration of intravenous contrast agents, they show centripetal fill-in (from the periphery inward to the center). Larger lesions can fill incompletely and inhomogeneously [31]. On MRI, they are iso- to hypointense with respect to the splenic parenchyma on T1-weighted imaging, while they are hyperintense on T2-weighted imaging. After the administration of contrast medium, they demonstrate early nodular centripetal enhancement, with uniform enhancement on delayed images, while smaller lesions can show homogeneous enhancement and remain enhanced on delayed images [18] [32] [4]. Exemplary cases of hemangioma and splenic hemangiomatosis can be found in ▶ **Fig. 3**.

Littoral cell angioma

Littoral cell angioma is a rare, primary splenic hemangioma that appears in the red sinus shore cells of the reticuloendothelial system in the spleen. It can present as single or multiple lesions, often accompanied by splenomegaly [33]. It appears similar to angiosarcoma, lymphoma, or metastasis on imaging, making it necessary to confirm the diagnosis histopathologically [34]. Due to hemosiderin deposits in the nodules, the lesions are often hypointense on T1- and T2-weighted images [27]. The treatment of choice is splenectomy.

Hamartoma

Hamartomas are also uncommon benign nodular malformations of the spleen. They are tumor-like proliferations of the cells and tissues of the normal spleen, containing red and white pulp [35]. They can appear heterogeneous due to hemorrhage or cystic changes. On CT imaging, they appear iso- or hypodense with heterogeneous contrast enhancement. On MRI, they are mostly isointense on T1-weighted imaging, while they are typically heterogeneously hyperintense on T2-weighted imaging. After the application of contrast medium, they show vivid enhance-



▶ **Fig. 4** Exemplary case of a histologically proven sclerosing angiomatoid nodular transformation of the spleen (SANT). MRI imaging (**a** coronal T2w, **b** axial T2w, **c** diffusion-weighted imaging, **d** apparent diffusion coefficient, **d** T1w **f** T1w with fat suppression, **g** contrast-enhanced T1w with fat suppression in the arterial phase, **h** contrast-enhanced T1w with fat suppression in the venous phase) of an SANT shows the typical appearance, with a well-circumscribed splenic lesion, hypointense in T2w, isointense in T1w, with progressive enhancement in delayed images after the injection of contrast medium, a hypoenhancing central scar, and enhancement of the vascularized tissue, resulting in a "spoked wheel" pattern.

▶ **Abb. 4** Beispielfall einer histologisch gesicherten "Sclerosing Angiomatoid Nodular Transformation of the Spleen" (SANT). MR-Bildgebung (**a** coronale T2w, **b** axiale T2w, **c** Diffusionswichtung **d** apparent diffusion coefficient **d** T1w **f** T1w mit Fettsuppression **g** kontrastverstärkte T1w mit Fettsuppression in arterieller Phase **h** kontrastverstärkte T1w mit Fettsuppression in venöser Phase) einer SANT zeigt das typische Erscheinungsbild, mit einer umschriebenen Milzläsion, hypointens in der T2w, isointens in der T1w, mit einer zunehmenden Anreicherung in späteren Phasen nach Injektion von Kontrastmittel, mit einer hypointensen zentralen Narbe und Anreicherung des vaskularisierten Gewebes, was zu einem Speichenrad-Muster führt.

ment immediately after injection. On delayed postcontrast images, they enhance relatively uniformly with central hypovascular areas [36].

Sclerosing angiomatoid nodular transformation of the spleen (SANT)

SANTs are rare non-neoplastic vascular lesions of uncertain etiology that are a fibrosing variant of hamartoma. On CT scans they appear as well-circumscribed lesions with smooth or lobular borders that show a hypovascular center with an enhancing rim and radiating vascularized tissue penetrating from the periphery toward the center of the lesion [36]. On delayed imaging, progressive central enhancement can be observed, penetrating the center of the lesion from the vascular rim, described as a *"spoked wheel"* pattern [37]. On MRI, they are heterogeneous and hypo- to isointense on T1-weighted imaging, while they are hypointense on T2-weighted imaging. After the administration of contrast medium, similar enhancement to that of CT scans is found, with a central hypoenhancing stellate scar [37]. An exemplary case of SANT can be found in ▶ **Fig. 4**.

Other benign differential diagnoses

Radiologists also have to keep other rare differential diagnoses in mind that primarily occur in other locations, but can also have manifestations in the spleen, including solitary fibrous tumors, teratoma, myelolipoma, lipoma and angiomyolipoma, fibroma, myxoma, chondroma, and even osteoma. A very rare entity is the inflammatory pseudotumor which can mimic lymphoma and is therefore challenging to diagnose on imaging [38].

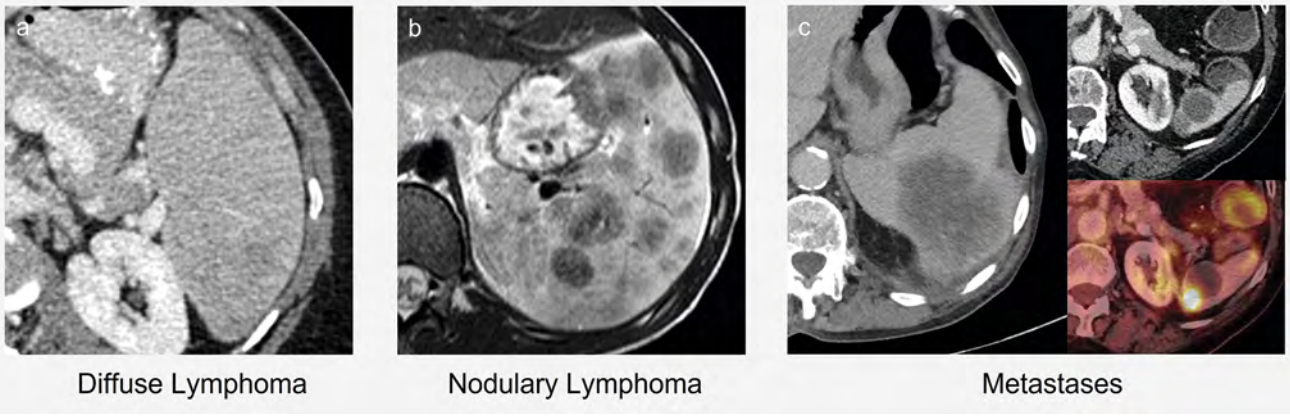
Malignant solid lesions

Lymphoma

Primary splenic lymphoma is usually diffuse large B-cell lymphoma (DLBCL), but splenic involvement can also occur in other types of lymphoma. The most common is splenomegaly, but a regular-sized spleen does not exclude splenic involvement in lymphoma patients. On CT scans, manifestations are hypodense compared to the splenic tissue after the administration of contrast medium, and calcifications may be seen after therapy. On MRI scans, these lesions are hypo- to isointense on T1- and T2-weighted imaging. After the administration of contrast medium, they only show mild enhancement. As is typical for lymphomas, they exhibit diffusion restriction on diffusion-weighted imaging [18, 36, 39]. Examples of diffuse and nodular lymphoma can be found in ▶ **Fig. 5a, b**, respectively.

Angiosarcoma

While angiosarcomas from other locations can metastasize to the spleen, there are also primary splenic angiosarcomas. Although rare, they are the most common primary non-hematolymphoid splenic malignancy and they have a very aggressive nature [36, 40, 41]. On CT scans, solitary or multiple masses are visible with



▶ **Fig. 5** Exemplary cases of malignant splenic lesions. **a** Diffuse lymphoma of the spleen on a portal venous CT scan presenting with splenomegaly. **b** Nodular lymphoma with numerous nodular lesions that are hypointense on T2w MRI and a resulting splenomegaly. **c** Metastases in the spleen occur in widespread metastatic disease, in a variety of different entities. Examples of two different patients with splenic metastases are shown: on the left a diffuse large hypodense metastasis of a patient with a tongue carcinoma on a contrast-enhanced scan in the venous phase, while the PET CT with the corresponding contrast-enhanced CT on the right side shows a metastatic lesion of a patient with a malignant melanoma presenting as a homogeneous hypodense lesion with vivid FDG uptake (SUV max. 19.9) next to a simple epithelial cyst.

▶ **Abb. 5** Beispielfälle von malignen Milzläsionen. **a** Die diffuse Lymphommanifestation in der Milz in einem venösen CT zeigt sich als Splenomegalie. **b** Noduläres Lymphom mit diversen nodulären hypointensen Läsionen in einer T2w MRT und einer konsekutiven Splenomegalie. **c** Metastasen in der Milz sind ein Ausdruck einer disseminierten Metastasierung unterschiedlicher Entitäten. Beispiele von zwei verschiedenen Patienten mit Milzmetastasen: auf der linken Seite ein Patient mit einer diffusen, großen hypodensen Metastase eines Zungenkarzinoms in venöser Phase, während das PET CT mit dem korrespondierenden kontrastverstärkten CT auf der rechten Seite eine metastatische Läsion von einem Patienten mit einem Malignen Melanom zeigt, welche sich als eine hypodense Läsion mit einem kräftigen FDG-Uptake (SUV max. 19.9) angrenzend an eine simple Epithelzyste präsentiert.

necrotic and hemorrhagic areas [36] and an irregular and poorly defined border [42]. Subcapsular bleeding or even a hemoperitoneum can be present. After the administration of contrast medium, they show strong peripheral enhancement with irregular margins. However, they can also present as micronodular involvement of the organ [42], making it more difficult to diagnose. On MRI, angiosarcomas are hypointense on T1- and T2-weighted imaging compared to the splenic parenchyma, with possible areas of increased signal intensity due to subacute hemorrhage or necrosis. After the injection of contrast medium, these tumors present as heterogeneous masses with intense multinodular enhancement and focal non-enhancement in areas of necrosis and hemorrhage [43].

Hemangioendothelioma

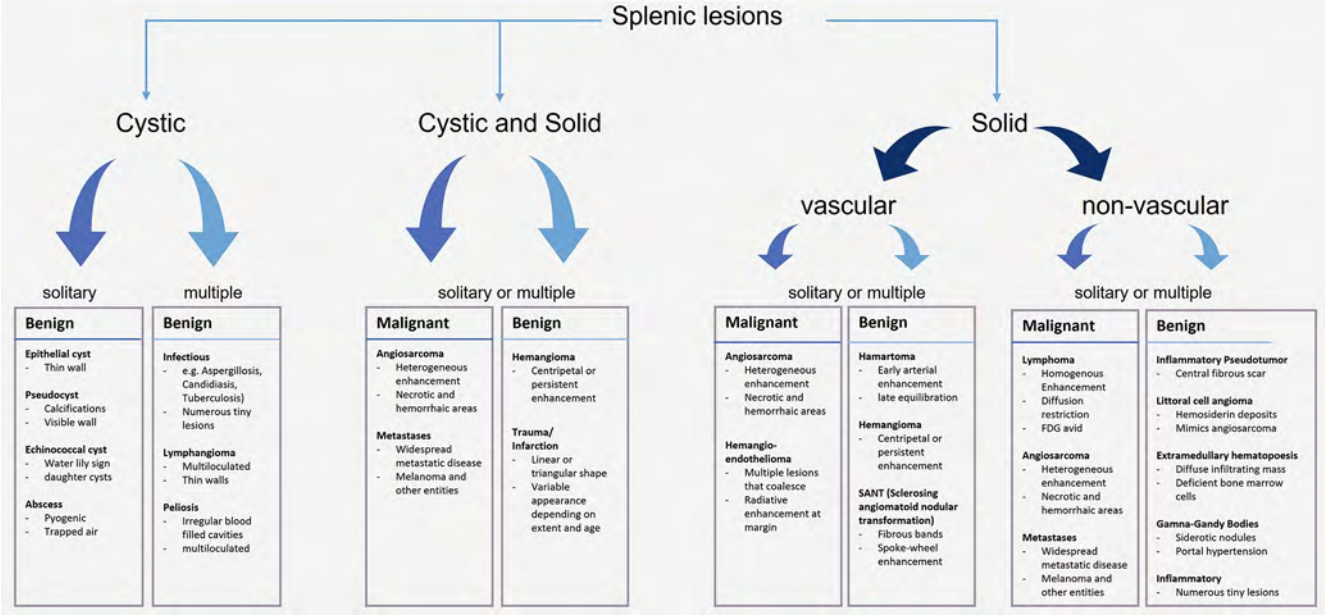
These tumors are low- to intermediate-grade malignant vascular tumors that can arise at different locations including the spleen and can metastasize systemically [44]. There are no distinct imaging features. Therefore, a biopsy is often necessary to determine the diagnosis. They typically appear as hypodense lesions on CT images, while on MRI, they appear hypointense on T1-weighted imaging and hyperintense on T2-weighted imaging [44]. There are often multiple lesions that coalesce to form larger confluent tumor regions. Circular, radiative enhancement at the margin can be seen with delayed enhancement in the center [45].

Metastases

Splenic metastases are typically part of a widespread metastatic disease. They are mostly solitary solid or cystic masses [46]. Primary sources include a variety of entities. The most common splenic metastases are from malignant melanoma, but also from breast, ovarian and colorectal cancer, as well as endometrial carcinoma and gastric and lung cancer [36, 46, 47]. On CT imaging, they are hypodense with possible cystic components. On MRI, they show a low signal intensity on T1-weighted images and a high signal intensity on T2-weighted images, with variable contrast enhancement depending on the primary malignancy [36]. Two examples of splenic metastases can be found in ▶ **Fig. 5c**.

Other malignant tumors that can occur primarily in the spleen

There are a number of other rare malignancies that may also occur primarily in the spleen and usually have to be identified in combination with an image-guided biopsy. These are primarily sarcomas including undifferentiated pleomorphic sarcoma (previously malignant fibrous histiocytoma), Kaposi sarcoma, and leiomyosarcoma.



▶ **Fig. 6** Flowchart of a diagnostic approach for the most important splenic lesions in the clinical routine, based on appearance on imaging.

▶ **Abb. 6** Flow Chart für einen diagnostischen Ansatz zur Diagnostik von Milzläsionen in der klinischen Routine basierend auf den Eigenschaften in der Bildgebung.

Conclusion

In this review, the most important differential diagnoses of splenic lesions were presented with their typical appearance on CT and MR imaging. The flowchart (▶ **Fig. 6**) can aid in the diagnostic workup in the clinical routine, which often makes it possible to diagnose incidental findings in the spleen. However, if the diagnosis still remains unclear after the extraction of imaging features in conjunction with laboratory and clinical findings, an image-guided biopsy should be preferred over splenectomy.

Conflict of Interest

The authors declare that they have no conflict of interest.

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