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Impact of Various Fatty Liver Imaging Patterns on Early Fibrosis Detection: A Review of MRI, CT, and Ultrasound Studies

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Abstract
Objective: To assess the effects of various fatty liver imaging patterns on the early identification of hepatic fibrosis in investigations using magnetic resonance imaging (MRI), computed tomography (CT), and ultrasound.
Methods: A comprehensive assessment of radiological and clinical literature was carried out, with an emphasis on studies that linked histologically verified fibrosis with imaging findings of hepatic steatosis. We examined publications that looked at patterns of diffuse and atypical fat distribution, such as subcapsular, perivascular, geographic, and localized steatosis. Particular focus was placed on the impact of heterogeneous fat deposition on image interpretation, limits in early fibrosis diagnosis, and modality-specific diagnostic performance.
Results: Although diffuse steatosis can usually be detected with any imaging modality, unusual or heterogeneous fat patterns can make diagnosis more difficult. Despite being widely available and sensitive for moderate-to-severe steatosis, ultrasound is not very reliable in identifying early fibrotic remodeling when fatty infiltration changes the echotexture of the liver. Because density changes overlap, fibrosis in fat-dominant livers may be underestimated by CT attenuation-based evaluation. Superior tissue characterisation and enhanced distinction between fibrosis and steatosis are provided by MRI techniques, especially chemical-shift imaging and quantitative fat fraction mapping. However, it may still be difficult to identify mild early fibrosis noninvasively, particularly in livers that are highly steatotic.
Conclusions: The identification of early fibrosis is greatly impacted by variations in fatty liver imaging patterns. CT and ultrasound are not always able to detect early fibrotic change, although MRI shows better diagnostic accuracy than both of these techniques. Clinical risk assessment in conjunction with a pattern-aware, multimodal imaging strategy may improve patient classification and early diagnosis.
Keywords: MRI, CT, ultrasound, liver fibrosis, hepatic steatosis, and fatty liver disease early identification; patterns in imaging; Non-invasive evaluation

I. Introduction

An estimated 25–30% of persons worldwide suffer from nonalcoholic fatty liver disease (NAFLD), which is now frequently referred to as metabolic dysfunction–associated fatty liver disease (MAFLD). It includes a range of conditions, from simple steatosis (fat buildup) to nonalcoholic steatohepatitis (NASH), which can lead to cirrhosis and hepatocellular cancer. The best histologic indicator of unfavorable outcomes in NAFLD is the stage of fibrosis. For instance, patients with stage 4 fibrosis have demonstrated an approximately 11-fold increase in liver-related mortality and a 3.4-fold increase in all-cause mortality compared to those without fibrosis. However, imaging is being used more and more for noninvasive staging because liver biopsy, the gold standard, is invasive and prone to sample error. In this review, we look at how various hepatic fat patterns on magnetic resonance imaging (MRI), computed tomography (CT), and ultrasound (US) affect the early diagnosis of fibrosis. We go over typical distribution patterns of steatosis, how they present on imaging, and how they could help or hinder the use of sophisticated imaging modalities to assess early fibrosis.

II. The Pathophysiology of Fibrosis and Steatosis and their Significance

Excessive triglyceride buildup in hepatocytes (>5% of cells) without significant alcohol usage is the hallmark of fatty liver disease. NAFLD may be genetically driven (e.g., PNPLA3, TM6SF2 polymorphisms) or "metabolic" (linked to obesity and insulin resistance). The prognosis is significantly worsened by progression to NASH and fibrosis, regardless of the source. Imaging attempts

to noninvasively approximate fibrosis staging (0–4), which is typically done on biopsy. Unfortunately, neither laboratory tests nor conventional imaging fully quantify steatosis, inflammation, or fibrosis. Therefore, it's crucial to comprehend how fat is distributed in the liver and how it shows up on imaging because some patterns can resemble lesions or mask early fibrotic alterations.

III. Imaging Techniques for Fibrosis and Hepatic Steatosis

Steatosis can be detected with standard B-mode ultrasonography, CT, and MRI (typically with chemical-shift or proton-density fat fraction techniques). The benefits and limitations of each modality are distinct. Widely accessible, ultrasound is sensitive to moderate-to-severe steatosis (80–90% sensitivity for ≥33% hepatocytes involved); however, it performs worse for mild fat. In addition to attenuating the ultrasound beam and obscuring intrahepatic arteries, fatty liver appears hyperechoic (bright) on ultrasonography as compared to the kidney. While fat detection is improved by this enhanced echogenicity, deeper structures may become obscured, making mild fibrosis more difficult to see.

Steatosis is shown by CT as decreased liver attenuation (usually ≥10–25 HU lower than spleen or ≤40 Hounsfield units). While CT is generally insensitive to mild steatosis (pooled sensitivity ~46%, specificity ~93%), it is very specific (severe fat is obviously hypodense). The most precise quantitative method for measuring fat is MRI with proton-density fat fraction (PDFF) or spectroscopy; meta-analyses show that MRI has a sensitivity of about 82% and a specificity of about 90% for steatosis. Furthermore, liver stiffness for fibrosis is measured using elastography techniques (based on ultrasound or MRI); for instance, MRI elastography (MRE) has a 91% specificity and a ~86% sensitivity for detecting advanced fibrosis (≥F3), although it has a limited capacity to detect mild (F1–2) fibrosis. Key performance characteristics are compiled in Table 1.

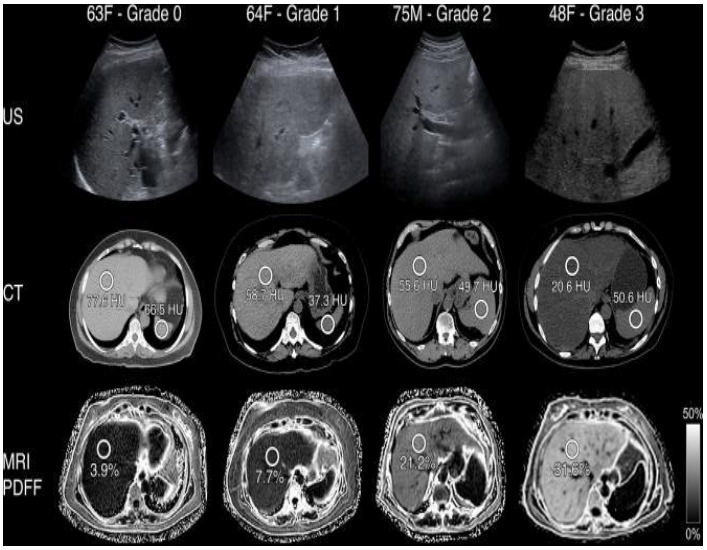

Figure 1 shows MRI, CT, and ultrasound images of hepatic steatosis. Images from MRI-PDFF (row 3), CT (row 2), and ultrasound (row 1) are displayed for steatosis grades 0 (none) to 3 (severe). Unenhanced CT reveals decreasing liver attenuation (darker parenchyma) while spleen attenuation stays greater; MRI PDFF values rise (showing more fat); and ultrasound indicates gradually increased liver echogenicity and blurring of arteries as the steatosis grade increases from left to right. These show how the fat burden is reflected in each modality.

Modality / Technique	Steatosis Detection	Fibrosis Detection (Early)	Advantages / Limitations
Ultrasound (B-mode)	Moderate to severe steatosis has a sensitivity of about 70–90% and a specificity of about 80–90%. When	Sensitivity for early fibrosis is poor, at about 50–60%. Fibrosis cannot be staged unless the cirrhosis is advanced (nodular surface, smaller liver on US).	Broadly accessible, inexpensive, and radiation-free. Operator- and BMI-dependent; limited sensitivity for moderate fibrosis and

	compared to the kidney or spleen, a bright liver on B-mode indicates fat.		mild steatosis due to beam attenuation by fat.
Ultrasound Elastography (Transient/SWE)	Fat (qualitative brightness only) is N/A.	Good for NAFLD patients with moderate-to-advanced fibrosis (≥F2). Technology-specific sensitivity and specificity vary; fibrosis-induced stiffness rise can be detected.	Portable and real-time. Operator-dependent and less effective in cases of extreme obesity or steatosis.
CT (unenhanced / contrast)	Specificity: ~88–94%, sensitivity: ~46–72% (poor for moderate fat). A hypodense appearance is indicative of a fatty liver (attenuation <40 HU or liver–spleen differential ≥10–25 HU).	Ability to recognize advanced stages of fibrosis morphologic symptoms, such as splenomegaly, surface nodularity, and lobar atrophy/hypertrophy. ≥F2 fibrosis, including pre-cirrhosis, can be identified using new quantitative CT scores (liver surface nodularity index, caudate–right lobe ratio).	Measures liver density and evaluates the entire organ. Ionizing radiation, insensitivity to moderate fat, and confusion by iron and contrast are the drawbacks. New technology (dual-energy, photon-counting CT) could make it easier to quantify fat and fibrosis.
MRI (chemical-shift, PDFF)	MRI (PDFF, chemical-shift)for any steatosis, the highest sensitivity (~82–97%) and specificity (~89–95%). Fat is shown by a signal drop on out-of-phase imaging. PDFF provides an exact fat percentage.	The best method for staging fibrosis is MRE, which has a 91% specificity and a ~86% sensitivity for identifying advanced fibrosis (≥F3). Other MRI metrics, including as diffusion and T1 mapping, are being investigated.	No radiation, best for measuring fat and fibrosis (using MRE). Cost, scan time, and the requirement for certain sequences are the limitations. MRE is not always accessible and is less dependable at the early fibrosis threshold.

IV. Imaging Patterns of Hepatic Steatosis

Diffuse or localized patterns are common for the accumulation of fat in the liver. Fat is usually macrovesicular in histology, and imaging shows both uniform involvement and regional variation. Understanding these trends can help prevent incorrect diagnoses (such as confusing fat for a tumor) and may also reveal underlying medical conditions. Among the primary patterns are:

4.1 Diffuse Steatosis

The most prevalent pattern, diffuse steatosis, has fat dispersed uniformly throughout the liver parenchyma. The liver exhibits homogenous signal-drop on out-of-phase MRI, diffuse hypodense on CT, and uniform hyperechoic on US imaging (see Figure 1). Either quantitative mapping (CT or MRI) or echotexture can be used to grade diffuse steatosis. Crucially, generalized steatosis by itself does not always signify inflammation; nevertheless, when paired with hepatomegaly and an elevated caudate-to-right-lobe volume ratio, it raises suspicions of steatohepatitis (NASH). Radiologists should be aware that modest fibrotic abnormalities may be obscured by a very bright (hyperechoic) liver on US.

4.2 Geographic (Segmental) Steatosis

Fat restricted to an area or lobe, usually in the right lobe or in the surgical or biliary planes, is known as geographic (segmental) steatosis. When imaging reveals patchy involvement, the surrounding parenchyma is less fatty, and the affected area may appear as a wedge or dome-shaped area that decreases signal on opposed-phase images (Figure 2a–c). Sometimes, changed portal inflow is followed by segmental steatosis. For instance, if the right lobe receives its supply from the superior mesenteric (or alimentary venous) return, fat may deposit preferentially there. Additionally, geographic fat may develop in areas that have already been injured (for example, during resection or cholangitis). It's critical to identify geographic steatosis since, if asymmetrically spread, it can resemble localized lesions.

4.3 Focal fatty infiltration

Localized, usually wedge-shaped patches of steatosis imbedded in a normally functioning

liver. These usually occur around the porta hepatis, in the medial segment close to the falciform ligament, and in the gallbladder fossa. They have distinct borders and no mass effect, allowing vessels to pass past them normally. They show up as tiny hypodense areas on CT scans, and on MRIs, they are isointense or hypererintense on in-phase sequences and drastically lose signal on opposed-phase (fat) sequences. The majority of localized fatty lesions have minimal to no histological fibrosis and are benign steatosis. To establish fat content, however, rigorous evaluation—often using MRI—is required because they can mimic malignancies. In limited pathologic series, only a small percentage of focal lesions showed any fibrosis, and localized fat has not been substantially associated with early fibrosis.

4.4 Perivascular or Perivesicular Sparing

Even when the liver is fatty overall, a portion of the liver, such as the area around the gallbladder and perivascular areas, may not be fat. On the other hand, fat can accumulate in the perihepatic regions. These occurrences are explained by alternate venous drainage, such as Sapey's veins, which supply these zones with reduced portal flow and, consequently, lipids. CT/MRI displays these spared zones as regions without signal decrease, while ultrasound displays them as relative hypoechoic streaks in an otherwise bright liver. These sparing patterns might complicate the sonographic look of steatosis and should be noted even if they do not directly imply fibrosis (they are benign perfusion variants).

4.5 Subcapsular and multifocal steatosis

Small nodular fat deposits may develop directly under the liver capsule or dispersed throughout the parenchyma in cases of subcapsular and multifocal steatosis. Subcapsular fat frequently manifests as small hypodense (CT) or hyperechoic (US) foci around the liver. Multiple round echogenic nodules on US or equivalent CT/MRI signal dips are symptoms of multifocal steatosis, also known as "multinodular fatty infiltration." Once more, MRI fat-water imaging is essential to distinguish benign fat from malignancies since these multifocal lesions might closely resemble metastases. There is no proof that fibrosis is caused by these small focused fatty deposits; rather, they are a reflection of the same metabolic mechanism that produces diffuse fat.

In conclusion, diffuse versus regional (geographic), focal, sparing, and multifocal nodules are among the imaging patterns associated with fatty liver. The appearance of increased fat burden across modalities is illustrated in Figure 1. To prevent misunderstandings and to make sure that fatty areas are not confused for pathologic lesions, radiologists should be aware of these patterns.

V. Impact of Fat Patterns on the Identification of Fibrosis

Imaging visibility of fibrotic alterations can be affected by fat distribution. By enhancing overall echogenicity and attenuation, diffuse steatosis may obscure minute textural indicators of fibrosis. For instance, the thicker liver capsule or early surface nodularity of fibrosis may be more difficult to see on ultrasonography or CT in livers that are very steatotic. A bright, fatty liver reduces the penetration of ultrasound beams because it loses energy. Fibrotic septa or tiny regenerative nodules might therefore be less noticeable. On the other hand, significant fat can accentuate symptoms of hepatomegaly or enlargement of the caudate lobes, which are indirect indicators of NASH and fibrosis.

Sampling is also impacted by focal or regional steatosis; depending on heterogeneity, a biopsy or elastography measurement that takes a sample of a fatty area may underestimate or overestimate fibrosis. Measurements in isolated fat areas, in particular, may be misleadingly comforting since they do not exhibit histological fibrosis. Areas of fat seem hypodense on CT, which can make morphometric fibrosis scores more difficult to interpret. Certain CT fibrosis indices, such as the caudate–right-lobe ratio and liver surface nodularity, depend on changes in the shape and volume of the liver. Parenchymal shrinkage or changes in segmental volume may indicate both fibrosis and fat distribution in extremely fatty livers. To precisely identify fibrotic remodeling, advanced CT biomarkers (contrast-enhanced iodine quantification, extracellular volume maps) are being investigated.

When it comes to detecting fibrosis, MRI is less impacted by fat, particularly when elastography is used. PDFF separates the fat and water signals, and MRE measures stiffness regardless of fat level. Actually, an MRI can measure fibrosis and fat in the same test. Some MRI approaches (such as T1 mapping and corrected T1) try to capture the combined influence of fat, inflammation, and fibrosis. Recent studies, for instance, reveal that MRE predicts advanced fibrosis with ~86% sensitivity. Although extra fat can attenuate the shear wave signal and has been observed to marginally affect accuracy, ultrasound-based elastography (such as transient elastography or shear wave) can noninvasively stage fibrosis. In general, it is still difficult to identify early fibrosis (F1–F2) using any imaging modality unless it is paired with sophisticated methods or serial monitoring.

VI. Advances and Innovative Methods

The detection and measurement of liver fat (steatosis) and fibrosis are being revolutionized by recent developments in artificial intelligence and imaging technology. Clinicians can now detect subtle tissue changes considerably earlier and more accurately thanks to emerging quantitative and AI-driven techniques, whereas traditional imaging methods mainly concentrated on apparent structural changes.

The use of FibroScan's Controlled Attenuation Parameter (CAP), which measures the attenuation of ultrasound waves as they travel through liver tissue and offers a noninvasive method of estimating liver fat, is one significant advancement. Furthermore, cutting-edge quantitative ultrasonography methods including backscatter analysis and attenuation coefficient measurement are being investigated to increase the precision and dependability of fat detection.

The technology of computed tomography (CT) has also advanced dramatically. By more successfully differentiating fat from other liver components than traditional CT, dual-energy CT and photon-counting CT improve tissue characterization. Beyond basic eye evaluation, new research techniques that analyze minute patterns in imaging data include radiomics and CT texture analysis. These methods can identify early fibrotic alterations that conventional morphological evaluation could miss.

Liver imaging is becoming more and more dependent on artificial intelligence. On CT images, deep learning algorithms have been trained to automatically segment the liver and efficiently determine the hepatic fat fraction. In order to potentially eliminate the need for invasive liver biopsies, neural networks are also being investigated in pilot experiments to assess liver fibrosis using standard CT images.

Multiparametric procedures, which integrate many methodologies into a single comprehensive assessment, have significantly advanced magnetic resonance imaging (MRI). It is possible to combine techniques like Proton Density Fat Fraction (PDFF) imaging, MR elastography, and T1 and T2 relaxometry to provide comprehensive data regarding liver fat content, tissue stiffness, and general liver function. This integrated method improves disease monitoring and diagnosis by providing a more comprehensive view of liver health.

Modality	Steatosis Detection	Fibrosis Detection	Notes
Ultrasound (B-mode)	Sensitivity ~73% for ≥5% steatosis; ~90% for ≥33% fat. Bright liver echotexture and beam attenuation indicate fat.	Poor for mild fibrosis (sensitivity ~57%). Useful in established cirrhosis (nodularity, coarse echo).	Cheap and accessible; however, poor in obesity and operator-dependent. Cannot quantify fat accurately.
Ultrasound Elastography (TE, SWE, ARFI)	N/A for fat (only stiffness).	Good for ≥F2 fibrosis; e.g. FibroScan cutoff ~7–8 kPa for significant fibrosis.	Adds noninvasive staging; limited by obesity and steatosis for accuracy.
CT (unenhanced/contrast)	Moderate sensitivity (46–72%) with very high specificity (88–94%). Detects fat by decreased attenuation (e.g. liver HU < 40).	Indirect: can detect morphologic cirrhosis signs. New CT indices (surface nodularity score, volume ratios) can detect ≥F2 fibrosis with reasonable accuracy.	Widely available; quantifies liver density. Radiation exposure and limited sensitivity to mild changes. Advanced techniques (dual-energy, PCCT) under development.
MRI (PDFF)	Highest sensitivity (82–97%) and specificity (89–95%) for steatosis. Provides quantitative fat fraction.	MRI Elastography: ~86% sensitivity, 91% specificity for advanced fibrosis. Detects stiffness in early disease better than other imaging.	Gold standard noninvasive modality. No radiation. Limited by cost and availability.
MR Spectroscopy	Very high accuracy for fat quantification (95–100%).	Not used for fibrosis.	Research tool; not routine in clinical practice.

Table 1. The comparative effectiveness of the major imaging modalities in identifying hepatic fibrosis and steatosis. Estimates of sensitivity and specificity are combined from meta-analyses.

VII. Conclusion

Radiologists must be aware of the varied imaging patterns (diffuse, localized, regional, and sparing) associated with fatty liver disease. Even though these patterns don't necessarily indicate fibrosis, they do affect how fat and fibrotic alterations show up on imaging. In contrast to localized or nodular fat, which can occasionally cause needless workup, diffuse steatosis might obscure architectural elements of early fibrosis. While MRI (using PDFF and elastography) provides quantitative measurements of fat and stiffness and is the most sensitive for early fibrotic change, conventional ultrasonography and CT diagnose steatosis subjectively but miss moderate illness and early fibrosis. For instance, an ultrasound examination revealing a "bright liver" would trigger quantification using MRI-PDFF and potentially MR elastography if fibrosis is anticipated. In practice, combining modalities frequently results in the best evaluation.

The identification of early fibrosis in NAFLD is still difficult. Recent data indicates that imaging is more accurate in tracking fat and detecting advanced cirrhosis or fibrosis than it is in diagnosing F1–2 fibrosis. Future studies should concentrate on improving noninvasive imaging biomarkers (such as radiomics and AI) for subtle disease stages and establishing a connection between particular fat distribution patterns and the risk of fibrosis. In the interim, knowledge of fatty liver patterns might enhance the accuracy of diagnosis.

References

[1]. Anstee, Q. M., Targher, G., & Day, C. P. (2013). Progression of NAFLD to diabetes mellitus, cardiovascular disease or cirrhosis. *Nature Reviews Gastroenterology & Hepatology, 10*(6), 330–344.

[2]. Bravo, A. A., Sheth, S. G., & Chopra, S. (2001). Liver biopsy. *New England Journal of Medicine, 344*(7), 495–500.

[3]. Brunt, E. M., Janney, C. G., Di Bisceglie, A. M., Neuschwander-Tetri, B. A., & Bacon, B. R. (1999). Nonalcoholic steatohepatitis: A proposal for grading and staging the histological lesions. *The American Journal of Gastroenterology, 94*(9), 2467–2474.

[4]. Byrne, C. D., & Targher, G. (2015). NAFLD: A multisystem disease. *Journal of Hepatology, 62*(1), S47–S64.

[5]. Castera, L., Friedrich-Rust, M., & Loomba, R. (2019). Noninvasive assessment of liver disease in patients with NAFLD. *Gastroenterology, 156*(5), 1264–1281.

[6]. Chalasani, N., Younossi, Z., Lavine, J. E., et al. (2018). The diagnosis and management of nonalcoholic fatty liver disease: Practice guidance from the AASLD. *Hepatology, 67*(1), 328–357.

[7]. European Association for the Study of the Liver (EASL). (2016). EASL–EASD–EASO clinical practice guidelines for NAFLD. *Journal of Hepatology, 64*(6), 1388–1402.

[8]. Ferraioli, G., Wong, V. W.-S., Castera, L., et al. (2018). Liver ultrasound elastography: An update to the WFUMB guidelines. *Ultrasound in Medicine & Biology, 44*(12), 2419–2440.

[9]. Hernaez, R., Lazo, M., Bonekamp, S., et al. (2011). Diagnostic accuracy and reliability of ultrasonography for the detection of fatty liver: A meta-analysis. *Hepatology, 54*(3), 1082–1090.

[10]. Idilman, I. S., Keskin, O., Celik, A., et al. (2013). A comparison of liver fat content as determined by MRI, CT, and biopsy. *European Radiology, 23*(2), 417–425.

[11]. Kleiner, D. E., Brunt, E. M., Van Natta, M., et al. (2005). Design and validation of a histological scoring system for NAFLD. *Hepatology, 41*(6), 1313–1321.

[12]. Lee, S. S., & Park, S. H. (2014). Radiologic evaluation of NAFLD. *World Journal of Gastroenterology, 20*(23), 7392–7402.

[13]. Li, Q., Dhyani, M., Grajo, J. R., Sirlin, C. B., & Samir, A. E. (2018). Current status of imaging in NAFLD. *World Journal of Hepatology, 10*(8), 530–542.

[14]. Loomba, R., & Adams, L. A. (2020). Advances in non-invasive assessment of hepatic fibrosis. *Gut, 69*(7), 1343–1352.

[15]. Mancini, M., Prinster, A., Annuzzi, G., et al. (2009). Sonographic hepatic–renal ratio for diagnosing steatosis. *AJR American Journal of Roentgenology, 193*(3), 770–775.

[16]. Neuschwander-Tetri, B. A., Clark, J. M., Bass, N. M., et al. (2010). Clinical, laboratory and histological associations in adults with NAFLD. *Hepatology, 52*(3), 913–924.

[17]. Park, S. H., Kim, P. N., Kim, K. W., et al. (2006). Macrovesicular hepatic steatosis: CT assessment. *Radiology, 239*(1), 105–112.

[18]. Pickhardt, P. J., Malecki, K., Hunt, O. F., et al. (2017). Hepatic steatosis: Radiologic–pathologic correlation. *Radiology, 284*(3), 859–871.

[19]. Rinella, M. E. (2015). Nonalcoholic fatty liver disease: A systematic review. *JAMA, 313*(22), 2263–2273.

[20]. Rockey, D. C., Caldwell, S. H., Goodman, Z. D., et al. (2009). Liver biopsy. *Hepatology, 49*(3), 1017–1044.
[21]. Sanyal, A. J., Brunt, E. M., Kleiner, D. E., et al. (2011). Endpoints and clinical trial design for NASH. *Hepatology, 54*(1), 344–353.
[22]. Sasso, M., Beaugrand, M., de Ledinghen, V., et al. (2010). Controlled attenuation parameter (CAP). *Journal of Hepatology, 53*(6), 1092–1098.
[23]. Singh, S., Muir, A. J., Dieterich, D. T., & Falck-Ytter, Y. T. (2015). Role of elastography in chronic liver disease. *Gastroenterology, 149*(6), 1544–1577.
[24]. Sirlin, C. B., & Reeder, S. B. (2010). Magnetic resonance imaging quantification of liver iron and fat. *Radiology, 257*(3), 642–651.
[25]. Stine, J. G., et al. (2020). Change in MRI-PDFF and histologic response in NASH. *Clinical Gastroenterology and Hepatology, 19*(11), 2274–2283.
[26]. Tang, A., Desai, A., Hamilton, G., et al. (2015). Accuracy of MR imaging for detecting steatosis and fibrosis: Meta-analysis. *Radiology, 274*(2), 416–425.
[27]. Tsochatzis, E. A., Gurusamy, K. S., Ntaoula, S., et al. (2011). Elastography meta-analysis. *Journal of Hepatology, 54*(4), 650–659.
[28]. van Werven, J. R., Marsman, H. A., Nederveen, A. J., et al. (2010). Assessment of hepatic steatosis: US, CT, MRI comparison. *Radiology, 256*(1), 159–168.
[29]. Vernuccio, F., Cannella, R., Bartolotta, T. V., et al. (2021). Advances in liver US, CT, and MRI. *European Radiology Experimental, 5*(1), 52.
[30]. Wong, V. W.-S., Adams, L. A., de Lédinghen, V., Wong, G. L.-H., & Sookoian, S. (2018). Noninvasive biomarkers in NAFLD and NASH. *Nature Reviews Gastroenterology & Hepatology, 15*(8), 461–478.
[31]. Younossi, Z. M., Koenig, A. B., Abdelatif, D., et al. (2016). Global epidemiology of NAFLD. *Hepatology, 64*(1), 73–84.
[32]. Younossi, Z. M., Stepanova, M., Afendy, M., et al. (2011). Changing prevalence of chronic liver disease. *Clinical Gastroenterology and Hepatology, 9*(6), 524–530.
[33]. Zhang, Y. N., Fowler, K. J., Hamilton, G., et al. (2018). Liver fibrosis imaging: MR elastography and beyond. *Radiographics, 38*(2), 552–570.