# Key concepts of Ultrasound LI-RADS for daily practice: a pictorial review.

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## Learning objectives

- to highlight ultrasound role in the hepatocellular carcinoma (HCC) diagnostic, screening and surveillance algorithm.
- to explain through illustrative examples US LI-RADS categories and their imaging features.
- to appreciate US LI-RADS decision tree for assigning an observation category and visualisation score.

# Background

HCC represents more than 90% of primary liver cancers and is a major global health problem, being the second most common cause of cancer-related death in the world [1].

Prognosis is often poor as HCC is typically diagnosed at a late stage. In case of opportune detection, this malignancy may be managed surgically by local ablation, resection, or liver transplantation. Nowadays such locoregional treatment options as radiofrequency ablation, microwave ablation, and transcatheter arterial chemoembolization (TACE) have improved general prognosis for patients with HCC [2].

US is advocated as screening and surveillance modality in patients at risk for developing HCC by most societies because it is safe, widely available and relatively cheap modality[2].

Until now, this method has lacked standardized guidelines.To address this need, the American College of Radiology (ACR) has convened a multidisciplinary team of experts to develope the Ultrasound Liver Imaging Reporting and Data System (US LI-RADS) algorithm [3].

Although some papers regarding CT/MRI diagnostic LI-RADS adoption and pitfalls have already been published [4], there is still no many information about US LI-RADS practical applications and only a small number of studies have addressed the efficacy of US in HCC surveillance [2].

To review US LI-RADS we illustrate classification with our cases to show features that determine observation category and detection score.

## Findings and procedure details

Screening is the application of a diagnostic test to a population at risk for developing the disease.

Surveillance is the repeated application of the screening test.

Reliable screening and surveillance HCC program is crucial in any patient with cirrhosis irrespective of cause because at an early stage it could potentially be cured.

Some institutions use contrast-enhanced (CT) or MR for screening and surveillance, but it is not considered to be cost-effective [2,3].

Currently alpha-fetoprotein (AFP) as a single screening tool is advised for use neither by the American Association for the Study of Liver Disease (AASLD) nor by the European Association for the Study of the Liver (EASL) [1]. It may be applied for screening only in combination with imaging tools [5].

All major international hepatology societies recommend US as the preferred screening and surveillance imaging test in patients at risk for HCC [2].

Nowadays LI-RADS is a complex structure of 4 imaging algorithms: (1) US LI-RADS for screening and surveillance, (2) CT/MRI Diagnostic LI-RADS for staging and diagnosis, (3) CEUS LI-RADS for diagnosis, and (4) CT/MRI Treatment Response algorithm for assessing response to locoregional therapies [4].

LI-RADS refers to unenhanced US as a "screening or surveillance" tool which in case of positive findings triggers further diagnostic contrast-enhanced investigations [5].

Recommended screening and surveillance populations are:

- Patients with cirrhosis of any etiology
- Noncirrhotic HBV Asian male > 40
- Noncirrhotic HBV Asian female > 50
- Noncirrhotic African/North American Blacks with HBV
- Noncirrhotic HBV patients with family history of HCC

Depending on regional HCC clinical practice guidelines this list may be added.

The US LI-RADS and diagnostic LI-RADS populations are not always the same because for some patients undergoing screening and surveillance algorithm diagnostic LI-RADS is inappropriate (e.g. patients with cirrhosis due to vascular disorders).

On the other hand there are cases when we may use LI-RADS while screening and surveillance are not appropriate (e.g., patients with cirrhosis and short life expectancy due to non-hepatic disease) [5].

The US LI-RADS algorithm consists of two components (category, visualization score) and 4 steps:

1. Assign category;
2. If unsure between two categories, choose the most suspicious one;
3. Assign visualisation score;
4. Proceed final check.

Categories guide further management and are as follows: US-1 Negative, US-2 Subthreshold, and US-3 Positive.

Fig. 1 describes steps for assigning US LI- RADS category.

Each category features are presented in the table 1.

The US LI-RADS category definition is based on the size of liver "observation". Observation is a distinctive area compared to background liver.

This term is used instead of term "lesion" as histologically observations sometimes turn out to be areas of unaltered parenchyma.

LI-RADS US-1 (negative): no evidence of HCC. There are no focal observations or only definitely benign observations (simple cyst, focal fat sparing or deposition). Previously diagnosed with contrast-enhanced examinations benign observations and subcentimeter observations with confirmed stability over 2 years are also in this category. Individuals with negative category continue routine surveillance with a 6-month US scan. Fig.2,3,4.

LI-RADS US-2 (subthreshold): short-term US follow-up is required. These abnormalities are less than 10 mm in diameter and not definitely benign. US LI-RADS permits follow-up interval flexibility between 3 and 6 months as there is still no scientific evidence to establish univocal surveillance period [2]. If the observation regresses or doesn't grow for 2 years the patient may return to a routine surveillance interval (6 months). Fig.5

LI-RADS US-3 (positive): further diagnostic contrast-enhanced examination is needed. These findings include focal observations greater than or equal to 10 mm in diameter which are not definitely benign, or a new thrombus in vein. Fig.6

Management summary is presented in Fig.7.

One of 3 visualization scores describes current US examination sensitivity for detecting focal liver lesions: A: No or minimal limitations, B: Moderate limitations, C: Severe limitations.

Visualization score A: no limitations to significantly affect examination sensitivity for detecting HCC. In this case we are dealing with a homogeneous or minimally heterogeneous liver which can be entirely or near entirely visualized. There is no or minimal beam attenuation. Fig.8

Visualization score B: limitations may obscure small observations. These are for example rib shadows, obscuration by bowel gas or lung, moderately heterogeneous liver parenchyma, or moderate acoustic beam attenuation. Small parts of the liver or diaphragm may not have been visualized. Fig.9

Visualization score C: significant limitations for observation detection. These include severely heterogeneous liver, prominent beam attenuation. More than 50% of the liver may not be visualized. Fig.10

Nowadays US LI RADS does not have recommendations for management of patients with visualization score C as it has not been established that alternative imaging modalities for screening and surveillance are cost-effective in this population. Nevertheless, specific recommendations may be provided in the future [2].

At the final step ask yourself if the assigned US category and visualization score seem reasonable and appropriate.

If yes**:** You are done.
If no**:** Assigned US category and/or visualization score may be inappropriate, so reevaluate.

US examination should be in accordance with ACR Practice Parameter and Technical Standard for Performance of Ultrasound of the Abdomen and Retroperitoneum [6].

Technical considerations for surveillance ultrasound of the liver are listed in the table 2.

Recommended views for surveillance ultrasound of the liver are in the table 3.

**Images for this section:**

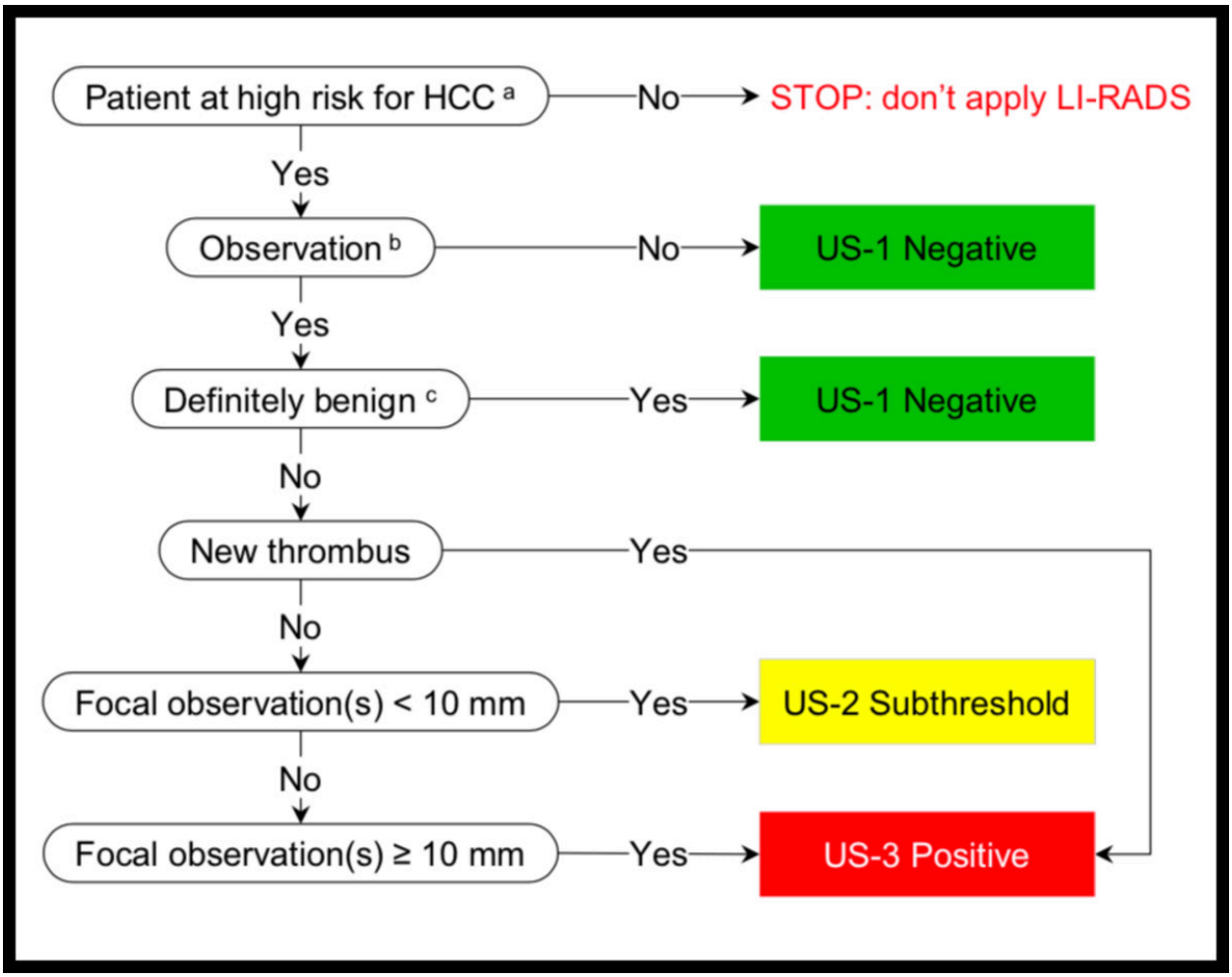


**Fig. 1:** US LI-RADS decision tree for choosing detection category.

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| Category | Concept | Definition | Recommendation |
|---|---|---|---|
| US-1 Negative | No US evidence of HCC | No observation, or only definitely benign observations | 6-mo follow-up US |
| US-2 Subthreshold | Observation that may warrant short-term US surveillance | Observations <10 mm in diameter, not definitely benign | US follow-up at 3–6 mo |
| US-3 Positive | Observation that may warrant multiphasic contrast-enhanced imaging | Observations ≥10 mm in diameter, not definitely benign, or new thrombus in vein | Multiphasic contrast-enhanced CT or MR imaging, or CEUS |

**Table 1:** US LI-RADS Screening and Surveillance observation categories.

© Fetzer, David T. et al. Screening and Surveillance of Hepatocellular Carcinoma. Radiologic Clinics 2017; 55(6).

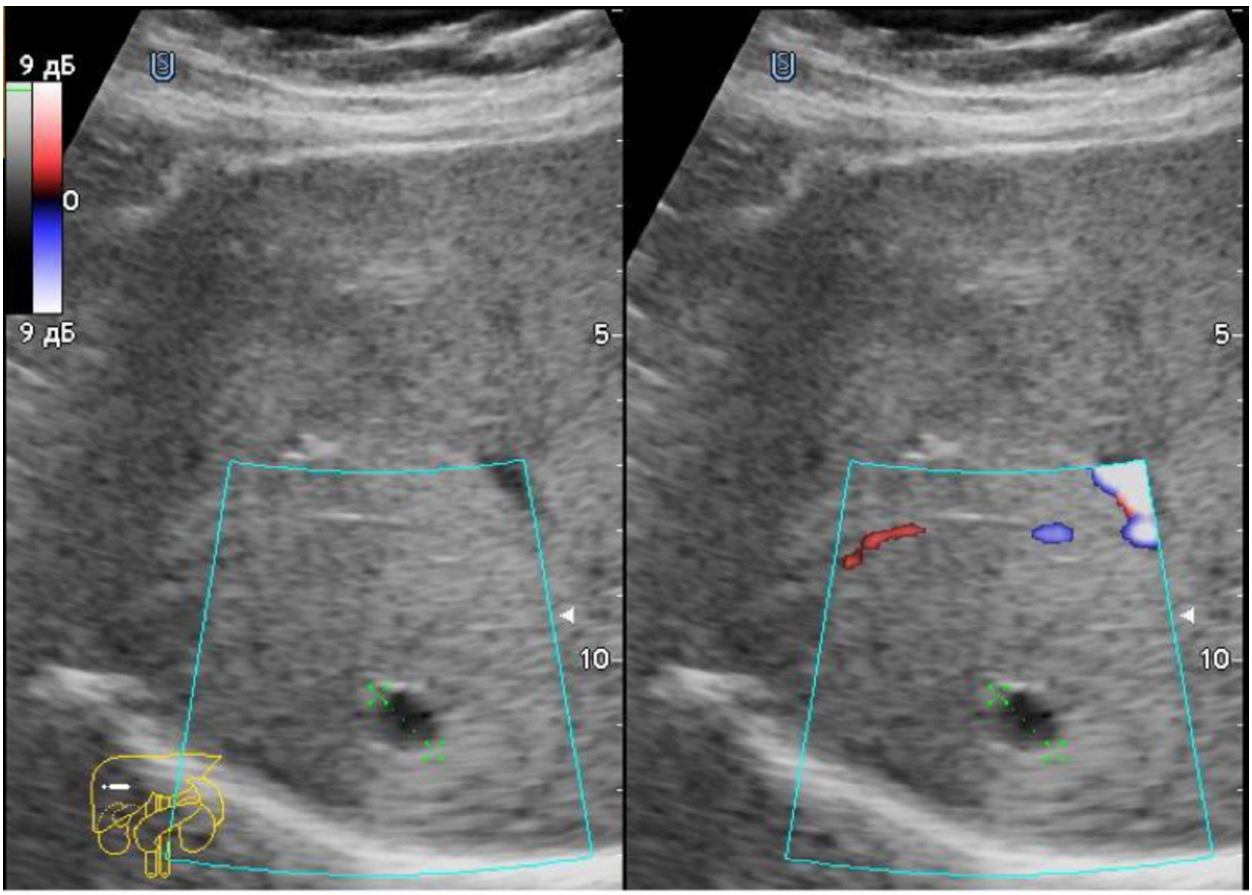


**Fig. 2:** LI-RADS US-1: Negative. Ultrasound image with color Doppler shows focal observation larger than 1 cm - simple cyst (definitely benign observation).

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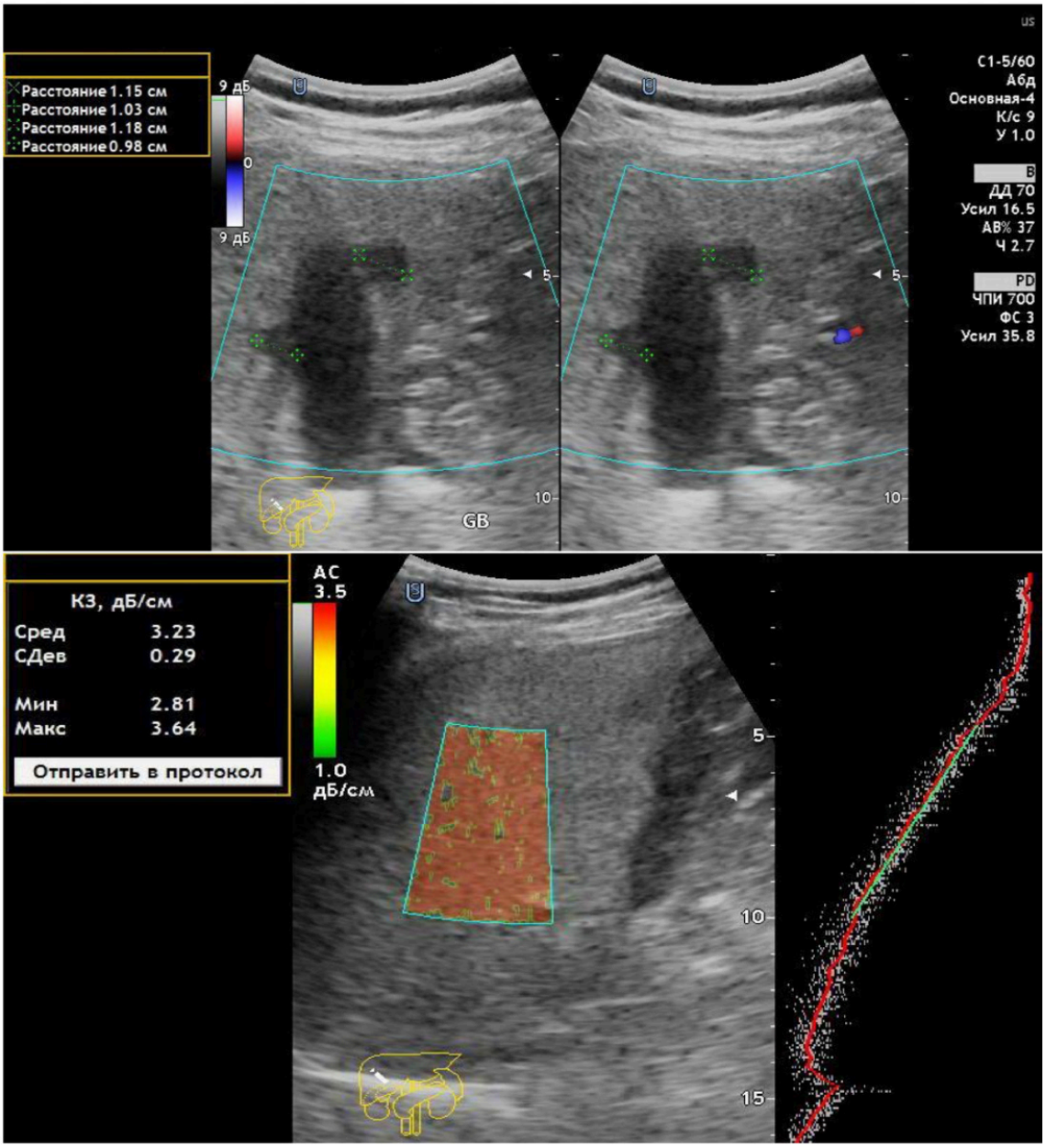


**Fig. 3:** LI-RADS US-1: Negative. Multiparametric ultrasound (power doppler, attenuation coefficient measurement) shows hypoechoic area adjacent to the gallbladder- focal fat sparing (definitely benign observation).

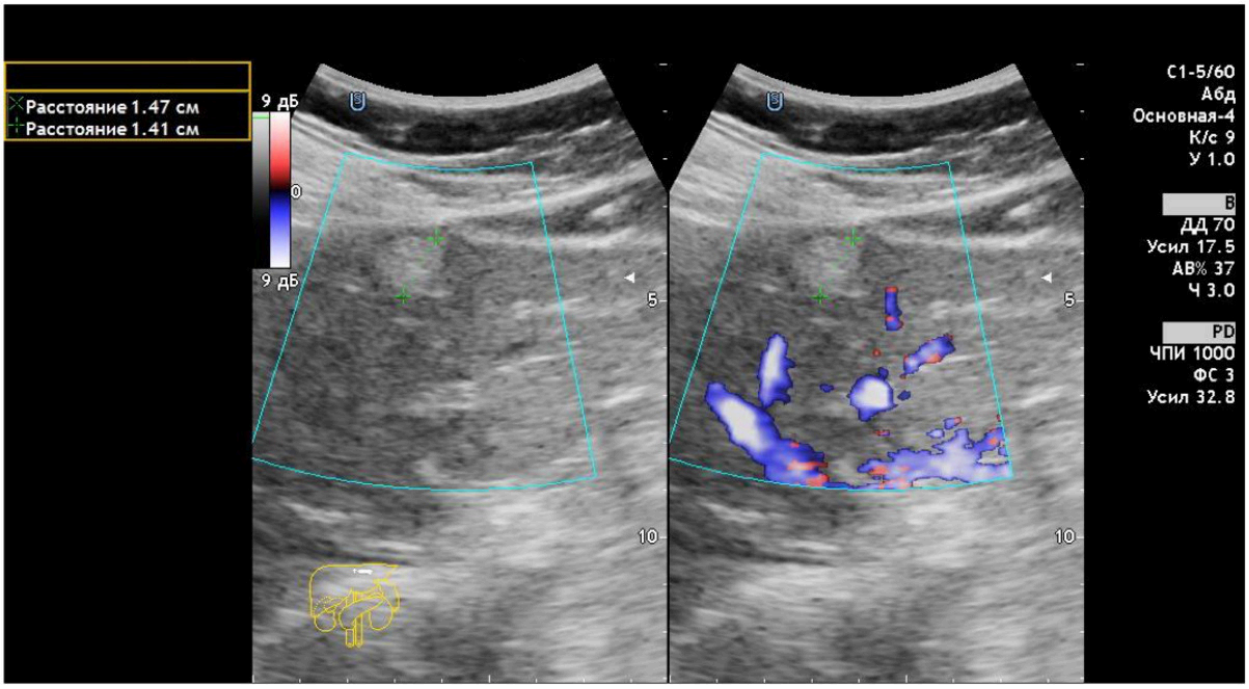


**Fig. 4:** LI-RADS US-1: Negative. Ultrasound image with color Doppler shows hemangioma, previously diagnosed by contrast enhanced CT (definitely benign observation).



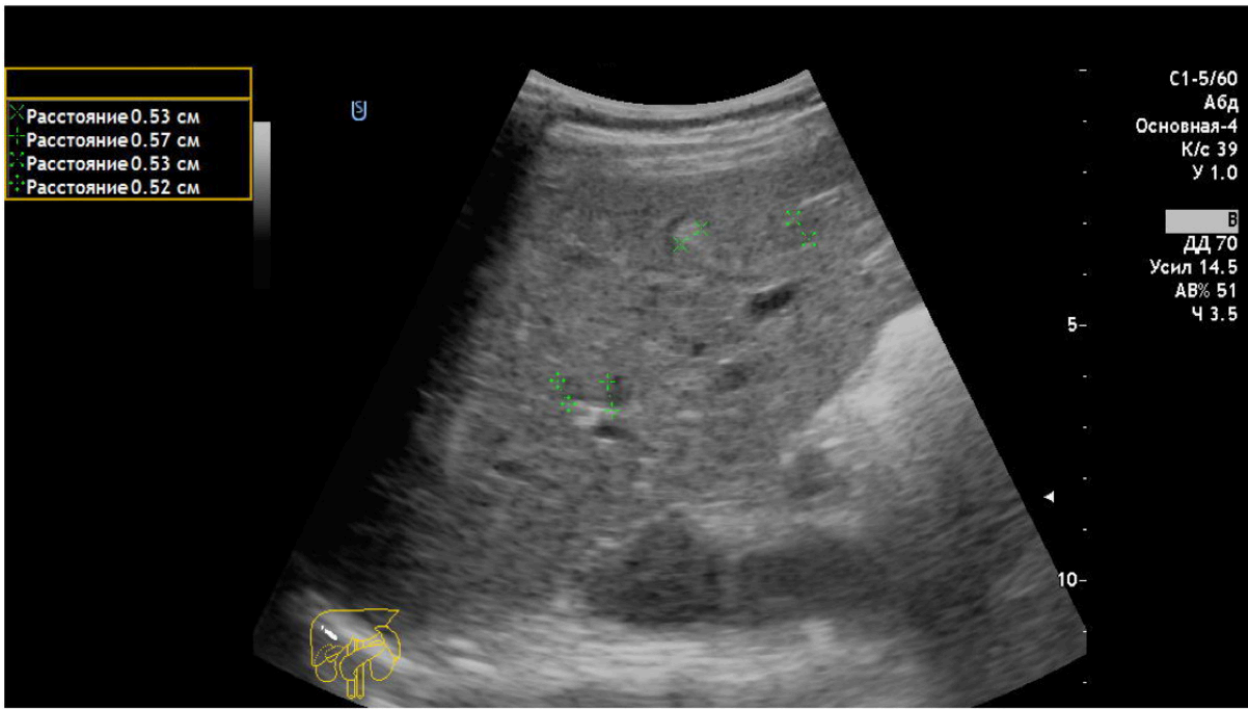


**Fig. 5:** LI-RADS US-2: Subthreshold. Multiple small (5-9 mm) heterogenic observations in the right and left lobes, not definitely benign.

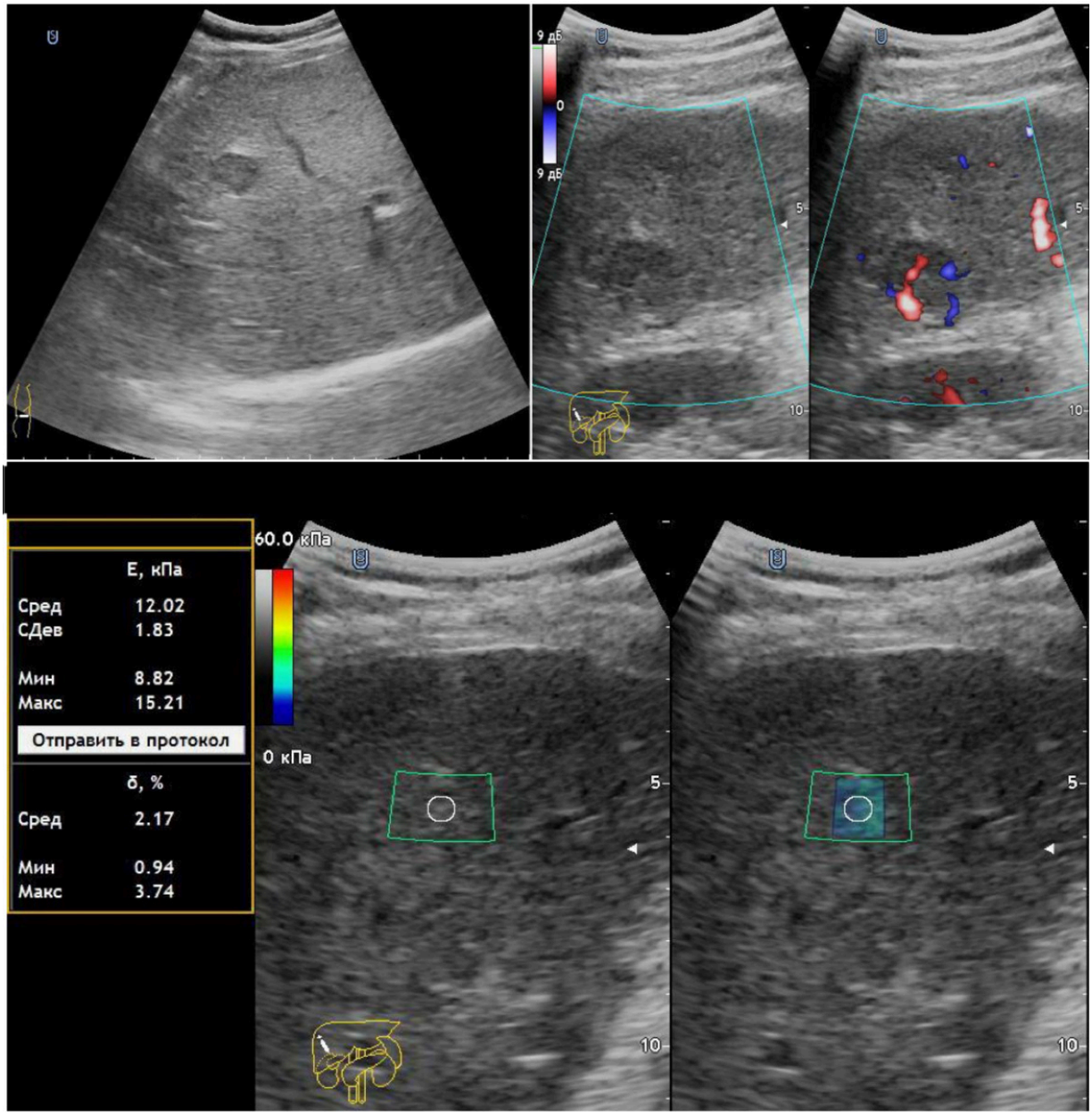


**Fig. 6:** LI-RADS US-3: Positive. Multiparametric ultrasound: power doppler, shear wave elastography (SWE) demonstrates focal hypervascular observation larger than 20 mm in patient with cirrhosis (E=120kPa - F4 fibrosis stage according to SWE).

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**Fig. 7:** US LI-RADS Management summary.

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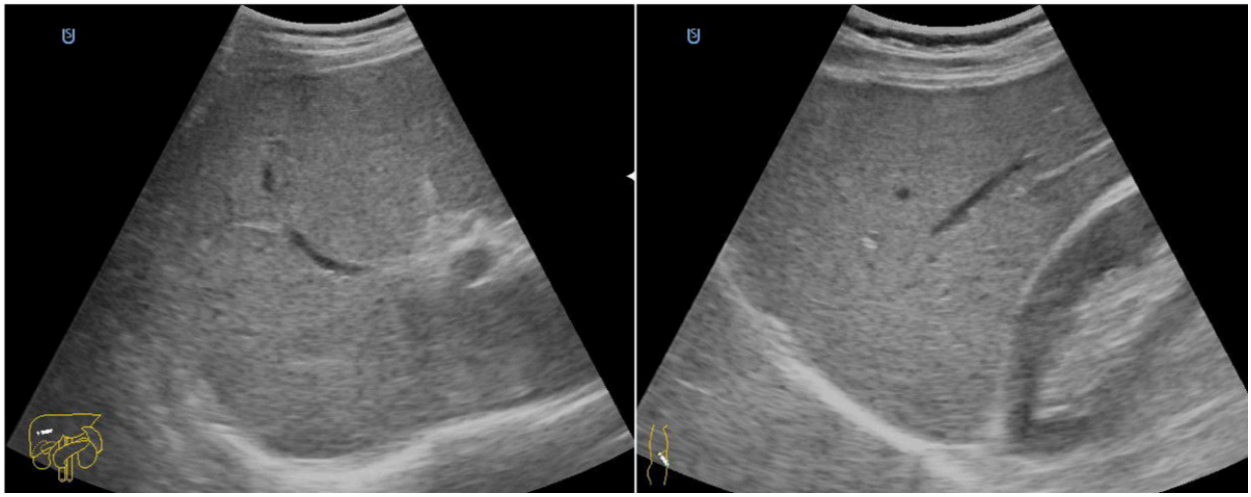

**Fig. 8:** Visualization score A: No or minimal limitations. Homogeneous liver, minimal beam attenuation or shadowing. Liver visualized in near entirety.

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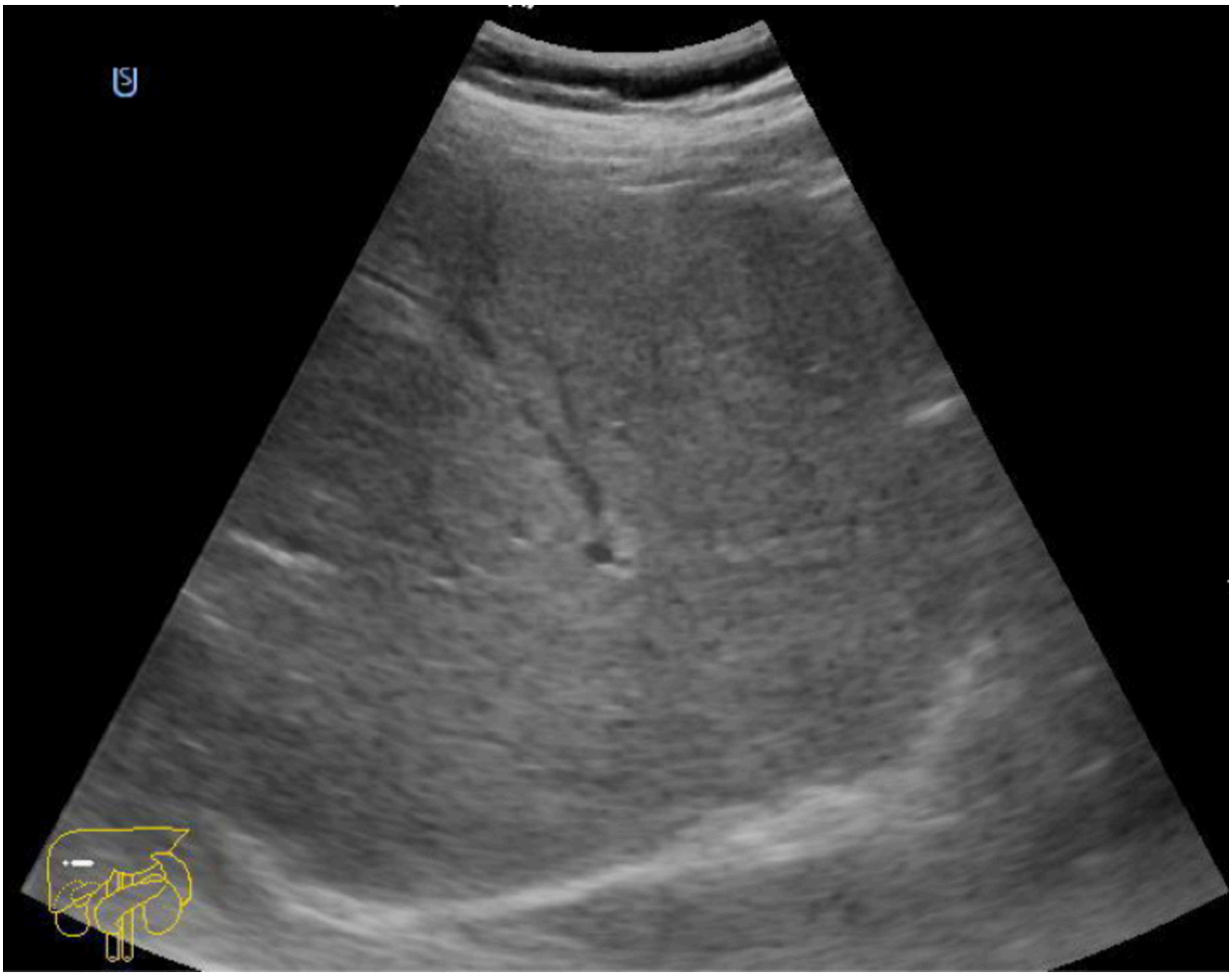

**Fig. 9:** Visualization score B: Moderate limitations. Liver is moderately heterogeneous, moderate beam attenuation or shadowing. Some portions of liver or diaphragm are not visualized.

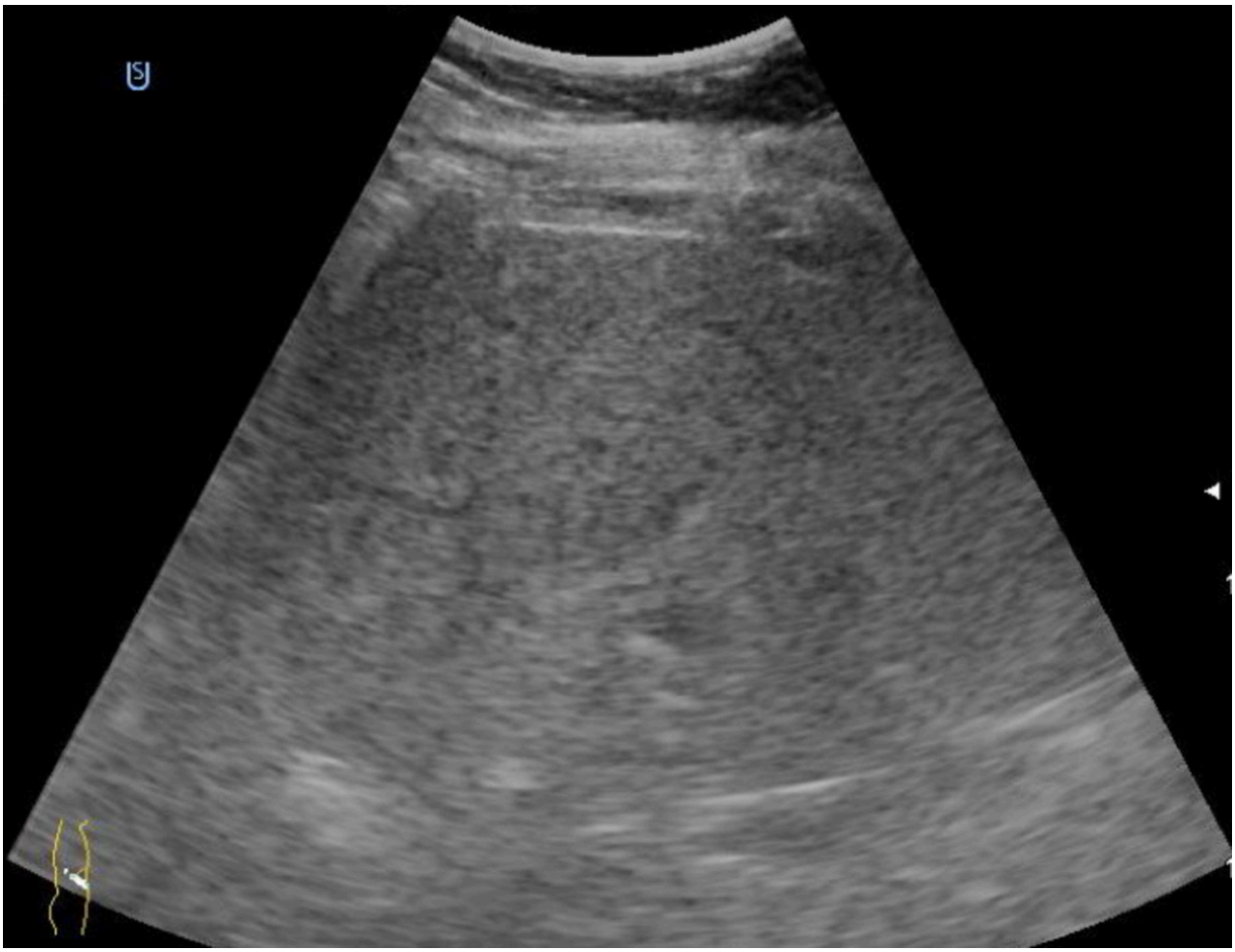

**Fig. 10:** Visualization score C: Severe limitations. Liver is severely heterogeneous, severe beam attenuation or shadowing. Majority (>50%) of liver not visualized.



| Clinical Factor | Recommendation |
|---|---|
| Patent preparation | Patients may be NPO for 4–6 h prior to ultrasound examination in order to decrease bowel gas and avoid organ obscuration |
| Patient positioning and acoustic windows | Screening ultrasound examination of liver will commonly include views obtained with patient in supine and left posterior oblique/left lateral decubitus positions; subcostal and intercostal acoustic windows may be used |
| Ultrasound equipment and scanner settings | Examinations are typically performed using utilizing curvilinear and/or sector transducers |
| | Image quality should be optimized, while keeping total ultrasound exposure, thermal index (TI) and mechanical index (MI), as low as reasonably achievable |
| | Highest clinically appropriate frequency should be used, realizing trade-off between resolution and beam penetration—for adults, mean frequencies of 2–9 MHz are most commonly used; image optimization should allow for adequate penetration to visualize entire depth of liver and diaphragm |
| | Spectral, color, and power Doppler may be useful to differentiate vascular from nonvascular structures in any location |

**Table 2:** Technical considerations for surveillance ultrasound of the liver.

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|---|---|
| Longitudinal images | |
| Recommended views | Left lobe<br>left of midline<br>at midline; include proximal abdominal aorta, celiac artery, and SMA<br>with IVC; include caudate lobe, MPV, and pancreatic head<br>with left portal vein<br>Right lobe<br>with gallbladder<br>with right kidney<br>including right hemidiaphragm and adjacent pleural space<br>far lateral<br>Main portal vein; include grayscale and color Doppler<br>Common bile duct at porta hepatis; include diameter measurement |
| Optional views | Color Doppler of right and left portal veins, and hepatic veins<br>Spectral Doppler of main portal vein to assess waveform, velocity, and flow direction |
| Transverse images | |
| Recommended views | Dome with hepatic veins; include entire right and left lobe with medial and lateral liver edges (on separate images as needed)<br>Left lobe<br>umbilical vein area to evaluate for presence of patent paraumbilical vein<br>with left portal vein<br>Main portal vein bifurcation<br>Right lobe<br>with right portal vein<br>with main portal vein<br>with gallbladder<br>with right kidney<br>near liver tip |
| Optional views | Color Doppler view of hepatic veins |
| Cine loops | |
| Recommended views | None specified |
| Optional views | Longitudinal and transverse cine sweeps of left and right lobes, including as much hepatic parenchyma as possible |
| Note | Recommended views can be obtained in any order per institutional protocol, with additional views of focal observations obtained as needed; additional anatomical and Doppler measurements may be included per institutional preferences and needs |

**Table 3:** Recommended views for surveillance ultrasound of the liver.

© Morgan, T.A., Maturen, K.E., Dahiya, N. et al. US LI-RADS: ultrasound liver imaging reporting and data system for screening and surveillance of hepatocellular carcinoma. Abdom Radiol 2018; 43(41).

# Conclusion

1. US is accepted by most societies as primary screening and surveillance HCC imaging tool because it is widely available, cheap, noninvasive and lacks ionizing radiation.
2. US LIRADS is a complementary screening and surveillance element of complex LI-RADS paradigm.
3. There is still no many information about US LI-RADS practical applications and only a small number of studies have addressed the efficacy of US in HCC surveillance - further investigations are needed.

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