American College of Radiology®

LI-RADS®
CEUS v2027 Core

Liver Imaging Reporting and Data System



LI-RADS® CEUS v2027 Core

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LI-RADS® CEUS v2027 CORE

Untreated nodule visible on precontrast US and without pathologic proof in patient at high risk for HCC

If nodule is not visible on precontrast B-mode US—use optional Occult Nodule Algorithm

- If cannot be categorized due to image degradation or omission → CEUS LR-NC
- If definite tumor in vein (TIV) → CEUS LR-TIV
- If definitely benign → CEUS LR-1
- If probably benign → CEUS LR-2
- If probably or definitely malignant but not HCC specific (i.e., if meets CEUS LR-M criteria[a]) → CEUS LR-M

Otherwise, use CEUS diagnostic table below

- If intermediate malignancy probability → CEUS LR-3
- If probably hepatocellular adenoma (HCC) → CEUS LR-4
- If definitely HCC → CEUS LR-5

CEUS Diagnostic Table

Arterial phase hyperenhancement (APHE)	No APHE		APHE (not rim[b], not peripheral discontinuous nodular[c])	
Nodule size (mm)	<20	≥20	<10	≥10
Blood-pool agent (BPA): No washout of any type Kupffer-cell agent (KCA): No hypoenhancement at 1–5 min	CEUS LR-3	CEUS LR-3	CEUS LR-3	CEUS LR-4
BPA: Late (≥60 s) and mild washout KCA: Hypoenhancement at 1–5 min[d]	CEUS LR-3	CEUS LR-4	CEUS LR-4	CEUS LR-5

[a] CEUS LR-M criteria—any of following:

- Rim APHE followed by washout of rim-enhancing components **OR**
- Early (<60 s) washout **OR**
- Marked BPA washout at <2 min **OR**
- Marked KCA hypoenhancement at <2 min

[b] Rim APHE indicates LR-M

[c] Peripheral discontinuous nodular indicates hemangioma (LR-1)

[d] Mild hypoenhancement at 1-2 min **OR** any hypoenhancement at 2-5 min

Note: KCAs approved for use in some countries, but not currently [2027] approved for use in the United States.

If unsure about the presence of any major feature: characterize that feature as absent

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What is LI-RADS®?

The Liver Imaging Reporting And Data System (LI-RADS):

- Is a comprehensive system for standardizing the terminology, technique, interpretation, reporting, and data collection of liver imaging
- Comprises a dynamic document, to be expanded and refined as knowledge accrues and in response to user feedback
- Was designed to improve communication, patient care, education, and research
- Is supported and endorsed by the ACR
- Was developed by a multidisciplinary, international consortium of diagnostic and interventional radiologists, hepatobiliary surgeons, hepatologists, and hepato-pathologists. Contributors include academic and community physicians as well as members in training.

LI-RADS may be used for clinical care, education, or research by:

- Community and academic radiologists
- Radiologists in training
- Other healthcare professionals providing care to patients with liver disease
- Researchers

LI-RADS fully integrated into:

- American Association for the Study of Liver Diseases (AASLD) clinical practice guidance
- Organ Procurement and Transplantation Network (OPTN)/United Network for Organ Sharing Policies

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LI-RADS is consistent with:

- National Comprehensive Cancer Network guidelines

What is CEUS?

Contrast-Enhanced Ultrasound (CEUS):

- Is an advanced form of ultrasound (US) in which images are acquired:
  - Using intravenously injected microbubble contrast agents
  - With software package optimized for visualizing those agents
- Permits dynamic characterization of lesion and liver blood flow similar to CT and MRI
- Allows characterization of limited number of liver nodules visible on B-mode US
- May be used with caution by expert practitioners to characterize nodules occult on precontrast B-mode images
- Can be used in select cases with endoscopic US; however, this particular use is outside of scope of current LI-RADS guidelines

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Key differences of CEUS compared with CT and MRI include:

- CEUS permits real-time imaging, which virtually eliminates possibility of arterial phase misiming and may allow detection of arterial phase hyperenhancement (APHE) or late washout not identified on CT or MRI.
- Microbubble agents have better safety profile compared with CT and MRI contrast agents.
- CEUS enables multiple injections of microbubble contrast agents in the same examination, permitting accurate characterization of the same nodule and/or assessment of additional nodules.
- CEUS does not depict capsule; therefore, it is not a CEUS major feature.
- CEUS permits characterization of limited number of nodules and cannot fully assess extrahepatic disease; hence, it may not be suitable for hepatocellular carcinoma (HCC) staging.
- CEUS may use purely intravascular contrast agents (blood-pool agents [BPAs]), or agent with Kupffer-cell accumulation (Kupffer-cell agent [KCA[a]]), which affects washout characterization.
  - With BPA, CEUS washout is due to relative reduction of the amount of intravascular contrast agent within the lesion as compared with surrounding liver parenchyma.
  - With KCA, CEUS washout assessment is replaced with assessment of early transitional phase hypoenhancement (1–5 min after injection), which is a combination of intravascular contrast washout and decreased Kupffer-cell contrast retention within the lesion as compared with surrounding liver parenchyma.
- CEUS characterization of washout (BPA) or early transitional phase hypoenhancement (KCA) requires assessment of its onset (late versus early) and degree (mild versus marked), not just its presence.

Indications for CEUS in patients at risk for HCC:

- Assess nodules detected on surveillance US.
- Assess LR-3, LR-4, and LR-M observations detected on prior CT or MRI.
- Detect APHE when misiming is suspected as the reason for its absence on prior CT or MRI.
- Assess biopsied nodules with inconclusive histology.
- Guide biopsy or treatment of nodules difficult to visualize with precontrast US.
- Help select appropriate nodule(s) or nodule component(s) for biopsy.
- Monitor changes in enhancement pattern over time for selected CEUS LR-3 or CEUS LR-4 nodules.
- Differentiate tumor in vein (TIV; “tumor thrombus”) from bland thrombus.

[a.] KCA - Kupffer cell agent (*approved for use in some countries, but not currently [2027] approved for use in the USA)*

Why is an update needed in 2027?

- The LI-RADS mission and long-term vision is to unify diagnostic imaging criteria for HCC. A critical milestone was recently achieved with the integration of LI-RADS CEUS into the clinical practice guidance of the AASLD, adoption by the OPTN National Liver Review Board, and endorsement by the European Association for the Study of the Liver for diagnosing HCC in cases of indeterminate lesions identified at CT or MRI. To support broader clinical acceptance of CEUS for HCC diagnosis, we have clarified certain imaging criteria within LI-RADS CEUS.

- The integration of KCA CEUS into LI-RADS reflects a growing need for more sensitive and specific tools in the evaluation of liver nodules in patients at risk for HCC. Unlike pure blood-pool contrast agents, KCA provides both vascular-phase and Kupffer-phase imaging, enabling better detection of lesions with reduced Kupffer-cell activity—a hallmark of many HCCs and nonhepatocellular malignancies. Including KCA expands the diagnostic utility of CEUS in LI-RADS, aligning imaging recommendations with evolving clinical practice and regional contrast agent availability.

- The LI-RADS Occult Nodule Algorithm offers a standardized framework to guide next steps, optimize lesion characterization, and support timely and appropriate care decisions. Occult hepatic nodules—lesions not seen on precontrast US but recognized on prior CT or MRI or discovered during the performance of CEUS for other reasons—pose a common and clinically important dilemma in the surveillance and management of patients at high risk for HCC.

What is New in LI-RADS® CEUS v2027?

New LI-RADS® Adequacy Score

Rationale: Accurate application of LI-RADS categories depends on the adequate quality of the imaging examination. Variability in image acquisition—such as suboptimal timing of arterial phase, inadequate liver coverage, or imaging artifacts—can lead to misinterpretation. To address this, the LI-RADS Adequacy Score was developed as a standardized tool to safeguard diagnostic accuracy, while maintaining the high specificity and reproducibility of LR-5 categorization.

Revised, simplified criteria for LR-M

- Rim APHE as a major feature of LR-M now requires washout of rim-enhancing components.

  Rationale: Washout of rim-enhancing components was added to:
  - Minimize risk of calling abscesses at LR-M
  - Minimize risks of overinterpreting perilesional perfusional alterations as rim-APHE
  - Avoid miscategorization of large hemangiomas with incomplete central filling as LR-M:
    - Hemangiomas presenting with peripheral discontinuous nodular hyperenhancement do not demonstrate contrast washout.
    - Malignant lesions presenting with rim APHE typically demonstrate rapid washout of the rim.

- Marked BPA washout at <2 min or KCA hypoenhancement at <2 min.

  Rationale: Clarified that marked BPA washout or KCA hypoenhancement occurring any time within first 2 min after contrast injection can be used to categorize lesion as LR-M.

Revised criteria for LR-5 now include assessment with KCA

- LR-5 criteria for KCA CEUS include assessment of early transitional phase hypoenhancement (1–5 min after injection):
  - Size >10 mm
  - APHE
  - Early transitional phase hypoenhancement (mild hypoenhancement at 1–2 min OR any hypoenhancement at 2–5 min)

- LR-5 criteria for BPA CEUS remain the same:
  - Size >10 mm
  - APHE
  - Late, mild washout

  Rationale: To permit categorization of liver nodules imaged with either BPA or KCA CEUS.

What is New in LI-RADS® CEUS v2027?

New ancillary feature (AF) of malignancy favoring HCC in particular

- KCA hypoenhancement not present at 5 min and appearing ≥10 min after injection.

  Rationale: KCA hypoenhancement, which is not present at 5 min after injection (early transitional phase) and appearing ≥10 min after injection (Kupffer phase), is commonly seen in well-differentiated HCC and small number of nonmalignant lesions, such as hemangiomas. Approximately 95% of HCCs show hypoenhancement on 10-min Kupffer-phase imaging[1]. Likewise, hepatic hemangiomas (which also lack Kupffer cells) that typically show no hypoenhancement at 5 min after injection may develop hypoenhancement at 10 min in up to 30% of cases[2]. Therefore, to preserve high PPV and specificity of LR-5 categorization, *KCA hypoenhancement not present at 5 min and appearing ≥10 min after injection* will be used as an AF to upgrade nodules to LR-3 or LR-4, but it cannot be used as a major feature for LR-5 categorization.

- **Removing downgrade from LR-5 to LR-4 using AFs favoring benignity**

  Rationale: LR-5 is defined to be near-definitive for HCC, and size stability ≥2 years or definite size reduction does not refute that diagnosis. Well-differentiated HCC may grow very slowly, and a subset of nodules may transiently decrease in size due to tumor necrosis; neither behavior provides sufficient evidence to overturn a LR-5 categorization that was correctly assigned on major imaging features.

- **New LI-RADS® CEUS v2027 Occult Nodule Algorithm**

  Rationale: As a rule, LI-RADS CEUS does not apply to nodules occult on precontrast US. However, guidance is needed for categorization of nodules not visible on precontrast US.

- **New KCA CEUS imaging protocol**

  Rationale: To date, there has been no universally accepted KCA CEUS protocol that facilitates LI-RADS categorization by integrating Kupffer-phase findings while maintaining a high specificity for HCC. Developing a dedicated KCA CEUS protocol within LI-RADS is essential to standardize KCA CEUS practice, reduce interobserver variability, and enhance noninvasive HCC diagnosis in high-risk patients worldwide.

[1] Zhou J, et al. Expert consensus regarding the clinical application of liver contrast-enhanced US with Sonazoid (Sonazoid CEUS). *Int J Surg*. 2026;112(1):55–70.
[2] Kakegawa et al. Ultrasonography. Washout-parametric imaging with Sonazoid for enhanced differentiation of focal liver lesions. Ultrasonography. 2024;43(6):457–468.

LI-RADS® v2027 CEUS

Apply in patients at high risk for HCC, namely those with:

- Cirrhosis **OR**
- Chronic hepatitis B viral infection **OR**
- Current or prior HCC

Including adult liver transplant candidates and recipients after transplant

Do not apply in patients:

- Without the above risk factors
- <18 years old
- With cirrhosis due to congenital hepatic fibrosis
- With cirrhosis due to a vascular disorder such as hereditary hemorrhagic telangiectasia, Budd-Chiari syndrome, chronic portal vein occlusion, cardiac congestion, or diffuse nodular regenerative hyperplasia

Apply to nodules:

- Visible at precontrast US
- Select cases of US-occult nodules

Do not assign LI-RADS CEUS categories for nodules:

- That are path-proven malignancies **OR**
- That are path-proven benign lesions of nonhepatocellular origin

See *page 32* for guidance on reporting path-proven lesions.

Apply for CEUS exams performed with:

- BPAs such as Sulfur hexafluoride lipid-type A microspheres and Perflutren lipid microspheres
- KCA Perfluorobutane (*approved for use in some countries, but not currently [September 2026] approved for use in the United States*)

See *page 14* for more information on CEUS agents.

Apply for CEUS exams with appropriate LI-RADS Adequacy Score

- Apply to all cases with LI-RADS Adequacy Score A
- Apply to select cases with LI-RADS Adequacy Score B

See *page 8* for more information on LI-RADS Adequacy Score.

LI-RADS® Adequacy Score

Diagnostic CEUS in patient at high risk for HCC

LI-RADS Adequacy Score

A	No or minimal limitations
B	Moderate limitations
C	Severe limitations

Score	Interpretation	Common examples[a]	Recommendations
A: No or minimal limitations	Imaging is adequate for liver assessment[b]	High-quality key image acquisitions Appropriate arterial phase timing Major features are assessable No or minimal artifacts	Imaging does not need to be repeated Follow-up imaging can use the same technique or modality[c]
B: Moderate limitations	Imaging has limitations but is acceptable for liver assessment	Degradation of some image acquisitions Arterial phase mistiming[d] Some features are not assessable Moderate artifacts	Imaging may not need to be repeated Suggest a different technique or modality for follow-up imaging
C: Severe limitations	Imaging is inadequate for liver assessment	Key image acquisitions are degraded or not obtained Arterial phase mistiming[d] Major features are not assessable Severe artifacts	Imaging may need to be repeated[e] Indicate whether imaging needs to be repeated, and suggest a different technique or modality for repeat or follow-up imaging

Footnotes

[a] This list of examples illustrates common scenarios but is not meant to be exhaustive.

[b] Liver assessment refers to the range of indications for which diagnostic CEUS exams may be performed in a patient at high risk for HCC. This includes, but is not limited to, detection of new observations, characterization and follow-up of known observations, assessment of locoregional treatment response, and assessment of vascular anatomy and patency.

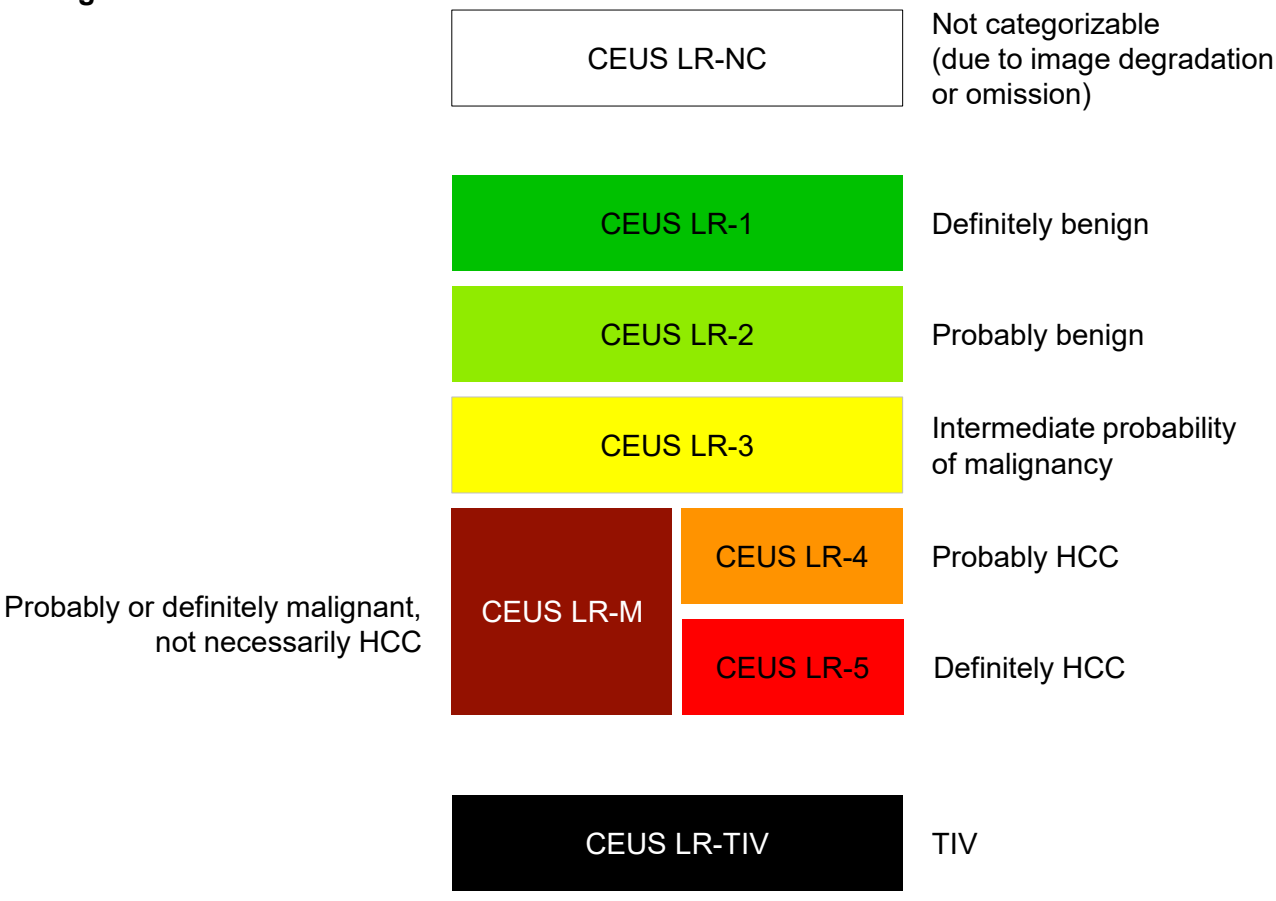
[c] Technique broadly refers to aspects of image acquisition that are potentially modifiable, such as choice of US scanners and transducers, choice between contrast agents, imaging parameters, and methods of compensating for respiratory motion.

[d] Arterial phase mistiming should be categorized as B or C. In a patient in whom multiple other high-quality image acquisitions in the same exam are adequate for a specific indication, a mistimed arterial phase may still be acceptable (B). However, in situations in which appropriate arterial phase timing is vital, this would be a severe limitation (C).

[e] It is not always necessary to repeat imaging even if the imaging is severely limited. This could be because the specific clinical question can still be confidently answered, or because the reasons for image degradation are not modifiable.

LI-RADS® CEUS v2027 Categories

Diagnostic Categories



Diagnostic categories are assigned in 4 steps
(pages 10-12)

Step 1. Apply LI-RADS® CEUS Diagnostic Algorithm

Untreated nodule visible on precontrast US and without pathologic proof in patient at high risk for HCC

If nodule is not visible on precontrast B-mode US—use optional Occult Nodule Algorithm

- If cannot be categorized due to image degradation or omission → CEUS LR-NC
- If definite TIV → CEUS LR-TIV
- If definitely benign → CEUS LR-1
- If probably benign → CEUS LR-2
- If probably or definitely malignant but not HCC specific (i.e., if meets CEUS LR-M criteria[a]) → CEUS LR-M

Otherwise, use CEUS diagnostic table below

- If intermediate malignancy probability → CEUS LR-3
- If probably HCC → CEUS LR-4
- If definitely HCC → CEUS LR-5

CEUS Diagnostic Table

APHE	No APHE		APHE (not rim[b], not peripheral discontinuous nodular[c])	
Nodule size (mm)	<20	≥20	<10	≥10
BPA: No washout of any type KCA: No hypoenhancement at 1–5 min	CEUS LR-3	CEUS LR-3	CEUS LR-3	CEUS LR-4
BPA: Late (≥60s) and mild washout KCA: Hypoenhancement at 1–5 min [d]	CEUS LR-3	CEUS LR-4	CEUS LR-4	CEUS LR-5

[a] CEUS LR-M criteria—any of following:

- Rim APHE followed by washout of rim-enhancing components **OR**
- Early (<60 s) washout **OR**
- Marked BPA washout at <2 min **OR**
- KCA hypoenhancement at <2 min

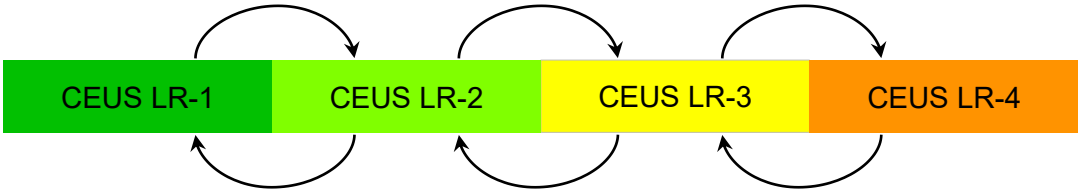
[b] Rim APHE indicates LR-M
[c] Peripheral discontinuous nodular indicates hemangioma (LR-1)
[d] Mild hypoenhancement at 1–2 min **OR** any hypoenhancement at 2–5 min
Note: KCA approved for use in some countries, but not currently [2027] approved for use in the United States

If unsure about the presence of any major feature: characterize that feature as absent

Step 2. Optional: Apply CEUS AFs

CEUS AFs may be used at interpreter's discretion for increased categorization confidence or LR category adjustment as follows:

One or more AFs favoring malignancy: upgrade by 1 category up to CEUS LR-4
(absence of these AFs should not be used to downgrade)



One or more AFs favoring benignity: downgrade by 1 category
(absence of these AFs should not be used to upgrade)

If there are conflicting AFs (i.e., one or more favoring malignancy and one or more favoring benignity):
Do not adjust category

AFs favoring malignancy cannot be used to upgrade to CEUS LR-4 to LR-5

AFs benignity cannot be used to downgrade CEUS LR-5 to LR-4

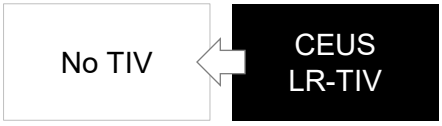
CEUS AFs favoring malignancy	CEUS AFs favoring benignity
Favoring malignancy in general, not HCC in particular • Definite growth **Favoring HCC in particular** • Nodule-in-nodule architecture • Mosaic architecture • KCA: hypoenhancement not present at 1–5 min and appearing ≥10 min after injection	• Size stability ≥2 years • Definite size reduction

If unsure about presence of any AF: characterize that feature as absent

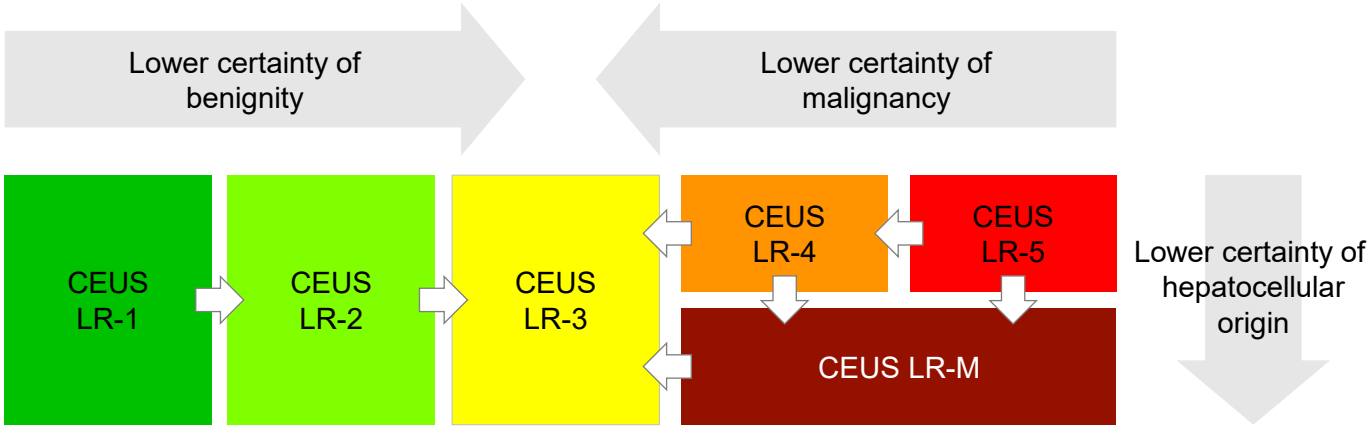
Definitions of AFs favoring malignancy (page 26)
Definitions of AFs favoring benignity (page 26)

Step 3. Apply Tie-Breaking Rules if Needed

If unsure about presence of TIV, do not categorize as CEUS LR-TIV



If unsure between two categories, choose the one reflecting lower certainty



Step 4. Final Check

After Steps 1, 2, and 3:

Ask yourself if the assigned category seems reasonable and appropriate

If YES: You are done, move on the next nodule (if any).

If NO: Assigned LI-RADS category may not be appropriate, so reevaluate.

LI-RADS® CEUS v2027 Occult Nodule Algorithm

LI-RADS CEUS v2027 generally does not apply to nodules occult on precontrast US. However, expert practitioners may apply the following LI-RADS CEUS Occult Nodule Algorithm when a nodule is not visible on initial precontrast US

Untreated observation visible on CT/MRI or prior US, and
NOT visible on initial precontrast US in patient at high risk for HCC

→ Perform CEUS using anatomic landmarks, which could include one or more injections[a]

→ If masslike enhancement is definitely present[b]

→ Reimage with B-mode in area of masslike enhancement

→ If nodule is identified → **Assign CEUS LR using CEUS Diagnostic Algorithm**

LR-1 | LR-2 | LR-3 | LR-4 | LR-5 | LR-M

Recommendation: per CEUS LR Algorithm

→ If nodule NOT identified → **Do not assign CEUS LR Category**
Report: Likelihood of malignancy is **high**[c]
Recommend: Multidisciplinary discussion (MDD) referral

→ If masslike enhancement is not definitely present[b]

→ Manage according to the LI-RADS Adequacy Score[d]

→ If Adequacy A → **Do not assign CEUS LR Category**
Report: Likelihood of malignancy is **low**[e]
Recommend: Alternate multiphase imaging at next routine follow-up, or MDD referral

→ If Adequacy B or C → **Do not assign CEUS LR Category**
Report: Indeterminate likelihood of malignancy[f]
Recommend: Alternate multiphase imaging

Footnotes

[a] Repeat injection may be considered if washout without APHE is seen, as repeat injection may show APHE missed on earlier injection.
[b] Masslike enhancement may include APHE (any agent), washout (BPA), or transitional or Kupffer-phase hypoenhancement (KCA).
[c] Presence of masslike enhancement without a correlate on precontrast B-mode imaging raises concern for malignancy that is intrinsically isoechoic to liver.
[d] LI-RADS Adequacy Score is assigned by operator based on confidence that suspected nodule is included in field of view based on landmarks and that the acoustic window is sufficient to detect a nodule if present.
[e] Nonvisualization of nodule on precontrast B-mode and of masslike enhancement on postcontrast imaging makes malignancy unlikely (Differential diagnosis: nonmalignant nodule; pseudolesion; perfusion variant).
[f] This can occur if the area of suspected nodule was poorly visualized due to technical factors, or there is low confidence that suspected nodule was included in the field of view.

Considerations Before Performing a CEUS Exam

Vascular phases and their typical timing:

- Arterial phase: usually occurs from about 10–20 s to 30–40 s after contrast injection.
- BPA portal venous phase (PVP): lasts from about 30–40 s to 2 min after contrast injection.
- BPA late phase: lasts from end of PVP until there is unequivocal clearance of microbubbles from the circulation at about 6–8 min after contrast injection.
- KCA PVP: lasts from about 30–40 s to 1 min after contrast injection.
- KCA transitional phase: lasts from about 1 min to ~10 min after contrast injection:
    - Early transitional phase: 1–5 min after contrast injection
    - Late transitional phase: 5–10 min after contrast injection
- KCA Kupffer phase: typically starts ~10 min after contrast injection.

Continuous imaging: Acquisition of images in real time, typically 10–20 frames/second. Provides improved assessment of arterial phase enhancement.

Intermittent imaging: A series of brief image acquisitions, each lasting a few seconds and spaced about 60 s apart without any imaging in between. Helps reduce microbubble destruction during assessment of washout.

Recording: Saving cinematic loops and/or representative static images.

Reinjection: Microbubbles may be reinjected in the same exam to permit more complete characterization of the same nodule and/or assessment of additional nodules.

Become acquainted with CEUS dual-screen display and timing

Use dual-screen display to demonstrate B-mode and contrast-mode images side by side. Position electronic calipers on nodule on B-mode screen, then use scanner software to automatically place calipers at the same position on the contrast-mode screen. Simultaneous display of calipers on both screens facilitates correlation between B-mode findings and APHE and washout on contrast-mode image. Use scanner timer to record time after contrast injection on all images (required for characterizing washout).

Become acquainted with US contrast agents available in your region

Generic name	Manufacturer	Distribution
Sulfur hexafluoride lipid-type A microspheres	Bracco Diagnostics	Blood pool
Perflutren lipid microsphere	Lantheus	Blood pool
Perflutren protein-type A microspheres	GE HealthCare	Blood pool
Perfluorobutane	GE HealthCare	Blood pool Kupffer cells

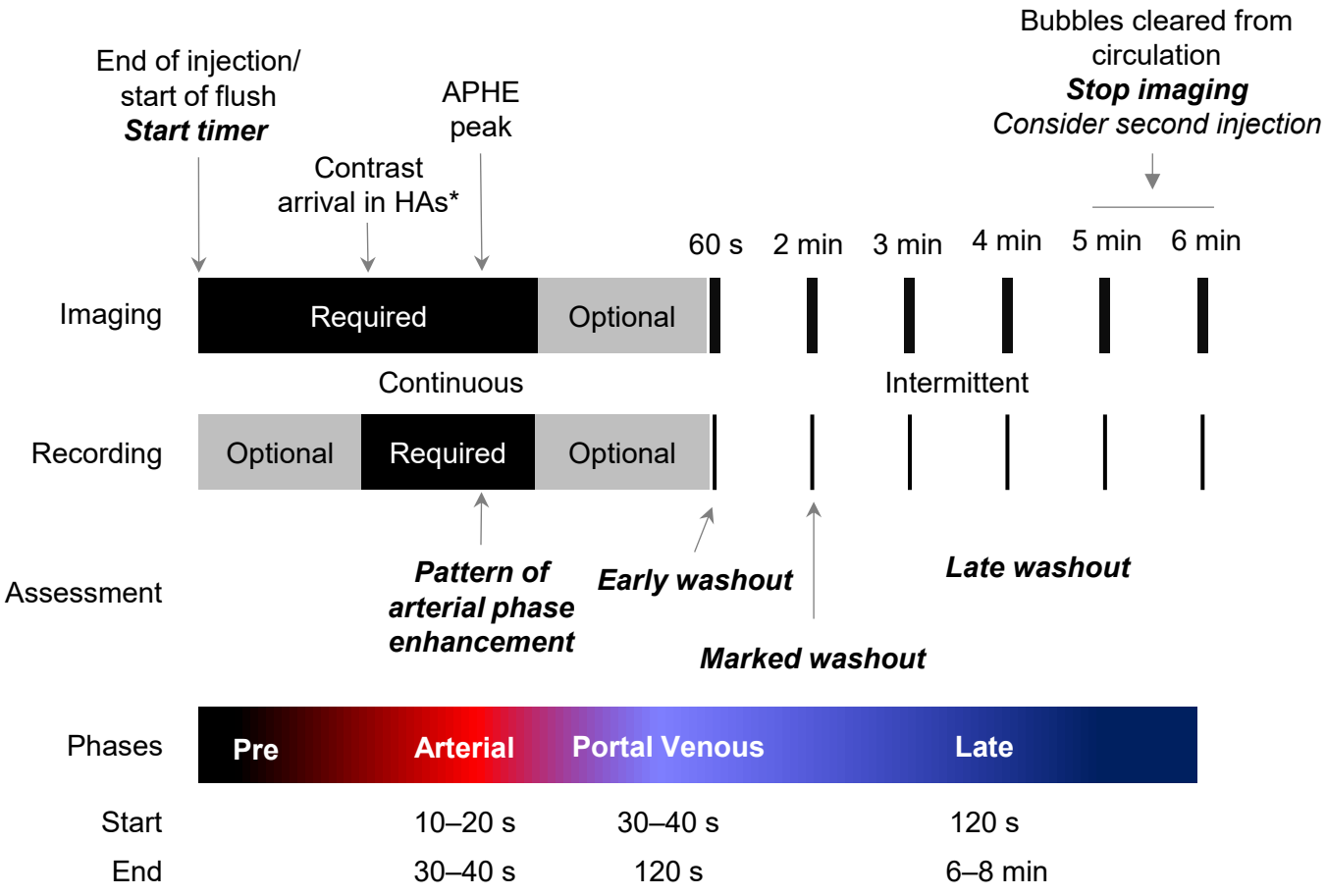
LI-RADS® CEUS Technical Recommendations

US scanner	• US scanner with contrast-specific imaging capability • Refer to contrast-specific instructions provided by scanner manufacturer
Contrast agent	• Current version of LI-RADS CEUS applies to both BPA and KCA

Imaging	• Precontrast B-mode—identify the following:
	  • Target nodule(s)
	  • Optimal patient position: supine, oblique, or left lateral decubitus
	  • Optimal scan plane: usually longitudinal (reduces out-of-plane motion)
	  • Optimal patient breathing: quiet or suspended (neutral, inspiration, expiration)
	• Arterial phase:
	  • Image continuously from contrast injection until peak arterial phase enhancement of liver parenchyma and/or nodule to characterize pattern of arterial phase enhancement.
	• BPA PVP:
	  • Image continuously or intermittently to detect early washout up to 60 s.
	• BPA late phase:
	  • Image intermittently (every 60 s) to minimize microbubble destruction until microbubbles have cleared completely from the circulation (4–6 min) to detect late washout and assess its degree.
	• KCA early transitional phase:
	  • Start imaging around 5 min to evaluate for intralesional hypoenhancement.
	• KCA Kupffer phase:
	  • If intralesional hypoenhancement is not present at 5 min, consider additional Kupffer-phase image acquisition at 10–15 min.

Recording	• Record continuous cine loop from microbubble arrival through peak APHE as minimum requirement. Optionally, continue the cine loop beyond the APHE peak until 60 s after injection. • Record static images at 60 s and with intermittent acquisition thereafter.
Imaging parameters	• Use low mechanical index to avoid microbubble destruction.
Dual-screen imaging	• Place calipers on nodule on both B-mode and CEUS screens simultaneously to facilitate correlation of B-mode observation and enhancement characteristics.
Timing	• Begin timer after end of contrast injection, at beginning of saline flush (i.e., time 0 coincides with beginning of flush). • Record time in seconds at which washout is first detected.
Injection technique	• Use ≥20-gauge intravenous catheter. • Central venous lines and infusion ports are acceptable if safety and aseptic requirements are met. • Hand inject contrast over 2–3 s, maintaining constant syringe pressure. • Flush with 5–10 mL normal saline at about 2 mL/s. • Repeat injection as needed.
Diameter measurement	• Use B-mode (precontrast). • Use same imaging mode and plane as prior exam to assess interval change.

LI-RADS® CEUS Technique: BPA CEUS Schematic Illustration



The phases of contrast enhancement listed above are provided for general reference only, and their timing may vary based on a variety of patient-related factors.

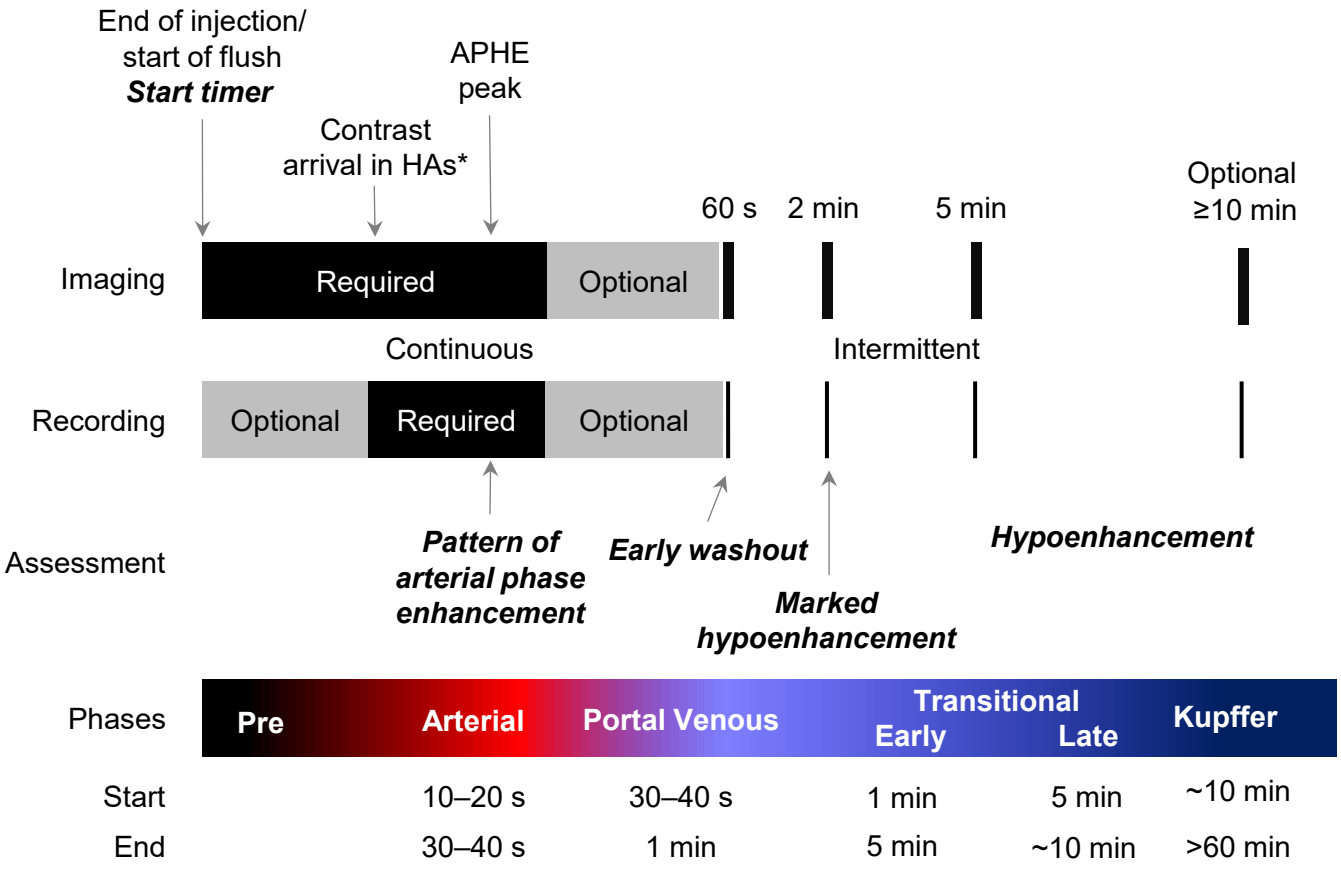
LI-RADS CEUS categorization is based on assessing the lesion enhancement at predetermined diagnostic interpretation windows, such as the peak arterial phase enhancement followed by 1, 2, 3, 4, and 5 min, and so on after contrast injection.

*HA, hepatic artery.

Additional Injections (if needed)

- Use your judgment in determining whether additional injections are needed, based on the features (e.g., presence of APHE, onset of washout, degree of washout) that require additional characterization.
- If masslike hypoenhancement is identified, consider repeat injection to reassess presence/pattern of arterial phase enhancement.
- If washout is detected without a B-mode correlate, consider a superimposed reinjection to revaluate for arterial phase enhancement pattern while using the washout as a target.
- Wait until near-complete clearance of the contrast agent (about 10 min) before next injection.

LI-RADS® CEUS Technique: KCA CEUS Schematic Illustration



The phases of contrast enhancement listed above are provided for general reference only, and their timing may vary based on a variety of patient-related factors.

LI-RADS CEUS categorization is based on assessing the lesion enhancement at predetermined diagnostic interpretation windows, such as the peak arterial phase enhancement followed by 1, 2,and 5 min, and so on after contrast injection.

*HA, hepatic artery.

Additional Injections (if needed)

- Use your judgment in determining whether additional injections are needed, based on the features (e.g., presence of APHE, onset of washout, degree of washout) that require additional characterization.
- If intralesional hypoenhancement is detected at 5 min, additional imaging at ≥10 min will be optional.
- If intralesional hypoenhancement is **NOT** detected at 5 min, additional imaging at ≥10 min could be performed to detect hypoenhancement in Kupffer phase.

LI-RADS® CEUS-Based Management: Suggested Imaging Workup Options and Time Intervals

Below are suggestions.
Interpreters are encouraged to use their judgment and tailor the recommendations to each patient.

LI-RADS CEUS category for untreated nodules	Imaging Workup Options for Untreated Nodules		
	Return to routine surveillance	Alternative diagnostic imaging (i.e., CT or MRI)	Repeat CEUS
CEUS LR-NC	Not recommended	≤3 mo[a]	≤3 mo[b]
CEUS LR-1	6 mo**	Not recommended	Not recommended
CEUS LR-2	6 mo**	≤6 mo**	≤6 mo*
CEUS LR-3	Not recommended	≤3 mo**	≤3 mo*
	MDD may be needed for consensus management of LR-3 cases.		
CEUS LR-4	MDD may be needed for consensus management. If neither biopsy, CT/MRI, nor treatment is planned, repeat or use alternative diagnostic imaging in ≤3 months.		
CEUS LR-5	Diagnostic of HCC. MDD for consensus management.		
CEUS LR-M	MDD for consensus management. Often include biopsy, alternative or repeat imaging, or treatment.		
CEUS LR-TIV	MDD for consensus management. May include biopsy or biomarker correlation to determine etiology of TIV.		

Footnotes

[a] *Preferred option, particularly if nonmodifiable quality issues exist.*

[b] *May be considered if modifiable correction to CEUS technique would allow for diagnostic imaging.*

*** Preferred option in most cases.*

** Reasonable alternative option.*

LI-RADS® CEUS v2027 Reporting: Considerations Before Issuing a LI-RADS® CEUS Report

Apply clinical judgment and consider the individual patient context.

Tailor your recommendations to your patient.

- *Page 18* provides general guidance for imaging workup options, but the optimal management may vary depending on the nodule or patient, local practice preferences, and access.

Is a nodule path-proven to your knowledge?

If a nodule has been biopsied and the pathologic diagnosis is certain (i.e., the diagnosis is a malignant entity such as HCC or nonhepatocellular malignancy, or is a nonhepatocellular benign entity such as hemangioma), then it is preferable to report the pathologic diagnosis rather than the LI-RADS CEUS category.

If a nodule has been biopsied but there is either uncertainty about the pathologic diagnosis or the diagnosis is a potential HCC precursor (i.e., regenerative or dysplastic nodule), it is preferable to report the LI-RADS CEUS category and the pathologic diagnosis together.

Rationale: Reporting both may alert the referrer to possible false-negative biopsy results and/or to the need for close follow-up to detect progression to frank malignancy.

Is there TIV?

If yes, report the likely etiology. Most cases of TIV are associated with HCC, but some may be intrahepatic cholangiocarcinoma (ICC), hepatocholangiocarcinoma, or other non-HCC malignancies. See *page 25* for guidance on CEUS LR-TIV.

LI-RADS® CEUS v2027 Reporting

Untreated nodule	Reporting	Recommended report content
CEUS LR-NC	Must be reported in Findings and Impression.	Provide causative technical limitations or artifacts, and management suggestions.
CEUS LR-1 CEUS LR-2 CEUS LR-3 CEUS LR-4 CEUS LR-5 CEUS LR-M	Must be reported in Findings and Impression.	Provide major features, growth, size stability for >2 years, and other contributory features. Indicate relevant change since prior.
CEUS LR-TIV	Must be reported in Findings and Impression.	Indicate likely etiology (HCC, non-HCC, unsure); describe vessel(s) involved.
No nodule on precontrast B-mode US	Should be reported in Impression.	Use Occult Nodule Algorithm.

All reported nodules should include:

- **Identifier:** sequential number or other unique identifier, consistent on all exams.
- **Contrast agent used:** BPA or KCA.
- **Arterial phase enhancement features:** qualitative description as not rim (diffuse or partial), rim, or peripheral discontinuous nodular.
- **Onset of washout or early transitional phase hypoenhancement if present:** time in seconds at which washout is first detected.
- **Degree of washout or early transitional phase hypoenhancement if present:** qualitatively characterized as marked within first 2 min or mild.

See *page 22* and *page 23* for more information on washout and early transitional phase hypoenhancement characterization.

Note: If nodule is a path-proven malignancy or is a benign lesion of nonhepatocellular origin, report pathology diagnosis rather than the LI-RADS category.

LI-RADS® CEUS Major Imaging Features

APHE (not rim or peripheral discontinuous) 	Enhancement in arterial phase that is neither rim-like nor peripheral discontinuous nodular. Enhancing part must be higher in echogenicity than liver in arterial phase, unequivocally greater in whole or in part than liver. Generally diffuse, although may be partial. Contrast with **rim APHE** followed by washout of rim-enhancing components is CEUS LR-M major feature. See diagnostic table, *page 10*.
BPA washout 	BPA CEUS: Visually assessed temporal reduction in enhancement in whole or in part relative to liver, beginning in or after arterial phase and resulting in hypoenhancement. Can apply to any enhancing nodule. • Early (<60 s) and/or marked washout: Major feature for LR-M • Late (≥60 s) and mild washout: Major feature for HCC See diagnostic table, *page 10*. See *page 22* for more information on characterizing washout.
KCA Early transitional phase hypoenhancement 	KCA CEUS: Visually assessed temporal reduction in enhancement in whole or in part relative to liver in early transitional phase (1–5 min after injection). Can apply to any enhancing nodule. See diagnostic table, *page 10*. See *page 23* for more information on characterizing early transitional phase hypoenhancement.

LI-RADS® BPA CEUS v2027 —Characterizing Washout

At BPA CEUS, all malignant nodules typically show washout, including ICC and other fibrotic tumors that have delayed central enhancement on CT or MRI.

Explanation: When using pure blood-pool contrast agents (e.g., microbubbles), washout reflects the blood volume of lesion relative to liver. Since all malignant lesions have lower blood volume than liver, all appear to wash out. In fact, although the exact mechanism is not yet understood, ICCs and other non-HCC malignancies typically wash out earlier and more completely than HCCs.

Implication: To maintain specificity for HCC, CEUS characterization of washout requires assessment of its "onset" and "degree," not just its presence.

		Washout onset[a]	
		Early (<60 s)	Late (>60 s)
Washout degree[b]	Marked at <2 min	Typical of ICC and metastases	Suggests malignancy in general, not specific for any particular type
	Mild	Suggests malignancy in general, not specific for any particular type	Typical of HCC and HCC precursor nodules

a. Onset: time after injection at which washout is first detected relative to liver:
- Early: onset detected <60 s after contrast injection.
- Late: onset detected ≥60 s after contrast injection.

b. Degree: degree of washout, assessed by comparing nodule to liver enhancement in PVP and late phase:
- Marked: nodule virtually devoid of enhancement ("punched out") <2 min after contrast injection.
- Mild: nodule less enhanced than liver, but not devoid of enhancement (i.e., some enhancement persists). If this persistent enhancement disappears after 2 min, the degree of washout is still considered mild, even if the nodule eventually becomes "punched out."

Effect on categorization: Nodules with late and mild washout may be categorized as CEUS LR-3, LR-4, or LR-5. Nodules with early OR marked washout at <2 min should be categorized LR-M.

	No APHE		APHE (not rim, not peripheral discontinuous nodular)	
Nodule size (mm)	<20	≥20	<10	≥10
No washout of any type	CEUS LR-3	CEUS LR-3	CEUS LR-3	CEUS LR-4
Late and mild washout	CEUS LR-3	CEUS LR-4	CEUS LR-4	CEUS LR-5
Early washout or Marked washout at <2 min	CEUS LR-M	CEUS LR-M	CEUS LR-M	CEUS LR-M

LI-RADS® KCA CEUS v2027—Characterizing Early Transitional Phase Hypoenhancement

- In the first minute after contrast injection, Kupffer-cell retention is negligible. Therefore, KCA CEUS is evaluated using criteria identical to BPA CEUS.
- Between 1 and 5 min after contrast injection, KCA contrast enhancement reflects a combination of intravascular contrast and contrast retention within Kupffer cells, if present.
- Most non-HCC malignant lesions demonstrate early intravascular contrast washout and negligible Kupffer-cell retention between 1 and 2 min, resulting in marked intralesional hypoenhancement.
- Most HCC will demonstrate progressive intravascular contrast washout and low intralesional Kupffer-cell retention between 1 and 5 min, resulting in often mild intralesional hypoenhancement.
- Most nonmalignant hepatocellular lesions demonstrate no contrast washout and some degree of Kupffer-cell retention, resulting in persistent hyperenhancement or iso-enhancement 1–5 min after injection.
- At later phases (≥10 min), some nonmalignant nodules might demonstrate hypoenhancement; therefore, hypoenhancement that was not present at 5 min and occurred at ≥10 min is not specific for HCC. Therefore, it should be used as AF of HCC but cannot be used to upgrade nodules to LR-5 categorization.

Implication: KCA CEUS characterization requires assessment of its “early washout” and “early transitional phase hypoenhancement,” not just its presence.

Early washout (<60 s) **OR** Marked hypoenhancement at <2 min	Early transitional phase hypoenhancement (1–5 min)
Suspicious for malignancy, not specific for any particular type	Typical of HCC and HCC precursor nodules

Effect on categorization:

- Nodules with early washout or marked hypoenhancement at <2 min should be categorized LR-M.
- Nodules with mild hypoenhancement at 1–2 min OR any hypoenhancement at 2–5 min are categorized as LR-3, LR-4, or LR-5.

	No APHE		APHE (not rim, not peripheral discontinuous nodular)	
Nodule size (mm)	<20	≥20	<10	≥10
No hypoenhancement	CEUS LR-3	CEUS LR-3	CEUS LR-3	CEUS LR-4
Mild hypoenhancement at 1–2 min or Any hypoenhancement at 2–5 min	CEUS LR-3	CEUS LR-4	CEUS LR-4	CEUS LR-5
Early washout or Marked hypoenhancement at <2 min	CEUS LR-M	CEUS LR-M	CEUS LR-M	CEUS LR-M

LI-RADS® CEUS LR-M Criteria

Rim enhancement



Spatially defined subtype of APHE in which arterial phase enhancement is most pronounced along the margins of the nodule.
To qualify for LR-M categorization, rim enhancement must be followed by washout of rim-enhancing components.

Early washout



Temporally defined subtype of washout in which onset is within 60 s from contrast injection. Usually marked in degree (see below).

Marked BPA washout at <2 min



Degree-defined subtype of BPA washout in which the level of intralesional contrast washout within 2 min after injection is significant, resulting in the nodule appearing black or punched out.

Marked KCA hypoenhancement at <2 min



Degree-defined subtype of KCA hypoenhancement in which the level of intralesional contrast hypoenhancement within 2 min after injection is significant, resulting in the nodule appearing black or punched out.

LI-RADS® CEUS TIV

Tumor in vein



Unequivocal enhancing soft TIV, regardless of visualization of a parenchymal mass

Differentiation from bland thrombus

- TIV enhancement generally demonstrates APHE with various patterns of washout.

The arrival time of microbubble contrast agent to the vein helps to differentiate TIV versus partially occlusive/recanalized bland thrombus:

- Early arrival (~same time as HA opacification): favors TIV.
- Arrival several (~10) seconds after hepatic artery opacification: favors portal flow in patent portion of nonocclusive/recanalized bland thrombus.

Categorization:

Categorize as CEUS LR-TIV.

Reporting:

Indicate in report most likely etiology.

See below for guidance:

CEUS LR-TIV

- If contiguous with CEUS LR-5 → "Definitely due to HCC"
- If contiguous with CEUS LR-4 → "Probably due to HCC"
- If associated with infiltrative mass → "Probably due to HCC"
- If contiguous with CEUS LR-M → "May be due to non-HCC malignancy"
- Otherwise → "Etiology uncertain"

LI-RADS® CEUS Ancillary Imaging Features

Favoring malignancy, not specific for HCC

 Definite growth	Unequivocal spontaneous increase in nodule size. Note: CEUS does not include “threshold growth” as a major feature. Instead, “definite growth” is an AF.

Favoring HCC

 Nodule-in-nodule architecture	Presence of smaller inner nodule within and with different imaging features than larger outer nodule. In cirrhosis, suggests HCC.
 Mosaic architecture	Presence of randomly distributed internal nodules or compartments, usually with different imaging features.
 Kupffer phase defect appearing ≥10 min after injection	Intralesional hypoenhancement, not present at 5 min after contrast injection, but appearing ≥10 min after injection (only in KCA).

Favoring benignity

Size stability ≥2 years	No significant change in nodule size measured on exams ≥2 years apart in absence of treatment.
Definite size reduction	Unequivocal spontaneous decrease in size over time, not attributable to artifact, measurement error, technique differences, or blood product resorption.

Examples of CEUS LR-1 and Criteria for LR-2 Entities

CEUS LR-1

Examples and criteria:

- Cyst
  - Anechoic lesion with increased posterior acoustic through transmission showing no contrast enhancement in any phase.
- Hemangioma
  - Variable echogenicity lesion with peripheral discontinuous nodular enhancement in arterial phase followed by progressive centripetal contrast filling and iso- or hyperenhancement in portal venous and late phase.
  - The filling may be complete or partial depending on lesion size.
- Hepatic focal fat/focal fat sparing
  - Nonmasslike, hyper/hypoechoic area of without parenchymal distortion of destruction in a characteristic location for fat deposition/sparing and with isoenhancement in all phases.
  - Characteristic areas include around the gallbladder fossa and anterior to the right portal vein in segment IV.
  - If the hyper/hypoechoic area is not in a characteristic location for fat deposition/sparing, categorize as CEUS LR-2 (see below).
  - See LI-RADS CEUS manual (pending) for more information.

CEUS LR-2

Criteria:

- Distinct isoenhancing solid nodule <10 mm
  - If isoenhancing nodule is ≥10 mm, categorize as CEUS LR-3. See LI-RADS CEUS diagnostic algorithm (*page 5*).
- Nonmasslike isoenhancing nodule of any size, not typical hepatic focal fat/focal fat sparing
  - If the nodule represents focal fat/focal fat sparing, and is in a characteristic location, categorize as CEUS LR-1 (see above).
- CEUS LR-3 nodules with interval size stability for ≥2 years.

Explanation: Nodules meeting these criteria are probably regenerative or low-grade dysplastic nodules.



Caution: The CEUS enhancement features for HCC, focal nodular hyperplasia (FNH), and hepatocellular adenoma (HCA) overlap. Therefore, in patients at risk for HCC in whom application of LI-RADS CEUS is appropriate, nodules with CEUS features suggestive of FNH or HCA should be categorized conservatively. In general, they should NOT be categorized CEUS LR-1 or CEUS LR-2.

Getting Started

What is a LI-RADS CEUS nodule? How does it differ from a CT/MRI observation?

A nodule is a distinctive area compared with background liver at imaging. In CT and MRI, it may be a lesion or pseudolesion such as an arterioportal shunt (APS). Unlike in CT or MRI, vascular pseudolesions are rare in CEUS. Thus, almost all CEUS nodules are true lesions.

I am not sure if my patient has cirrhosis. Can I apply LI-RADS CEUS?

You can apply LI-RADS CEUS and provide a conditional category. For example: “25-mm mass with APHE and washout. If the patient has cirrhosis or chronic hepatitis B, this meets criteria for CEUS LR-5 (definitely HCC).” If available, you can add elastography to the US exam to evaluate liver stiffness (or shear wave speed). If the elastographic measurement exceeds a validated threshold for advanced chronic liver disease using your scanner, you may provide a provisional LI-RADS CEUS category, making sure to comment that this assumes a diagnosis of cirrhosis as suggested by US elastography.

I do not see a lesion on precontrast US; can I do CEUS?

As a general rule, LI-RADS CEUS v2027 does not apply to nodules occult on precontrast US. However, expert practitioners may attempt CEUS when there is no nodule visible on precontrast US and categorize the observations using the Occult Nodule Algorithm.

Can LI-RADS CEUS be used in transplant candidates?

LI-RADS CEUS can be used in transplant candidates. The OPTN National Liver Review Board now officially accepts CEUS LR-5 as HCC diagnosis. Therefore, LI-RADS CEUS can be used in transplant candidates for HCC exception points, although multiphasic CT/MRI remains necessary for staging.

Why does LI-RADS not apply to patients without risk factors for HCC?

The positive predictive value of imaging for HCC may not be sufficiently high in such patients.

Why does LI-RADS not apply to patients with cirrhosis due to a vascular disorder such as hereditary hemorrhagic telangiectasia, Budd-Chiari syndrome, chronic portal vein occlusion, cardiogenic hepatopathy, or diffuse nodular regenerative hyperplasia?

Such conditions are associated with formation of benign hyperplastic nodules that may resemble HCC on imaging, potentially causing false positive diagnoses and reducing the specificity of LR-5 category for HCC.

I am not sure if my patient has risk factors for HCC. Can I apply LI-RADS CEUS?

You can apply LI-RADS and provide a conditional category. For example: “25-mm mass with APHE and washout. If the patient has risk factors for HCC, this meets criteria for LR-5 (definitely HCC).”

Diagnosis

Why does ICC show early marked washout on CEUS but delayed central enhancement on CT/MRI?

CEUS microbubbles are too large to pass through vascular endothelial fenestrations. Instead, they remain confined to the blood space or blood pool (hence, “blood space agents” or blood-pool agents”), and their postarterial phase distribution reflects regional blood volume. Because ICCs have low blood volume, they show early and marked postarterial phase washout after administration of these agents—earlier and more marked than most HCCs. By comparison, the low-molecular-weight (LMW) agents used in CT and MRI pass through endothelial fenestrations easily, extravasate into the interstitium, and accumulate progressively in the centrally located fibrous stroma of these tumors. This produces the characteristic delayed central enhancement of ICCs at CT or MRI.

Why do HCCs typically show washout on CEUS and on CT/MRI?

Washout is a poorly understood phenomenon. One partial explanation could be that because most HCCs have lower blood volume and lower extracellular volume than the liver, they generally exhibit relative washout with BPAs and with LMW extracellular space agents.

Why is LR-M termed “probably or definitely malignant”?

Because rare benign entities (e.g., inflammatory pseudotumor, sclerosed hemangioma, HCA, and abscess) may show LR-M features (e.g., rim APHE) on all dynamic imaging modalities (CEUS, CT, MRI), “probably or definitely malignant” is more appropriate than “definitely malignant.”

Does LR-M exclude HCC?

LR-M does not exclude HCC. The differential diagnosis for LR-M includes HCC with nonspecific imaging features in addition to ICC and other malignancies. Based on current data, about 50% of LR-M observations are HCC, about 45% are non-HCC malignancies, and about 5% are benign.

Is there a size threshold for CEUS LR-M?

No. Although CEUS is usually performed to assess nodules ≥10 mm detected on surveillance US, smaller nodules with CEUS LR-M features may be identified during CEUS and should be categorized LR-M.

Why are APS not visible on CEUS?

One plausible explanation is that the microscopic shunts are too small to be depicted by CEUS, whereas CT and MRI detect the extravasation of contrast material into the regional interstitium. Regardless of the mechanism, the insensitivity of CEUS to perfusion alterations is an advantage because these can cause diagnostic confusion. Additionally, APS does not have a B-mode correlate, and therefore LI-RADS CEUS would likely not apply anyway in these cases.

How do I determine if a nodule is noncategorizable (LR-NC)?

A nodule is considered noncategorizable if it cannot be categorized meaningfully because key phases were omitted or degraded, preventing assessment of one or more major features. LR-NC should not be applied if there is confusion or uncertainty about certain major or AFs (see “Tie-breaking rules”) As a direct result, reasonable categories range from those in whom cancer is unlikely (LR-1 or LR-2) to those in whom cancer is likely (LR-4, LR-5, LR-M).

Technique

I have not started using CEUS, how can I get started?

The following websites provide excellent educational materials and/or links to educational programs and activities:

- ACR–AIUM–SPR–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF CONTRAST ENHANCED ULTRASOUND
- ACR Contrast Manual
- International Contrast Ultrasound Society website: http://www.icus-society.org
- European Federation of Societies for Ultrasound in Medicine and Biology: https://efsumb.org/
- Contact LI-RADS CEUS WG if you have further questions.

What syringe size should I use for injection?

Typical syringe sizes used for ultrasound contrast agent administration vary by product; users should follow the manufacturer's current prescribing information and instructions for use for agent-specific preparation and administration requirements.

How should I inject contrast?

Contrast should be injected manually over 2–3 s, maintaining a steady rate without excessive pressure to prevent excess bubble destruction during delivery. The contrast bolus should be followed immediately by a 5–10 mL normal saline flush delivered at approximately 2 mL/sec.

How should I measure nodule size?

Step 1	Acquire images in the appropriate plane (i.e., along the nodule's longest axis). If CEUS is performed as a follow-up for a previously detected nodule, replicate the prior imaging plane using anatomic landmarks (e.g., portal and hepatic veins, gallbladder, falciform ligament) for orientation.
Step 2	Measure the nodule's outer-to-outer edge dimension along its longest axis, using precontrast B-mode images if possible. If the margins are not clear on precontrast B-mode images, choose the CEUS image on which the margins are most clearly defined, avoiding the peak of arterial phase enhancement if possible. To evaluate size change between exams, select images on each exam acquired in the same plane and temporal phase.

Management

The suggested management differs for CT/MRI LR-3 and CEUS LR-3. Why the difference?

- The suggested management for CT/MRI LR-3 is alternative or repeat diagnostic imaging in 3–6 months.
- By comparison, the suggested management for CEUS LR-3 is alternative or repeat diagnostic imaging in ≤3 months and will often require MDD. The reason for emphasizing MDD for CEUS LR-3 is that the probability of HCC is thought to be greater for CEUS LR-3 than for CT/MRI LR-3[1].

Can biopsy be considered for CEUS LR-3 nodules?

Biopsy of selected CEUS LR-3 nodules may be performed based on MDD recommendations, particularly in cases such as:

- Significantly elevated or rising tumor markers
- High clinical suspicion of malignancy (e.g., new LR-3 nodule not present on prior imaging, known prior HCC, advanced cirrhosis)
- Patient cannot tolerate or comply with repeated short-interval imaging
- Definitive diagnosis will change management (e.g., transplant listing, downstaging, systemic therapy)
- LR-3 observation in patients with other primary malignancies

What is the importance of the multidisciplinary approach for patient management?

The multidisciplinary approach is considered essential and is strongly recommended by all major international guidelines. It is especially crucial when imaging is equivocal (e.g., CEUS LR-3 or LR-4, LR-M), when multiple treatment options are possible, or when the patient is being considered for transplantation or clinical trials.

References

1. Lyshchik et al. Contrast-enhanced ultrasound liver imaging reporting and data system: Clinical validation in a prospective multinational study in North America and Europe. *Hepatology*. 2024;79(2):380–391.

Reporting

Why does LI-RADS CEUS require reporting of each nodule individually while LI-RADS CT/MRI allows aggregate reporting in some circumstances?

A primary goal of LI-RADS is to facilitate clear and simple communication between radiologists, other specialists, and patients. To communicate simply and clearly, radiologists are given the discretion to report CT and MRI nodules in aggregate. By comparison, CEUS is a focused exam that evaluates a limited number of specifically targeted nodules. Since only a limited number of specifically targeted nodules are evaluated, each nodule should be reported individually.

What should I report if a nodule is biopsied and has a path-proven diagnosis?

- If malignant or if definitely benign of non-hepatocellular origin (e.g., hemangioma): report nodule's pathology diagnosis, clinically relevant imaging features, and change since prior.
- If benign of hepatocellular origin (e.g., regenerative or dysplastic nodule): report nodule's CEUS LI-RADS category and path diagnosis, imaging features, and change since prior. Also specify the date of pathology acquisition as the lesion may have changed over time.

What if the pathology of a biopsied nodule is discordant with the LI-RADS CEUS category?

Indicate discordance in your report and provide the LI-RADS CEUS category and the path diagnosis. Specify the date of pathology acquisition as the lesion may have changed over time and explain briefly why you believe this represents a discordance. Consider multidisciplinary discussion with consensus review of the histology, imaging, and other clinical data to adjudicate the discordance.

How should I report findings if a nodule has been treated?

For nodules treated with non-radiation-based locoregional therapies, such as radiofrequency or microwave ablation, or trans-arterial chemo-embolization or surgical resection, use the LI-RADS CEUS Nonradiation Treatment Response Assessment (TRA) algorithm[1]. For nodules or other observations treated with radiation-based locoregional therapies or systemic chemotherapy, generally CEUS is not recommended, as it is assumed that the patient has advanced disease and requires staging, unless particular assessment is needed for one or a few target liver observations, such as to determine viability for biopsy planning.

What should I do if there are multiple observations requiring diagnostic imaging workup?

CEUS is a focused exam that evaluates a limited number of specifically targeted nodules, typically up to 5. Prior imaging should be reviewed, and nodules that are the most clinically significant should be targeted. These may be LR-3 or LR-4 nodules, when obtaining a diagnosis of HCC would impact management. This may be an LR-M nodule, and CEUS used to confirm HCC or a non-HCC malignancy.

If more than one nodule can be targeted during the same injection, more than one observation can be evaluated at a time. If nodules have previously been diagnosed as nonsuspicious (LR-1 or LR-2), further imaging could be deferred in favor of other actionable findings. If there are innumerable nodules with similar or identical imaging features, these can be reported in aggregate, such as for multifocal HCC or innumerable metastases.

References

1. American College of Radiology Committee on LI-RADS®. LI-RADS CEUS Nonradiation TRA v2024 Core. Available at: American College of Radiology. Accessed on 9/17/2026.

Imaging Features

What is the difference between BPA and KCA?

- BPA: purely intravascular agent with negligible agent retention.
- KCA: behaves initially as a BPA but is subsequently phagocytosed by Kupffer cells. This phagocytosis creates a transitional phase (beginning ~1 min after injection) in which normal liver parenchyma remains enhanced due to a combination of intravascular agent and Kupffer-cell uptake, but lesions without functioning Kupffer cells appear hypoenhanced. The transitional phase is followed by Kupffer phase (beginning ~10 min after injection) in which the intravascular agent is no longer present and normal liver parenchyma remains enhanced due to Kupffer-cell uptake.

What is the difference between BPA washout and KCA early transitional and Kupffer-phase hypoenhancement?

- BPA washout refers to the dynamic phenomenon in which a lesion becomes hypoenhancing relative to the surrounding liver parenchyma because contrast clears from tumor vessels more rapidly than from normal hepatic sinusoids. Washout is therefore a vascular phenomenon, assessed in the portal venous and late phases.
- The KCA transitional phase is divided into an early transitional phase (1–5 min after contrast injection) and a late transitional phase (5–10 min after contrast injection).
- In the early KCA transitional phase, most contrast microbubbles remain intravascular, with relatively low Kupffer-cell accumulation. Therefore, the contrast kinetics of KCA roughly mirror those of BPA. As a result, early transitional-phase KCA hypoenhancement has diagnostic utility similar to BPA washout and is used as one of the major imaging features of LR-5.
- The late KCA transitional phase is characterized by progressive Kupffer-cell contrast accumulation and disappearance of free-circulating contrast agent, and it is not currently used for LI-RADS categorization.
- KCA Kupffer-phase hypoenhancement reflects an isolated deficiency of Kupffer-cell uptake within the nodule compared with the surrounding normally enhanced liver parenchyma.

Does BPA washout or KCA hypoenhancement apply only to nodules with APHE?

No. Both BPA washout and KCA hypoenhancement apply to isoenhancing or hypoenhancing nodules in addition to nodules with APHE. For example, both of the following nodules should be characterized as having BPA washout or KCA hypoenhancement:

- Arterial phase isoenhancement followed by late-phase hypoenhancement
- Arterial phase hypoenhancement followed by isoenhancement followed by hypoenhancement
- Arterial phase hypoenhancement followed by a more pronounced hypoenhancement on late phase images, often with a marked degree

BPA washout/KCA hypoenhancement does NOT apply to nodules that remain the same level of hypoenhancement in all phases.

The lesion shows mild washout on BPA CEUS initially and then washes out completely to look black. Is it mild or marked?

If the washout becomes marked at or before 2 min, characterize as marked. If the washout becomes marked only after 2 min, characterize as mild. If unsure, characterize as marked (to prevent false CEUS LR-5 categorization for non-HCC malignancies with borderline marked washout).

How much growth is “unequivocal growth”?

There is no threshold for determining unequivocal growth on CEUS. This is up to the interpreter. As a general rule, more than 5 mm is unequivocal.

Abbreviations

AASLD	American Association for the Study of Liver Diseases
AF	Ancillary feature
APHE	Arterial phase hyperenhancement
APS	Arterioportal shunt
BPA	Blood-pool agent
CEUS	Contrast-enhanced ultrasound
FNH	Focal nodular hyperplasia
HA	Hepatic artery
HCA	Hepatocellular adenoma
HCC	Hepatocellular carcinoma
ICC	Intrahepatic cholangiocarcinoma
KCA	Kupffer-cell agent
LI-RADS	Liver Imaging Reporting And Data System
LMW	Low-molecular-weight
MDD	Multidisciplinary discussion
MRI	Magnetic resonance imaging
OPTN	Organ Procurement and Transplantation Network
PVP	Portal venous phase
TIV	Tumor in vein
US	Ultrasound

Why is an update needed in 2027?

- The LI-RADS mission and long-term vision is to unify diagnostic imaging criteria for HCC. A critical milestone was recently achieved with the integration of CEUS LI-RADS into the clinical practice guidance of the American Association for the Study of Liver Diseases (AASLD), adoption by the Organ Procurement and Transplantation Network (OPTN) National Liver Review Board, and endorsement by the European Association for the Study of the Liver (EASL) for diagnosing HCC in cases of indeterminate lesions identified at CT or MRI. To support broader clinical acceptance of CEUS for HCC diagnosis, we have clarified certain imaging criteria within CEUS LI-RADS.

- The integration of KCA CEUS into LI-RADS reflects a growing need for more sensitive and specific tools in the evaluation of liver nodules in patients at risk for HCC. Unlike pure blood-pool contrast agents, KCA provides both vascular-phase and Kupffer-phase imaging, enabling better detection of lesions with reduced Kupffer cell activity — a hallmark of many HCCs and nonhepatocellular malignancies. Including KCA expands the diagnostic utility of CEUS in LI-RADS, aligning imaging recommendations with evolving clinical practice and regional contrast agent availability.

- The LI-RADS Occult Nodule Algorithm offers a standardized framework to guide next steps, optimize lesion characterization, and support timely and appropriate care decisions. Occult hepatic nodules — lesions not seen on pre-contrast ultrasound but recognized on prior CT or MRI or discovered during the performance of CEUS for other reasons— pose a common and clinically important dilemma in the surveillance and management of patients at high risk for HCC.



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