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2017 Version of LI-RADS for CT and MR Imaging: An Update

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2017 Version of LI-RADS for CT and MR Imaging: An Update[1]

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The Liver Imaging Reporting and Data System (LI-RADS) is a reporting system created for the standardized interpretation of liver imaging findings in patients who are at risk for hepatocellular carcinoma (HCC). This system was developed with the cooperative and ongoing efforts of an American College of Radiology–supported committee of diagnostic radiologists with expertise in liver imaging and valuable input from hepatobiliary surgeons, hepatologists, hepatopathologists, and interventional radiologists. In this article, the 2017 version of LI-RADS for computed tomography and magnetic resonance imaging is reviewed. Specific topics include the appropriate population for application of LI-RADS; technical recommendations for image optimization, including definitions of dynamic enhancement phases; diagnostic and treatment response categories; definitions of major and ancillary imaging features; criteria for distinguishing definite HCC from a malignancy that might be non-HCC; management options following LI-RADS categorization; and reporting.

Abbreviations: APHE = arterial phase hyperenhancement, HCC = hepatocellular carcinoma, LI-RADS = Liver Imaging Reporting and Data System, TIV = tumor in vein

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Identify the appropriate population for application of LI-RADS.
- Define major and ancillary imaging features for the diagnosis of HCC.
- Describe LI-RADS categories and differentiate between definite HCC and non-HCC malignancy.

See www.rsna.org/education/search/RG.

Introduction

Hepatocellular carcinoma (HCC) is the most common primary malignancy of the liver, the fifth most common cancer in men, the seventh most common cancer in women, and the second leading cause of cancer-related deaths in the world (1). Risk factors for HCC include hepatitis B and C viruses, which account for more than 80% of HCC cases worldwide (2). Most HCCs occur in cirrhotic livers (3,4), although certain populations with chronic hepatitis B without cirrhosis also are at high risk. Nonviral causes of cirrhosis include chronic alcohol abuse, nonalcoholic fatty liver disease, chronic biliary obstruction, autoimmune diseases, inherited metabolic disorders, nonviral infections, drug use, and environmental toxins (5). The annual risk of developing HCC among patients with cirrhosis is 2%–8%, depending on the cause and number of concurrent risk factors (6).

TEACHING POINTS

- The LI-RADS diagnostic population includes adult (ie, older than 18 years) patients with cirrhosis, patients with chronic hepatitis B, and/or patients with current or prior HCC with or without cirrhosis, including adult liver transplantation candidates and liver transplant recipients.
- Pediatric patients are excluded from the LI-RADS diagnostic population because the performance of LI-RADS has not been validated in this age group.
- The newly added LR-NC category is intended to allow the radiologist to defer designating a final LI-RADS category when technical limitations (ie, image degradation or omission) prevent the differential diagnosis from being meaningfully narrowed.
- *Threshold growth*, a major feature, is now defined as a minimal 5-mm increase in lesion size and either a 50% or greater increase in size before or at 6 months or a 100% or greater increase in size after 6 months.
- In LI-RADS v2017, ancillary imaging features are designated as optional—that is, for use at the radiologist's discretion for a more refined categorization of lesions, increased confidence in the chosen category, and/or category adjustment.

HCC that develops in symptomatic patients is associated with a 5-year survival rate of 1%–10%. However, if it can be treated with transplantation or resection, the 5-year survival rate greatly improves—to greater than 50% (6). Therefore, the detection of HCC at an early stage by means of screening and surveillance is paramount for an optimal outcome. Although ultrasonography (US) is accepted as the most cost-effective tool for HCC screening, once a finding is detected, a diagnostic examination such as contrast material–enhanced computed tomography (CT), magnetic resonance (MR) imaging, or contrast-enhanced US is warranted to establish the diagnosis.

In most current clinical practice guidelines, CT and MR imaging have supplanted biopsy as the preferred method of diagnosing HCC when imaging features are characteristic (7). This approach is possible because the high risk of HCC in the selected screening cohort engenders high specificity and positive predictive value for the imaging-based diagnosis. Contrast-enhanced US is emerging as a potential alternative examination for confirming HCC once it is detected with screening US and is expected to be incorporated into clinical guidelines soon. If a benign or malignant diagnosis cannot be definitively established with noninvasive imaging, biopsy may be needed.

In North America, the American Association for the Study of Liver Diseases (AASLD) and the United Network for Organ Sharing and Organ Procurement and Transplantation Network (UNOS-OPTN) have provided diagnostic guidelines for patients at risk for HCC and liver transplantation candidates, respectively (6,8). These organizations provide criteria for the diagnosis of HCC that are based on imaging features such as arterial phase hyperenhancement (APHE), washout, capsule appearance, and lesion size and growth pattern. Contemporaneous to UNOS-OPTN and building on the experience of AASLD, the Liver Imaging Reporting and Data System (LI-RADS) *(https://www.acr.org/Quality-Safety/Resources/LIRADS)* (9) was developed by diagnostic radiologists with the support of the American College of Radiology and initially released in 2011 (10). LI-RADS provides *(a)* a comprehensive lexicon with definitions, schematics, and case examples for all imaging features incorporated; *(b)* an algorithm for the diagnosis of definite HCC and an ordinal approach to risk stratification for lesions that do not meet the criteria for the diagnosis of HCC; and *(c)* guidance for image acquisition and management.

LI-RADS is intended to reduce variability in the interpretation of imaging findings, improve communication through standardized reporting, and facilitate therapeutic decision making and outcome monitoring (9). It was designed for use by community and academic radiologists, radiologists in training, researchers, and any health care professional involved in providing care to patients at risk for HCC. LI-RADS, version 2017 (LI-RADS v2017) (11), represents the third update of this system; previous updates were released in 2013 and 2014 (12,13). The Table summarizes the key differences in categories between the 2014 and 2017 versions of LI-RADS.

In this article, we review LI-RADS v2017 for CT and MR imaging. The US surveillance and contrast-enhanced US sections of version 2017 are not discussed. Specific topics include the appropriate population for application of LI-RADS; technical recommendations for image optimization, including definitions of dynamic enhancement phases; diagnostic and treatment response categories; definitions of major and ancillary imaging features; criteria for distinguishing between definite HCC and a malignancy that might be non-HCC; management options following LI-RADS categorization; and reporting.

Overview of LI-RADS v2017

Prior versions of LI-RADS provided standard terminology and diagnostic criteria to assign probabilistic categories that reflected the relative risk of HCC or other malignancy for each observation in an at-risk population (13,14). In version 2017, new LI-RADS categories have been introduced to better characterize observations for both diagnosis and treatment response assessment.

The new material resides in a core module (11) that contains all of the essential content related to diagnosis, treatment response, management,

Comparison of Lesion Categories in 2014 and 2017 Versions of LI-RADS

Category	2014 Version	2017 Version
LR-NC	No LR-NC category	Lesion cannot be categorized owing to image degradation or omission
LR-1	Definitely benign	Same
LR-2	Probably benign	Same
LR-3	Intermediate probability of HCC	Same
LR-4	Probably HCC	Same
LR-5	Definitely HCC	Same
LR-5 V	Mass with definite tumor in vein (TIV)	No LR-5 V category; replaced with LR-TIV
LR-TIV	No LR-TIV category	Unequivocal enhancing soft-tissue TIV, regardless of the visualization of a parenchymal mass
LR-M	Probably or definitely malignant; features suggestive of non-HCC malignancy, such as rim APHE and peripheral washout appearance	Targetoid mass or nontargetoid mass with one or more of the following: infiltrative appearance, marked diffusion restriction, necrosis or severe ischemia, other feature that in radiologist's judgement suggests a non-HCC malignancy
LR-TR	Any lesion that has undergone local-regional treatment, regardless of the outcome	Treatment response algorithm with the following categories: LR-TR nonevaluable, LR-TR nonviable, LR-TR equivocal, LR-TR viable

technique, and reporting. Expanded and more detailed content resides within a comprehensive manual in which a redesigned algorithm, improved schematics, and list-view and supplemental materials are incorporated. Major additions and clarifications are summarized in Figure 1.

The new content is aimed primarily at addressing gaps in prior versions, such as the lack of treatment response criteria and specific criteria for inclusion in the LR-M category (malignancy that may not be HCC). It is also intended to clarify existing information—for example, inclusion and exclusion criteria for defining the LI-RADS at-risk population are now provided. As in prior versions, the content in LI-RADS v2017 reflects a combination of expert consensus, evidence-based, and multidisciplinary feedback from hepatologists, pathologists, surgeons, interventional radiologists, and diagnostic radiologists from national and international perspectives. In addition to new material for CT and MR imaging, there are also new sections on US surveillance and screening, and contrast-enhanced US (11,15), which are beyond the scope of this review.

LI-RADS v2017 Diagnostic Population

Unlike prior versions, LI-RADS v2017 provides criteria that define the population in which it can be applied. The LI-RADS diagnostic population includes adult (ie, older than 18 years) patients with cirrhosis, patients with chronic hepatitis B, and patients with current or prior HCC with or without cirrhosis, including adult liver transplantation candidates and liver transplant recipients. LI-RADS v2017 does not apply to patients who meet any of the following exclusion criteria: cirrhosis due to a vascular disorder (eg, hereditary hemorrhagic telangiectasia, Budd-Chiari syndrome, nodular regenerative hyperplasia, or cardiac cirrhosis), cirrhosis due to congenital hepatic fibrosis, and pediatric patients. Patients with cirrhosis caused by vascular disorders are excluded from the LI-RADS diagnostic population because of the large number of arterialized nonmalignant hepatocellular nodules that may resemble HCC at imaging, which lowers diagnostic specificity (16–18). Pediatric patients are excluded from the LI-RADS diagnostic population because the performance of LI-RADS has not been validated in this age group.

LI-RADS v2017 Categories

In LI-RADS v2017, the new diagnostic category LR-NC has been added. In addition, substantive changes have been made to two existing categories: LR-TIV (previously LR-5 V) and LR-M (Figs 1, 2) (Table).

LR-NC (Not Categorizable).—The newly added LR-NC category is intended to allow the radiologist to defer designating a final LI-RADS category when technical limitations (ie, image degradation or omission) prevent the differential diagnosis from being meaningfully narrowed. For instance, if the diagnostic considerations for an observation ranged from probably benign to potentially malignant because dynamic phase imaging had not been performed, LR-NC would be an appropriate category for the observation.

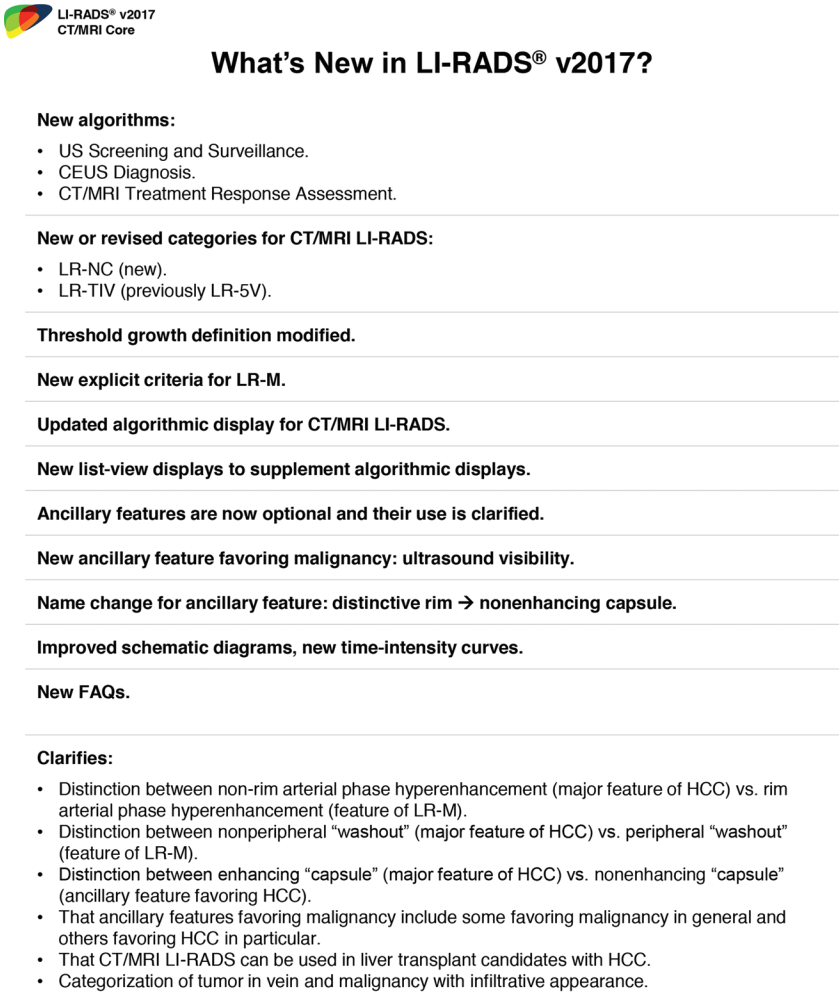


Figure 1. Clarifications and new and revised categories in LI-RADS v2017. *CEUS* = contrast-enhanced US. (Reprinted, with permission, from reference 11.)

For LR-NC observations, repeat imaging performed with all sequences at 3 months or sooner is usually appropriate. Radiologists should use their judgment, however, as there may be cases in which only those sequences in which images were degraded or omitted need to be repeated. Moreover, depending on the cause of image degradation, imaging with an alternative modality may be preferable. For example, if blooming artifact from a vascular embolization coil precludes lesion categorization with use of MR imaging, alternative imaging with CT should be suggested. In the unlikely event that no imaging modality facilitates a diagnosis, a multidisciplinary discussion is warranted, with biopsy considered.

LR-TIV (Definitely Malignant with TIV).—An unequivocal TIV (Fig 3) was previously categorized as an LR-5V lesion, although other malignancies such as cholangiocarcinoma and combination tumors also can invade veins (19). Because TIVs can occur in non-HCC malignancies, in LI-RADS v2017, the category LR-5 is replaced with LR-TIV, which can apply to HCC or other malignancies. Note that a TIV may be more conspicuous than the corresponding parenchymal mass. In some cases, the mass may go unnoticed until recognition of the TIV prompts closer scrutiny of the parenchyma.

LR-M.—The imaging criteria for inclusion in category LR-M (probable or definite malignancy, not specific for HCC) are redefined in LI-RADS v2017. Prior versions include a list of ancillary features that are suggestive of other malignancies, but they do not provide specific guidelines for application of the features. The LR-M category is now defined by the inclusion criteria listed in Figure 4. These features are most closely associated with intrahepatic cholangiocarcinomas but

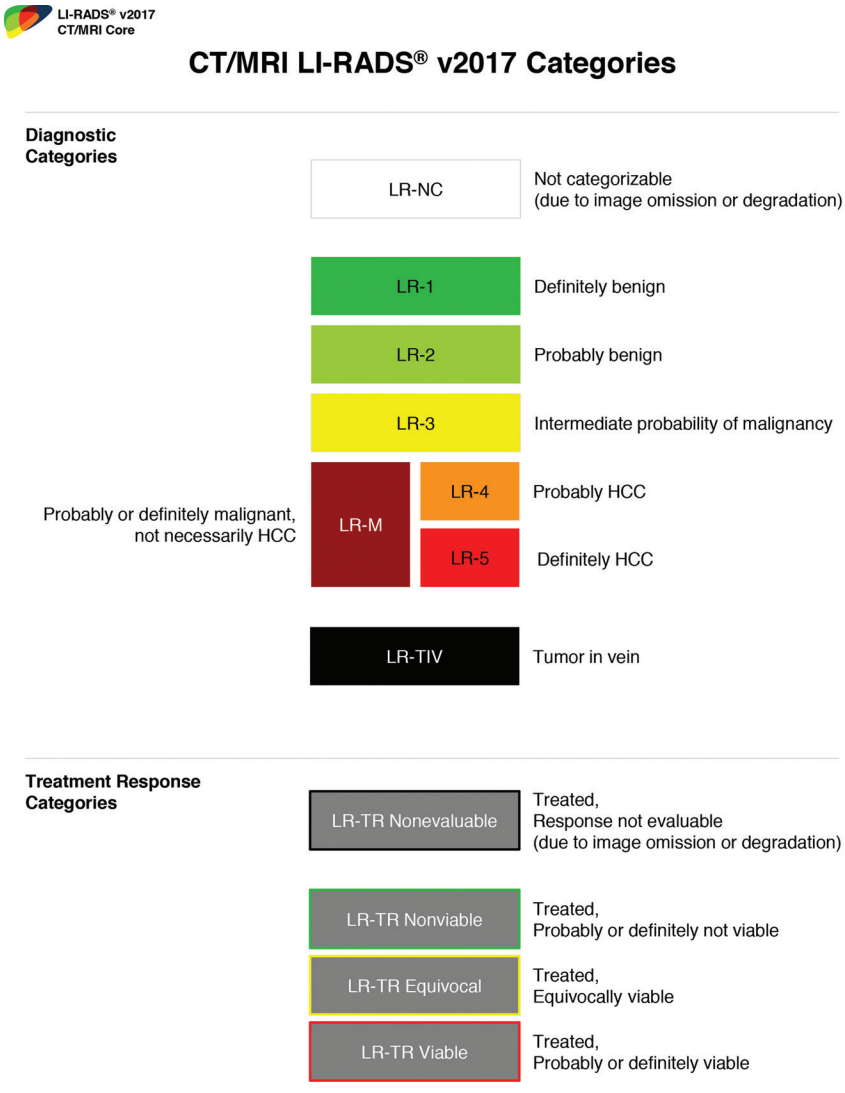
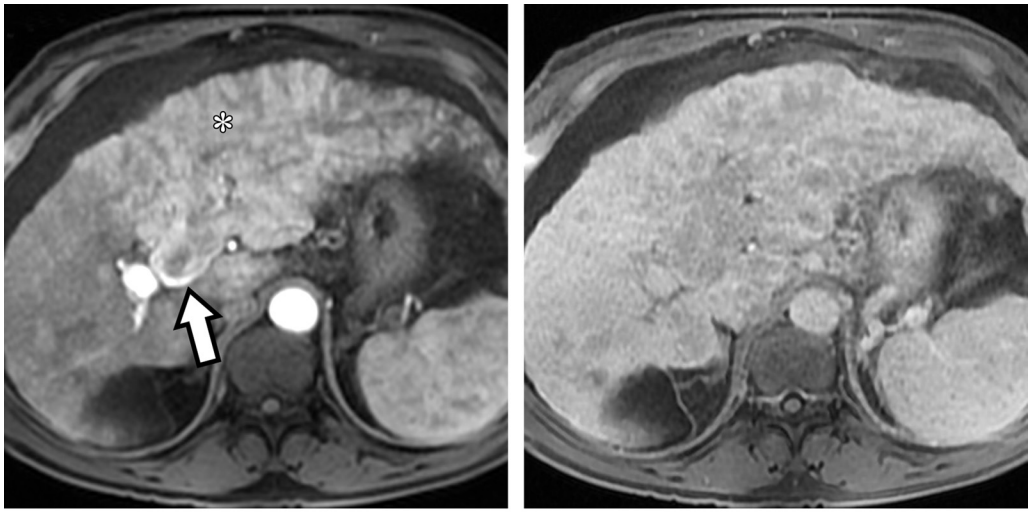


Figure 2. LI-RADS v2017 diagnostic and treatment response categories for CT and MR imaging. (Reprinted, with permission, from reference 11.)



a. **b.**

Figure 3. Infiltrative HCC in a 54-year-old man with a lesion categorized as LR-TIV (definitely TIV) on the basis of major imaging features. Axial dynamic late arterial phase **(a)** and delayed phase **(b)** MR images show an infiltrative HCC (* in **a**) with an enhancing TIV (arrow in **a**).

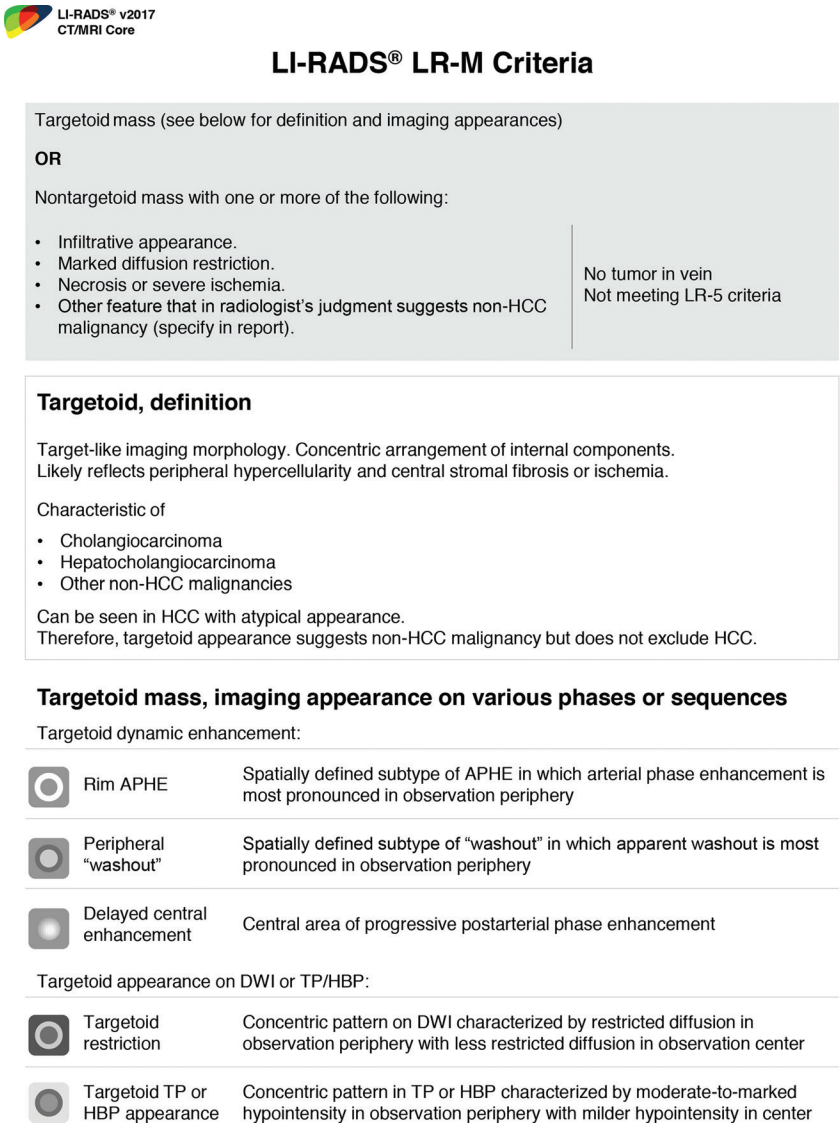


Figure 4. LI-RADS v2017 LR-M criteria. *DWI* = diffusion-weighted imaging, *HBP* = hepatobiliary phase, *TP* = transitional phase. (Reprinted, with permission, from reference 11.)

may also be present in combination tumors (eg, hepatocholangiocarcinomas) and metastases. However, metastases are extremely rare in cirrhotic livers (20,21). The updated, more explicit criteria for inclusion in the LR-M category are intended to preserve the specificity of the LR-5 category for HCC without loss of sensitivity for the detection of malignancy and to improve interreader agreement. Many LR-M lesions represent HCC but do not meet the imaging criteria for this diagnosis. Multidisciplinary discussion is usually required for the appropriate management of LR-M lesions.

Changes to Major Feature Definitions

The definition of threshold growth is modified and more clearly defined in LI-RADS v2017. *Threshold growth*, a major feature, is now defined as a minimal 5-mm increase in lesion size and either a 50% or greater increase in size before or at 6 months or a 100% or greater increase in size after 6 months. A lesion that was previously unseen for up to 24 months but is now 10 mm in diameter or larger also is considered to have threshold growth. It is imperative to perform comparative measurements during the same phase, with the same imaging sequence, and in the same plane in serial examinations whenever possible. Performing these measurements with arterial phase and diffusion-weighted MR imaging should be avoided if possible (19,22) (Figs 5, 6).

Prior terminology that generated confusion is clarified in LI-RADS v2017. Example clarifications include distinctions between nonrim APHE, a major feature of HCC, and rim APHE, which is a criterion for inclusion in the LR-M category (Fig 7); between nonperipheral washout, a major feature of HCC, and peripheral washout, which is a criterion for inclusion in the LR-M category (Fig 8); and between enhancing capsule, a major

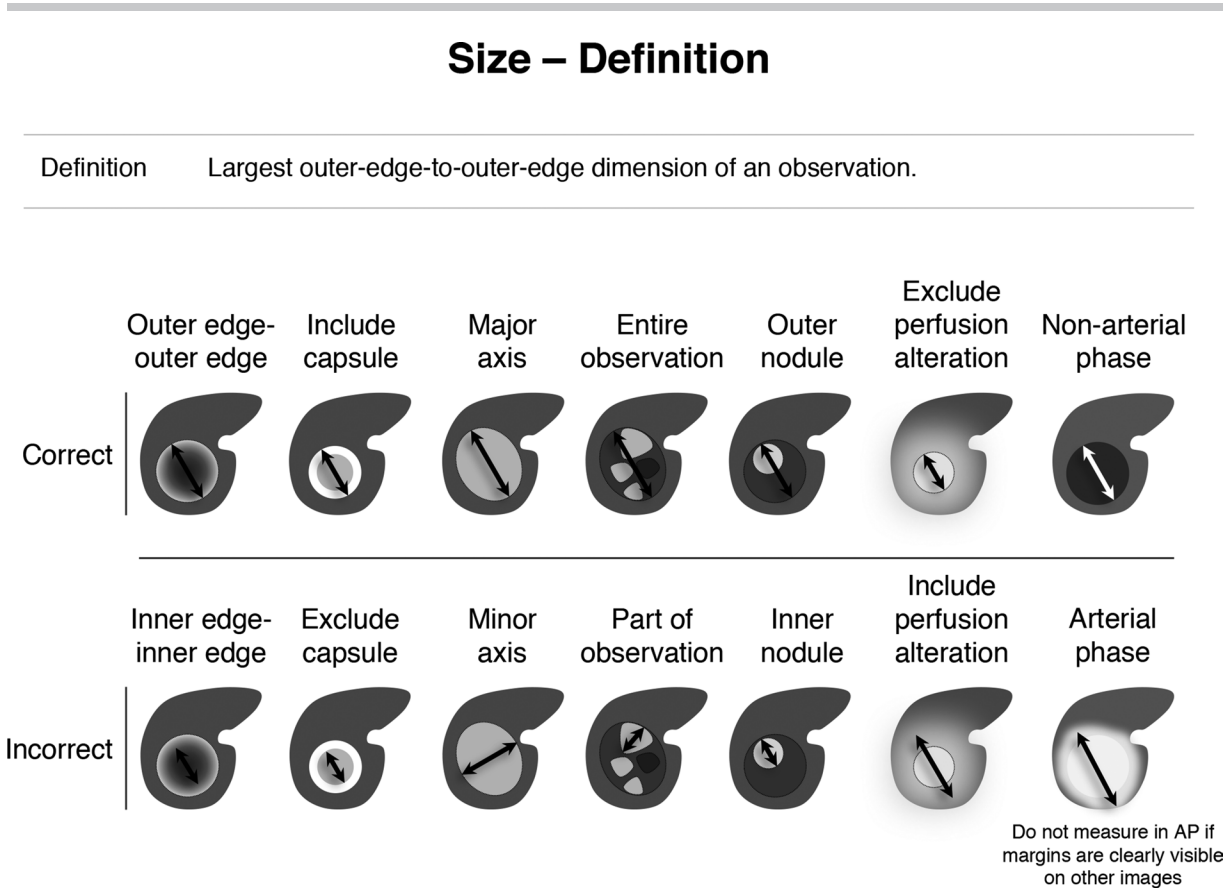


Figure 5. Lesion size measurement. The lesion size should be measured with the imaging sequence and in the enhancement phase and imaging plane with which the margins are most sharply demarcated and there is no anatomic distortion. The lesion should be measured from outer edge to outer edge, including the capsule, and in the long dimension, including the entire lesion but excluding perfusion alterations. *AP* = arterial phase. (Reprinted, with permission, from reference 13.)

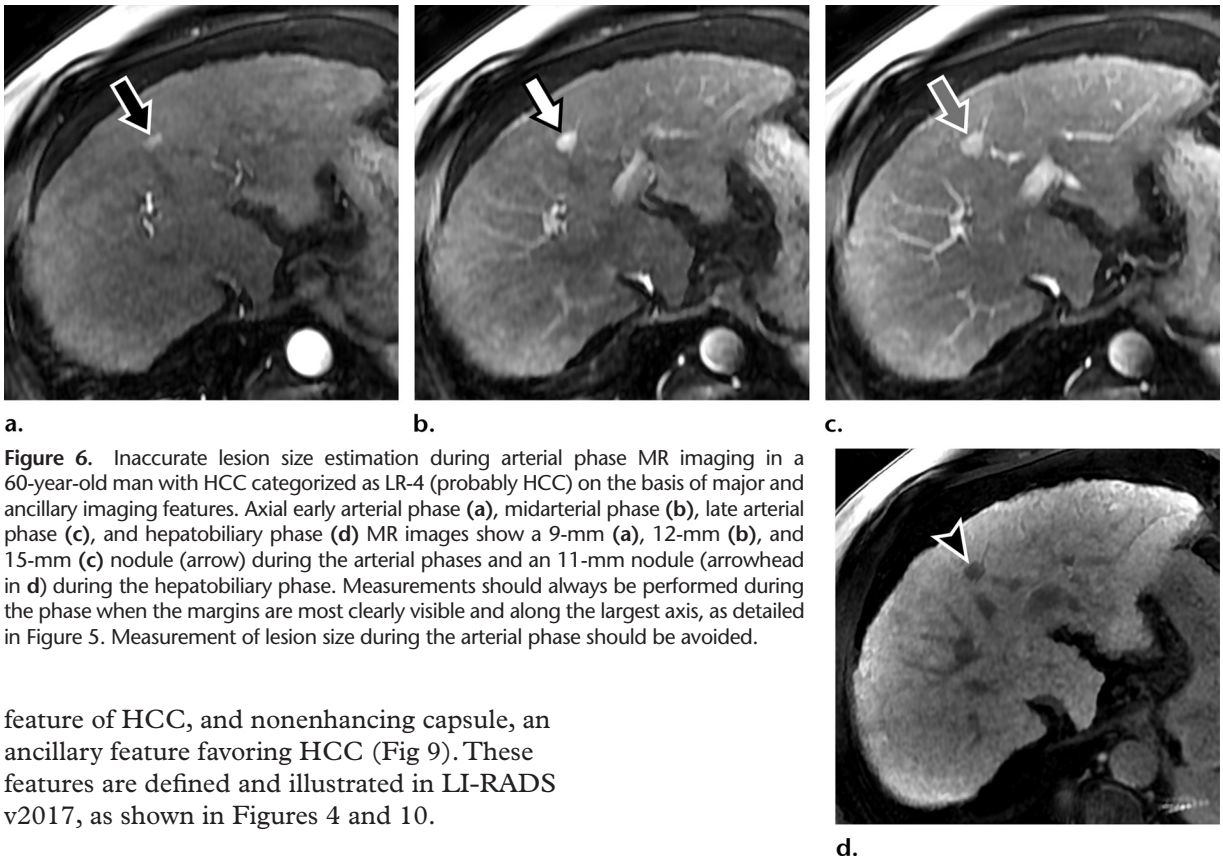
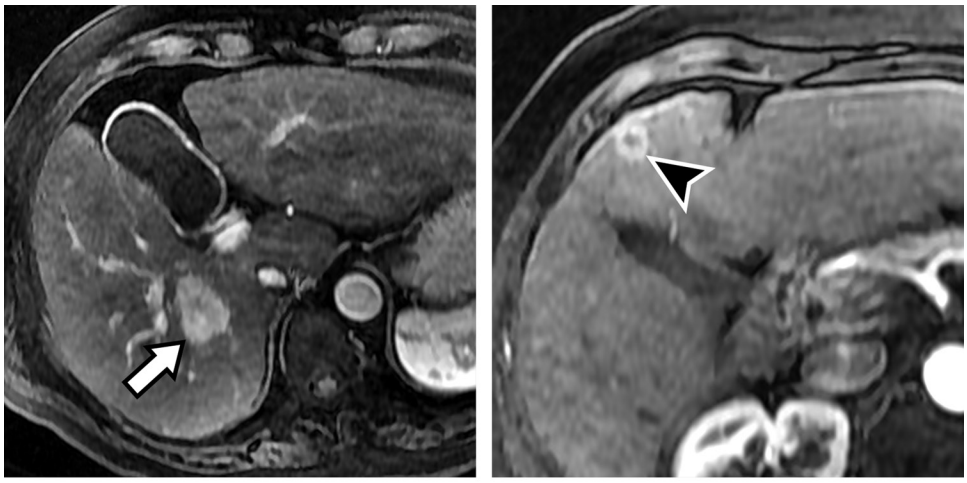


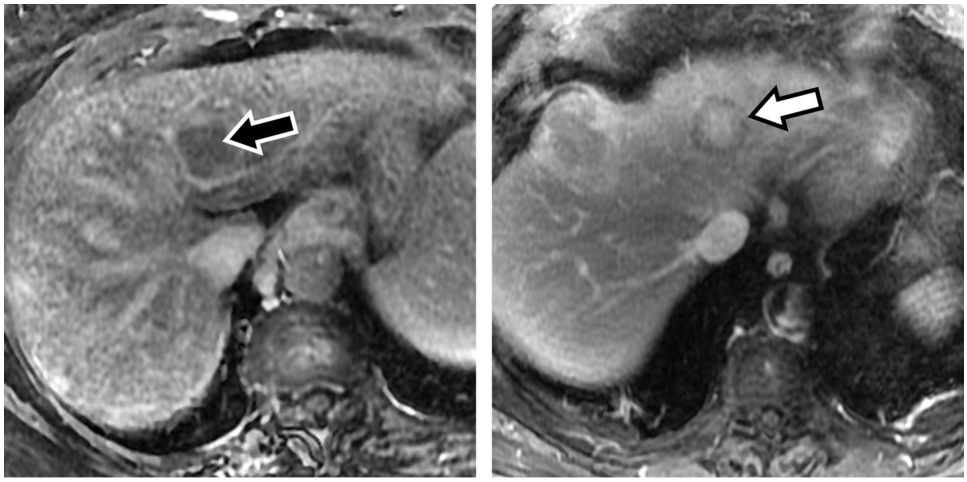
Figure 6. Inaccurate lesion size estimation during arterial phase MR imaging in a 60-year-old man with HCC categorized as LR-4 (probably HCC) on the basis of major and ancillary imaging features. Axial early arterial phase **(a)**, midarterial phase **(b)**, late arterial phase **(c)**, and hepatobiliary phase **(d)** MR images show a 9-mm **(a)**, 12-mm **(b)**, and 15-mm **(c)** nodule (arrow) during the arterial phases and an 11-mm nodule (arrowhead in **d**) during the hepatobiliary phase. Measurements should always be performed during the phase when the margins are most clearly visible and along the largest axis, as detailed in Figure 5. Measurement of lesion size during the arterial phase should be avoided.

feature of HCC, and nonenhancing capsule, an ancillary feature favoring HCC (Fig 9). These features are defined and illustrated in LI-RADS v2017, as shown in Figures 4 and 10.



a. b.

Figure 7. APHE in a 70-year-old man with a lesion categorized as LR-5 (definitely HCC) **(a)** and a 58-year-old woman with a lesion categorized as LR-M (probably or definitely malignant) **(b)**. Axial T1-weighted late arterial phase MR images show non–rimlike APHE (arrow in **a**) versus rim APHE (arrowhead in **b**).



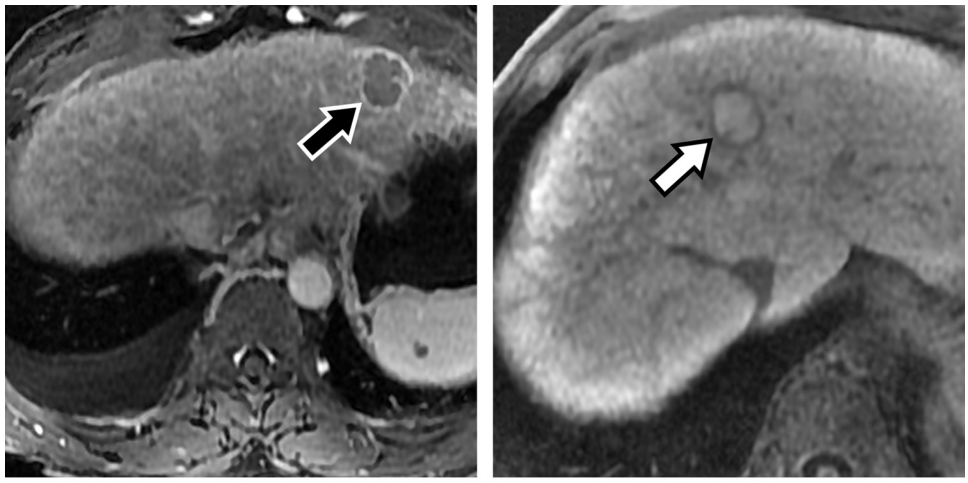
a. b.

Figure 8. Washout appearance in a 70-year-old woman with a lesion categorized as LR-5 (definitely HCC) **(a)** and a 79-year-old man with a lesion categorized as LR-M (probably or definitely malignant) **(b)**. Axial T1-weighted delayed phase MR images show a nonperipheral **(a)** versus peripheral **(b)** washout appearance (arrow).

Ancillary Imaging Features

In LI-RADS v2017, ancillary imaging features are designated as optional—that is, for use at the radiologist's discretion for a more refined categorization of lesions, increased confidence in the chosen category, and/or category adjustment. Ancillary features can be used to upgrade or downgrade an observation by no more than one category but cannot be used to upgrade an observation to category LR-5, given insufficient evidence that any ancillary feature has sufficient specificity for the diagnosis of HCC (19). Generally, if an observation demonstrates one or more ancillary features favoring malignancy, the observer may upgrade it by one category, up to LR-4. If an observation demonstrates one or more features favoring benignity, the observer can downgrade it by one category. If there are conflicting ancillary features—that is, the observation has one or more features favoring malignancy and one or more features favoring benignity—then the category should not be changed. The ancillary features used in LI-RADS v2017 and the imaging modalities with which they may be visible are listed in Figure 11. These features are separated into those favoring malignancy in general, those favoring HCC in particular, and those favoring benignity.

The ancillary features themselves are similar to those described in the 2013 and 2014 versions of LI-RADS, with two exceptions: First, the appearance of a lesion that was identified at CT or MR imaging and seen as a discrete nodule at



a. b.

Figure 9. Capsule in a 63-year-old woman **(a)** and 54-year-old man **(b)**, each of whom has an LR-5 (definitely HCC) lesion. **(a)** Axial delayed phase MR image shows an enhancing capsule (arrow). **(b)** Axial hepatobiliary phase MR image shows a nonenhancing capsule (arrow).

Figure 10. Definitions of major imaging features in LI-RADS v2017. *CEUS* = contrast-enhanced US, *DP* = delayed phase, *DWI* = diffusion-weighted imaging, *ECA* = extracellular agent, *HBP* = hepatobiliary phase, *PVP* = portal venous phase, *TP* = transitional phase. (Reprinted, with permission, from reference 11.)

LI-RADS® v2017
CT/MRI Core

LI-RADS® Major Imaging Features

APHE (not rim)	Nonrim-like enhancement in arterial phase unequivocally greater in whole or in part than liver. Enhancing part must be higher in attenuation or intensity than liver in arterial phase. *Contrast with rim APHE (inclusion criterion for LR-M, page 20).*
"Washout" (not peripheral)	Nonperipheral visually assessed temporal reduction in enhancement in whole or in part relative to composite liver tissue from earlier to later phase resulting in hypoenhancement in the extracellular phase: • portal venous or delayed phase if ECA or gadobenate is given • portal venous phase if gadoxetate is given Can apply to any enhancing observation, even if no APHE. *Contrast with peripheral "washout" (inclusion criterion for LR-M, page 20) or TP or HBP hypointensity (ancillary features favoring malignancy, page 21).*
Enhancing "capsule"	Smooth, uniform, sharp border around most or all of an observation, unequivocally thicker or more conspicuous than fibrotic tissue around background nodules, and visible as an enhancing rim in PVP, DP, or TP. *Contrast with nonenhancing capsule (ancillary feature favoring HCC, page 21) or corona enhancement (ancillary feature favoring malignancy, page 21).*
Size	Largest outer-edge-to-outer-edge dimension of an observation: • Include "capsule" in measurement. • Pick phase, sequence, plane in which margins are clearest. • Do not measure in arterial phase or DWI if margins are clearly visible on different phase (size may be overestimated in arterial phase due to summation with periobservation enhancement and is not measured reliably on DWI due to anatomic distortion).
Threshold growth	Size increase of a mass by a minimum of 5 mm AND as follows: • ≥ 50% increase in size in ≤ 6 months **OR** • ≥ 100% increase in size in > 6 months **OR** • Previously unseen on CT or MRI, now ≥ 10 mm, in ≤ 24 months Measure on same phase, sequence, and plane on serial exams. ⚠ Note: Apply threshold growth *only* if there is a prior CT or MRI exam of sufficient quality and appropriate technique to gauge if an observation is new or has grown. Do not assess threshold growth by comparing to prior US or CEUS exams.

LI-RADS® v2017
CT/MRI Core

LI-RADS® Ancillary Imaging Features Favoring Malignancy & The Imaging Modalities in Which They Are Visible

Ancillary features favoring malignancy, not HCC in particular

Feature	Definition	CT	MRI ECA	MRI HBA
US visibility as discrete nodule	Unenhanced US visibility as discrete nodule or mass corresponding to CT- or MRI-detected observation	+	+	+
Subthreshold growth	Unequivocal size increase of a mass, less than threshold growth.	+	+	+
Corona enhancement	Periobservational enhancement in late arterial phase or early PVP attributable to venous drainage from tumor	+	+	+
Fat sparing in solid mass	Relative paucity of fat in solid mass relative to steatotic liver **OR** in inner nodule relative to steatotic outer nodule	+ / –	+	+
Restricted diffusion	Intensity on DWI, not attributable solely to T2 shine-through, unequivocally higher than liver and/or ADC unequivocally lower than liver	—	+	+
Mild-moderate T2 hyperintensity	Intensity on T2WI mildly or moderately higher than liver and similar to or less than non-iron-overloaded spleen	—	+	+
Iron sparing in solid mass	Paucity of iron in solid mass relative to iron-overloaded liver **OR** in inner nodule relative to siderotic outer nodule	—	+	+
Transitional phase hypointensity	Intensity in the transitional phase unequivocally less, in whole or in part, than liver	—	—	+
Hepatobiliary phase hypointensity	Intensity in the hepatobiliary phase unequivocally less, in whole or in part, than liver	—	—	+

Ancillary features favoring HCC in particular

Feature	Definition	CT	MRI ECA	MRI HBA
Nonenhancing "capsule"	Capsule appearance not visible as an enhancing rim.	+	+	+
Nodule-in-nodule architecture	Presence of smaller inner nodule within and having different imaging features than larger outer nodule	+	+	+
Mosaic architecture	Presence of randomly distributed internal nodules or compartments, usually with different imaging features	+	+	+
Fat in mass, more than adjacent liver	Excess fat within a mass, in whole or in part, relative to adjacent liver	+ / –	+	+
Blood products in mass	Intralesional or perilesional hemorrhage in the absence of biopsy, trauma or intervention	+ / –	+	+

+ usually evaluable – not evaluable + / – may or may not be evaluable

ADC = apparent diffusion coefficient, *DWI* = diffusion-weighted imaging, *ECA* = extracellular agent, *HBA* = hepatobiliary agent, *PVP* = portal venous phase, *T2WI* = T2-weighted imaging

a.

Figure 11. **(a)** Definitions of ancillary imaging features favoring malignancy in LI-RADS v2017. (Reprinted, with permission, from reference 11.) *(Fig 11 continues.)*

nonenhanced US is now considered an ancillary feature favoring malignancy. The rationale is that while US alone has modest sensitivity (58%–89%) for the diagnosis of HCC, it has higher specificity (85%–90%) (23). A US-visible lesion that is also identified with MR imaging, which has a per-lesion sensitivity and specificity of 83% and 87%, respectively, or with CT, which has a per-lesion sensitivity and specificity of 76% and 89%, respectively, is considered more likely to be malignant (24).

Second, a nonenhancing capsule, defined as a capsule that is not depicted as an enhancing rim (ie, it does not meet the definition criteria for capsule appearance), is considered an ancillary feature that favors HCC in particular. More specifically, this is the description of a smooth uniform sharp border around most or all of a lesion. This border is distinct from the fibrotic tissue around background nodules and does not enhance during any phase of imaging (11). Nonenhancing "capsules" typically are hypoattenutating at CT, hypointense on nonenhanced or gadolinium-enhanced T1-weighted MR images, and of variable signal intensity on T2- and diffusion-weighted MR images.

Assigning a LI-RADS Diagnostic Category in Four Steps

Step 1: Apply the CT and MR Imaging LI-RADS Diagnostic Algorithm

A new simplified four-step approach to assigning a LI-RADS category is provided in version 2017 (Figs 12–14). First, the images must be reviewed for the appropriate elements, including the presence of all necessary dynamic enhancement phases, to determine whether they can be used to reliably assign a category. If this is not the case, the radiologist should categorize the observation as LR-NC. If the observation is categorizable and there is a definite TIV, the observation is categorized as LR-TIV.

LI-RADS® v2017
CT/MRI Core

LI-RADS® Ancillary Imaging Features Favoring Benignity & The Imaging Modalities in Which They Are Visible

Ancillary features favoring benignity

Feature	Definition	CT	MRI ECA	MRI HBA
Size stability ≥ 2 years	No significant change in observation size measured on exams ≥ 2 years apart in absence of treatment	+	+	+
Size reduction	Unequivocal spontaneous decrease in size over time, not attributable to artifact, measurement error, technique differences, or resorption of blood products	+	+	+
Parallels blood pool enhancement	Temporal pattern in which enhancement eventually reaches and then matches that of blood pool	+	+	+
Undistorted vessels	Vessels traversing an observation without displacement, deformation, or other alteration	+	+	+
Iron in mass, more than liver	Excess iron in a mass relative to background liver	+ / –	+	+
Marked T2 hyperintensity	Intensity on T2WI markedly higher than liver and similar to bile ducts and other fluid-filled structures	—	+	+
Hepatobiliary phase isointensity	Intensity in hepatobiliary phase nearly identical to liver	—	—	+

+ usually evaluable – not evaluable + / – may or may not be evaluable

ECA = extracellular agent, *HBA* = hepatobiliary agent, *T2WI* = T2-weighted imaging

b.

Figure 11. *(Continued)* **(b)** Definitions of ancillary imaging features favoring benignity in LI-RADS v2017. (Reprinted, with permission, from reference 11.)

LI-RADS® v2017
CT/MRI Core

Step 1. Apply CT/MRI LI-RADS® Diagnostic Algorithm

Untreated observation without pathologic proof in patient at high risk for HCC

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

Otherwise, use CT/MRI diagnostic table below

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

CT/MRI Diagnostic Table

Arterial phase hyperenhancement (APHE)		No APHE		APHE (not rim)		
Observation size (mm)		< 20	≥ 20	< 10	10-19	≥ 20
Count major features: • "Washout" (not peripheral) • Enhancing "capsule" • Threshold growth	None	LR-3	LR-3	LR-3	LR-3	LR-4
	One	LR-3	LR-4	LR-4	LR-4 / LR-5	LR-5
	≥ Two	LR-4	LR-4	LR-4	LR-5	LR-5

LR-4 / LR-5

Observations in this cell are categorized LR-4, except:
- LR-5g, if ≥ 50% diameter increase in < 6 months (equivalent to OPTN 5A-g)
- LR-5us, if "washout" and visibility at screening ultrasound (per AASLD HCC criteria)

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

Figure 12. Step 1 of the LI-RADS v2017 CT and MR imaging diagnostic algorithm: apply the algorithm. *AASLD* = American Association for the Study of Liver Diseases, *OPTN* = Organ Procurement and Transplantation Network. (Reprinted, with permission, from reference 11.)

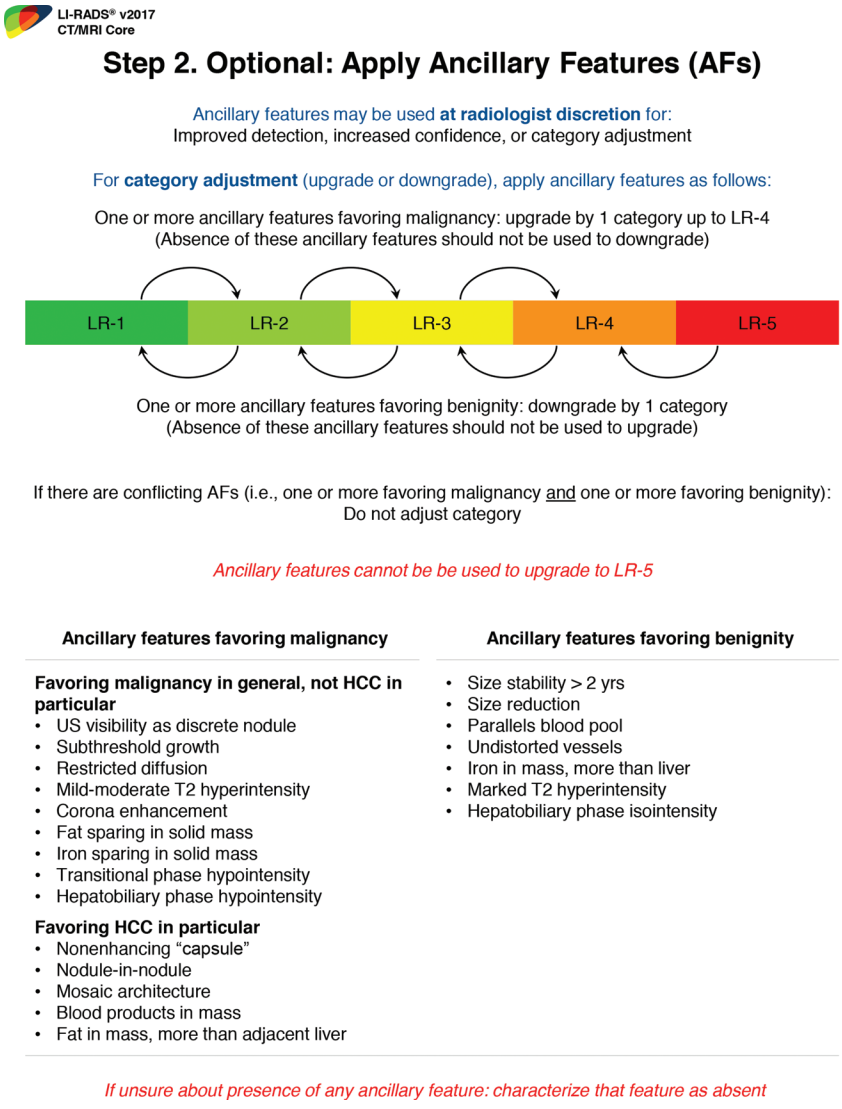


Figure 13. Step 2 of the LI-RADS v2017 CT and MR imaging diagnostic algorithm: apply the ancillary features. (Reprinted, with permission, from reference 11.)

If there is no definite TIV, the radiologist should consider whether the lesion is definitely (LR-1) or probably (LR-2) benign. LR-1 observations include definite cysts (Fig 15), hemangiomas, focal fat accumulation or sparing, and scars or confluent fibrosis (13). These are usually categorized on the basis of the radiologist's prior knowledge. In addition, findings that spontaneously resolve are categorized as LR-1.

Probably but not definitively benign observations are categorized as LR-2 lesions. These have a high but not 100% probability of being benign and include any of the benign entities just described if there is any doubt regarding the diagnosis. Common entities assigned to the LR-2 category include probable perfusion alterations (Fig 16), probable hemangiomas, and distinctive nodules without malignant features.

Distinctive nodules with no malignant features are thought to correspond to dysplastic nodules in most instances, but they are assigned to the LR-2 category because the small possibility of HCC cannot be excluded. The LI-RADS criteria for inclusion in this category are a solid nodule smaller than 20 mm in diameter with a distinctive imaging appearance compared with that of the background nodules, as well as no major feature of HCC, no feature of LR-M lesions, and no ancillary feature of malignancy. Examples include otherwise unremarkable nodules that have any combination of T1 hyperintensity, T2 hypointensity, siderosis, and/or hepatobiliary phase high signal intensity.

Most focal perfusion alterations related to nonmalignant arterioportal shunts or portal venous branch obstruction are similarly categorized as LR-2, rather than LR-1, observations because their benignity usually cannot be established with certainty (25). If an observation does not meet the criteria to be assigned to category LR-1 or LR-2, the next step is to determine whether it meets the criteria for inclusion in category LR-M (Fig 4).

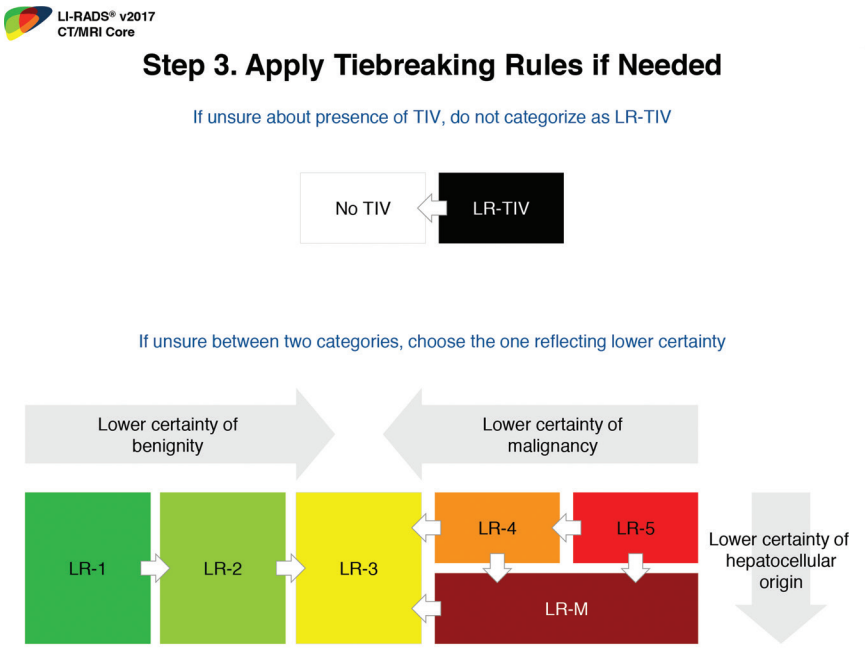
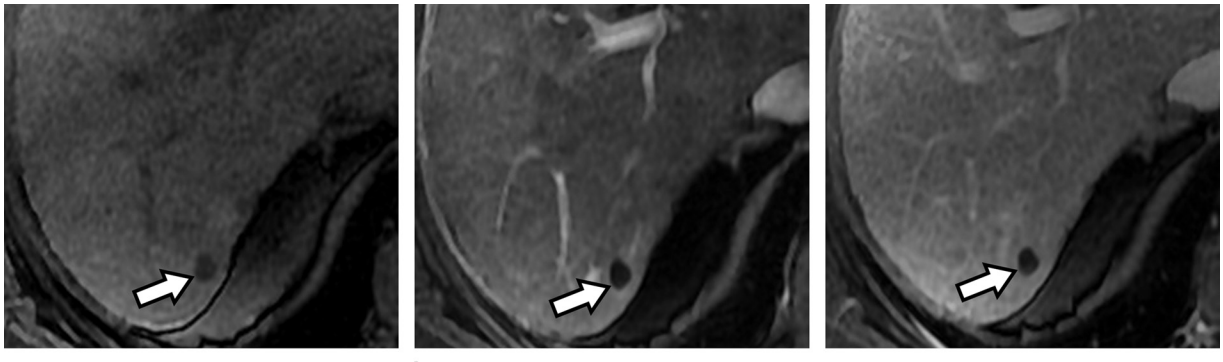
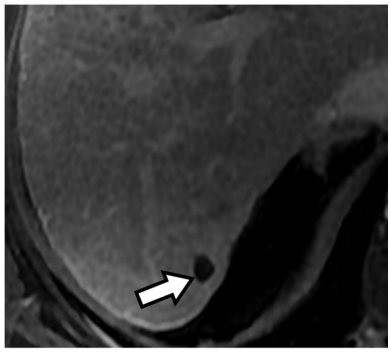


Figure 14. Steps 3 and 4 of the LI-RADS v2017 CT and MR imaging diagnostic algorithm: apply the tie-breaking rules for the category assigned and perform a final check. (Reprinted, with permission, from reference 11.)



a. **b.** **c.**



d.

Figure 15. Definite cyst in a 57-year-old man with an LR-1 (definitely benign) lesion. Axial dynamic nonenhanced **(a)**, arterial phase **(b)**, portal venous phase **(c)**, and delayed phase **(d)** MR images show a nonenhancing hypointense nodule (arrow).

The radiologist next refers to the diagnostic table (Fig 12) to determine the appropriate category for all other observations according to the size and major features of the lesion. The table guides the radiologist in determining the level of malignancy of an observation, from LR-3 (Fig 17) to LR-5.

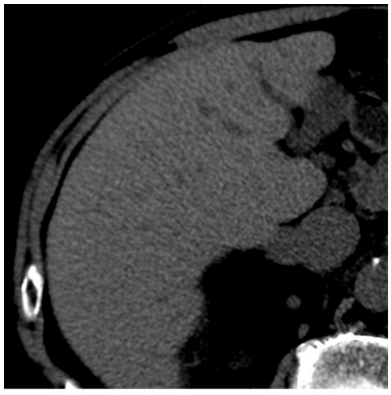
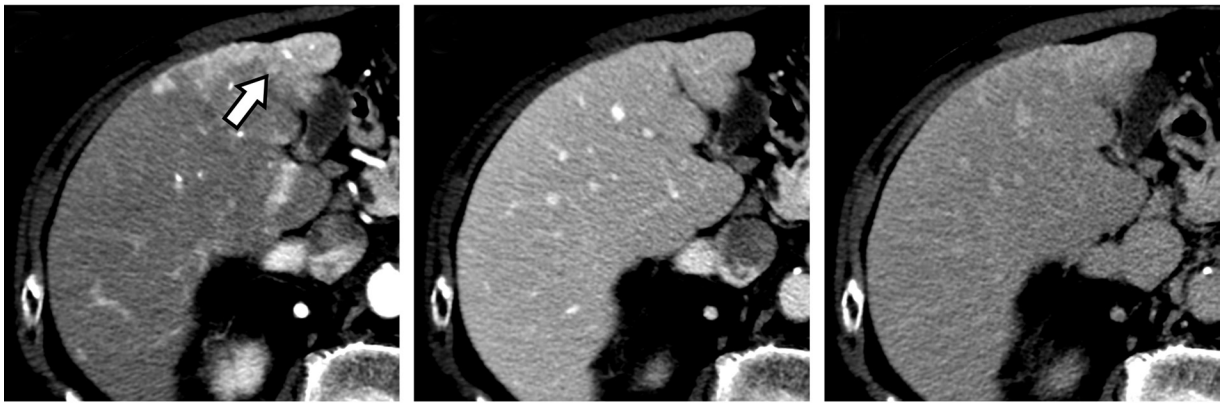


Figure 16. Perfusion alteration associated with a region of confluent fibrosis in a 76-year-old man with an LR-2 (probably benign) lesion. Axial dynamic nonenhanced **(a)**, late arterial phase **(b)**, portal venous phase **(c)**, and delayed phase **(d)** CT images were obtained. A subcapsular area of perfusion alteration (arrow in **b**) is visible during the late arterial phase only and associated with capsular retraction.

a.



b. **c.** **d.**

Step 2: Apply Ancillary Features

As discussed earlier, the application of ancillary features is cited as optional—that is, left to the discretion of the radiologist—in LI-RADS v2017. Ancillary features can be used to upgrade or downgrade an observation, support the initial category choice, and/or enhance lesion detection. Ancillary features cannot be used to upgrade a lesion to category LR-5.

Step 3: Apply Tie-Breaking Rule If Necessary

After following steps 1 and 2, if there is uncertainty as to which of two categories should be assigned, the radiologist is advised to choose the category that reflects lower diagnostic certainty (Fig 14). For example, if debating whether to assign a lesion to category LR-4 or LR-5, the category with less certainty (LR-4) should be chosen. Similarly, if there is uncertainty regarding the presence of a TIV, a category other than LR-TIV should be assigned.

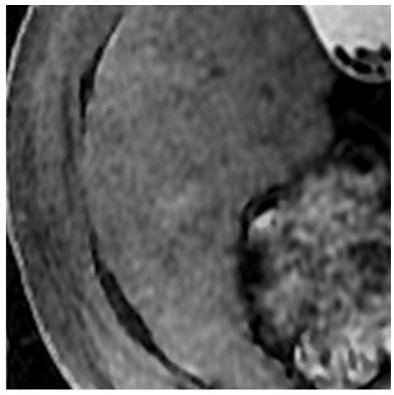
Step 4: Perform a Final Check

The radiologist should question whether the assigned category seems reasonable and appropriate. If the answer is "yes," then the evaluation is finished and the next observation can be considered. If the answer is "no," then the assigned category may not be appropriate and the observation warrants reevaluation.

Technical Recommendations for CT and MR Imaging Examinations

Historically, the choice of imaging modality to evaluate patients at risk for HCC has been influenced by guidelines from the American Association for the Study of Liver Diseases, European Association for the Study of the Liver, Asian Pacific Association for the Study of the Liver, National Comprehensive Cancer Network, Korean Liver Cancer Study Group and National Cancer Center, and Japanese Society of Hepatology (6,26–30). A particular modality or contrast agent for imaging is not recommended in LI-RADS v2017; rather, this system offers guidance regarding equipment parameters and proper imaging technique for each modality (Fig 18). Radiologists are encouraged to use the imaging modality and agent that best suit the individual patient and/or institution and according to availability and radiologist expertise. If possible, consistent use of the same modality in serial imaging examinations of a single patient is recommended to facilitate longitudinal comparison.

Previous LI-RADS versions have included specified dynamic enhancement phases and timing parameters but no equipment recommendations



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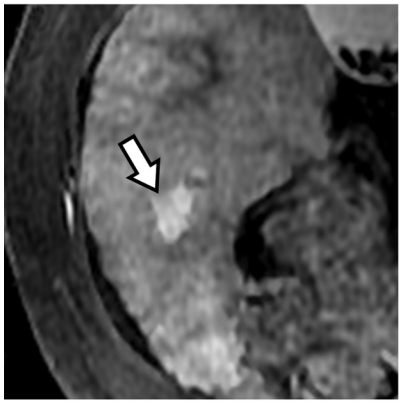

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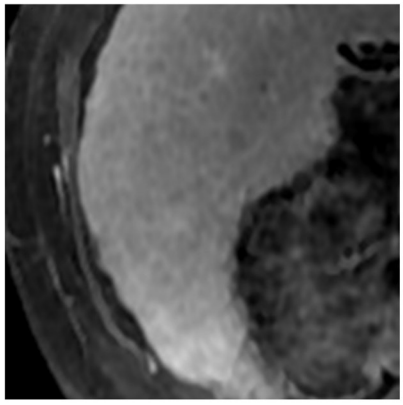
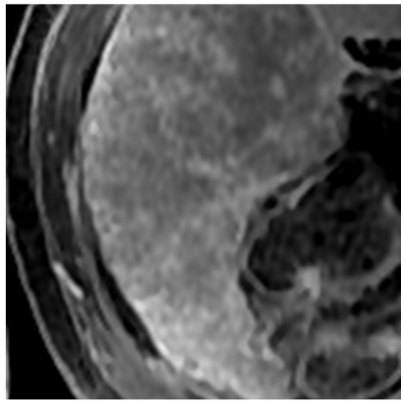


c.



d.

Figure 17. LR-3 observation. Axial dynamic nonenhanced **(a)**, arterial phase **(b)**, portal venous phase **(c)**, and delayed phase **(d)** MR images show a 13-mm nodule (arrow in **b**) that is hyperenhancing during the arterial phase, isointense during the other phases, and without evidence of washout or a capsule appearance.

(12,13). Equipment recommendations are included in LI-RADS v2017 to facilitate consistent image acquisition techniques among examinations and institutions.

For CT evaluations, a multidetector examination involving the use of eight or more detector rows is recommended. The required images include late hepatic arterial phase, portal venous phase, and delayed phase scans. These images are necessary for confident categorization of an observation, and the absence of any of these might render an observation noncategorizable (LR-NC). In patients who have undergone local-regional treatment, the acquisition of nonenhanced images and multiplanar reformations is recommended.

The MR imaging equipment recommendations are the same, regardless of the contrast agent used, and include a magnetic field strength of 1.5 or 3.0 T and a torso phased-array coil. However, enhancement phase recommendations differ according to the type of contrast material used. When extracellular contrast agents are used, the required MR imaging sequences include nonenhanced T1-weighted imaging, T2-weighted imaging with fat suppression (applied according to institutional preference), and multiphase T1-weighted imaging, including examinations performed in the late arterial, portal venous, and 2–5-minute delayed phases. Suggested or optional sequences include diffusion-weighted, subtraction, and multiplanar image acquisitions.

When the hepatobiliary agent gadoxetate disodium is used, the required MR imaging sequences are the same as those used with extracellular contrast media, with the exception that the phase 2–5 minutes after the injection is considered the transitional rather than delayed phase. An additional phase, which generally occurs 20 minutes after the injection, is the hepatobiliary phase. Since use of the hepatobiliary agent gadobenate dimeglumine involves a delayed extracellular phase at 3–5 minutes after the injection and a hepatobiliary phase at 1–2 hours, it may be used as an extracellular or hepatobiliary agent.

Definitions of Dynamic Phases

Arterial Phase

In LI-RADS v2017, dynamic enhancement phases are defined on the basis of their appearance and the degree of enhancement in the hepatic arterial system, portal venous system, hepatic veins, and liver parenchyma (Fig 19). During the hepatic arterial phase, the hepatic arterial branches appear fully enhanced, but the hepatic veins are not yet enhanced by antegrade contrast material flow. The arterial phase is divided into two subtypes: the early arterial phase, when the portal vein is not yet enhanced,

LI-RADS® v2017
CT/MRI Core

CT/MRI LI-RADS® v2017 Technical Recommendations

CT	
Recommended equipment	• Multidetector CT with ≥ 8 detector rows
Required images	• Arterial phase (late arterial phase strongly preferred) • Portal venous phase • Delayed phase
Suggested images	• Precontrast, if patient has had locoregional treatment • Multiplanar reformations
MRI with extracellular contrast agents or gadobenate dimeglumine	
Recommended equipment	• 1.5T or 3T • Torso phased-array coil

Required images	• Unenhanced T1-weighted OP and IP imaging
	• T2-weighted imaging (fat suppression per institutional preference)
	• Multiphase T1-weighted imaging
	  • Precontrast imaging
	  • Arterial phase (late arterial phase strongly preferred)
	  • Portal venous phase
	  • Delayed phase

Suggested or optional images	• Diffusion-weighted imaging • Subtraction imaging • Multiplanar acquisition • 1- to 3-hr hepatobiliary phase with gadobenate dimeglumine
MRI with gadoxetate disodium	
Recommended equipment	• 1.5T or 3T • Torso phased-array coil

Required images	• Unenhanced T1-weighted OP and IP imaging
	• T2-weighted imaging (fat suppression per institutional preference)
	• Multiphase T1-weighted imaging
	  • Precontrast imaging
	  • Arterial phase (late arterial phase strongly preferred)
	  • Portal venous phase
	  • Transitional phase (2 to 5 minutes after injection)
	  • Hepatobiliary phase

Suggested or optional images	• Diffusion-weighted imaging • Subtraction imaging • Multiplanar acquisitions

Figure 18. LI-RADS v2017 technical recommendations for CT and MR imaging. *IP* = in-phase, *OP* = opposed-phase. (Reprinted, with permission, from reference 11.)

and the late arterial phase, when the portal vein is at least partially enhanced (19). The late hepatic arterial phase is strongly preferred for the diagnosis and staging of HCC because the degree of HCC enhancement is usually higher during this phase (31,32). In fact, some HCCs demonstrate enhancement during the late hepatic arterial phase only.

Extracellular Phase

The extracellular phase is the phase after contrast material administration during which enhancement of the liver is due mainly to extracellular distribution of the contrast agent. From an operational aspect, this refers to the portal venous and delayed phases when an extracellular agent or gadobenate dimeglumine is administered or only the portal venous phase when gadoxetate disodium is administered.

Portal Venous Phase

The portal venous phase occurs when antegrade enhancement of the hepatic veins is most conspicuous, the portal veins are fully enhanced, and—if an extracellular agent is administered—the liver parenchyma is at or near its peak enhancement (19).

Delayed Phase

The delayed phase occurs after the portal venous phase when extracellular contrast agents are used, with images usually acquired 3–5 minutes after the contrast agent injection. The portal veins, hepatic veins, and liver parenchyma are less enhanced during the delayed phase than during the portal venous phase. This is sometimes referred to as the equilibrium or interstitial phase; however, the LI-RADS group discourages the use of these terms since the contrast agent is neither in true equilibrium nor confined to the interstitium. It should be noted that when gadoxetate disodium is used, no equivalent delayed phase images are obtainable owing to the concurrent hepatic uptake of contrast material. The images acquired within a few minutes after the portal venous phase are instead referred to as transitional phase images.

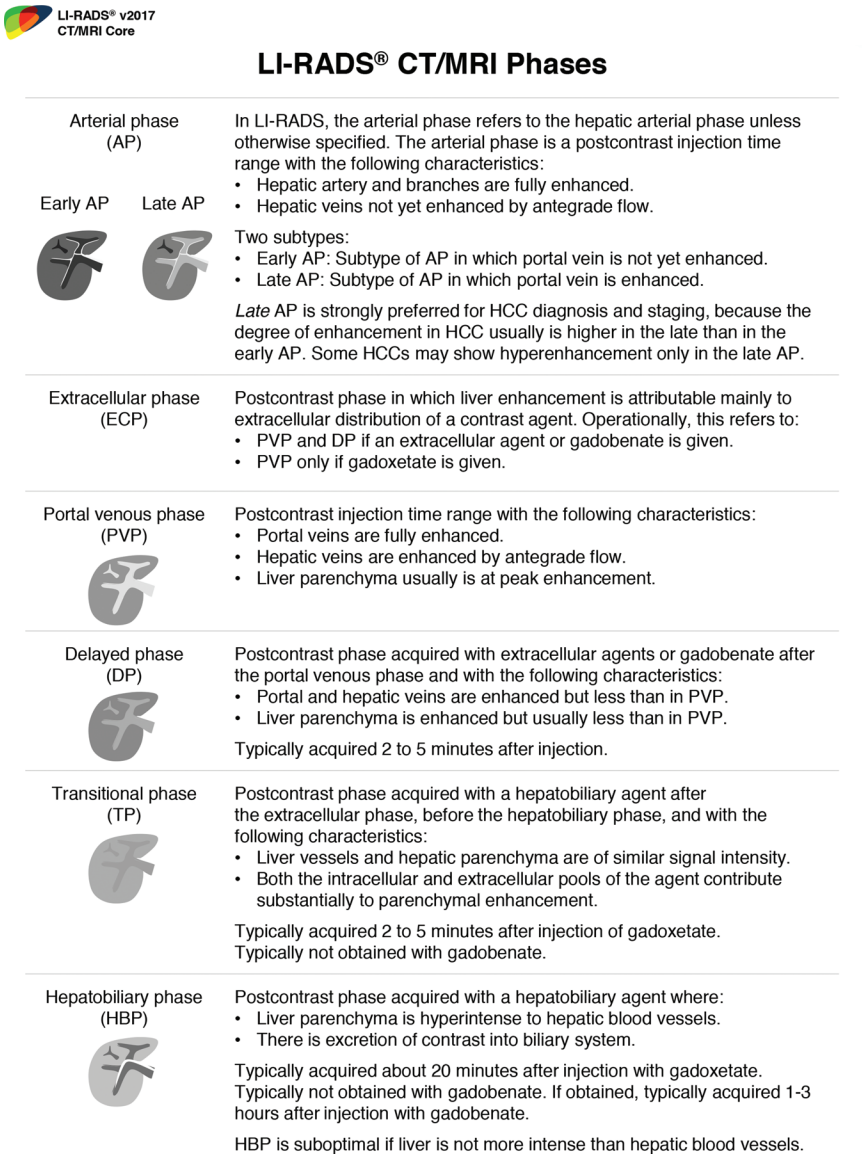


Figure 19. Vascular phases defined and illustrated in LI-RADS v2017. The early arterial phase involves enhancement of the hepatic arterial system without portal venous enhancement. The late arterial phase involves enhancement of the hepatic arteries and portal vein. The portal venous phase involves full portal venous enhancement, antegrade enhancement of the portal veins, and peak enhancement of the liver parenchyma. The delayed phase involves enhancement of the portal veins, hepatic veins, and liver parenchyma, which enhance less during this phase than during the portal venous phase. During the transitional phase, the liver vessels and parenchyma have similar signal intensity. During the hepatobiliary phase, the liver parenchyma is hyperintense compared with the blood vessels, with excretion of contrast material into the biliary system. (Reprinted, with permission, from reference 11.)

Transitional Phase

The transitional phase is the phase following administration of a hepatobiliary contrast agent—after the portal venous phase and before the hepatobiliary phase—during which the liver vessels and hepatic parenchyma have similar signal intensity and both intracellular and extracellular pools of the agent contribute substantially to parenchymal enhancement. Transitional phase images are usually acquired 2–5 minutes after the intravenous injection of gadoxetate disodium.

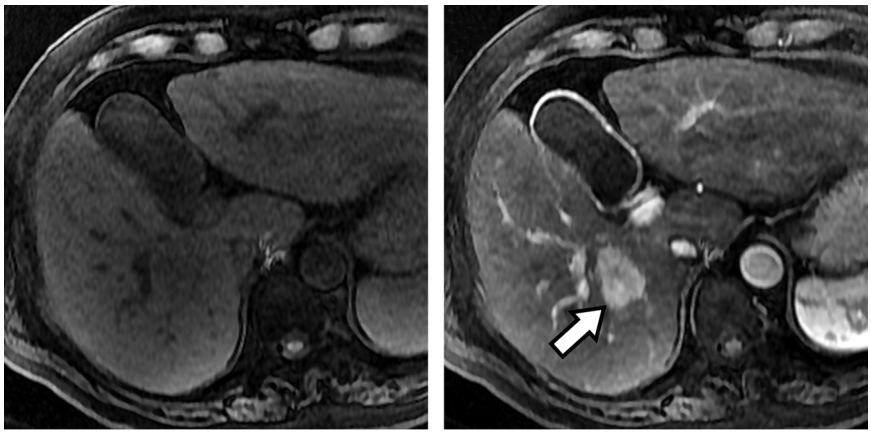
Hepatobiliary Phase

The hepatobiliary phase is that following administration of a hepatobiliary contrast agent when the liver parenchyma is unequivocally hyperintense to the hepatic blood vessels and contrast material usually is excreted into the biliary system (33). Images are usually acquired about 20 minutes after the injection of gadoxetate disodium or 1–3 hours after the injection of gadobenate dimeglumine.

Major Imaging Features

Arterial Phase Hyperenhancement

Hepatocarcinogenesis results in increased arterial vascularization, with a concomitant decrease in the portal venous supply (34–36). This phenomenon creates the appearance of APHE, with which the lesion is unequivocally more enhanced and more intense than the surrounding liver parenchyma (Fig 20) (36,37). Only those lesions with an unequivocal presence of APHE can be assigned to category LR-5 (13). This rule ensures that the LR-5 category is concordant with diagnostic criteria established by the United Network for Organ Sharing and Organ Procurement and Transplantation Network, which stipulate that HCC cannot be diagnosed on the basis of the imaging findings of lesions lacking



a. b.

Figure 20. APHE in a 70-year-old man with a lesion categorized as LR-5 (definitely HCC) on the basis of major imaging features. Axial dynamic nonenhanced **(a)** and late arterial phase **(b)** MR images show a 33-mm nodule (arrow in **b**) with APHE.

APHE (8,38,39). LI-RADS further distinguishes between nonrim APHE and rim APHE, with the latter commonly being present in cholangiocarcinomas and metastases and thus serving as a criterion for inclusion in the LR-M category.

Nonperipheral Washout

Referred to as *washout appearance* or *washout,* nonperipheral washout is a major feature that is attributable to the reduced extracellular volume of HCCs compared with the extracellular volume of the background liver tissue. Additional factors that can contribute to the washout appearance include rapid venous drainage and reduced intranodular portal venous supply. Since it reflects reduced extracellular volume, this feature is best evaluated during the extracellular phase (ie, portal venous or delayed phase with use of extracellular contrast agent and portal venous phase with use of gadoxetate disodium) (Fig 21) (4,40). The washout appearance is present when the lesion appears hypoenhancing compared with the background liver tissue (4,41–43). A potential pitfall is that nonmalignant regenerative or dysplastic nodules, and hypertrophic pseudomasses surrounded by fibrosis may appear hypoenhancing during these later phases and be mischaracterized as showing washout (4).

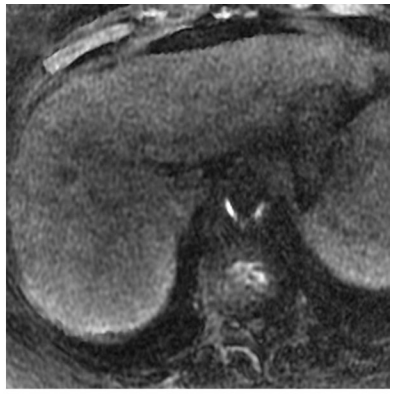
The presence of APHE is not required to characterize a lesion as showing washout, but there must be some degree of enhancement initially (40). The presence of washout in an arterially hyperenhancing lesion is one of the most reliable predictors of HCC, with a sensitivity of 89% and a specificity of 96% (44). The areas of APHE and washout do not have to be the same region; thus, radiologists do not need to verify whether the areas of APHE and washout coincide exactly. They need only determine that both areas are present within the same observation. Owing to angiogenesis and venous drainage through the surrounding sinusoids, HCC tends to demonstrate diffuse or patchy washout. Peripheral washout is atypical with HCC but common with cholangiocarcinoma and other non-HCC malignancies. Thus, the presence of peripheral washout prompts assignment to the LR-M category (13).

Enhancing Capsule

Enhancing capsule is a major feature characterized by smooth peripheral rim enhancement during the portal venous, delayed, or transitional phase. The determination of whether it is a true capsule or pseudocapsule can be made at pathologic analysis only (Fig 22) (39–41). Fibrous capsules are composed of an inner layer of tight, relatively pure fibrous tissue with slitlike channels and an outer layer composed of looser fibrovascular tissue containing portal venules, newly formed bile ducts, and prominent sinusoids (40,41,45). The degree of enhancement tends to increase from the early to later phases. This phenomenon is probably due to slow flow within the intracapsular vessels and contrast agent retention in the extravascular connective tissue within the capsule, which often make the delayed phase superior to the portal venous phase for the detection of capsule enhancement (40,46). It has been reported that tumors with an intact capsule tend to have a better prognosis after resection or ablative therapy (40,46). This is probably because the intact capsule acts as a barrier to extranodular spread of cancer cells.

Lesion Size

In LI-RADS v2017, lesion size is described; this major feature was referred to as *diameter* in prior versions. The strict definition of diameter applies to circles only, whereas masses often have an ovoid or irregular shape. *Size* is defined operationally as the largest outer edge–to–outer edge dimension of an observation. The size of the capsule, if present, also should be included in size measurements (Fig 5). Accurate measurement of the size of an observation is critical, because size is one of the major features that influence the LI-RADS categorization and is used to determine the HCC stage.



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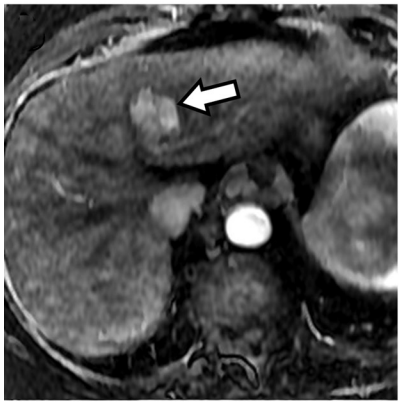

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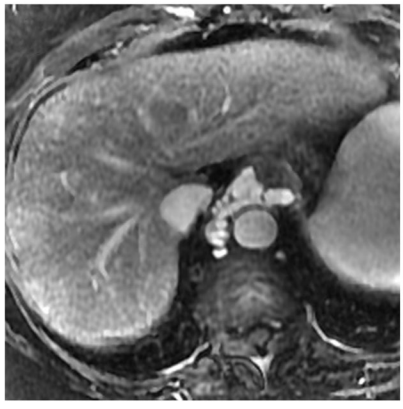

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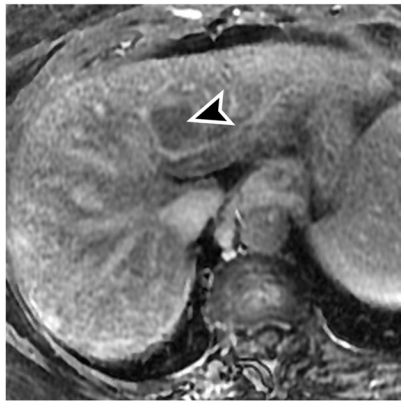
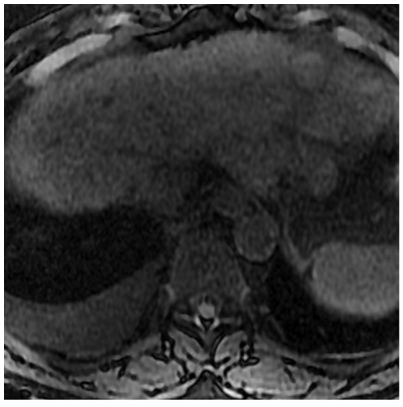


d.

Figure 21. Washout appearance in a 70-year-old woman with a lesion categorized as LR-5 (definitely HCC) on the basis of major imaging features. Axial dynamic nonenhanced **(a)**, late arterial phase **(b)**, portal venous phase **(c)**, and delayed phase **(d)** MR images show a 25-mm nodule with APHE (arrow in **b**) and washout (arrowhead in **d**).



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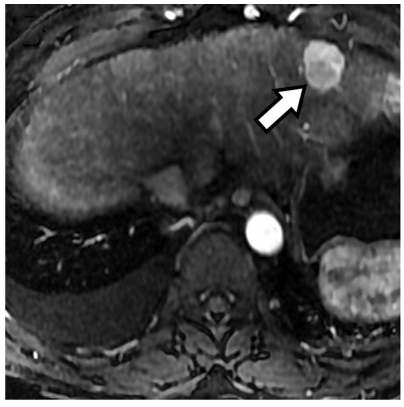

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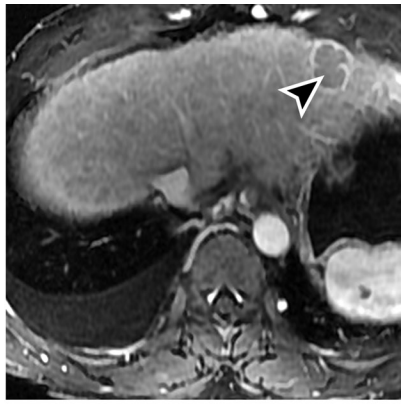

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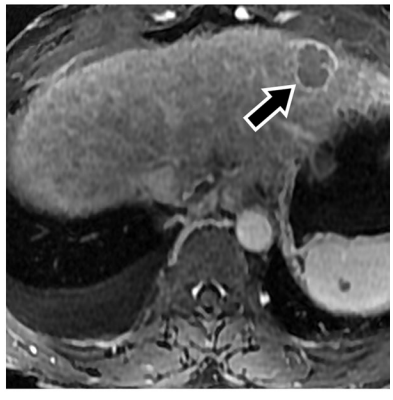


d.

Figure 22. Capsule appearance in a 63-year-old woman with a lesion categorized as LR-5 (definitely HCC) on the basis of major imaging features. Axial dynamic nonenhanced **(a)**, late arterial phase **(b)**, portal venous phase **(c)**, and delayed phase **(d)** MR images show a 27-mm nodule with APHE (arrow in **b**), washout (arrowhead in **c**), and a capsule (arrow in **d**). This is an example of an enhancing capsule, as it is visibile as an enhancing rim; a nonenhancing capsule would be visible as a nonenhancing rim.

This feature also has the potential to affect liver transplantation eligibility. Furthermore, accurate measurement of the observation size enables accurate assessment of interval tumor growth.

When measuring size, the radiologist must choose the imaging phase, sequence, and plane with which the lesion margins are most clearly depicted. Use of the arterial phases and diffusion-weighted

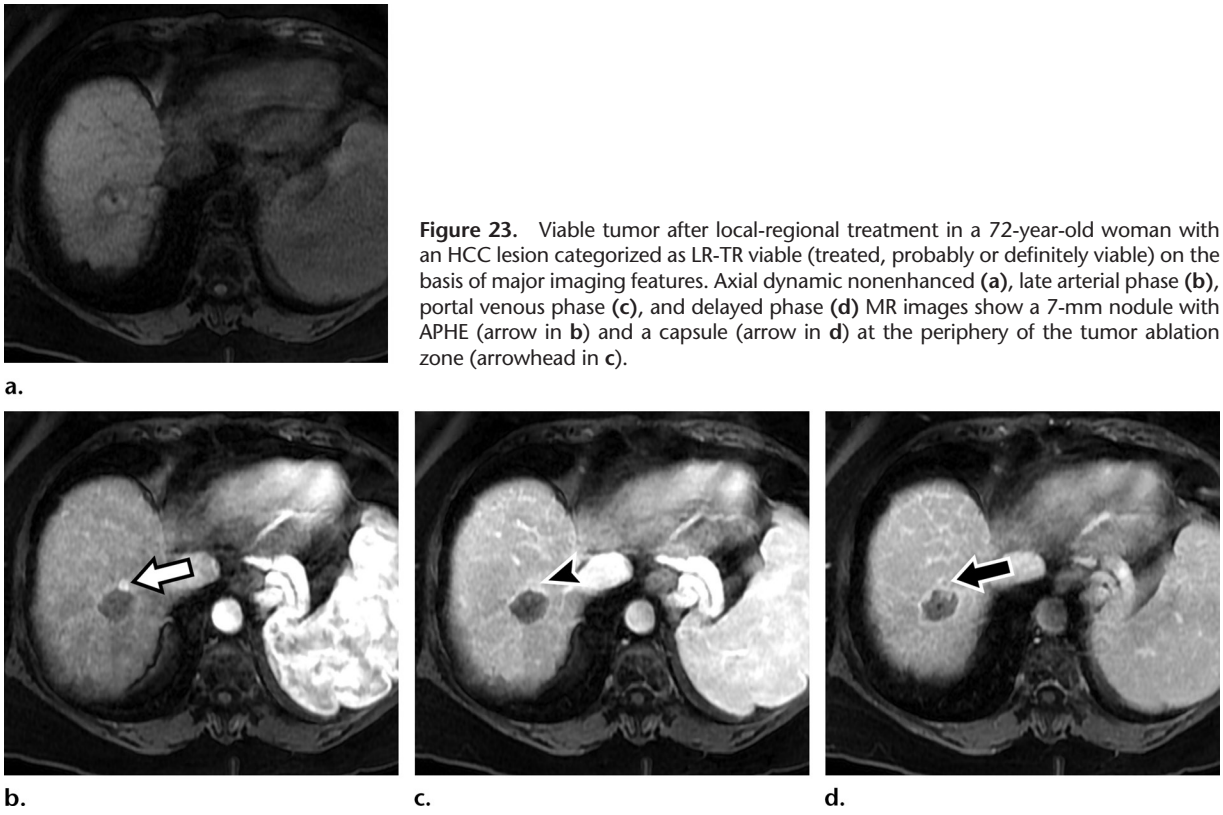


Figure 23. Viable tumor after local-regional treatment in a 72-year-old woman with an HCC lesion categorized as LR-TR viable (treated, probably or definitely viable) on the basis of major imaging features. Axial dynamic nonenhanced **(a)**, late arterial phase **(b)**, portal venous phase **(c)**, and delayed phase **(d)** MR images show a 7-mm nodule with APHE (arrow in **b**) and a capsule (arrow in **d**) at the periphery of the tumor ablation zone (arrowhead in **c**).

a. **b.** **c.** **d.**

imaging can lead to size overestimation due to summation with periobservational enhancement and anatomic distortion, respectively, and thus should be avoided if the margins are clearly visible with other available phases or sequences (19,22) (Fig 6).

Treatment Response Assessment Categories and Criteria

The inclusion of categories and criteria used to assess residual or recurrent malignancy after local-regional therapies is new in LI-RADS v2017. Performing posttreatment imaging in 3-month intervals and with use of the same imaging modality (preferable) or another modality (acceptable) is recommended in most cases. However, performing an initial posttreatment imaging examination at 1 month may be helpful after certain treatments; this will be addressed in the upcoming LI-RADS manual. When assessing treatment response, the radiologist must first decide whether the treated lesion can be adequately evaluated and then assign a category on the basis of the presence or absence of features that are suggestive of viable tumor.

LR-TR Nonevaluable

A treatment response is categorized as LR-TR nonevaluable when the treated lesion cannot be reliably evaluated owing to image degradation or the omission of necessary enhancement phases. This category is separate from LR-NC (noncategorizable), which applies to nontreated lesions.

LR-TR Nonviable

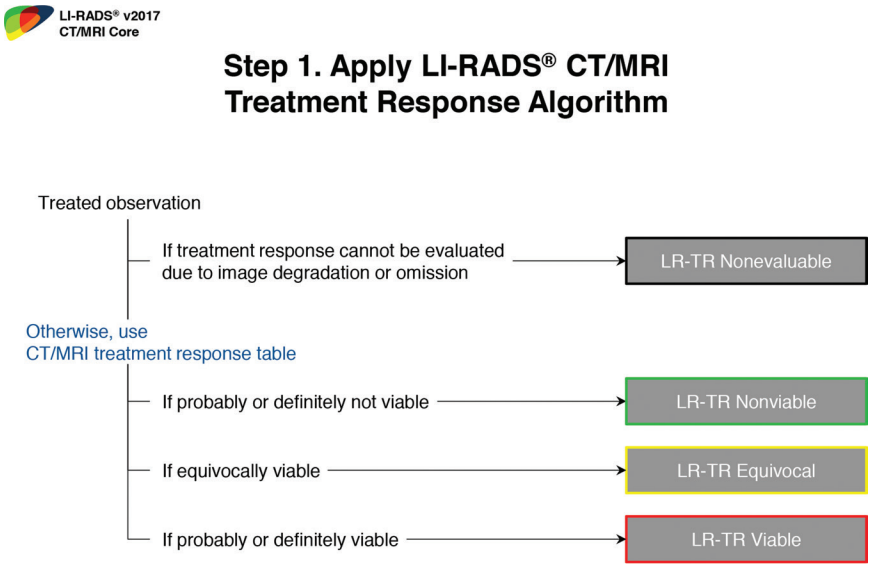
The treatment response category LR-TR nonviable is reserved for treated lesions with no enhancement or expected treatment-specific enhancement patterns. Examples of expected posttreatment enhancement patterns include a thin rim of enhancement around the treated nonviable tumor, which is occasionally seen after embolization or ablation. It is important to note that radiologic nonviability does not indicate a lack of pathologic viability, because imaging is not sensitive for the detection of microscopic or small foci of residual tumor (47).

LR-TR Viable

The category LR-TR viable is assigned when a treated lesion has viable tumor tissue within or along its margin. The feature that indicates tumor viability after treatment is enhancing nodular, masslike, or thick irregular tissue in or along the margin of the treated lesion, with any of the following: APHE, washout, and enhancement similar to pretreatment enhancement (Fig 23).

LR-TR Equivocal

The category LR-TR equivocal applies to lesions that are evaluable but have imaging features that are equivocal for the presence of viable tumor. This category is reserved for observations that do not clearly fall into the LR-TR nonviable or LR-TR viable category. With some treatments—for



CT/MRI Treatment Response Table

Response Category	Criteria
LR-TR Nonviable	• No lesional enhancement **OR** • Treatment-specific expected enhancement pattern
LR-TR Equivocal	Enhancement atypical for treatment-specific expected enhancement pattern and not meeting criteria for probably or definitely viable
LR-TR Viable	Nodular, masslike, or thick irregular tissue in or along the treated lesion with any of the following: • Arterial phase hyperenhancement **OR** • Washout appearance **OR** • Enhancement similar to pretreatment

Figure 24. LI-RADS v2017 treatment response algorithm for CT and MR imaging. (Reprinted, with permission, from reference 11.)

example, transarterial radioembolization—early posttreatment enhancement of the tumor may not reliably differentiate viable from nonviable tumor (48). Both incompletely necrotic tumor and granulation tissue may show mild early enhancement that is increased on delayed phase images.

Assigning a Treatment Response Category in Four Steps

Radiologic assessment of treatment response has a key role in the management of HCC and differs among modalities (49). The new treatment response algorithm is intended to improve communication within the multidisciplinary teams that treat patients with HCC. The CT/MR imaging treatment response algorithm illustrates the thought process for assigning treatment response categories (Fig 24).

Step 1: Apply the LI-RADS CT/MR Imaging Treatment Response Algorithm

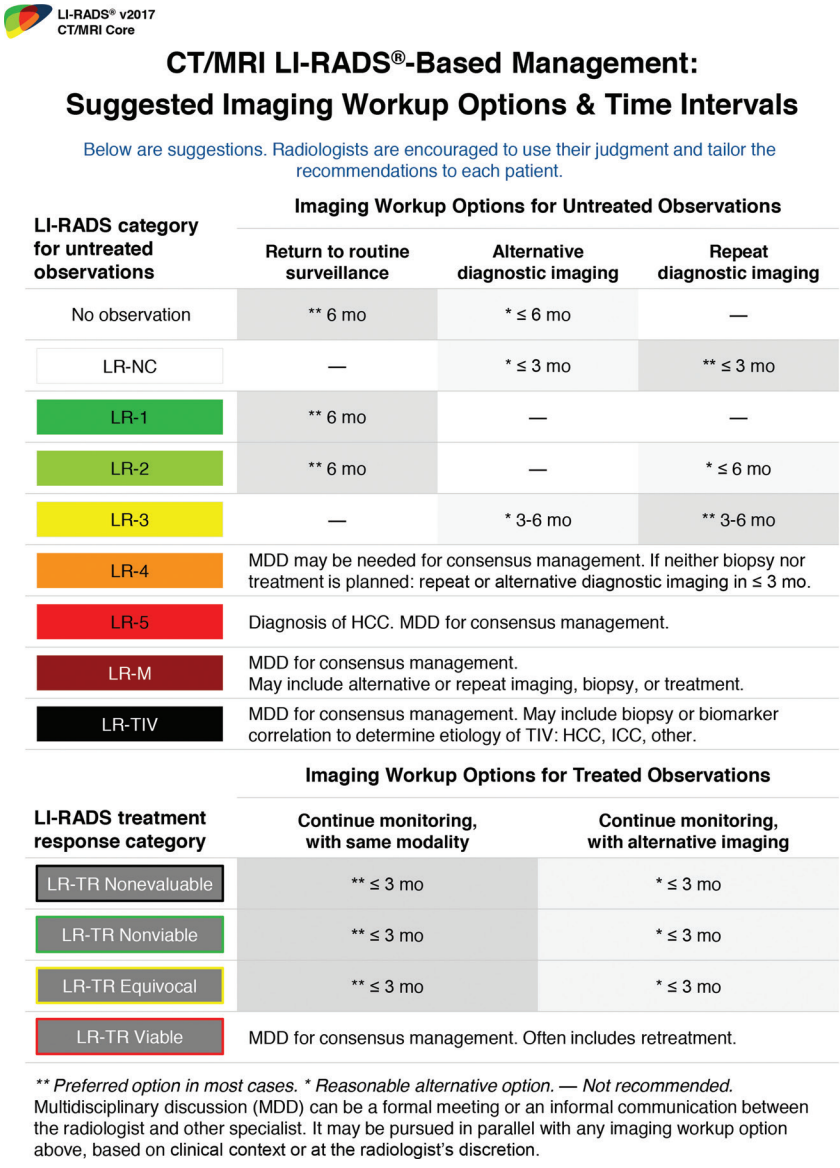
The radiologist must first establish that a treated lesion is evaluable. He or she should then classify the observation as LR-TR nonviable (treated and probably or definitely not viable), LR-TR equivocal (treated, equivocally viable), or LR-TR viable (treated, probably or definitely viable) according to the criteria outlined in Figure 24.

Step 2: Measure Viable Tumor Size

The measured size of the viable or equivocally viable portion of the treated lesion should be reported. A viable tumor size measurement is that of the longest diameter through the enhancing area of the treated lesion but not traversing a nonenhancing area, similar to measurement guidelines in the modified Response Evaluation Criteria in Solid Tumors (50).

Steps 3 and 4: Apply Tie-Breaking Rule, If Needed, and Perform Final Check

As in cases in which diagnostic categories are applied to nontreated lesions, if there is uncertainty regarding which of two treatment response categories should be assigned, the radiologist should choose the category that reflects lower certainty: LR-TR equivocal.



LI-RADS® v2017
CT/MRI Core

CT/MRI LI-RADS®-Based Management: Suggested Imaging Workup Options & Time Intervals

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

LI-RADS category for untreated observations	Imaging Workup Options for Untreated Observations		
	Return to routine surveillance	Alternative diagnostic imaging	Repeat diagnostic imaging
No observation	** 6 mo	* ≤ 6 mo	—
LR-NC	—	* ≤ 3 mo	** ≤ 3 mo
LR-1	** 6 mo	—	—
LR-2	** 6 mo	—	* ≤ 6 mo
LR-3	—	* 3-6 mo	** 3-6 mo
LR-4	MDD may be needed for consensus management. If neither biopsy nor treatment is planned: repeat or alternative diagnostic imaging in ≤ 3 mo.		
LR-5	Diagnosis of HCC. MDD for consensus management.		
LR-M	MDD for consensus management. May include alternative or repeat imaging, biopsy, or treatment.		
LR-TIV	MDD for consensus management. May include biopsy or biomarker correlation to determine etiology of TIV: HCC, ICC, other.		

LI-RADS treatment response category	Imaging Workup Options for Treated Observations	
	Continue monitoring, with same modality	Continue monitoring, with alternative imaging
LR-TR Nonevaluable	** ≤ 3 mo	* ≤ 3 mo
LR-TR Nonviable	** ≤ 3 mo	* ≤ 3 mo
LR-TR Equivocal	** ≤ 3 mo	* ≤ 3 mo
LR-TR Viable	MDD for consensus management. Often includes retreatment.	

*** Preferred option in most cases. * Reasonable alternative option. — Not recommended.*
Multidisciplinary discussion (MDD) can be a formal meeting or an informal communication between the radiologist and other specialist. It may be pursued in parallel with any imaging workup option above, based on clinical context or at the radiologist's discretion.

Figure 25. LI-RADS v2017 suggested CT- and MR imaging–based options and time intervals for the workup of lesions. *ICC* = intrahepatic cholangiocarcinoma. (Reprinted, with permission, from reference 11.)

The radiologist should question whether the assigned treatment response category seems reasonable and appropriate. If the answer is "yes," then the evaluation is finished and the next observation can be considered. If the answer is "no," then the assigned category may be inappropriate and the observation warrants reevaluation.

Lesion Management Based on LI-RADS v2017 for CT and MR Imaging

The optimal management is ultimately determined by a multidisciplinary treatment team by using a combination of the assigned LI-RADS category and clinical assessment findings, including biomarkers and other diagnostic information, patient preferences, comorbidities, hepatic disease burden, liver transplantation eligibility, socioeconomic and health insurance status, and treatment availability. The management cannot be chosen solely on the basis of the assigned LI-RADS category. However, LI-RADS v2017 offers suggested options and time intervals for the workup of individual observations, as well as preferred and reasonable alternatives, to help guide radiologists and all members of the treatment team in developing the most acceptable plan for each patient (Fig 25).

For observations assigned to the new category LR-NC, performing repeat diagnostic imaging within 3 months or sooner is sufficient in most cases. However, it might be reasonable to perform diagnostic imaging with an alternative modality—for example, MR imaging instead of CT. For treated observations assigned to category LR-TR nonevaluable, LR-TR nonviable, or LR-TR equivocal, performing repeat imaging with the same modality every 3 months is generally appropriate. However, the use of an alternative imaging modality may be acceptable.

Reporting

All observations that influence Organ Procurement and Transplantation Network staging (ie, category LR-5 and treated viable lesions) and that represent malignancy (LR-M, LR-TIV, and treated equivocal lesions) must be reported clearly and concisely. LR-4 lesions do not influence the Organ Procurement and Transplantation Network stage but also should be reported because they have a high likelihood of representing HCC. The decision of whether to report multiple observations individually (listing each LI-RADS category) or in aggregate should be left to the radiologist's discretion, with the goal of communicating the overall impression as clearly as possible.

If an observation, whether malignant or nonmalignant, is unequivocally histopathologically proven, then the histopathologic diagnosis rather than the LI-RADS category should be reported. However, if the lesion has been analyzed with biopsy but there is uncertainty regarding the histopathologic diagnosis or the diagnosis represents a potential HCC precursor (ie, regenerative or dysplastic nodule), the histopathologic diagnosis and LI-RADS category should be reported together. The intent is to alert the referring clinician to possible false-negative biopsy results and/or the need for close follow-up to detect progression to malignancy.

Finally, the radiologist generally should avoid language that compellingly advocates performing biopsy or any other invasive procedure. Biopsy may be appropriate when a definitive diagnosis cannot be made with imaging alone. This decision should be made in a concerted effort between the radiologist and all members of the primary treatment team, who can make the decision after weighing the clinical factors.

Conclusion

Since the introduction of the first version in 2011, LI-RADS has evolved in clarity, breadth, and scope. LI-RADS v2017 marks the third update of this reporting system, with new features that are intended to help improve its use, communication with referring physicians, and ultimately patient care. Supported by the American College of Radiology, this system will continue to evolve and be updated as evidence for its use accumulates, imaging technology evolves, and user feedback is collected.

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