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Review Article

Iconographic Review of the CT/MRI-LI-RADS 2018 Classification

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Abstract

Learning objectives:

- To Present the LI-RADS 2018 system.
- To Define the major and auxiliary imaging criteria for classifying hepatic lesions.

Materials and Methods: Patients with chronic liver disease, cirrhotics, carriers of current HCC or with a history of treated HCC constituted our sample. Patients with CT angiography and/or MRI angiography, whose iconography is semiological, were selected for the illustration of the LI-RADS lexicon.

Results: Patients were classified according to the presence of major and auxiliary LI-RADS imaging criteria according to the following categories:

Diagnostic categories: LR-NC (not classified): due to altered or incomplete imaging; LR-1 certainly benign; LR-2: probably benign; LR-3: intermediate probability of malignancy; LR-4: probable HCC; LR-5: HCC certain; LR-M: certainly malignant with no specific sign of HCC; LR-TIV: endovenous tumor invasion.

Categories of response to treatment: LR-TR not evaluable: treated not evaluable due to altered or incomplete imaging; LR-TR not viable: treated probably or certainly not viable; Equivocal LR-TR: equivocal viability treaty; LR-TR viable: treated probably or certainly viable.

Conclusion: The Liver Imaging Reporting and Data System (LI-RADS) is a system for standardizing radiological reporting in liver imaging in patients at risk of HCC. Its adoption will therefore make it possible to better establish the therapeutic strategy for each patient while ensuring optimal follow-up.

Keywords: *Liver Imaging Reporting and Data System (LI-RADS); HCC*

Introduction

What is LI-RADS?

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

- A comprehensive system for standardizing liver imaging terminology, technique, interpretation, reporting and data collection.
- A dynamic document, to be developed and refined as knowledge accumulates and in response to user feedback.

- Designed to improve communication, patient care, education and research.
- Backed and approved by the American College of Radiology (ACR) [1].
- Developed by a multidisciplinary and international consortium of diagnostic and interventional radiologists, hepatobiliary surgeons, hepatologists and hepatopathologists. Contributors include academic, community, and scientific organizations: American Association for the Study of Liver Diseases (AASLD), and National Comprehensive Cancer Network (NCCN).
- 1st version of LI-RADS was released in 2011, the system was updated in 2013, 2014 and 2017, depending on the evolution of published evidence, the integration of new technologies and the integration of comments users [1].

Objectives of LI-RADS

- Improve communication between radiologist and clinician.
- Reduce variability and interpretation errors.
- Reduce the omission of relevant information from the minutes.
- Reduce the frequency of technically inadequate examinations.
- Ensure follow-up and establish a therapeutic strategy to ensure optimal survival [1].

Who can use LI-RADS?

- Radiologists, researchers.
- Interns in radiology.
- Healthcare professionals caring for patients with liver disease [1].

Target population of LI-RADS®?

The LI-RADS applies:

- Cirrhotic patients.
- Patients with chronic infection with hepatitis B virus, C.
- Patients with HCC or previous.
- History of liver transplantation.
- Candidates for liver transplantation.

LI-RADS is not applicable to patients:

- Age < 18 years old.
- With cirrhosis due to congenital hepatic fibrosis, vascular disorder such as hereditary hemorrhagic telangiectasia, Budd-Chiari syndrome, chronic portal vein occlusion, cardiac congestion, or diffuse nodular regenerative hyperplasia.
- Malignant tumors confirmed on histological data [2].

LI-RADS categories

The LI-RADS categories reflect the likelihood of diagnosing HCC for each observation. An observation is defined as any anomaly or focal intrahepatic lesion demonstrated by imaging. The LI-RADS diagnostic categories apply to untreated findings without pathologic evidence in the at-risk population, while the LI-RADS treatment response categories are intended for patients with proven and treated HCC [2].

CT/MRI LI-RADS v2018 categories diagnostics: LR-NC (not classified) when a category cannot be assigned due to non-interpretable images (e.g. due to the presence of artefacts) or whose technique does not allow a diagnosis (e.g. e.g. absence of acquisition after injection

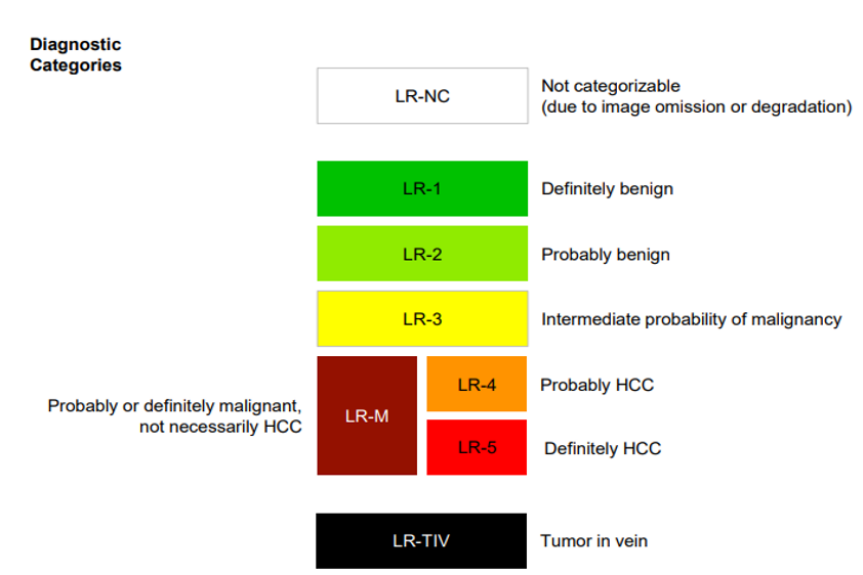


Figure 1: *LI-RADS diagnostics categories in CT/MRI [1].*

of intravenous contrast agent) and which prevents a decision on the presence or absence of one or more major criteria. LR-1 when considered certainly benign (cyst, hemangioma, perfusion abnormality, focus of steatosis, hypertrophic pseudomass and confluent fibrosis or focal scar. An observation that resolves without treatment is also classified as LR-1. LR-2 when considered likely benign. The entities are the same as those described above for the LR-1 category (but with one or more atypies) and also include: a distinct nodule without malignant characteristic on imaging, a solid nodule of size < 20 mm distinct from other nodules and without HCC or LR-M criteria or other criteria of malignancy. Dysplastic nodules and perfusion abnormalities are classified as LR-2, because although benign in the majority of cases, the low possibility of HCC cannot be excluded. If the nodule is ≥ 20 mm, the observation should be classified at least LR-3. LR-3 when it presents on imaging an intermediate probability of HCC. This category is not specific for HCC and does not exclude non-hepatocellular malignancy [2]. LR-4 when it presents in imaging the criteria for a probable HCC. LR-5 when it presents in imaging the criteria for a certain HCC. LR-TIV when there is endovenous tissue enhancement. LR-M when it shows signs in favor of a probable or certain malignant entity, but not specific to HCC [2].

CT/MRI LI-RADS v2018 Treatment response categories: LR-TR not evaluable when it cannot be evaluated with certainty due to uninterpretable images (e.g. due to the presence of artefacts) or incomplete (e.g. no acquisition after injection of contrast, or inappropriate acquisition phase). LR-TR viable when it has at least a still viable portion (in nodular form, pseudomass or irregular tissue thickening) and demonstrates at least one of the following signs of viability: hypervascularization in the arterial phase; washing; enhancement similar to pre-treatment enhancement. The size of the observation corresponds to the longest axis measured of the heightened portion, excluding any non-enhanced portion. LR-TR is not viable when it does not show signs of viability, but may nevertheless show an expected enhancement depending on the type of treatment. It should be emphasized that radiological non-viability is not synonymous with pathological non-viability since imaging is less sensitive than microscopic examination to detect residual tumor micro-foci. Equivocal LR-TR A treated case is considered equivocal when the imaging is sufficient for evaluation but its viability remains equivocal, as it does not meet the conditions for viable LR-TR and non-viable LR-TR [2].

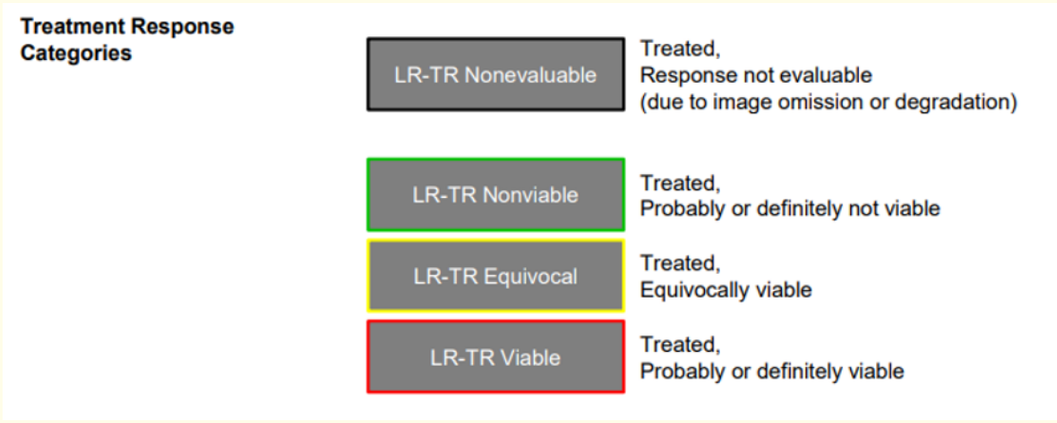


Figure 2: *LI-RADS treatment response categories in CT/MRI [1].*

Major diagnostic criteria

The major criteria visible on CT and MRI performed with injection of contrast agent are:

- Arterial phase hypervascularization (HVPA), Washing in portal phase, The enhancement of the capsule, The size of the sighting and Growth above the progression threshold.
- Hypervascularization in the arterial phase (HVPA), corresponding to an enhancement in the arterial phase, non-peripheral, unequivocal, in part or in whole of the observation and whose intensity or density is greater than that of the hepatic parenchyma.

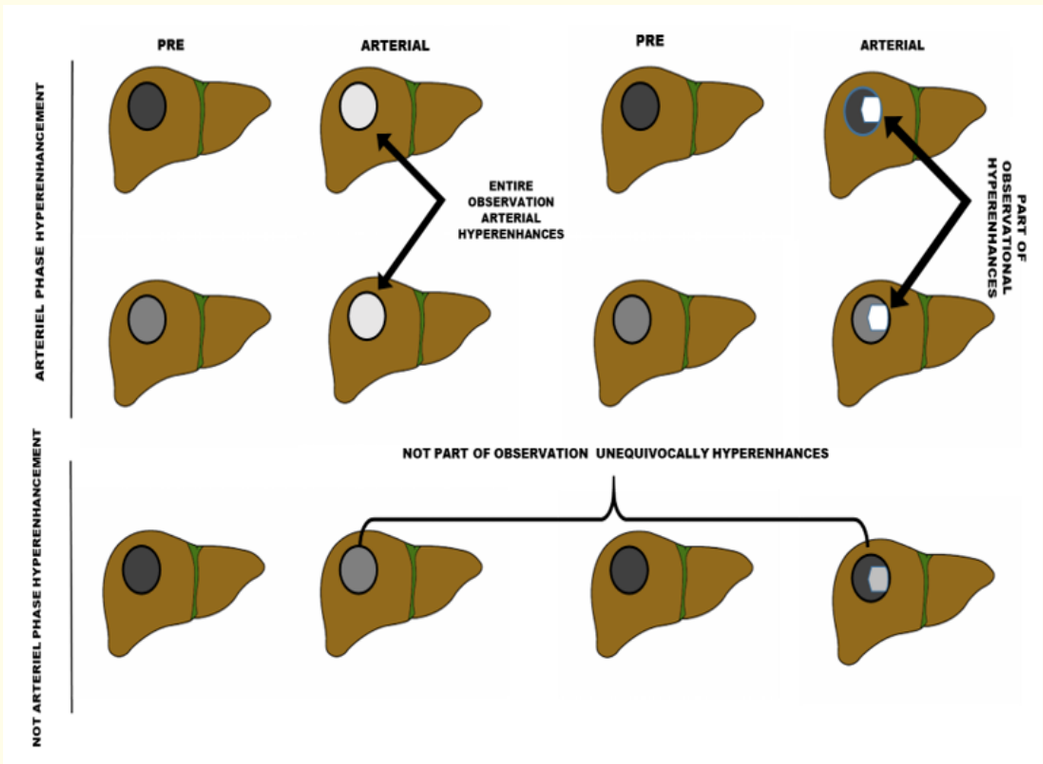


Figure 3: *Arterial phase hyper-enhancement [3].*

Arterial phase hyper-enhancement: schematic diagrams illustrate observation with (top two rows) and without (bottom row) arterial phase hyper –enhancement. Arterial phase hyper-enhacing observations unequivocally enhance in the arterial phase more than liver. In whole (left set of images) or in part (right set of images). They may be lower (top row), similar, or higher (second row) in attenuation or intensity relative to liver pre-contrast.

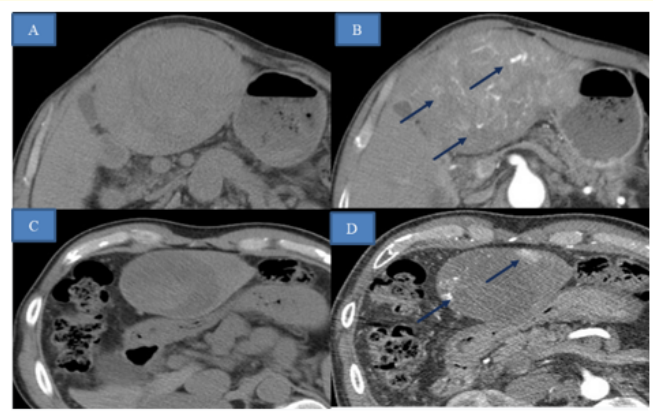


Figure 4: *CT Axial cut without contrast (A) and in the arterial phase (B): tissue mass at the expense of hepatic segments II and III, with exophytic development, well limited, encapsulated, of polylobed outlines, enhanced early in the arterial phase (blue arrows). CT Axial cut without contrast (C) and at the arterial phase (D): tissue mass at the expense of hepatic segment III, intensely enhanced in places at the arterial phase (blue arrows).*

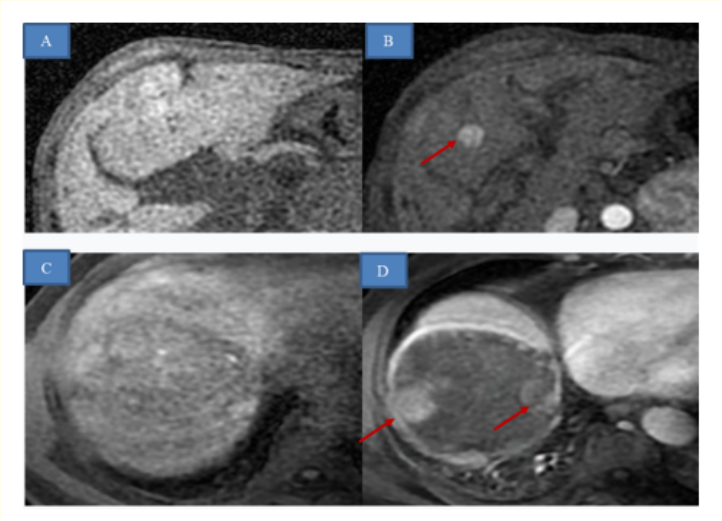


Figure 5: *MRI Axial T1FATSAT section without contrast (A) and during arterial phase (B): tissue mass at the expense of hepatic segments II and III, with exophytic development, well limited, encapsulated, with polylobed contours, enhanced early in arterial phase (red arrows). MRI Axial T1FATSAT section without contrast (C) and at arterial phase (D): tissue mass at the expense of hepatic segment III, intensely enhanced in places at arterial phase (red arrows).*

Washing: Corresponding to the non-peripheral visual decrease over time (during the early to later phases) of the enhancement of a portion or all of the observation compared to the adjacent parenchyma.

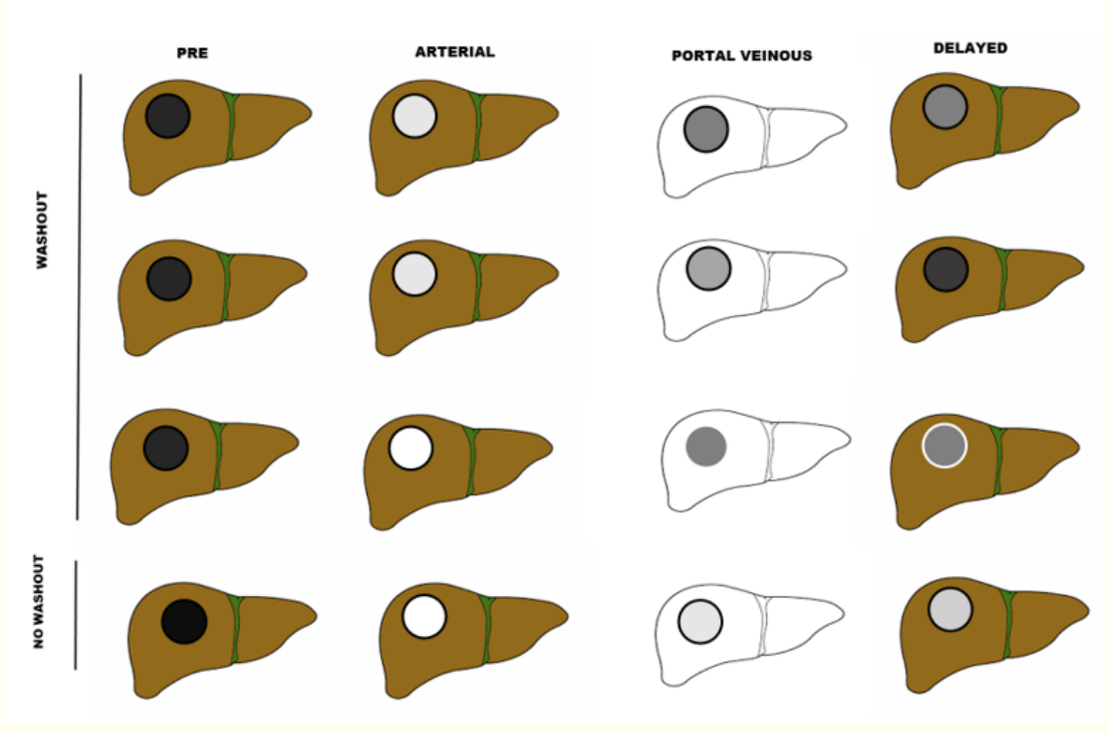


Figure 6: *Washing in portal phase.*

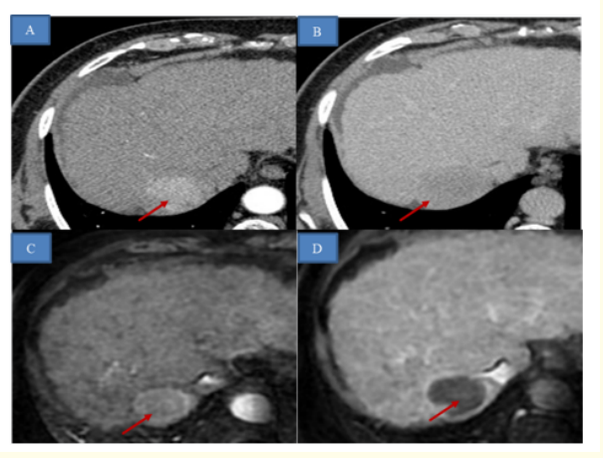


Figure 7: *CT Axial cut in the arterial phase (A) and in the portal phase (B): tissue lesion at the expense of hepatic segments VII, enhanced early in the arterial phase with washing in the portal phase (red arrows). MRI Axial T1FATSAT section in the arterial phase (C) and in the portal phase (D): tissue lesion at the expense of hepatic segments VII, enhanced early in the arterial phase with washing in the portal phase (red arrows).*

The enhancement of the capsule: corresponding to an enhancement with smooth, uniform and well-defined contours, of most or all of the observation. This enhancement is thicker than the perinodular fibrous spans and must be visible and increase between the portal or late venous phase.

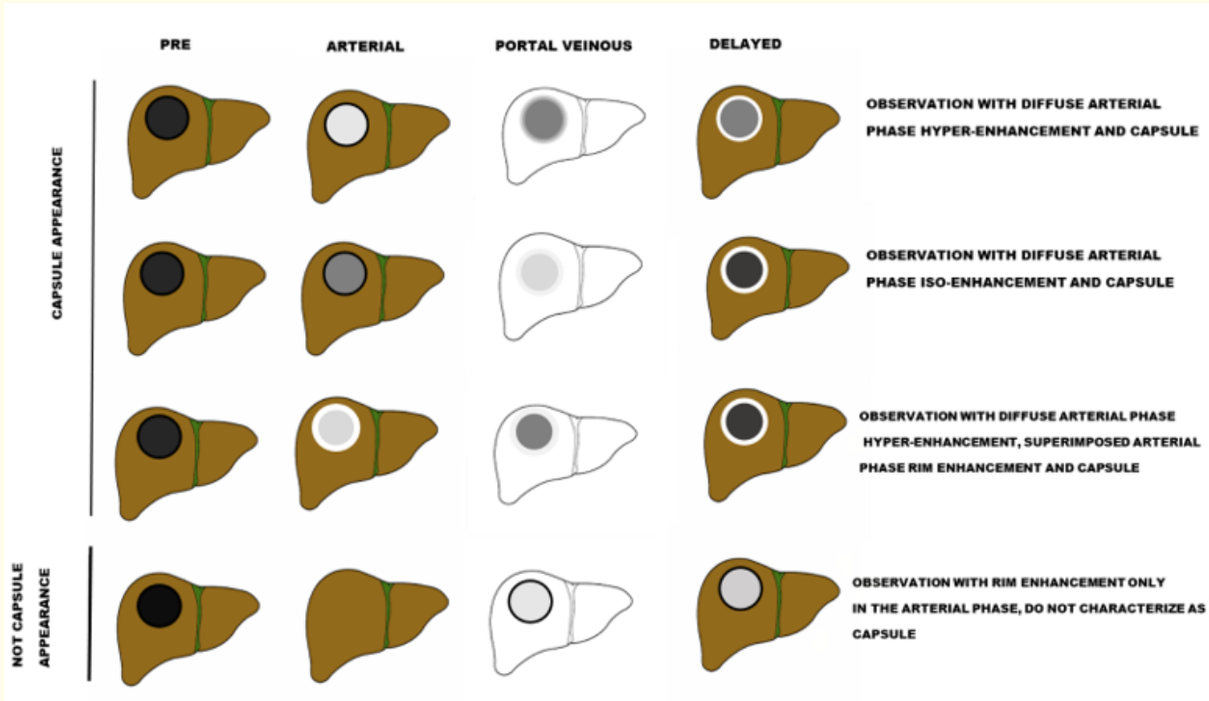


Figure 8: *The enhancement of the capsule [3].*

CAPSULE APPEARANCE : schematic diagrams illustrate observations with (top three rows) and without (bottom row) "caspule". observations with « caspule » show unequivocal peripheral rim enhancement in portal venous phase or delayed phase. The degree of enhancement usually is gretae in the delayed phase than in the portal venous phase. Such observations may have arterial phase hyper-enhacement (top and third row) or arterial phase iso or hypo-enhancement (second row). A rim of arterial phase hyper-enhancement also may be present. however ? If rim enhancement is present only in the arterial phase (bottom row), do not characterize as "caspule".

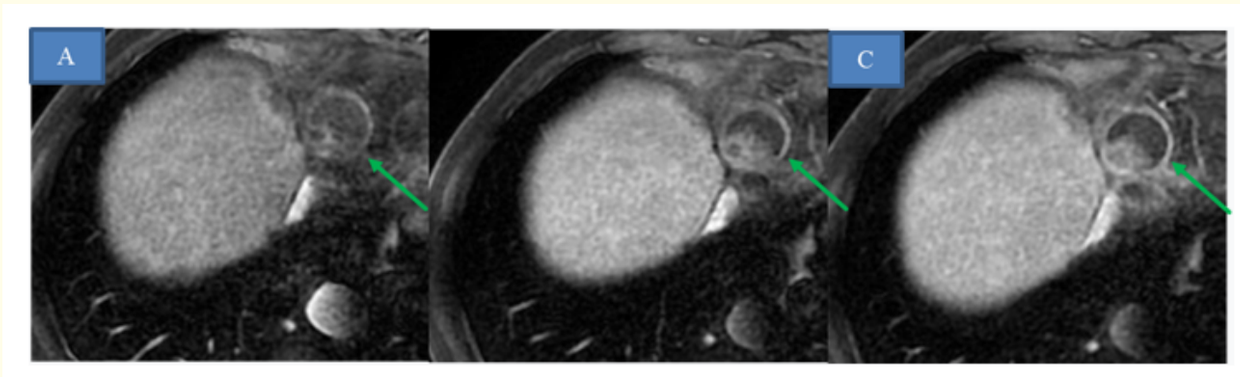


Figure 9: *MRI Axial T1FATSAT section in the arterial phase (A) in the portal phase (B) and in the late phase (C): tissue lesion at the expense of hepatic segments II, with a bud which is enhanced early in the arterial phase with an enhanced capsule increased over time portal and late (green arrows).*

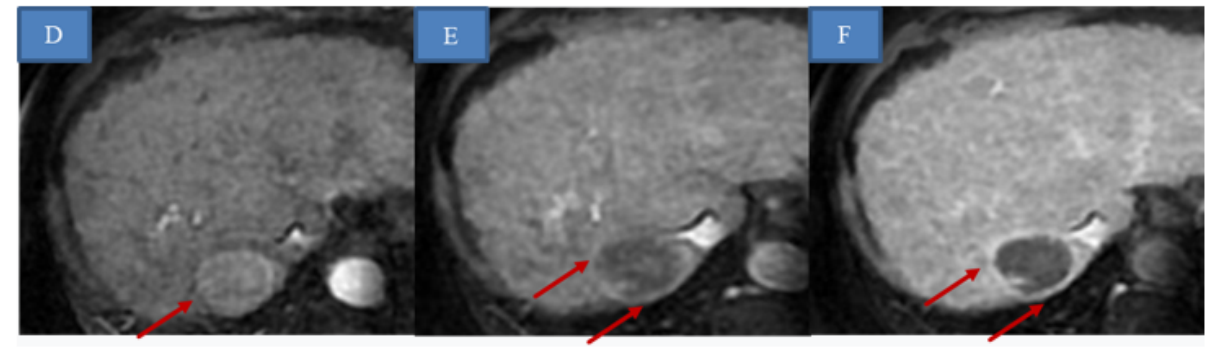


Figure 10: *MRI Axial T1FATSAT section in the arterial phase (D) in the portal phase (E) and in the late phase (F): tissue lesion at the expense of hepatic segments VII, which is enhanced early in the arterial phase with portal washing with a larger enhanced capsule in portal and late phase (red arrows).*

The size of the observation: Refers to its longest axis on either side of its outer edges, including the capsule. The use of arterial phase and diffusion-weighted sequence to measure height should be avoided, the former being less reliable due to peri-lesional perfusion abnormalities, the latter due to anatomical distortion.

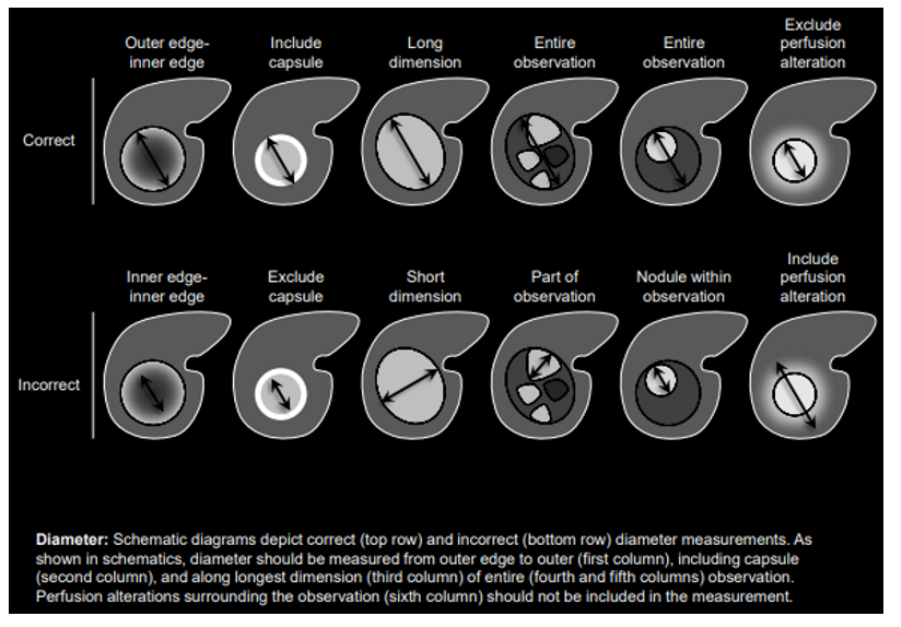


Figure 11: *The size of the observation [3].*

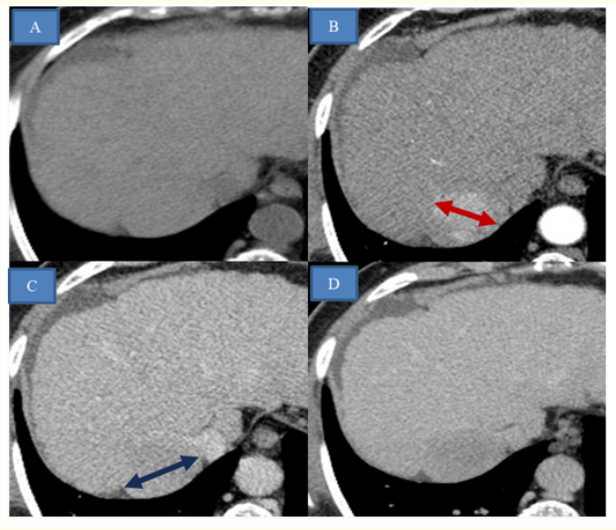


Figure 12: *CT Axial cut without contrast (A) in the arterial phase (B) in the portal phase (C) and in the late phase (D): The lesion size at arterial time (red arrow) measured is 20 mm (bad measurement) and at portal phase (blue arrow) is 28 mm (good measurement).*

The size of the sighting and Growth above the progression threshold. is defined by: an increase in the size of the observation of a minimum of 5 mm and a 50% increase in size in 6 months; a size increase of 100% increase in > 6 months; the appearance of a 10 mm observation that was not visible on CT or MRI scans dating back 24 months.

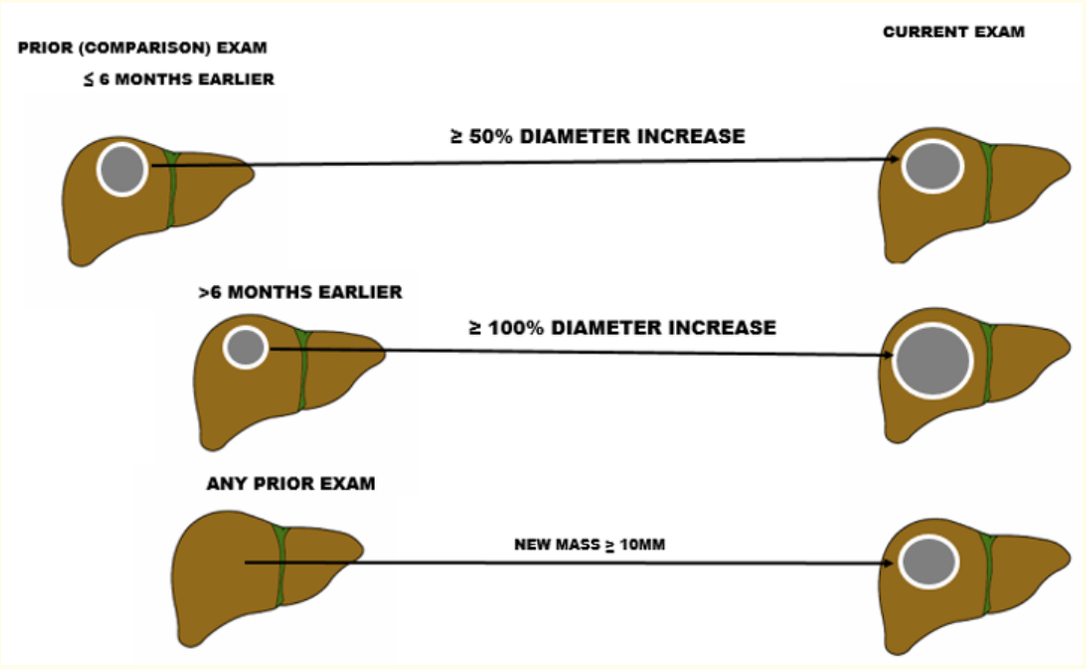


Figure 13: *The size of the sighting and growth above the progression threshold*
GROWTH : Schematic diagrams depict the increase in diameter that define threshold growth, depending on whether the prior examination was perofrmed ≤6 months earlier (top row) or > 6 months earlier (bottom row). A new ≥10mm mass also represents threshold growth.

Auxiliary criteria

Auxiliary criteria are used to improve the detection of observations, increase the radiologist's certainty or adjust the category. Their use is left to the discretion of the radiologist. The auxiliary criteria are divided as follows: auxiliary criteria in favor of malignancy, not specific for HCC; auxiliary criteria in favor of CHC; the auxiliary criteria in favor of benignity.

Ancillary features favoring malignancy	Ancillary features favoring benignity
Favoring malignancy in general not HCC in particular • US visibility as discrete nodule • Subthreshold growth • Restricted diffusion • Mild-moderate T2 hyperintensity • Corona enhancement • Fat sparing in solid mass • Iron sparing in solid mass • Transitional phase hypointensity • Hepatobiliary phase hypointensity	• Size stability > 2 yrs • Size reduction • Parallels blood pool • Undisorted vessels • Iron in mass, more than liver • Marked T2 hyperintensity • Hepatobiliary phase isointensity
Favoring HCC in particular • Nonenhancing capsule • Nodule-in-nodule • Mosaic architecture • Blood products in mass • Fat in mass, more than adjacent liver	

***Table 1**: Auxiliary criteria [1].*

Technical requirements in CT and MRI [2]

CT

- Arterial phase and portal venous phase imaging are required.
- Late arterial phase strongly preferred over early arterial phase.
- Pre-contrast imaging suggested.
- Delayed phase imaging suggested.
- Multi-planar reformations suggested.

MRI:

- Pre-contrast, arterial phase, portal venous phase, and delayed phase required.
- Late arterial phase strongly preferred over early arterial phase.
- Unenhanced T1w OP and IP required.
- T2w FSE or T2w SSFSE required.
- DWI suggested.

- Multi-planar acquisitions or reformations may be helpful.
- Post-processing with generation of subtraction images (arterial phase - pre; arterial phase - portal venous phase or arterial phase - delayed phase) may be helpful in select cases.

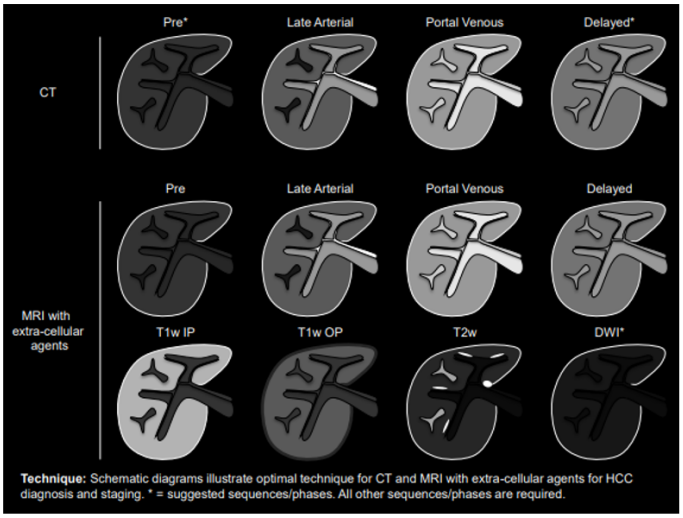


Figure 14: *Technical requirements IN CT and MRI [3].*

Step 1: Apply the LI-RADS® CT/MRI diagnostic algorithm

- Establish whether the observation is evaluable and if not classify it LR-NC.
- If the observation is evaluable, consider whether the observation belongs to categories LR-TIV, LR-M, LR-1 or LR-2.
- When the observation does not belong to any of these categories, then apply the diagnostic table and classify the observation LR-3, LR-4 or LR-5 according to its size and other major criteria.

Arterial phase hyperenhancement (APHE)		**No APHE**		**Nonrim APHE**		
Observation size (mm)		<20	≥20	<10	10-19	≥20
Count additional major features: • Enhancing capsule • Nonperipheral washout • 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

Table 2: *CT/MRI diagnostic table [2].*

Observations in this cell are categorised based on one additional major feature:

LR-4: If enhancing capsule.

LR-5: If nonperipheral washout OR threshold growth.

Step 2: Optional: apply auxiliary criteria [2].

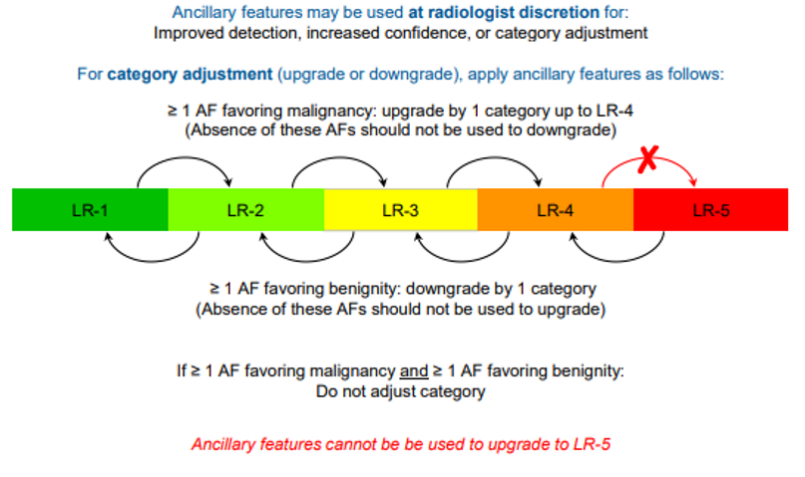


Figure A

Step 3: Apply tiebreaking rules if needed.

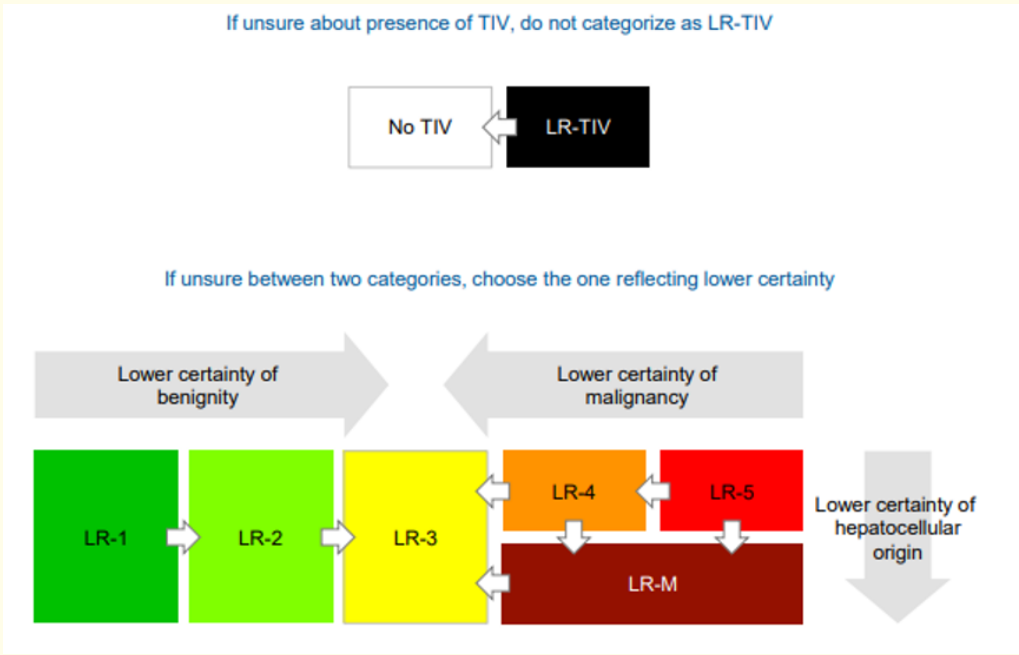


Figure B

Step 4: Final check [2]

Once the observation is closed, the radiologist must assess whether the chosen category seems reasonable. If he is satisfied, then he can move on to analyze the next observation. If the category seems inappropriate to him, it may be relevant to reassess the lesion.

Cases

Case 1: 77-year-old patient followed for cirrhosis presents a mass of 15 cm long axis in the right liver. LR?

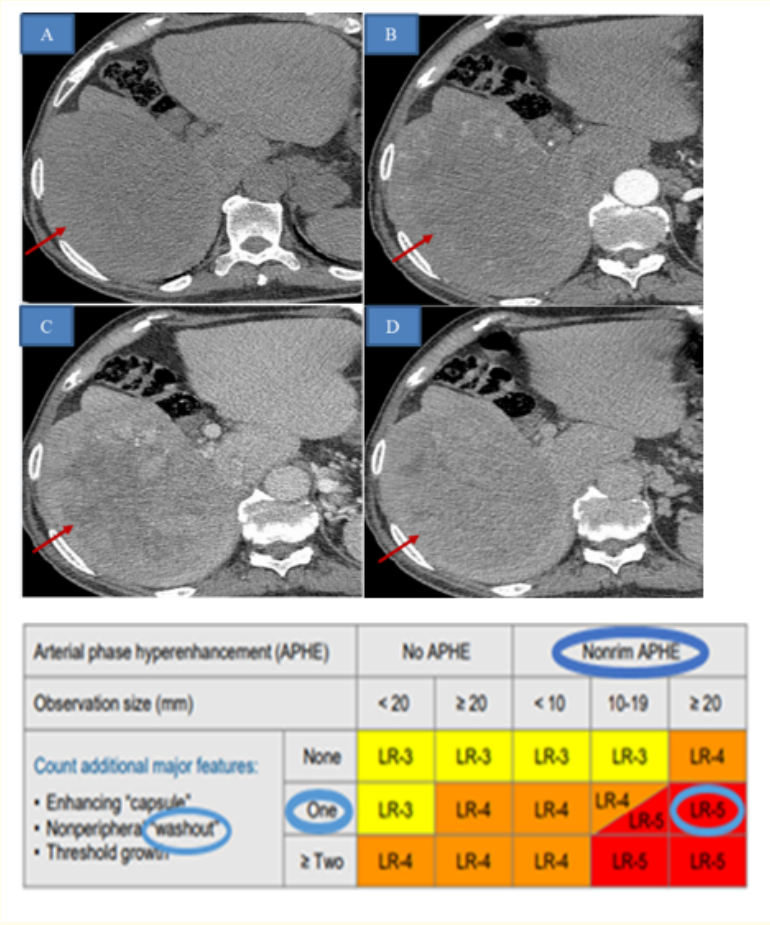


Figure 15: *CT Axial section without contrast (A) arterial phase (B) in portal phase (C) and late phase (D): Mass occupying almost all of the right liver hypodense in spontaneous contrast, presenting hypervascularization in arterial phase with washing with portal time with a size measuring 15 cm classified LR-5.*

Case 2: 54-year-old followed for post-viral B cirrhosis has a mass of 65mm long axis in segment III LR?

Case 3: 65-year-old, followed for post viral cirrhosis C presents an 80mm lesion of hepatic segment II LR?

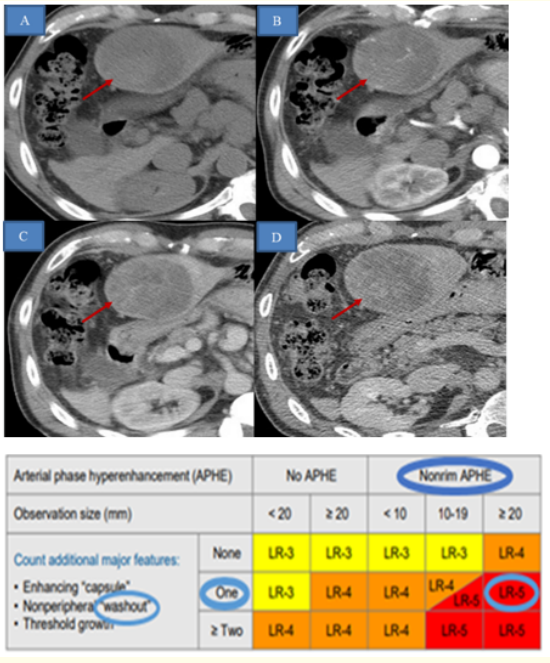


Figure 16: *CT Axial section without contrast (A) arterial phase (B) in portal phase (C) and late phase (D): Mass of heterodense segment III in spontaneous contrast, presenting hypervascularization in arterial phase in places without washing over time portal with a size of 65mm = LR-4 = LR-4.*

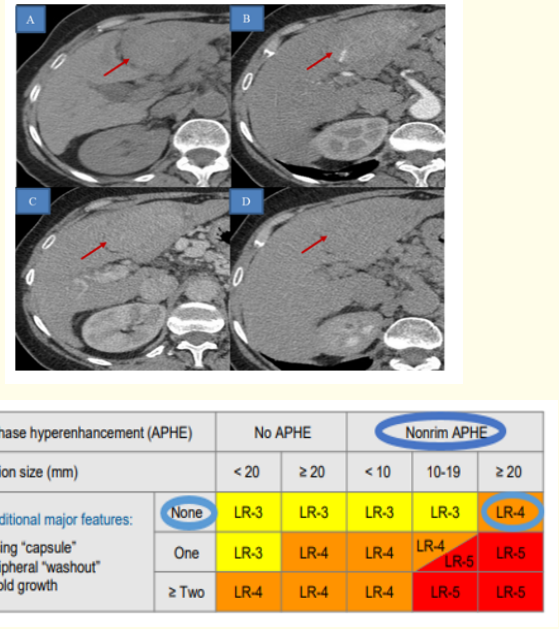


Figure 17: *CT Axial section without contrast (A) arterial phase (B) in portal phase (C) and late phase (D): Mass of segment II heterodense in spontaneous contrast, presenting arterial hypervascularization with washing at late stage with a size measuring 80 mm = LR-5.*

Case 4: 58-year-old, HTP +cirrhosis B and C presents a lesion of 30mm long axis in segment VIII LR?

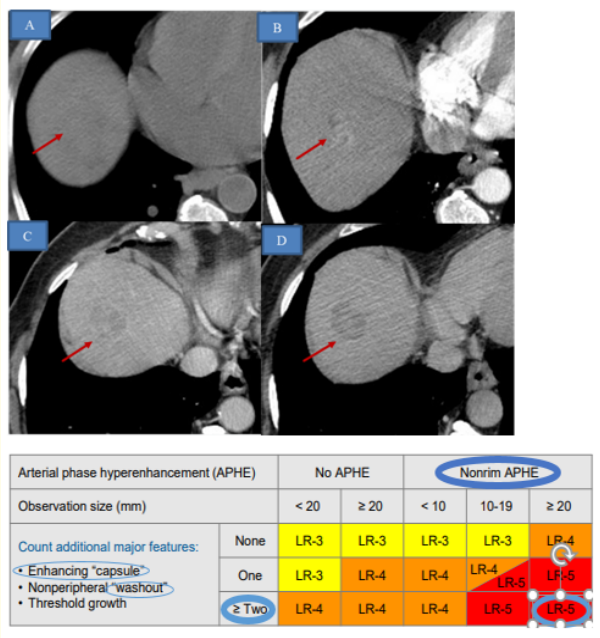


Figure 18: *CT Axial section without contrast (A) arterial phase (B) in portal phase (C) and late phase (D): Lesion of segment VIII hypodense in spontaneous contrast, presenting arterial hypervascularization with portal washing with a capsule enhanced at late time classified LR-5.*

Case 5: 29-year-old followed for cirrhosis B, presents a lesion of 25 mm long axis at the junction of segments V and VIII. LR?

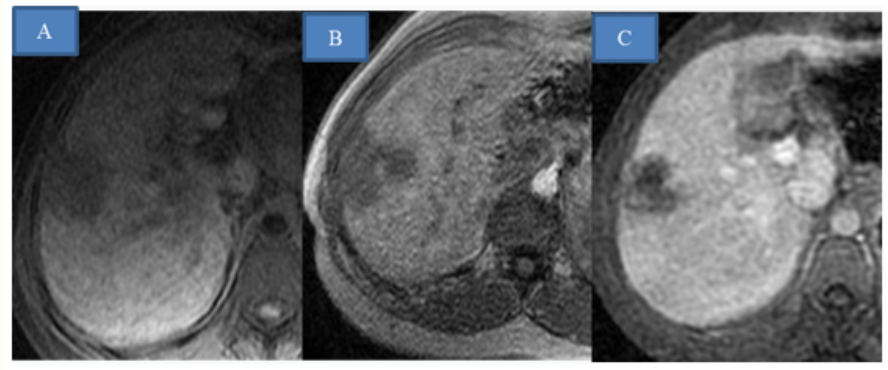
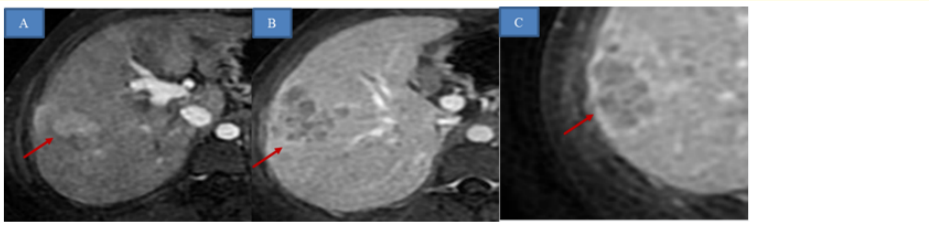


Figure 19: *CT Axial section without contrast (A) arterial phase (B) in portal phase (C) and late phase (D): Lesion of segment VIII hypodense in spontaneous contrast, presenting arterial hypervascularization with portal washing with a capsule enhanced at late time classified LR-5.*

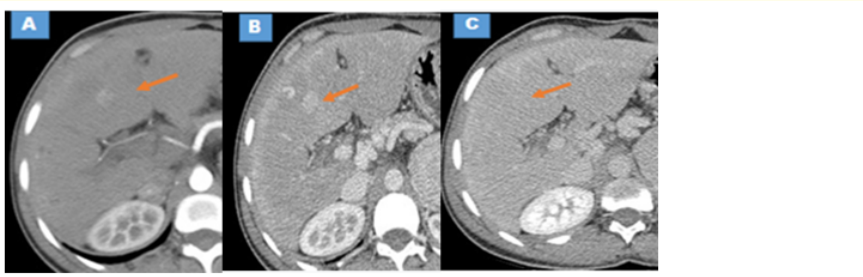
Case 6: 29-year-old, followed for B cirrhosis with a 25 mm long axis lesion at the junction of segments V and VIII classified LR-NC on the previous MRI. (Continuation case 5).



Arterial phase hyperenhancement (APHE)		No APHE		Nonrim APHE		
Observation size (mm)		< 20	≥ 20	< 10	10-19	≥ 20
Count additional major features: • Enhancing "capsule" • Nonperipheral "washout" • 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

Figure 20: *MRI Axial section T1FATSAT late arterial phase (A in portal phase (B) in late phase (C): lesion at the level of the junction of segments V and VIII, presenting hyper vascularization in late arterial phase with portal washing with a capsule enhanced at late time measuring 31mm versus 25 mm classified LR-5.*

Case 7: 25 years follow-up for HTP on cirrhosis liver.



Arterial phase hyperenhancement (APHE)		No APHE		Nonrim APHE		
Observation size (mm)		< 20	≥ 20	< 10	10-19	≥ 20
Count additional major features: • Enhancing "capsule" • Nonperipheral "washout" • 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

Figure 21: *CT Axial section late arterial phase (A) in portal phase (B) in late phase (C): Lesion of hyper vascular segment IV without Wash out with homogenization at late phase measuring 17 mm classified LR-3.*

Case 8: 45-year-old followed for cirrhosis admitted in a state of shock.

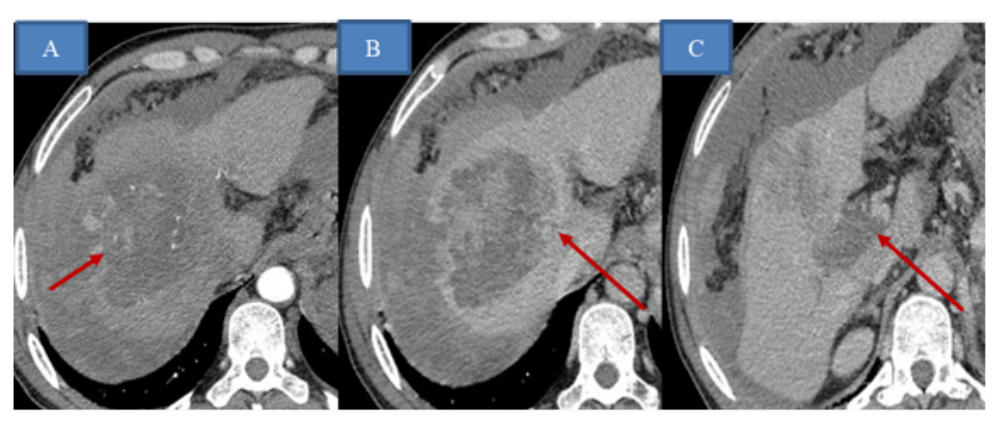


Figure 22: *CT Axial sectional arterial phase (A) portal (B) late phase (C): Mass of segments V, VII and VIII presenting arterial hypervascularization in places with portal washing invading the portal branch and the right vein hepatic with rupture of its intraperitoneal capsule classified LR-TIV.*

Case 9: 80-year-old patient admitted for mapping and evaluation of his HCC.

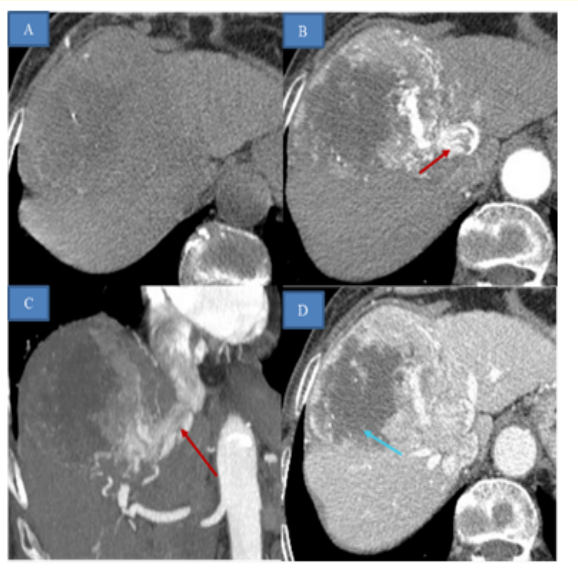


Figure 23: *CT Axial section without contrast (A) arterial phase (B) Coronal section arterial phase (C) in portal phase (D): Mass of segments IV, and VIII presenting hypervascularization in arterial phase in places with portal washing invading the vein sus median hepatic and the inferior vena cava classified LR-TIV.*

Step 1: Apply LI-RADS CT/MRI treatment response algorithm [1].

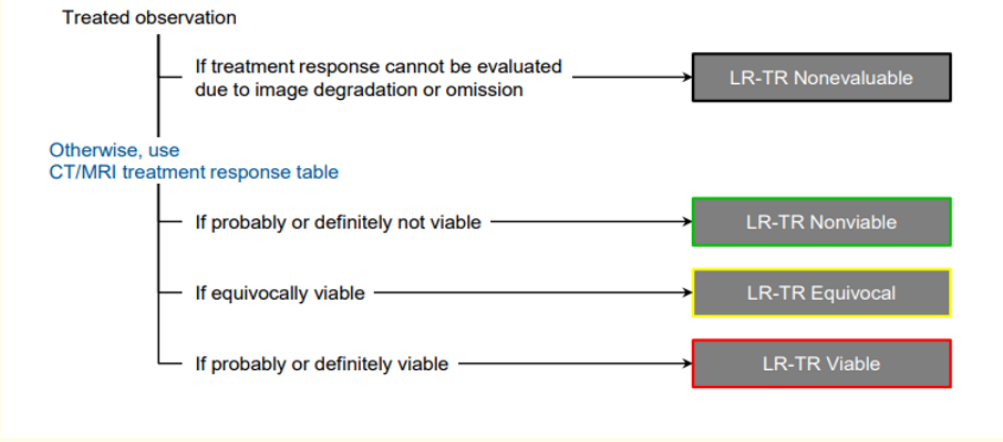


Figure C

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 one of the following: • Arterial phase hyperenhancement OR • Washout appearance OR • Enhancement similar to pretreatment

Table 3: *CT/MRI treatment response [1].*

Step 2: Measure viable tumor size [1].

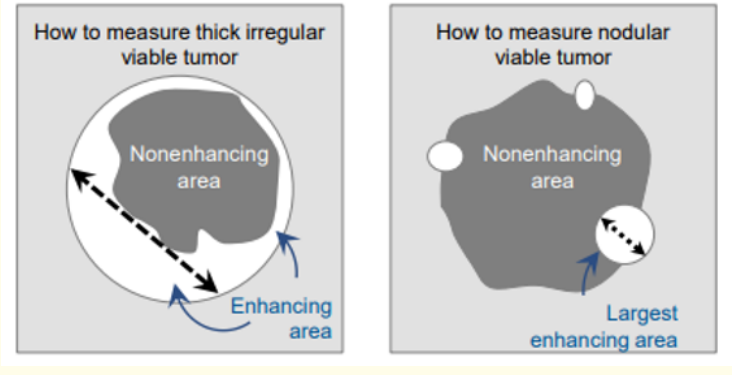


Figure D

Step 3: Apply tiebreaking rule if needed [2]. If unsure between two categories, choose the one reflecting lower certainty as illustrated below.

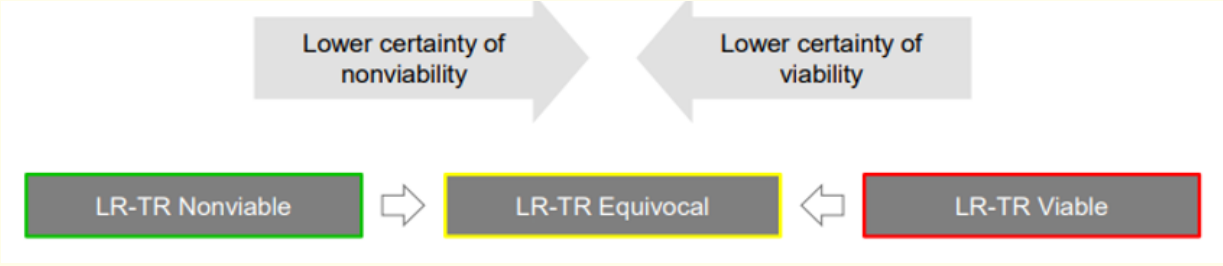


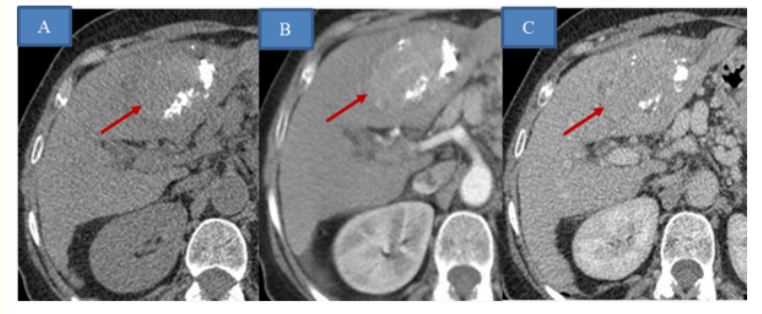
Figure E

Step 4: Final check [1].

Ask yourself if the assigned response category seems reasonable and appropriate.

- If yes: You are done, move on the next observation (if any).
- If no: Assigned LI-RADS category may be inappropriate, so reevaluate.

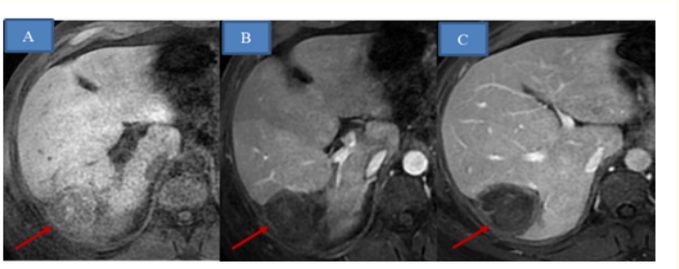
Case 10: 65-year-old, HCC in hepatic segment II who received chemoembolization.



Response Category	Criteria
LR-TR Nonviable	• No lesional enhancement **OR** • Treatment-specific expected enhancement pattern
LR-TR Equivocal	Enhancement atypical for treatment-specific expected enhanceme 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: *CT Axial section without contrast (A) arterial phase (B) in portal phase (C): Mass of segment II with partial heterodense lipiodol fixation in spontaneous contrast, presenting arterial hypervascularization in places with washing in portal phase with a size measuring always 80 mm = LR-TR Viable.*

Case 11: 40-year-old, followed for HCC of hepatic segments VI and VII having benefited from chemoembolization LR-TR?



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 25: *MRI Axial T1FATSAT section without contrast (A) early arterial phase (B) in portal phase (C): Mass of segments VI and VII in T1 hypointense, without enhancement at the different times performed = LR-TR non-Viable.*

Management recommendations for CT and MRI diagnostic and treatment response Liver Imaging Reporting and Data System categories

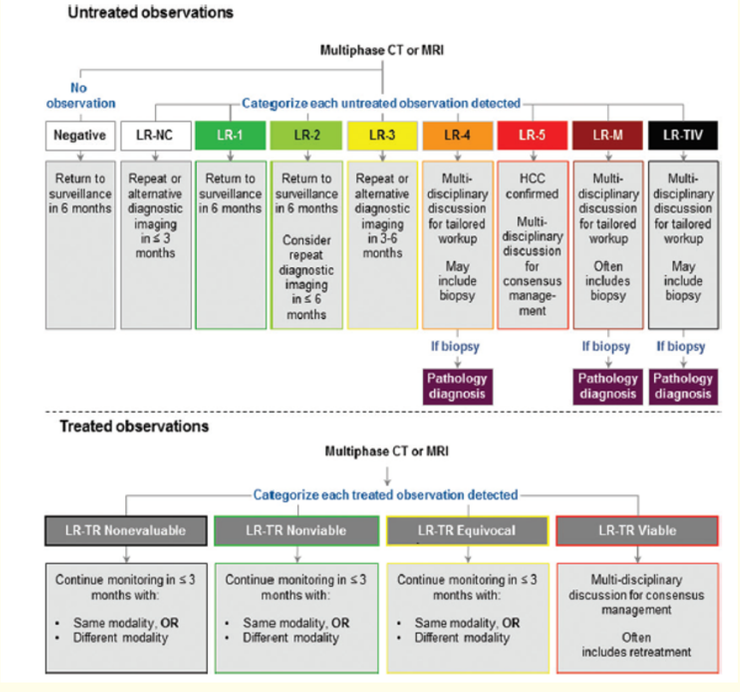


Figure 26: *Summary of management recommendations for CT and MRI diagnostic and treatment response Liver Imaging Reporting and Data System categories.*

Conclusion

In short, LI-RADS reflects the advancement of knowledge in HCC imaging. This system is intended for all radiologists, medical specialists or general practitioners in charge of these patients. It is based on the use of an algorithm and a table for the classification of observations within the framework of a diagnosis of HCC. Its wide distribution and adoption will help standardize practice and optimize the care of patients at risk.

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1. CT/MRI LI-RADS® v2018.
2. Cerny M., *et al*. "LI-RADS pour le diagnostic de carcinome hépatocellulaire en TDM et IRM". *Journal d'imagerie Diagnostique et Interventionnelle* 1.3 (2018): 195-206.
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