Understanding LI-RADS: approach for daily practice.

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Authors: C. Pérez Ramírez\textsuperscript{1}, M. M. Buitrago Torres\textsuperscript{2}, J. C. Pérez Tejada\textsuperscript{1}; \textsuperscript{1}Seville/ES, \textsuperscript{2}Sevilla/ES
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Learning objectives

1. To understand and review LI-RADS (liver imaging reporting and data system) last versión, illustrating with cases of our hospital.
2. To describe the most important imaging features; are diameter, vascular characteristics (arterial phase hyperenhancement and "washout") and encapsulation, making easy their application in clinical practice.
Background

Hepatocellular carcinoma (HCC) is the fifth most common tumor in the world and its incidence is rising.

Risk factors for the development of HCC are chronic viral hepatitis infection, alcoholic and non-alcoholic fatty liver disease, and other types of chronic inflammatory liver diseases.

To obtain the best treatment result for HCC, early diagnosis is the key. The diagnosis of HCC is based on imaging examinations in combination with clinical and laboratory findings and occasionally histologic features. To date, HCC is the only tumor in which a fully non-invasive diagnosis is accepted.

LI-RADS applies only to patients at risk for HCC and it aims to provide detailed descriptions and supporting illustration of all imaging features, enhance communication and reduce interpretation variability.

LI-RADS, initially released in 2011, is a dynamic system that will continue to be refined and updated (2013 and 2014). We will do a review of the latest version (v2014) using the algorithm, diagrams and examples of our database.
Findings and procedure details

LI-RADS categorizes imaging information for each individual observation (lesion) into five major categories ranging from LR-1 (definitely benign) to LR-5 (definitely HCC). (Fig. 1, Fig. 2). LI-RADS includes additional categories for observations that have infiltrated the vascular system (LR-5V), already treated HCC (LR-Treated) and indicate other malignancies (LR-M).

An observation refers to an area with imaging features that differ from those of adjacent liver parenchyma.

The term "observation" is preferred over the term "lesion", because some observations are not true lesions but pseudo-lesions such as perfusion alterations or imaging artifacts.

1. **Technical requirements.**

We must carry out a multiphase MDCT or MRI of the liver consist of non-contrast, late arterial, portal venous, as well as equilibrium phase imaging.

- **Non-contrast phase**: is useful to detect hyperattenuation due to hemorrhage before contrast administration, thus avoiding misinterpretation of arterial-phase hyperenhancement.
- **Late arterial phase** (which is characterized by full enhancement of the hepatic artery and beginning enhancement of the portal vein): is useful to detect hypervascular HCC.
- **Portal venous phase** (which is characterized by enhancement of hepatic veins as well as portal veins)
- **Equilibrium/delayed phase.** The majority of HCCs show washout of contrast medium in these phase.

In addition, in MRI we must get T1 IP-OP, T2 weighted FSE, T2 fat sat and diffusion is suggested.

2. **Diagnostic algorithm.**

In the diagnostic algorithm, first will need to determinate whether a observation has previously been treated. If so, it is categorized as LR-Treated. If not, you must determine
whether the imaging findings are diagnostic of benign entities (LR-1) or probably benign (LR-2). If you think that exists a possibility of non HCC-malignancies based on features, LR-M categorized is assigned. After, you have to look for the presence of tumor in vein (LR-5V).

If the hepatic observation, does not belong to any of these categories, is categorized as LR-3 (intermediate probability), LR-4 (probably HCC) or LR-5 (definitely HCC), based in the presence or not of major imaging features.

3. Major imaging features for HCC.

Major features include arterial-phase hyperenhancement, tumor diameter, washout appearance, capsule appearance, and threshold growth. (Fig. 3).

- Arterial phase hypo- or isoenhancement

Arterial phase iso enhancement applies to observations that enhancement in the arterial phase that is equivalent to that of liver. (Fig. 4).

Arterial phase hypoenhancement applies to observations that enhancement in the arterial phase that is less than that of liver. (Fig. 5).

Arterial phase hypo- or isoenhancement is a LI-RADS major feature. For such masses, those with this feature may be categorized LR-3 or LR-4, depending on diameter and other features, cannot be diagnosed with 100% certainty as HCC based on imaging alone.

- Arterial phase hyperenhancement

Applies to observations that, in the arterial phase, unequivocally enhance, in whole or in part, more than that of the surrounding liver parenchyma. This feature reflects the neoarterialization that accompanies the development of progressed HCC.

Arterial phase hyperenhancement is essential to categorize as a LR-5, but no sufficient, it must be found in combination with other major features.(Fig. 6, Fig. 7)
- **Washout appearance**

Washout appearance is defined as temporal reduction in contrast-enhancement relative to liver from an earlier to a later phase resulting in hypoenhancement in portal venous or delayed phase. Washout can be present in only part of the observation.

Delayed phase may be superior to portal venous phase for, since some observations may show washout appearance only in the delayed phase. (Fig. 8, Fig. 9, Fig. 10)

Washout of the periphery of an observation, should be characterized as peripheral washout. This is not a major feature, is a finding suggestive of intrahepatic cholangiocarcinoma rather than HCC and its presence favors a category of LR-M.

- **Capsule appearance**

Is defined as a peripheral rim of smooth hyperenhancement in the portal venous or delayed phase. The degree of enhancement increases in later phases, and the delayed phase may be superior to the portal venous phase for identifying this feature.

The rim of enhancement does not always represent a true tumor capsule, but may instead represent a pseudocapsule corresponding to loose fibrous tissue and dilated sinusoids around a nodule.

In at-risk patients, capsule appearance has high positive predictive value for HCC. (Fig. 11, Fig. 12, Fig. 13, Fig 14.)

- **Tumor diameter**

Is defined as the largest dimension of an observation, measured from outer edge to outer edge include capsule, in the imaging sequence, phase, and plane in which the margins are most sharply demarcated. Measurements in the arterial phase should be avoided if there are other valid sequences, since the apparent diameter in the arterial phase is variable depending on the acquisition time.

In LI-RADS, observations <1 cm cannot be categorized as definitely HCC. Larger observations are associated with a higher likelihood of HCC and progression.

- **Threshold growth**
Is defined as an increase in the diameter of an observation. The required growth rate is a minimum increase in nodule diameter of 0.5 cm in addition to either at least 50% diameter increase within 6 months or at least 100% diameter increase over more than 6 months.

A new $\geq 10$ mm mass also represents threshold growth, regardless of the time interval.

4. Ancillary features.

Ancillary features are imaging features that can be used to adjust the LI-RADS category at users' discretion. In isolation, these features do not permit reliable categorization. (Fig. 15).

Features that may favor malignancy can be used to upgrade category by one or more categories (up to but not beyond LR-4). (Fig. 16, Fig. 17)

Features that may favor benignity can be used to downgrade category by one or more categories. (Fig. 18).

5. LI-RADS categories.

- LR-1/ LR-2 categories. Benign/ Probably benign entity.

Benign entities usually are categorized LR-1 or LR-2, depending on radiologist's level of certainty. Benign entities with atypical or nonspecific features may be categorized LR-3 or higher.

Benign entities that frequently are encountered in patients with cirrhosis or other risk factors for HCC include: cysts, hemangiomas, vascular anomalies, perfusion alterations, hepatic fat deposition or sparing, hypodertrophic pseudomas, confluent fibrosis and focal scars. (Fig. 19, Fig. 20. Fig. 21)

In addition, the cirrhotic liver is characterized by the presence of innumerable cirrhosis-associated nodules that must not be categorized as LR-1.

In order for a cirrhosis-associated nodule to be categorized as LR-2, it should be homogeneous, less than 2 cm in diameter, and iso-enhancing relative to background liver. Nodules that do not meet these criteria should be categorized as LR-3 or higher depending on their imaging features.(Fig. 22)
- **LR-3 category. Intermediate probability for HCC.**

Is assigned to observations that do not meet the criteria for other LI-RADS categories and have a moderate probability of both HCC or a benign entity. (Fig. 23, Fig. 24).

- **LR-4 category. Probably HCC.**

LR-4 category is assigned when the imaging features are suggestive, but not diagnostic, of HCC. If there is a high probability of HCC but not 100% certainty. (Fig. 25).

- **LR-5 category. Definite HCC.**

LR-5 category is assigned only when there is 100% certainty that the observation is HCC or it is proven to be HCC at histology.

- **LR-5V. Definite tumor in vein.**

Is assigned when there is definite enhancing soft tissue in a vein irrespective of the presence or absence of visible intraparenchymal HCC. This category was created because macrovascular invasion usually constitutes a contraindication to curative treatments such as liver transplantation and hepatic resection.

- **LR- Treated. Treated observations.**

An observation that has undergone loco-regional treatment.

LR- treated does not imply that loco-regional treatment was successful. Residual or recurrent HCC may be present. (Fig. 26, Fig. 27).

- **LR-M. Probably malignant, non specific for HCC.**

Other malignant hypervascular liver lesions requiring differentiation from HCC comprise intrahepatic cholangiocarcinoma (ICC) and metastases, and should be categorized as LR-M.
ICC is the second most common malignancy in patients with cirrhosis or other risk factors for HCC. Differentiation between HCC and ICC is important as the management and prognosis differs.

Features that favor ICC over HCC are: rim or peripheral arterial phase hyperenhancement, portal venous and delayed phase central enhancement, progressive concentric enhancement, peripheral washout appearance, liver surface retraction and biliary obstruction disproportionate.

6. **Management.**

For observations definitely or probably benign (LR-1 and LR-2) it’s mandatory to continue standard surveillance.

For observations without a definite diagnosis by imaging (LR-3 and LR-4), decision-making between, alternative imaging, biopsy, or treatment without biopsy must be done from a clinical assessment that integrates all information (LI-RADS categories and clinician’s estimated probability).

The observations categorized as a LR-5 or LR-5v follows a treatment without biopsy.
**Fig. 1:** LIRADS version 2014 algorithm with LIRADS categories and major features.

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### LI-RADS categories. Concepts and definitions.

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<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>CONCEPT AND DEFINITION</th>
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<tbody>
<tr>
<td>LR1 DEFINITELY BENIGN</td>
<td>100% Certainty observation is benign.</td>
</tr>
<tr>
<td>LR2 PROBABLY BENIGN</td>
<td>High probability observation is benign.</td>
</tr>
<tr>
<td>LR3 INTERMEDIATE</td>
<td>Observation with imaging features suggestive but not diagnostic of a benign entity.</td>
</tr>
<tr>
<td>LR4 PROBABLY HCC</td>
<td>Both HCC and benign entity have moderate probability.</td>
</tr>
<tr>
<td>LR5 DEFINITELY HCC</td>
<td>Observation that does not meet criteria for other LI-RADS categories.</td>
</tr>
<tr>
<td>LR5V DEFINITELY HCC WITH TUMOR IN VEIN</td>
<td>High probability observation is HCC but there is not 100% certainty.</td>
</tr>
<tr>
<td>LR5T TREATED TREATED OBSERVATION</td>
<td>Observation with imaging features suggestive but not diagnostic of HCC.</td>
</tr>
<tr>
<td>LR-M PROBABLY MALIGNANCY, NOT SPECIFIC FOR HCC</td>
<td>100% certainty observation is HCC.</td>
</tr>
<tr>
<td></td>
<td>Observation with imaging features diagnostic of HCC or proven to be HCC at histology.</td>
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<tr>
<td></td>
<td>Observation with imaging features diagnostic of HCC invading vein.</td>
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<td>Loco-regionally treated observation.</td>
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<td></td>
<td>Observation that has undergone loco-regional treatment.</td>
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<tr>
<td></td>
<td>High probability that observation is a malignancy, but imaging features are not specific for HCC.</td>
</tr>
<tr>
<td></td>
<td>Observation with one or more imaging features that favor non-HCC malignancy.</td>
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Fig. 3: Diagrams illustrating imaging major features used to categorize LR-3, LR-4 or LR-5 observations.

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**Fig. 4:** 78-year-old man. Mass in segment IV that exhibits arterial phase iso enhancement with "washout" in portal venous and delayed phase (white arrows). Lesion measures more than 2 cm. Assignment was LR-4.

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Fig. 5: 66-year-old woman with cirrhosis. Mass in segment IVb that exhibits arterial phase hypoenhancement in contrast-enhanced CT and MRI (A,B). Lesion measures 2.8 cm and shows “washout” in delayed phase (C,D), LI-RADS 4. The liver has nodular surface, in keeping with cirrhosis. Large number of varices around the splenic hilum and splenorenal, as well as ascetic free fluid, both features of portal hypertension is also seen.

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Fig. 6: Subcapsular nodule (1.2 cm) in segment V, that unequivocally shows arterial hyperenhancement (white arrow), washout appearance and capsule appearance (yellow arrow) in delayed phase. This observation can be categorized as a LR-5.

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Fig. 7: Nodule (1.8 cm) that shows arterial phase hyperenhancement (white arrow) and washout appearance in delayed phase (yellow arrow). This observation can be categorized as a LR-4 or LR-5.

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Fig. 8: MRI of a 51-year-old male with cirrhosis that reveals a 4.6 cm mass in segment VII of the liver. This observation exhibits arterial hyperenhancement, washout (black arrow) and capsule appearance (white arrow) in portal and delayed phase. It was categorized as a LR-5.

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Fig. 9: 62-year-old man hepatitis C cirrhosis. MDCT shows mass in segment VII that measures 5 cm that exhibits arterial phase hyper-enhancement and washout appearance in portal venous and delayed phases (black arrows), therefore it is assigned to LI-RADS category 5.

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Fig. 10: 54-year-old man with hepatitis C and cirrhosis. MRI reveals nodule lobed in segment VII, that shows arterial phase hyper-enhancement (A) and washout with capsule appearance in delayed phase (B). Lesion measures 3,4 cm and shows restricted diffusion in diffusion-weighted image (C y D). Assignment was LI-RADS category 5.

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**Fig. 11:** Capsule appearance which refers to a peripheral rim of smooth hyperenhancement in the portal venous or delayed phase. Comparison with corona enhancement; a rim of peripheral enhancement in the late arterial phase that may have variable thickness and uniformity. It is typically fades toward iso in delayed phase.

**Fig. 12:** 81-year-old woman with cirrhosis. Example of capsula appearance on MRI. Mass in segment VIII, more than 2 cm, that presents arterial phase hyper-enhancement with marked "washout" in delayed phase and capsule appearance in portal and delayed phase: LI-RADS 5.

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**Fig. 13:** 58-year-old woman with hepatitis C and hepatocellular carcinoma. Example of corona enhancement on MRI. Lesion in segment II, measures 26 mm and exhibits rim of peri observation enhancement in the late arterial phase that fades in delayed phase, as well as washout in delayed phase. It is assigned to LI-RADS category 5.

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**Fig. 14:** Example of capsule appearance. MRI reveals T2 mild-moderate hyperintense nodule in segment VII, with arterial hyperenhancement, "washout" and capsule appearance in delayed phase (yellow arrow).

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Fig. 15: Ancillary features. Imaging features that modify likelihood of HCC.

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Fig. 16: Ancillary features favouring HCC. A. Mild hyperintensity hepatic nodule in segment VIII, in T2 weighted image. B. Nodule in segment IVa that exhibits loss of signal intensity on T1-weighted out-of-phase MR image compared with in-phase gradient echo image. C. Mass with higher signal intensity relative to liver on DWI and low apparent diffusion coefficient (ADC). D. A smooth border around the observation in T2 weighted image can be observed (white arrows).

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ANCILLARY FEATURES THAT MAY FAVOR BENIGNITY

Homogeneous marked T2 hyperintensity

A.

Homogeneous marked T2 or T2* hipointensity

B.

Fig. 17: Ancillary features that may favor benignity. A. Homogeneous marked hiperintensity nodule in segment VI, in T2 fat sat weighted image. B. Nodule in segment VII exhibits marked hipointensity in T2 weighted image.

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Fig. 18: Diagrams illustrating mosaic architecture. Observation that shows nodules or compartments with differing appearances (enhancement, attenuation, intensity). Is an ancillary feature favoring malignancy. A. Example of nodule-in-nodule. B. Example of multi-nodule-in-nodule.

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**Fig. 19:** 62-year-old woman with hepatitis C. Homogeneous fluid nodule in a cirrhotic liver without enhancement, example of simple cyst. LI-RADS 1.

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**Fig. 20:** 50-year-old man with hepatitis C cirrhosis. Example of hemangioma rounded in segment VI, with peripheral discontinuous nodule-like expanding enhancement (B, C y D). Ultrasound image previously performed shows a hyperecogenic nodule, well defined (A). It was assigned to LI-RADS category 1.

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Fig. 21: 55-year-old man with cirrhosis. Liver has nodular surface and atrophic, in keeping with cirrhosis. Example of focal scar. Bandlike area of increased signal intensity are present on T2-weighted fat sat and decreased signal intensity on T1-weighted image with delayed phase enhancement. It was assigned LI-RADS 2.
Fig. 22: Diagrams illustrating imaging features that enables categorize as LR-2 to the cirrhosis associated nodules.

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Fig. 23: 66-year-old woman with alcoholic hepatitis and cirrhosis. Lesion in segment VIII that exhibits arterial phase hyperenhancement without other major features. This observation measures 17 mm, finally categorized as a LR-3.

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Fig. 24: 52-year-old woman. Observation in segment IVa with arterial phase hyper-enhancement (yellow arrow) without washout in portal venous phase (black arrow), therefore it is assigned to LI-RADS category 3.

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**Fig. 25:** 65-year-old man with cirrhosis. MRI shows a solid and irregular nodule in segment VII with moderate T2 hyperintensity. Lesion measures 3 cm and exhibits arterial phase enhancement compared with unenhanced images with similar enhancement to the liver in delayed phase, therefore it is assigned to LI-RADS category 4.

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**Fig. 26:** 57-year-old man. Mass in segment VIII that exhibits arterial phase hyper-enhancement with mosaic architecture (multi-nodule-in-nodule) and “washout” in delayed phase. The mass was treated with trans-catheter arterial chemoembolization, six months after treatment CT shows hypodense area without enhancement in the various phases. LR-Treated.

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**Fig. 27:** The mass exhibits arterial phase hyper-enhancement in contrast-enhanced CT and iso-enhancement in portal venous phase (A y B). The observation was treated (chemoembolization) and CT after 1 year shows hypodense area with nodules that enhances in arterial phase (white arrows) compatible with residual tumor: LR-Treated.

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Conclusion

Diagnosing HCC at an early stage is crucial for optimizing treatment outcome. LI-RADS is a comprehensive system for interpreting and reporting hepatic observations in patients at high risk for HCC, simplifying the diagnostic.

The LI-RADS category codes summarizing probabilities allows; provide precise and unambiguous information and helps to take diagnostic and management decisions. It also enables standardization and coordination of the report, avoiding the omission of relevant information and facilitating the monitoring of findings in time.
References


