

Title:

The Adoption of LI-RADS: A Survey of Non-Academic Radiologists

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ABSTRACT

Purpose: To understand the practice and determinants of non-academic radiologists regarding LI-RADS and the four current LI-RADS algorithms: CT/MRI, contrast-enhanced ultrasound (CEUS), ultrasound (US), and CT/MRI Treatment Response.

Materials and Methods: Seven themes were covered in this international survey, as follows: (1) demographics of participants and sub-specialty, (2) HCC practice and interpretation, (3) reporting practice, (4) screening and surveillance, (5) HCC imaging diagnosis, (6) treatment response, and (7) CT and MRI technique.

Results: Of the 232 participants, 69.4% were from the United States, 25.0% from Canada, and 5.6% from other countries and 45.9% were abdominal/body imagers. During their radiology training or fellowship, no formal HCC diagnostic system was used by 48.7% and LI-RADS was used by 44.4% of participants. In their current practice, 73.6% used LI-RADS, 24.7% no formal system, 6.5% UNOS-OPTN, and 1.3% AASLD. Barriers to LI-RADS adoption included lack of familiarity (25.1%), not used by referring clinicians (21.6%), perceived complexity (14.5%), and personal preference (5.3%). The US LI-RADS algorithm was used routinely by 9.9% of respondents and CEUS LI-RADS was used by 3.9% of the respondents. The LI-RADS treatment response algorithm was used by 43.5% of the respondents. 60.9% of respondents thought that webinars/workshops on LI-RADS Technical Recommendations would help them implement these recommendations in their practice.

Conclusion: A majority of the non-academic radiologists surveyed use the LI-RADS CT/MR algorithm for HCC diagnosis, while nearly half use the LI-RADS TR algorithm for assessment of treatment response. Less than 10% of the participants routinely use the LI-RADS US and CEUS algorithms.

Key words: Hepatocellular carcinoma (HCC); Imaging; Clinical practice; Diagnosis; Standardization; LI-RADS.

Statements and Declarations:

The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. We are military service members.

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INTRODUCTION

Since 1993, and the development of the breast imaging reporting and data system (BI-RADS), the American College of Radiology (ACR) has promoted the use of reporting and data systems (RADS) aimed at standardizing radiology reports and improving communication with referring physicians [1, 2]. In the early 2000's, the CT Colonography reporting and data system (C-RADS) was developed, and soon after the prostate imaging reporting and data system (PI-RADS) for prostate cancer and thyroid imaging reporting and data system (TI-RADS) for thyroid cancer, amongst other RADS were developed [3-6]. In 2023, there are 9 well-established ACR RADS with many more in development [7].

Worldwide, multiple regional imaging and reporting systems exist for liver cancer imaging; however, these systems vary based on different target populations with differing risk factors and available management options related to regional resources [8]. In the United States, the liver imaging reporting and data system (LI-RADS) has been developed to improve consistency and clarity of imaging findings in radiology reports to better serve clinicians treating patients at increased risk for HCC and has grown into a fully indexed, comprehensive diagnostic algorithm with an atlas and lexicon of controlled terminology [9, 10]. LI-RADS was first released in 2011 and initially focused on computed tomography (CT) and magnetic resonance imaging (MRI) for the non-invasive diagnosis of HCC. Since, LI-RADS has grown to include a treatment response (TR) algorithm for locoregional therapy, ultrasound (US LI-RADS) for HCC surveillance, and contrast-enhanced ultrasound (CEUS LI-RADS) for the diagnosis of HCC [11].

Previous surveys on the perception of LI-RADS have targeted clinicians and surgeons [12] or abdominal radiologists predominantly working in an academic setting [8]. While LI-RADS has been broadly accepted and implemented in academic centers, its adoption in the non-academic setting has lagged [9, 13]. Reported barriers to adoption include complexity of the algorithms and terminology, radiologist refusal, inconsistent use, and failure of system integration into patient management paradigms [12, 14]. While these are the presumed barriers, to our knowledge, no study has assessed the use and opinions of LI-RADS by non-academic radiologists.

The purpose of this quality improvement survey was to understand the practice and determinants of non-academic radiologists in the United States and Canada regarding LI-RADS.

METHODS

This quality improvement survey was approved by the (withheld to preserve blinding).

Survey Designs

Members of the Society of Abdominal Radiology Disease-Focused Panel on HCC Diagnosis (SAR-DFP: HCC, 27 members) and members of the American College of Radiology (ACR) LI-RADS Outreach and Education working group (LI-RADS O&E, 32 members) developed and distributed a survey to non-academic radiologists regarding the use and opinions of LI-RADS. The survey working group comprising of members of both SAR-DFP: HCC and LI-RADS O&E consisted of 11 members ([initials withheld to preserve blinding]). The survey working group as well as members of the LI-RADS Steering Committee submitted survey questions, which were edited and reviewed in an iterative fashion by a subset of the survey working group consisting of 5 radiologists (initials withheld to preserve blinding). Survey questions were edited and revised to ensure the questions were non-leading and ordered sequentially in common groupings.

Survey outline

An introductory paragraph was provided to explain the purpose of the survey (**Appendix 1**). The survey consisted of 30 questions: 5 questions about respondent demographics, 4 questions about HCC practice and interpretation, 5 questions about reporting practices, 2 questions about HCC screening and surveillance, 5 questions about HCC diagnosis, 3 questions about HCC treatment response, and 6 questions about CT and MRI technique (**Appendix 2**). Most of the questions were multiple choice with nearly an even split between single choice questions and questions allowing more than one response. All questions had an optional text section for an explanation of responses (**Appendix 3**).

Survey participants and delivery

The survey was created and hosted using a commercial platform (Google Forms, USA). Members of the SAR-DFP: HCC and LI-RADS O&E were asked to share the survey with non-academic radiologists that they knew via email. In addition, the survey link was shared on the SAR-DFP: HCC twitter account, @LIRADS5, and on Facebook in the group pages “American Radiologists,” “RadChicks,” and “Navy Radiologists: Haze Gray”. The link was also distributed by both the SAR and *Société de radiologie du Québec* via email, in the ACR Quality and Safety newsletter, and via email to the Learning Community for Improvement in Radiology (LCIR) group. The survey remained open for 7 weeks (March 14, 2022 – May 4, 2022) with reminders sent via social media. Participants were not offered compensation or incentive to participate. No identifying data was requested by the survey, and anonymity was preserved for the respondents.

Data Collection

Responses to survey questions were recorded in the commercial study platform (Google Forms, USA) for each question with raw data saved in a commercial spreadsheet (Google Sheets, USA) for analysis. A descriptive analysis was performed.

RESULTS

Participant Demographics

Table 1 summarizes the demographic data of the survey participants. Although a total of 234 radiologists participated in the survey, two participants reported working in academic centers and were excluded from the analysis. Of the remaining 232 non-academic participants in the survey, 69.4% (161/232) were from the United States, 25.0% (58/232) were from Canada, with 5.6% (13/232) from other countries. The response rate could not be determined as the survey was administered via multiple platforms, including social media and personal emails.

A majority of the participants worked in private practice (46.6%, 108/232), and most of the participants (45.9% 106/231) reported being abdominal/body imagers, general radiologists (30.7%, 71/231), or breast/body imagers (8.7%, 20/231).

HCC Practice and Interpretation

Table 2 summarizes the responses for HCC practice and interpretation. During a typical week, a majority of participants (51.3%, 119/232) interpret 1-5 CT or MRI liver exams for HCC surveillance or diagnosis.

Figure 1 summarizes the diagnostic system used by participants during their training and in their current practice. The diagnostic system for HCC diagnosis most used during their radiology training, either during residency or during fellowship, was no formal system (48.7%, 113/232) and LI-RADS (44.4%, 103/232).

Nearly half of the participants actively use and understand LI-RADS (49.6%, 115/232), and 19.8% (46/232) actively use it but have questions when using it (**Figure 2**).

Reporting Practice

Table 3 summarizes the data for reporting practices. Of the participants, 73.6% (170/231) use LI-RADS, 24.7% (57/231) do not use a formal system, 5.6% (15/231) use UNOS-OPTN, and 1.3% (3/231) use the AASLD guidelines (**Figure 1**).

Most participants expressed confidence in using CT/MRI LI-RADS; 31.5% (73/232) are very confident, 24.6% (57/232) are moderately confident, and 19.0% (44/234) are extremely confident.

Although 51.1% (116/227) of participants reported having no barrier to using LI-RADS, reported barriers to using LI-RADS included: a lack of familiarity 25.1% (57/227), referring clinicians do not use it 21.6% (49/227), complexity 14.5% (33/227), and personal preference 5.3% (12/227) (**Figure 3**).

Screening and Surveillance

Table 4 summarizes the data of HCC screening and surveillance. Nearly half of the participants have heard of the US LI-RADS algorithm for HCC screening and surveillance but do not use it (48.7%, 113/232). Only 9.9% (23/232) use the US LI-RADS algorithm routinely (**Figure 4**). Methods used for HCC screening/surveillance include US 71.7% (165/230), multiphase contrast-enhanced CT 61.7% (142/230), multiphase contrast-enhanced MRI with extracellular contrast agents 71.7% (165/230), multiphase contrast-enhanced MRI with a hepatobiliary contrast agent 20.4% (47/230), single-phase CT 3.9% (9/230), non-contrast liver MRI 1.7% (4/230), and abbreviated MRI 1.7% (4/230).

Hepatocellular Carcinoma Diagnosis

Table 5 summarizes the data for HCC diagnosis. Most of the participants use the LI-RADS ancillary features to help assess liver lesions in patients at risk for HCC: 13.8% (32/232) always use them, 23.7% (55/232) often use them, and 27.2% (63/232) sometimes them. Most of the participants (69.8%, 162/232) do not perform CEUS and 12.9% (30/232) have never heard of the CEUS LI-RADS algorithm for HCC diagnosis. 13.4% (31/232) of participants are familiar with the algorithm, but have barriers to using it in their practice, and only 3.9% (9/232) use the algorithm in their practice (**Figure 5**).

Treatment Response

Table 6 summarizes the data for LI-RADS treatment response (TR). Most of the participants (70.5%, 155/220) read 1 to 5 treatment response cases after locoregional therapy for HCC per month, 14.1% (31/220) read 6 to 10 cases, 8.2% (18/220) read 11-15 studies, and 7.3% (16/220) read more than 15 exams per month. Regarding their familiarity with the LI-RADS TR algorithm, 33.9% (78/230) routinely use it, 30.0% (69/230) are unaware of it, 13.5% (31/230) are aware of and occasionally use it, and 22.6% (52/230) are aware of but do not use it (**Figure 6**). The barriers or limitations of using the LI-

RADS TR algorithm include: the algorithm is not clinically adopted 32.3% (51/158), a lack of confidence 27.8% (44/158), and 5.7% (9/158) use mRecist as an alternative. 6.3% of the responses consisted of written statements such as “the clinicians do not use it”, “it is not relevant in my practice”, “there are not enough cases”, and “we are in a rural practice where all cases go to the academic center”.

Technique

Table 7 and **Table 8** summarize the data for MRI technique and CT technique, respectively. A majority of participants (71.6%, 56/218) do not have scanners less than 1.5 Tesla (T) available in their practice, while 12.8% (28/218) report that no liver imaging is performed on these scanners despite having them, 10.6% (23/218) routinely use low field-strength scanners for liver imaging, and 5.0% (11/218) only use such scanners for liver imaging in situations related to body habitus or claustrophobia. Participants most favored webinars/workshops on LI-RADS technique (60.9%, 126/207), downloadable protocols (50.2% 104/207), out of the box exam cards from vendors (30.4%, 63/207) and direct communication with a LI-RADS expert (27.5%, 57/207) to help them implement the LI-RADS Technique Recommendations in their practices.

DISCUSSION

We conducted a survey of non-academic US and Canadian radiologists to understand their perception of LI-RADS, to address potential knowledge gaps, and to determine how future versions and educational materials could better address the needs of a non-academic audience. Our results reveal how often the various LI-RADS algorithms are used and the barriers to adoption of the algorithms in the non-academic environment.

Even though only 44.4% of the participants used LI-RADS in their radiology training, 73.6% of non-academic radiologists use it in their current practice. These numbers were similar to the previously reported international use of LI-RADS of 66.8% and the reported use of LI-RADS at academic institutions of 88% [8, 12]. The high use of LI-RADS by non-academic radiologists was unexpected based on previous papers; however, to our knowledge, the frequency of LI-RADS use in the non-academic setting had never been formally studied prior to this survey [9]. Not only was LI-RADS used by over 70% of respondents, but 50% reported actively using it and understanding it and 19.7% reported actively using it but have questions when using it.

The more common limitations to the use of the CT/MRI algorithm were a lack of familiarity and the algorithm not being used by referring clinicians, with less than 15% reporting complexity as a barrier for implementation. This result was surprising given common feedback by users is that the LI-RADS algorithms are too complex and using standardized reporting is more time consuming than free dictation [13, 14]. Despite these results, a simplification of the algorithm without compromising evidence, comprehensiveness, and precision is a goal of future versions of LI-RADS [14].

Despite over 70% of participants using US as the modality of choice for HCC screening and surveillance, only 9.9% routinely use the LI-RADS US algorithm while 48.7% have heard of it but do not use it and 29.3% have never heard of it. This may be explained as US LI-RADS debuted in 2017 while the LI-RADS CT/MRI algorithm debuted in 2011 and has been more established in practice and in the literature over a majority of the past decade [11]. Additionally, referring physicians may not be aware of it or are not requesting a change in practice to use it.

Similarly, over 95% of participants do not use CEUS for HCC diagnosis in their practice. This may be explained by the relatively recent approval of Lumason in 2016 by the United States Food and Drug

Administration for liver imaging [15, 16]. However, CEUS also had many reported barriers to its use in the non-academic setting including lack of radiologist and ultrasound technician expertise, a lack of training, the thought that it is too time consuming and too costly, and the lack of reimbursement, despite the approval of CPT codes specifically for CEUS of the liver in January 2019 [17].

The use of the LI-RADS Treatment Response algorithm was higher than that of the LI-RADS Ultrasound and CEUS algorithms. This may be explained by the TR algorithm being introduced with the CT/MRI algorithm in 2017. In addition, the CT/MRI Diagnostic and TR algorithms are contained together within the Core Document of LI-RADS v2018 rather than as a separate, stand-alone algorithm, like the CEUS and US LI-RADS algorithms [18]. The more commonly reported barriers to using the LI-RADS TR algorithm included lack of clinical adoption, lack of confidence, and the use of other treatment response algorithms like mRECIST.

We also asked questions regarding CT and MRI technique to determine what is being used in the non-academic centers. All required LI-RADS MRI sequences and CT contrast phases had less than 14% omission per the survey responses except for hepatobiliary imaging and transitional phases on MRI with gadoxetate as 24.3% reported not using gadoxetate as an MRI contrast agent. Other than the phases related to gadoxetate, diffusion-weighted imaging (23.1%) and subtraction imaging (61.5%) were the most commonly omitted sequences per participants. Although these sequences had been deemed optional per the LI-RADS technical recommendations, the recommendations describe the minimal requirements for diagnostic quality. These sequences were considered optional due to the inability of many older scanners to generate quality subtraction and diffusion-weighted images rather than due to their lack of added value [19]. For CT, the highest omitted required phase was the delayed phase (10.2%). Over 56% of respondents do not use dual-energy imaging.

Additionally, a small percentage of participants, over 15%, use low field strength (< 1.5 Tesla (T)) MRI systems for liver imaging, despite the LI-RADS technical recommendations of using 1.5 T or 3.0 T magnets for HCC diagnosis. LI-RADS recommends against using low field strength magnets as they are associated with an inferior signal-to-noise ratio, poor spatial resolution, and overall poorer image quality [20]. Additionally, gadolinium contrast enhancement on low field strength MRI is associated with lower contrast enhancement compared to 1.5 and 3.0 T imaging, which may be problematic in the detection of small HCC's [21].

This survey was also performed to help shape future versions of LI-RADS. Per the participants, over 50% would like a standardized LI-RADS reporting template on their dictation system, and 39.7% wanted AASLD management recommendations included in a reporting template. Additionally, a majority of participants do not utilize LR-1 (definitely benign) and LR-2 (probably benign) in their reports, and most do not think the differentiation of LR-1 and LR-2 is beneficial. The use of ancillary features was very mixed from radiologists always using ancillary features (13.8%) to those not being familiar with the features (21.1%). The results of this survey also show that multiple support tools may potentially improve future adoption and dissemination of LI-RADS, address knowledge gaps, and keep radiologists abreast with LI-RADS updates. These tools include webinars/workshops on LI-RADS technique, downloadable LI-RADS imaging protocols, distribution of out-of-the-box exam cards from vendors, and availability of a directory of LI-RADS experts that radiologists can reach out to as necessary. These items should be evaluated by the LI-RADS Steering Committee for future versions of LI-RADS and LI-RADS education.

Furthermore, as over 70% of respondents use LI-RADS CT/MRI but a majority do not use the US and CEUS algorithms, the LI-RADS O&E and SAR-DPF:HCC should focus on educational sessions on US and CEUS in the future to further promote their awareness and use.

Limitations to this study include potential bias as members of our group emailed the survey to non-academic radiologists who may be familiar with LI-RADS. Second, this study was sent out via social

media and by multiple societies and thus the denominator and corresponding response rate could not be determined. Third, as the survey did not ask for any identifying information and was anonymous, it is theoretically possible that one participant could have answered the survey more than once. Additionally, as this survey targeted non-academic radiologists in the United States and Canada through emails and the various societies, very few participants were from countries outside of North America who presumably saw and answered the survey through social media or emails. Furthermore, this survey was intended to be descriptive and not designed to perform statistical analyses. However, it would be interesting in the future to complement this questionnaire with qualitative interviews to more precisely identify the motivations and obstacles to the adoption of LI-RADS in non-academic practices.

Conclusion

In the cohort of non-academic radiologists who responded to our survey, we found that a majority of the participants use the LI-RADS CT/MRI algorithm for HCC diagnosis and 47.4% use the TR algorithm. However, less than 10% routinely use the US or CEUS algorithms despite most using US for HCC screening. Overall, the content of this survey may help improve education, webinars, and workshops, specifically in US and CEUS LI-RADS, and technique, to help improve quality in liver imaging for HCC and may help improve further versions of LI-RADS.

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Table 1. Demographic Data of 232 Respondents

Variable	Number of respondents (percentage)
Year of Final Radiology Training	
2020 – 2021	26 (11.2%)
2010 – 2019	97 (41.8%)
2000 – 2009	76 (32.8%)
1990 – 1999	25 (10.8%)
1980 – 1989	5 (2.2%)
1970 – 1979	3 (1.3%)
Type of Practice	
Private Practice	108 (46.6%)
Non-Academic Government/Military/VA	18 (7.8%)
Mixed Practice (Private Practice with Trainees)	28 (12.1%)
Hospital Employed Practice	45 (19.4%)
Hospital Employed Practice with Trainees	22 (9.5%)
Other	11 (4.7%)
What Country do you Practice In?	
United States	161 (69.4%)
Canada	58 (25.0%)
Other	13 (5.6%)
Sub-Specialty	
Abdominal/Body Imaging	106 (45.9%)
General Radiologist	71 (30.7%)
Body/Breast Imaging	20 (8.7%)
MRI Specialist	9 (3.9%)
Interventional Radiology	3 (1.3%)
Musculoskeletal Imaging	5 (2.2%)

Other	17 (7.3%)
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Table 2. HCC Practice and Interpretation

Variable	Number of respondents (percentage)
How many diagnostic CT or MRI exams do you interpret for HCC per week?	
More than 15	23 (9.9%)
11 - 15	17 (7.3%)
6 -10	37 (15.9%)
1 - 5	119 (51.3%)
None	36 (15.5%)
Does your practice have a dedicated multidisciplinary conference for HCC, hepatopancreaticobiliary disease, or liver transplant with radiology participation?	
Yes	103 (44.4%)
No	129 (55.6%)

Table 3. Reporting Practice

Variable	Number of respondents (percentage)
How confident are you with using LI-RADS v2018 CT/MRI? (232 responses)	
Extremely Confident	44 (19.0%)
Very Confident	73 (31.5%)
Moderately Confident	57 (24.6%)
Slightly Confident	16 (6.9%)
Not Confident	42 (18.1)
Would you use a standardized LI-RADS reporting template it were available directly on your dictation system? (231 responses)	
Yes, I have one and use it	31 (13.4%)
Yes, I would like to have it and use it	123 (53.2%)
I am indifferent in using the LI-RADS reporting template	40 (17.3%)
No, I use my own LI-RADS template	20 (8.7%)
No, I don't plan on using LI-RADS	17 (7.4%)
Would you include AASLD management recommendations using a template if it were available directly on your dictation systems? (229 responses)	
Yes, I would like to have it and use it	91(39.7%)
I am indifferent in using the AASLD management guidance	76 (33.2%)
No, I provide my own guidance	8 (3.5%)
No, I do not plan on using the AASLD management guidance	54 (23.6%)

Table 4. Screening and Surveillance

Variable	Number of respondents (percentage)
What imaging methods do you use for HCC screening/surveillance? Check all that apply (230 responses)	
Ultrasound	165 (71.7%)
Single Phase CT	9 (3.9%)
Multiphasic contrast-enhanced liver CT	142 (61.7%)
Multiphasic contrast-enhanced liver MRI with extracellular agents or with gadobenate dimeglumine (Multihance)	165 (71.7%)
Multiphasic contrast-enhanced liver MRI with gadoxetate disodium (Primovist or Eovist)	47 (20.4%)
Non-contrast liver MRI	4 (1.7%)
Abbreviated MRI	4 (1.7%)

Table 5. HCC Diagnosis

Variable	Number of respondents (percentage)
Do you utilize the categories definitely benign (LR-1) and probably benign (LR-2) in your reports? (231 responses)	
Yes	75 (32.5%)
No	102 (44.2%)
Unsure	5 (2.2%)
I do not use LI-RADS	49 (21.2%)
Do you think the differentiation between LR-1 and LR-2 is beneficial? (232 responses)	
Yes	30 (12.9%)
No	97 (41.8%)
Unsure	57 (24.6%)
I do not use LI-RADS	48 (20.7%)
What barriers exist in your practice to using CEUS for HCC diagnosis? Check all that apply (229 responses)	
Do not have radiologist expertise	151 (65.9%)
Lack of ultrasound technician expertise	163 (71.2%)
Too time consuming	113 (49.3%)
Cost	64 (27.9%)
Lack of training	146 (63.8%)
Reimbursement	70 (30.6%)
Do not have the software	97 (42.4%)
We have no barriers	7 (3.1%)
How often do you use LI-RADS ancillary features to help assess liver lesions in patients at risk for HCC? (232 responses)	
Always	32 (13.8%)
Often	55 (23.7%)

Sometimes	63 (27.2)
Rarely	19 (8.2%)
Never	14 (6.0%)
I am not familiar with ancillary features	49 (21.1%)

Table 6. Treatment Response

Variable	Number of respondents (percentage)
How frequently do you interpret treatment response cases after locoregional therapy for HCC per month? (220 responses)	
More than 15	16 (7.3%)
11 – 15	19 (8.2%)
6 – 10	31 (14.1%)
1-5	155 (70.5%)
Rate your familiarity with the LI-RADS treatment response algorithm (230 responses)	
Aware and routinely use it	78 (33.9%)
Aware and occasionally use it	31 (13.5%)
Aware but do not use it	52 (22.6%)
Not aware of it	69 (30.0%)
If you are aware of the LI-RADS treatment response algorithm and do not use it, what are the limitation/barriers? Check all that apply (158 responses)	
I use the LI-RADS treatment response algorithm	62 (39.2%)

Not clinically adopted	51 (32.3%)
Lack of confidence	44 (27.8%)
Use mRECIST	9 (5.7%)
Other	10 (6.3%)

Table 7. MRI Technique

Variable	Number of respondents (percentage)
Please check all the following sequences which your practice does NOT ROUTINELY include in your diagnostic liver MR imaging protocol (122 responses)	
T2-weighted imaging	16 (13.1%)
In/out of phase	15 (12.3%)
Arterial phase (either early or late)	16 (13.1%)
Portal venous phase	16 (13.1%)
Delayed phase	16 (13.1%)
Transitional phase if using gadoxetate (2-5 min after injection)	36 (29.5%)
Hepatobiliary phase if using gadoxetate (20 minutes after injection)	46 (37.7%)
Subtraction imaging	75 (61.5%)
Diffusion weighted imaging	26 (21.3%)
Please provide reason for the exclusion of any of the above sequences (check all that apply) (181 responses)	
I do not exclude any of the above sequences	71 (39.2%)
The sequence rarely adds information	17 (9.4%)
Acquisition of the sequence interferes with patient throughput	9 (5.0%)
This sequence is prone to artifacts and rarely adds information	17 (9.4%)
Unaware of LI-RADS technical recommendations	18 (9.9%)

Technologists often do not follow the protocol	14 (7.7%)
Our scanner cannot perform certain sequences	10 (5.5%)
Do not use gadoxetate (Eovist)	44 (24.3%)
Other	18 (9.9%)

Table 8. CT Technique

Please check all the following phases which your practice does NOT ROUTINELY include in your liver CT imaging protocol (205 responses)	
CT noncontrast phase	39 (19.0%)
Dual-energy subtraction	196 (95.6%)
CT arterial phase (either early or late)	3 (1.5%)
CT portal venous phase	2 (1.0%)
CT delayed phase (2-5 minutes after injection)	21 (10.2%)
Please provide the reason for the exclusion of an of the above sequences (check all that apply) (184 responses)	
I do not exclude any of the above sequences	18 (9.8%)
The sequence rarely adds information	36 (19.6%)
Acquisition of the sequence interferes with patient throughput	12 (6.5%)
The sequence is prone to artifacts and rarely adds information	4 (2.2%)
Patient safety issues, e.g., limited radiation exposure	20 (10.9%)
Do not have dual energy	95 (51.6%)
Other	2 (1.1%)

Figure 1. Diagnostic Systems Used in Training and in Current Practice

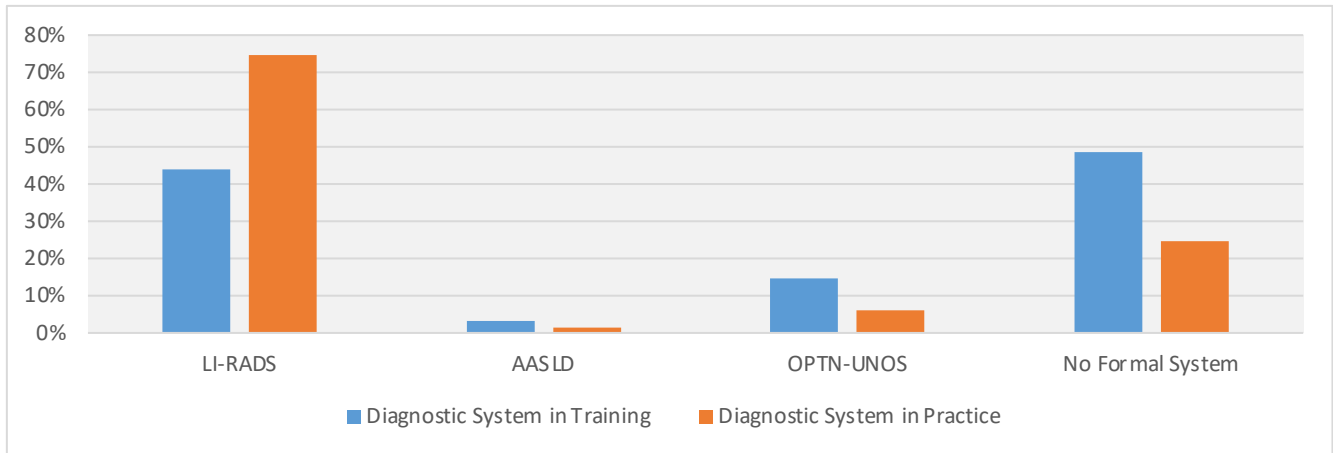


Figure 2. Participant familiarity with LI-RADS

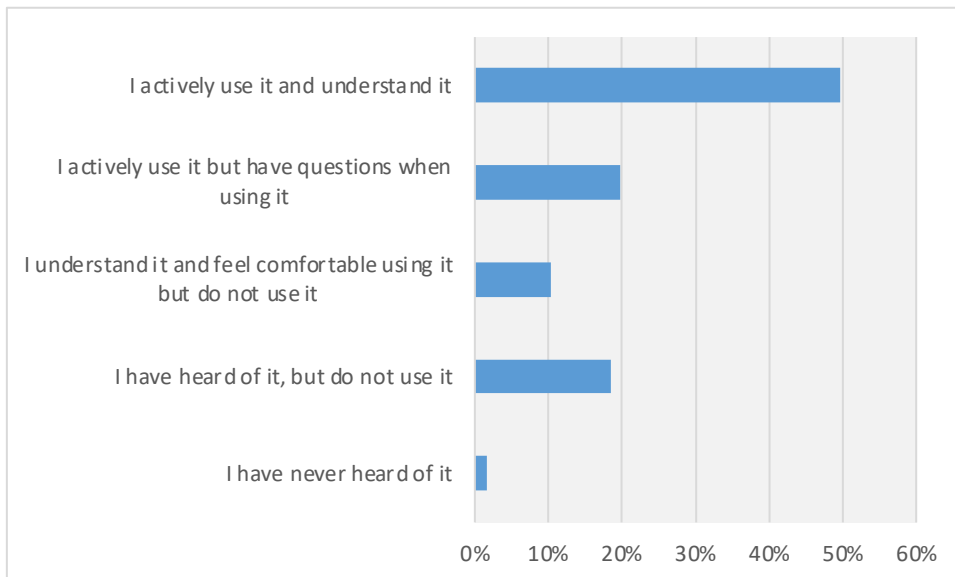


Figure 3. Barriers from Using LI-RADS

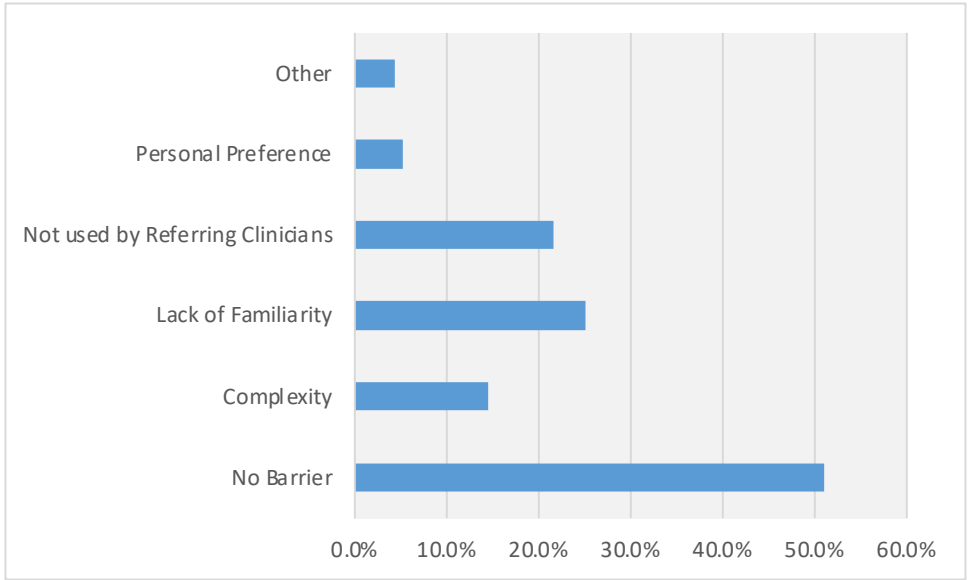


Figure 4. Familiarity with the Ultrasound LI-RADS algorithm for HCC screening and surveillance

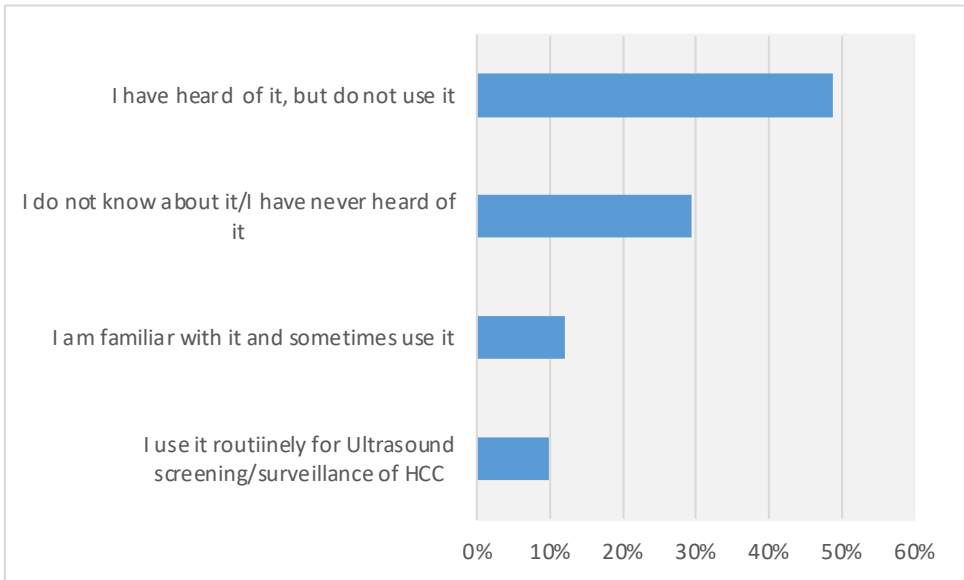


Figure 5. Familiarity with the CEUS Ultrasound LI-RADS algorithm for HCC diagnosis

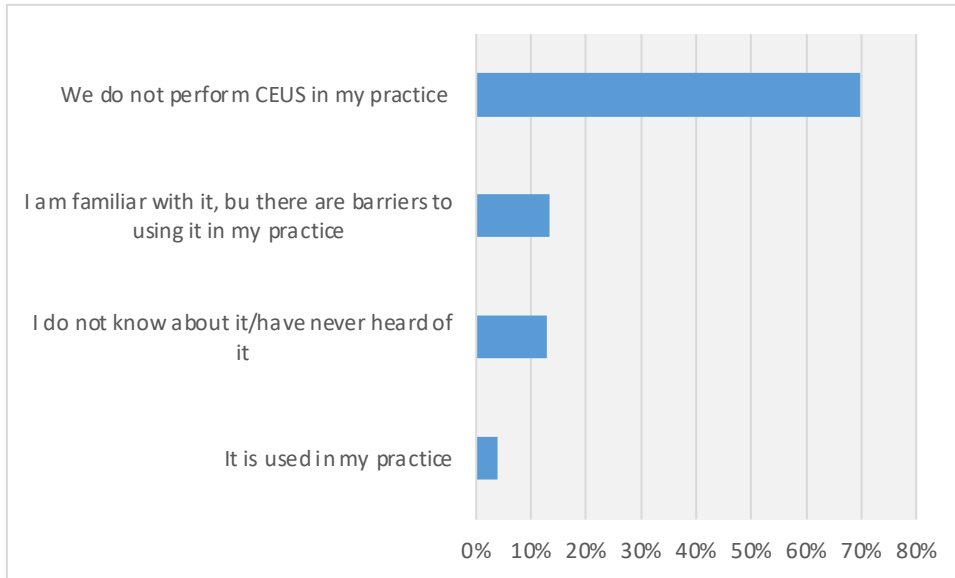
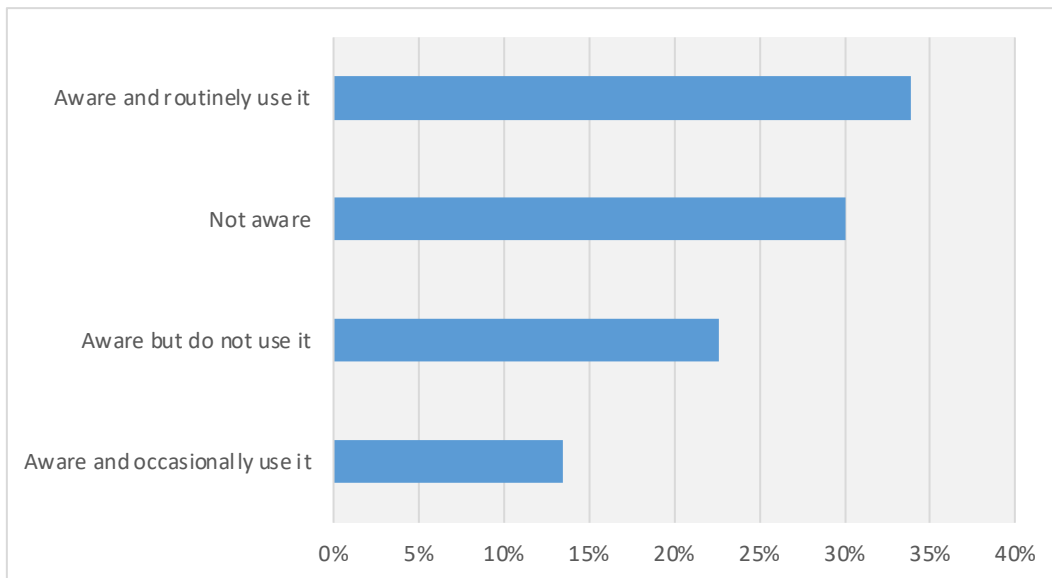


Figure 6. Familiarity with the LI-RADS treatment response algorithm.



Appendix 1: Introductory Statement

Dear Colleagues: First, if you are an academic-based radiologist, we respectfully request that you refrain from answering this survey. We are very interested in learning the thoughts of private practice and community radiologists about liver imaging and LI-RADS. This survey has been created by the American College of Radiology LI-RADS Outreach and Education Working Group and the Society of Abdominal Radiology Hepatocellular Carcinoma Diagnosis Disease-Focused Panel to further understand the use and attitudes toward LI-RADS by non-academic radiologists to help make future versions more helpful. Thank you for your time in answering the following questions.

Appendix 2: List of all questions in the survey.

Demographics

1. What year did you complete your final radiology training?
 - a. 2010-2021
 - b. 2000-2009
 - c. 1990-1999
 - d. 1980-1989
 - e. 1970-1979

2. What type of practice are you in?
 - a. Private Practice
 - b. Non-Academic Government/Military/VA practice
 - c. Mixed Practice (Private Practice with trainees)
 - d. Hospital employed practice
 - e. Hospital employed practice with trainees
 - f. Other (specify)

3. What country do you practice in?

4. In which city and state do you practice?

5. How would you best describe your sub-specialty?
 - a. Abdominal/Body Imaging
 - b. MRI Specialist
 - c. Body/Breast Imaging
 - d. General Radiologist
 - e. Other Sub-Specialist (specify)

HCC practice and interpretation

6. During a typical week, how many diagnostic CT or MRI liver exams do you interpret for HCC surveillance/diagnosis?
 - a. None
 - b. 1-5
 - c. 6-10
 - d. 11-15
 - e. More than 15

7. Do any of your practice sites have a dedicated multidisciplinary conference for hepatocellular carcinoma, hepatopancreaticobiliary disease, or liver transplant with radiology participation?
 - a. Yes
 - b. No

8. What hepatocellular (HCC) diagnostic system did you use during your radiology training (residency or fellowship)? Check all that apply.
 - a. Liver Imaging Reporting and Data System (LI-RADS)
 - b. American Association for the Study of Liver Diseases (AASLD)

- c. United Network for Organ Sharing and Organ Procurement and Transplantation Network (UNOS-OPTN)
- d. No formal system
- e. Other (please specify)

9. How familiar are you with the Liver Imaging Reporting and Data System (LI-RADS)?
- a. I actively use it and understand it
 - b. I actively use it but have questions when using it
 - c. I understand it and feel comfortable using it but I do not use it
 - d. I have heard of it, but do not use it
 - e. I have never heard of it

Reporting practice

10. Which HCC diagnostic system(s) do you use in your current practice? (Check all that apply)
- a. Liver Imaging Reporting and Data System (LI-RADS)
 - b. American Association for the Study of Liver Diseases (AASLD)
 - c. United Network for Organ Sharing and Organ Procurement and Transplantation Network (UNOS-OPTN)
 - d. No formal system
 - e. Other (please specify)

11. How confident are you with using LI-RADS v2018 CT/MRI?
- a. Extremely confident
 - b. Very confident
 - c. Moderately confident
 - d. Slightly confident
 - e. Not confident

12. What barriers prevent you from using LI-RADS?
- a. No barrier
 - b. Complexity
 - c. Lack of familiarity
 - d. Not used by our referring clinicians
 - e. Personal preference
 - f. Other—please specify

13. Would you use a standardized LI-RADS reporting template if it were available directly on your dictation system?
- a. Yes, I already have one and use it
 - b. Yes, I would like to have it and use it
 - c. I am indifferent in using the LI-RADS reporting template
 - d. No, I use my own LI-RADS template
 - e. No, I do not plan on using LI-RADS

14. Would you include AASLD management recommendations using a template if it were available directly on your dictation system?
- a. Yes, I would like to have it and use it
 - b. I am indifferent in using the AASLD management guidance
 - c. No, I provide my own guidance
 - d. No, I do not plan on using the AASLD management guidance

Screening/Surveillance

15. How familiar are you with the Ultrasound LI-RADS algorithm for HCC screening and surveillance?
- a. I do not know about it/have never heard of it
 - b. I have heard of it, but do not use it
 - c. I am familiar with it and sometimes use it
 - d. I use it routinely for Ultrasound screening/surveillance of HCC
16. What imaging methods do you use for HCC screening/surveillance? Check all that apply.
- a. Ultrasound
 - b. Single phase CT
 - c. Multiphasic contrast-enhanced Liver CT
 - d. Multiphasic contrast-enhanced Liver MRI with extracellular agents or with gadobenate dimeglumine (Multihance)
 - e. Multiphasic contrast-enhanced Liver MRI with gadoxetate disodium (Primovist or Eovist)
 - f. Non-contrast liver MRI
 - g. Abbreviated MRI

HCC Diagnosis

17. Do you utilize the categories definitely benign (LR-1) and probably benign (LR-2) in your reports?
- a. Yes
 - b. No
 - c. Unsure
 - d. I do not use LI-RADS
18. Do you think differentiation between LR-1 and LR-2 is beneficial?
- a. Yes
 - b. No
 - c. Unsure
 - d. I do not use LI-RADS
19. How often do you use ancillary features to help assess liver lesions?
- a. Always
 - b. Often
 - c. Sometimes
 - d. Rarely
 - e. Never
 - f. I am not familiar with ancillary features

20. How familiar are you with the Contrast-enhanced Ultrasound LI-RADS algorithm for HCC diagnosis?
- a. We do not perform contrast-enhanced ultrasound for focal liver lesions in my practice
 - b. I do not know about it/have never heard of it
 - c. I am familiar with it, but there are barriers to using it in my practice
 - d. It is used in my practice
21. What barriers exist in your practice to using Contrast-enhanced Ultrasound for HCC diagnosis? (check all that apply)
- a. Do not have radiologist expertise
 - b. Lack of ultrasound technician expertise
 - c. Too time consuming
 - d. Cost
 - e. Lack of training
 - f. Reimbursement
 - g. Do not have the software
 - h. We have no barriers

Treatment Response

22. How frequently do you interpret treatment response cases after locoregional therapy for HCC per month?
- a. None
 - b. 1-5
 - c. 6-10
 - d. 11-15
 - e. More than 15
23. Rate your familiarity with the LI-RADS treatment response algorithm.
- a. Not aware
 - b. Aware but do not use it
 - c. Aware and occasionally use it
 - d. Aware and routinely use it
24. If you are aware and do not use it, what are the limitations/barriers? Check all that apply.
- a. Not clinically adopted
 - b. Lack of confidence
 - c. Use mRECIST
 - d. Use EASL
 - e. Other (free text)

Technique

25. Please check all of the following sequences which your practice does **NOT ROUTINELY** include in your diagnostic liver MR imaging protocol:
- a. T2 WI
 - b. In/out of phase
 - c. Arterial phase (either early or late)
 - d. Portal venous phase

- e. Delayed Phase
- f. Transitional phase if using gadoxetate (2-5 minutes after injection)
- g. Hepatobiliary phase if using gadoxetate (20 minutes after injection)
- h. Subtraction imaging
- i. Diffusion-weighted imaging

26. Please provide the reason for the exclusion of any of the above sequences: (check all that apply)

- a. I do not exclude any of the above sequences
- b. The sequence rarely adds information
- c. Acquisition of the sequence interferes with patient throughput
- d. This sequence is prone to artifacts and rarely adds information
- e. Unaware of LI-RADS technical recommendations
- f. Technologists often do not follow the protocol
- g. Our scanner cannot perform certain sequences
- h. Do not use gadoxetate
- i. Other: (freeform text)

27. Please check all of the following phases which your practice does **NOT ROUTINELY** include in your liver CT imaging protocol:

- a. CT noncontrast phase
- b. Dual-energy subtraction
- c. CT arterial phase (either early or late)
- d. CT portal venous phase
- e. CT delayed phase (2-5 minutes after injection)

28. Please provide the reason for the exclusion of any of the above phases: (check all that apply)

- a. I do not exclude any of the above sequences
- b. This phase rarely adds information
- c. Acquisition of the phase interferes with patient throughput
- d. This phase is prone to artifacts and rarely adds information
- e. Patient safety issues, eg, limiting radiation exposure
- a. Unaware of LI-RADS technical recommendations
- b. Technologists often do not follow the protocol
- c. Other: (freeform text)

29. Do you perform liver MRI on scanners with a magnetic field <1.5T?

- a. Yes, these scanners are used routinely for liver imaging
- b. Yes, but only in situations related to body habitus or claustrophobia
- c. No, we do not have such scanners available
- d. No, we do not perform liver imaging on such scanners although we do have these scanners

30. What would be the most helpful in implementing LI-RADS Technique recommendations at your practice? (check all that apply)

- a. Out-of-the-box exam cards from vendors
- b. Downloadable protocols
- c. Direct communication with a LI-RADS expert
- d. Webinars/Workshops on LI-RADS Technique
- e. Other: freeform text

Appendix 3. Write in Responses

2. What type of practice are you in?

Not working

Multi specialty HMO group

clinique

community non-academic hospital

RAMQ

Physician Group

Telerad

telerad for 5 years, previously Private Practice and before that academics

Locums/telerad

PRN hospital employees and contract telerad

CLINIQUE DE RADIOLOGIE

3. What country do you work in?

Mexico

England

France

Germany

Italy

Egypt

China

Japan

Other (3)

4. What city do you work in?

Baton Rouge , LA

Baltimore MD

Bismarck

Alabama (2)

Bartlesville OK

Bismarck ND

Alexandria

Bethesda, MD

Bogota - Colombia

Austin, Texas

Birmingham, AL

british columbia

Bronx, NY	Granby	Miami, FL (2)
Brossard, Québec (2)	Grand Island NE	MICHIGAN
Buenos Aires	Greenville, SC	Middletown MY
Calgary	Hackensack, NJ	Minneapolis MN
California (2)	Hamilton, Ontario	Minnesota (2)
Charlotte, NC (2)	Hartford CT	Missouri
Châteauguay Québec (2)	Honolulu hawaii	Montana
Chicago IL (2)	Houston	Montréal, Québec
Colorado Springs, CO	Huntsville Alabama	Montreal Quebec (9)
Columbia MD	Illinois (3)	Morgantown, WV
Columbus, Ohio	Jersey City, NJ	Multiple (3)
Connecticut	Joliette, Quebec (2)	Mumbai, India
Corpus Christi, TX	Kansas City, Missouri	Nebraska
Dallas Texas	Kihei hawaii	New Albany, IN
Danville PA	KY	New Haven, CT
Dayton, Ohio	LA	New Jersey (2)
Des Moines, Iowa (2)	Laval	New Mexico
DFW	Lewes de	New Orleans/LA
Doha / Qatar	Lincoln, NE	New York NY (4)
Dover, NH (2)	Loma Linda, CA	New Zealand
Drummondville Québec (2)	Longueuil, Québec (2)	NJ (2)
Durham, NC	Los Angeles, CA (3)	Northern virginia
Edmonton, AB	MA (2)	NY
Eugene Oregon	Macon Georgia (2)	Ohio
Fort myers FL	Maria, Quebec	Oklahoma City
Fort Wayne, IN	MD	Oklahoma
Framingham, MA	Medellín, Colombia	Onrario
Fredericksburg, va	Memphis TN (2)	Oregon
Fresno, CA	Mendoza, Argentina	Orlando FL (2)
Geneva, Ohio	menlo park, ca	PA
		Paris, TX

Peoria, IL	Shreveport, LA
Phoenix AZ (2)	Sioux Falls SD
Portland maine	SLC, UT
Portland, OR (4)	Sohag
Prince George, BC	Spokane, Washington (2)
Quebec, Canada (15)	St Louis, MO (2)
QUITO ECUADOR	St-Jean-sur-Richelieu, Qc
Raleigh	Surfers paradise
Remotely, for a group in Allentown, PA	Queensland Australia
Roberval, Québec	Tampa, FL
Rochester, NY	Temple, Texas
Sacramento, California (2)	Terrebonne Quebec (2)
Saguenay	Trois-Rivières Qc
Saint Louis, MO	Tucson AZ
Saint-Jacques-de-Leeds, Quebec	Vancouver WA (2)
Saint-Jean-sur-Richelieu, Québec	Varies
Salem OR	Virginia Beach, VA
Salina KS	Washington
Salt Lake City, UT	Washington DC Metro
San Antonio, Texas (3)	Wilmington, DE
San Diego, CA (3)	Wilmington, NC
Santa Ana, CA (4)	Wisconsin (2)
Santa Barbara, CA	York, PA
Santiago Chile	Youngstown, Ohio
Seattle, WA	
SF Bay Area, California	
Shawinigan quebec	
Sheboygan, WI	

5. How would you best describe your sub-specialty?

Breast

Emergency (some vascular and body expertise)

Neuro/general

MSK with body mini fellowship

Emergency Radiology

Body/Chest/Breast

Neuro

Pediatric Radiology

PACS & Teleradiology

Emergency also

Neuro with some general

12. What barriers prevent you from using LI-RADS?

We have a clear understanding with the transplant surgeon and hepatologist and our reports reflect their preferences

Not enough volume

Transitioning to LI-RADS this year for transplant team

Rarely exposed to such patients

Not for ultrasound

Referring clinicians do not seem to understand the correct population to order screening MRI's on.

Suspicious of trying to fit everything into a "RADs" box

Unknown patient eligibility (cirrhosis or hep B not always documented)

Too few cases at my facility

Understand it

24. If you are aware of it but do not use it, what are the limitations/barriers? Check all that apply.

Clinicians do not use it

Not enough volume

Rarely have baseline or comparison studies

Few post follow-ups at current practice

Screening mostly

No such cases in my hospital

Not relevant to my practice

Not enough cases – we rarely see these cases

Need to learn it

Rural practice. All post treatment scans are typically done at an academic center where their primary team is

26. Please provide a reason for the exclusion of any of the above sequences (check all that apply)/

Request subtractions only when needed (9)

Use Multihance for hepatobiliary phase

Time consumption

Do not have this contrast agent

Too long

I do not do MRI of the liver

Difficult to have techs remember when to use Eovist

Not sure

Not very familiar

History

26. Please provide the reason for the exclusion of any of the above sequences: (check all that apply)

Non-con only after treatment

Non-con not usually helpful with CT

27. What would be the most helpful in implementing LI-RADS Technique recommendations at your practice? (check all that apply)

Convince transplant surgeons

Downloadable report templates

Use LI-RADS routinely.

An oncology program with greater than 1 to 2 HCC patients

Nothing

We dont plan tonise lirads since clinicians in our practice do not use it

Broader adoption by clinicians

Education of our referring clinicians

Acceptance by clinicians and all institutes use it

Hepatologist get involved

We have it pretty well running already

Our liver docs and surgeons want it instead of mRECIST and OPTN

User friendly standardized Templates

Templates

LI-RADS is fully integrated in my practice

Decision support software

Greater acceptance by the community gastroenterologists

A better interface for the chart that everyone googles

pre done report checks

Community acceptance of Lirads