

Evaluating the adequacy of late arterial phase MR liver imaging using a bolus tracking protocol: A LI-RADS-based Quality Improvement Project

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Introduction

- **Primary liver cancer** is the 6th most commonly diagnosed cancer worldwide.¹⁻²
 - This includes **hepatocellular carcinoma** (HCC) (75%-85% of cases) and intrahepatic cholangiocarcinoma (10%-15%)
- HCC is commonly diagnosed at an advanced stage when treatment options are more limited with a poorer prognosis
- Despite screening in patients at high risk (e.g. ultrasound surveillance in patients with cirrhosis), early detection remains a challenge
- Incidence of HCC is rising in the UK², and early detection is key in providing optimal treatment

Introduction

- **MRI with Gadolinium** has a higher sensitivity to CT in the detection of hepatocellular carcinoma (HCC)³
- **Liver Imaging Reporting and Data System (LI-RADS)** allows classification of a liver lesion to indicate its relative risk for HCC.⁴
 - LR1 – LR2: Likely benign
 - LR 3- 5: relate to arterial phase enhancement patterns
 - Arterial phase hyperenhancement (APHE) is concerning for HCC
 - Only applies in patients with cirrhosis or chronic HBV and are >18 years old
- **Late hepatic arterial phase** is preferred for evaluation of arterial hyperenhancement

Standard

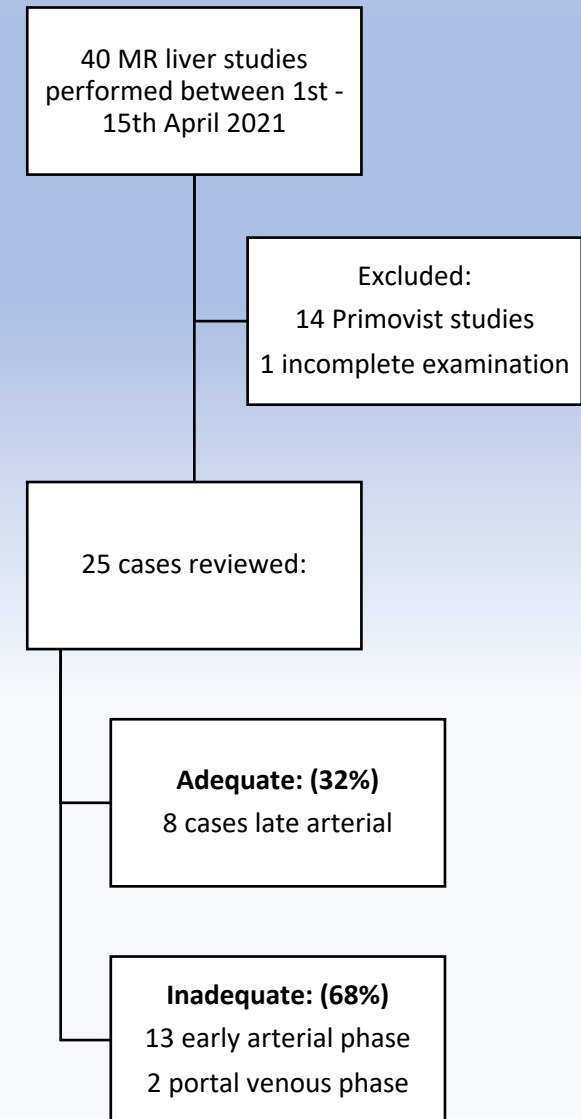
- Optimization of adequate late arterial phase imaging is required to improve diagnostic yield of liver MRI in the detection of HCC (diagnosis and follow up).
- **Standard: LI-RADS (2021) criteria for appropriate late arterial phase**
- *An arterial phase has been defined by LI-RADS (lexicon last updated June 2021)⁵⁻⁶ as:*
 - *a post-contrast phase where hepatic artery and branches are fully enhanced and hepatic veins are not enhanced more than liver by antegrade flow.*
- *The Late arterial phase is a subtype of this arterial phase where the portal vein is more enhanced than the liver.*



Fig 1: MR Liver study with LI-RADS defined adequate late arterial phase

Cycle 1: Fixed timing late arterial phase

- Retrospective data collection (via Soliton/ PACS) of MRI livers performed between 1st – 15th April 2021 until 25 cases [with Gadolinium] were identified for review
- Evaluation of each study images to check if study met LIRADS standard
- **Key findings:** inadequate arterial phase imaging (often too early) in majority of cases of fixed delay protocols
- **Action taken:** Bolus tracking implemented in practice from April 2022



Intervention: Planning Care Bolus

- ABEL protocol implemented in April 2022
 - Automated bolus enhanced liver
 - Bolus tracker ROI (Region of Interest) set to descending aorta
 - Scanners detect the contrast and trigger once a threshold is reached after a fixed delay.
 - **Siemens:** Carebolus (0.1ml per kg Gadovist) visualized and AI auto-triggers the scan once threshold reached in ROI. Has a delay of 12 seconds whilst auto voice breath hold commences.
 - **GE scanners:** Carebolus same as siemens with ROI, however the radiographers are unable to see bolus entering. After injection autotrigger, after detection of the bolus and autobreath hold commences, the scan is triggered after 8 seconds. If the bolus is not detected, then the scan is commenced 30 seconds regardless.

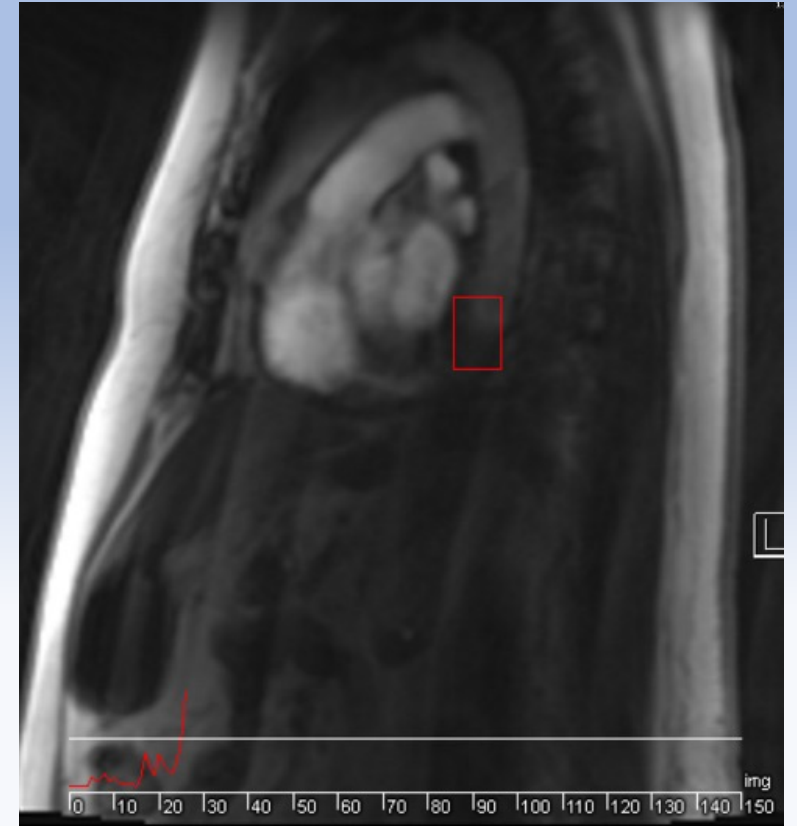
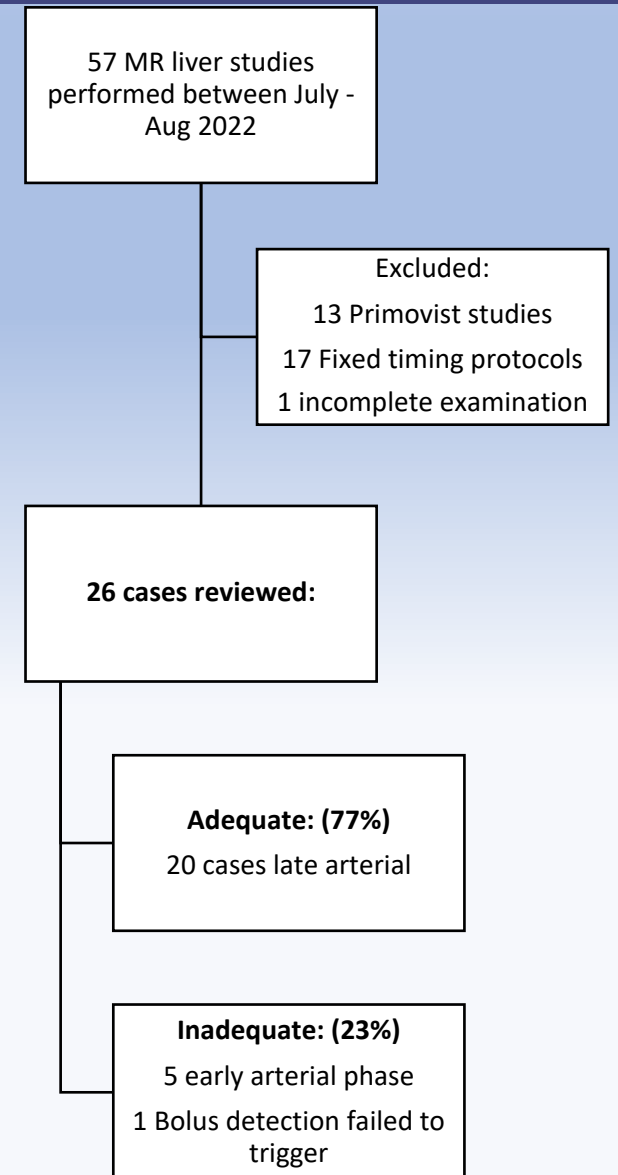


Fig 2: MR Liver study Bolus tracking sequence with ROI set to descending aorta

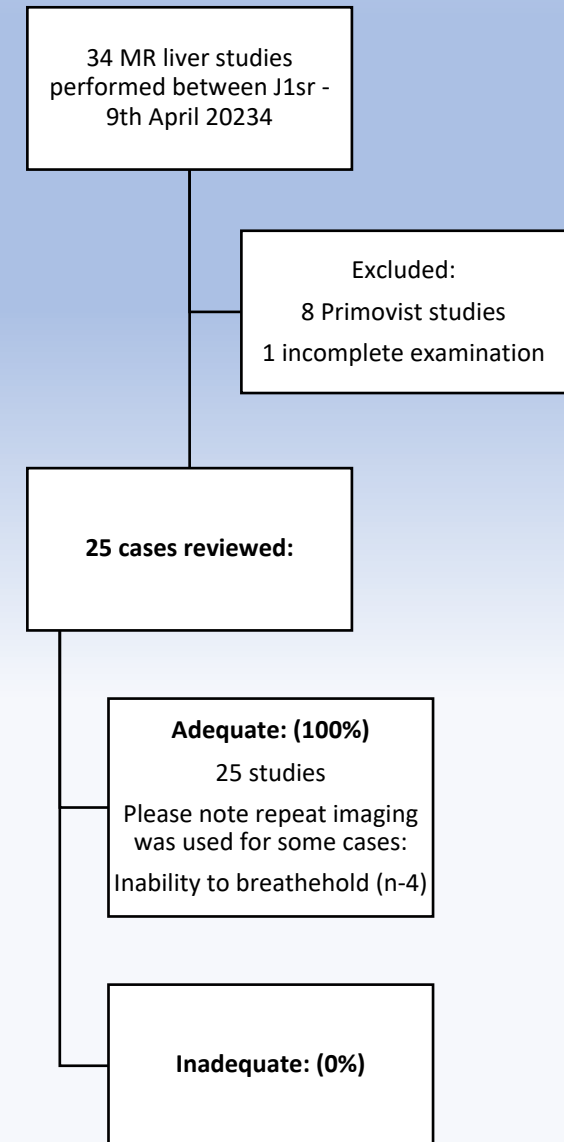
Cycle 2: Planned Care Bolus protocol

- Data acquisition of MR livers performed in July - Aug 2022
 - Labelled either smartprep or had bolus tracked images included in the series
- Evaluation of each study (via Soliton/ PACS) images to check study met LI-RADS standard
- **Key findings:** inadequate implementation of care bolus protocol. Noted that majority of MR liver studies were performed by external on-site Inhealth scanners with variability in adoption of the ABEL protocol between different scanners.
- **Key action:** Discussion and clarification of the ABEL protocol with MR radiographer leads with emphasis on the need to consistently follow the same protocol



Cycle 3: Consistent ABEL protocol use

- Data acquisition of MR livers performed in April 2023
- Evaluation of each study images (via Soliton/LIRADS) to check if study met LI-RADS standard
- **Key findings:**
 - Consistent use of MRI bolus tracking protocol throughout MR scanners
 - 100% of cases had an adequate late arterial phase.



Conclusions

- Inconsistency of acquiring adequate late arterial phase imaging using a fixed timing protocol highlights its limitations for HCC detection.
- When correctly implemented, utilization of a bolus tracking protocol in MR liver imaging increases the consistency of adequate late arterial phase images thereby enhancing the sensitivity and detection of HCCs

Limitations

- Slight discrepancy in the implementation of the ABEL protocol in the different GE and Siemens scanners, however this was not proven to be of any relevance. No significant disparity between the adequacy of late arterial phases.
- Small sample size per cycle

References

1. Sung H et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021; 71: 209-249. <https://doi.org/10.3322/caac.21660>
2. Arnold M. et al. Global Burden of 5 Major Types of Gastrointestinal Cancer. *Gastroenterology*. 2021; Volume 159, Issue 1, 335 - 349.e15. DOI: <https://doi.org/10.1053/j.gastro.2020.02.068>
3. Chou R et Al. Imaging Techniques for the Diagnosis of Hepatocellular Carcinoma: A Systematic Review and Meta-analysis. *Ann Intern Med*. 2015 May 19;162(10):697-711. doi: 10.7326/M14-2509. Erratum in: *Ann Intern Med*. 2015 Jun 16;162(12):880. PMID: 25984845.
4. Elmohr M, et al. LI-RADS: Review and Updates. *Clinical Liver Disease*. 2021;17(3):108-12. doi:10.1002/cld.991
5. Available from: <https://www.acr.org/-/media/ACR/Files/RADS/LI-RADS/LIRADS-Lexicon-Table.pdf>. Accessed January1, 2024.
6. Moura C G et al. Up-to-Date Role of CT/MRI LI-RADS in Hepatocellular Carcinoma. *J Hepatocell Carcinoma*. 2021 May 31;8:513-527. doi: 10.2147/JHC.S268288. PMID: 34104640; PMCID: PMC8180267.