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Quantitative magnetic resonance imaging predicts individual future liver performance after liver resection for cancer

Damian Mole[1], Jonathan Fallowfield[1], Fenella Welsh[2], Ahmed Sherif[3], Tim Kendall[1], Scott Semple[1], Matt Kelly[4], Ged Ridgway[4], John Connell[4], Henry Wilman[4], John McGonigle[4], Velicia Bachtiar[4], Rajarshi Banerjee[4], John Michael Brady[4], Dr Xiaozhong Zheng[1], Lucile Neyton[1], Anya Adair[3], Prof Ewen Harrison[1], Andrew Healey[3], Rowan W. Parks[1], Ravi Ravindran[3], Sarah Thomasset[3], Prof Stephen Wigmore[1], Prof O James Garden[1], Dr Michael Hughes[1], Joanna McClintock[2], Garry Tucker[5], Hilary Nailon[5], Dr Dilip Patel[6], Jim Gordon-Smith[6], Hamish Ireland[6], Neil Masson[6], Anthony Wackett[7], Michelle Steven[7], Angela Watson[3], Tim John[2], Asmat Mustajab[2], Dr Delia Peppercorn[2], Dr Karen Scott[2], Myrddin Rees[2]

[1]University of Edinburgh, United Kingdom, *[2]Hampshire Hospitals Foundation Trust, Basingstoke, United Kingdom*, *[3]NHS Lothian, Department of Surgery, Edinburgh, United Kingdom*, *[4]Perspectum Diagnostics, Oxford, United Kingdom*, *[5]NHS Lothian, Clinical Research Facility, Edinburgh,* , *[6]NHS Lothian, Clinical Radiology, Edinburgh,* , *[7]Edinburgh Clinical Trials Unit, Edinburgh, United Kingdom*

Email: john.connell@perspectum-diagnostics.com

Background and Aims: The future liver performance (FLP) of an individual undergoing surgical liver resection to remove cancer is critical for their survival and recovery. We report the development and clinical testing of a novel magnetic resonance image (MRI) post-processing tool that combines quantitative multiparametric MRI with anatomical liver segmentation to estimate FLP. This is intended to inform the assessment of individualised operative risk and augment patient and surgeon decision making prior to liver resection.

Method: This software combines iron-corrected T1 (cT1) mapping, previously demonstrated to correlate with fibroinflammation and predict clinical outcomes in chronic liver disease, with a 3D U-net pipeline to delineate the liver volume followed by semi-automatic delineation of Couinaud segments based on anatomical landmarks. Interactive removal of these segments, along with any interactively-defined virtual wedge resections, allows accurate estimation of the future liver remnant (FLR) volume, which when combined with quantitative cT1 mapping, provides a prediction of FLP, termed the "HepaT1ca score". The ability of this score to predict post-operative morbidity, length of stay and regenerative capacity was evaluated in a prospective clinical trial (ClinicalTrials.gov NCT03213314).

Results: Of the 143 patients recruited, 135 underwent liver resection. 84% of participants had liver metastases from colorectal cancer, with the remaining having primary liver cancer or other secondary cancers. 21% of participants had cT1 values above the upper limit of normal (795ms) indicating increased risk of background liver disease. The HepaT1ca score showed a significant linear correlation with the modified Hyder-Pawlik score, an indicator of post-operative morbidity (adjusted $R^2 = 0.26$, $P < 0.001$), and liver regenerative performance (adjusted $R^2 = 0.46$, $P < 0.001$). Furthermore, in patients with an FLR below 90%, a high mean cT1 (> 795ms) was associated with a longer duration of hospital stay (median (IQR) of 6.5 (5.3-12) vs. 5 (4-7.1); $P = 0.0053$). cT1 also correlated with histological measures of inflammation and ballooning.

Conclusion: We demonstrate the utility of a non-invasive quantitative MRI approach for predicting post-operative liver performance. This has the potential to transform surgical decision-making and augment individualised risk assessment for patients undergoing liver resection for cancer.

Figure:

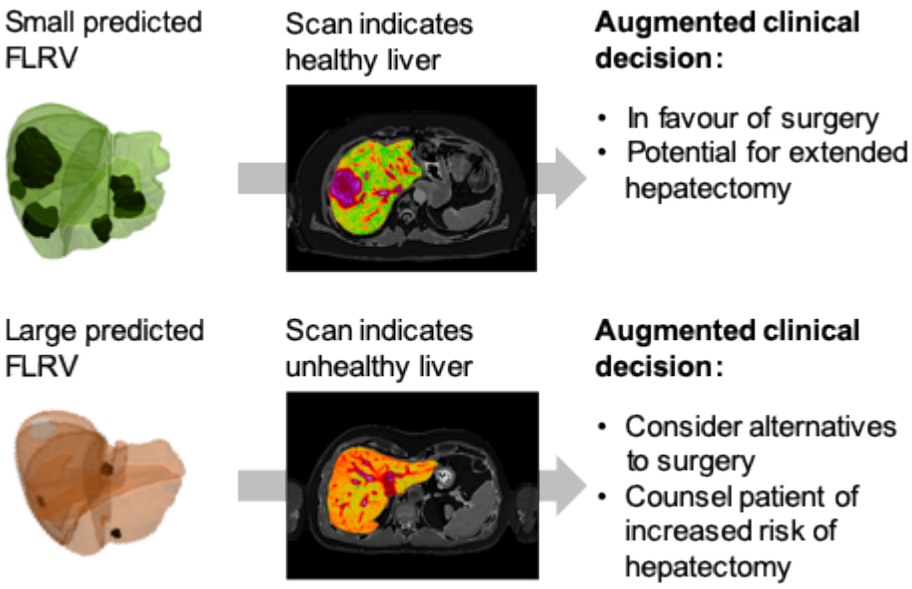

Figure: Concept diagram showing use of quantitative MRI in a clinical workflow highlighting exemplar cases from the HepaT1ca study.