Hyperpolarised MRI for Long COVID: Review and Future Directions

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Introduction

- This poster reviews a study by Grist et al. at the University of Oxford on using hyperpolarised (HP) MRI to detect lung abnormalities in individuals with long COVID that are not visible on standard imaging modalities[1].
- There are, however, numerous barriers to implementing this technology into routine clinical workflows, including high costs, along with limited access to equipment and expertise.
- Moving forward, gaining consensus on various aspects of HP MRI will be important to ensure standardisation for multi-centre studies[2].

Method

Hyperpolarisation:

- Hyperpolarisation is the process of temporarily aligning all nuclei in the same direction to significantly increase the signal of a particular compound[3].

Agent production:

- HP ^{129}Xe can be produced via spin-exchange optical pumping (SEOP). Infrared laser light excites electrons in an alkali metal, transferring angular momentum to Xe via collisions.
- HP lifetime is very short, requiring quick delivery, safe storage, and synchronisation between polarisation, patient preparation, and imaging.

Participants and MR System:

- Three groups participated: Hospitalised Long COVID (HLC) (12), Non-Hospitalised Long COVID (NHLC) (11), and healthy volunteer participants with no history of lung disease (15)[1].
- Imaging was performed using a 1.5 T GE Healthcare scanner equipped with a Xe transmit-receive coil and broadband radiofrequency amplifier.

Data Acquisition:

- Participants inhaled 1 L doses of ^{129}Xe gas and were imaged using fast flyback echo-planar spectroscopic pulse sequences with low flip angles to preserve magnetisation during a 15 s breath-hold.
- Xe gas moves from alveoli (gas phase) to tissue/plasma (TP) and red blood cells (RBCs), where signal changes allow direct measurement of gas transfer via the RBC:TP ratio.

Results

- Mean RBC:TP measurements showed that healthy volunteers had significantly better gas exchange (0.45 ± 0.07) compared to long COVID groups; however, HLC (0.31 ± 0.1) and NHLC (0.37 ± 0.1) results were not separable despite differences in spirometry results[1].
- HP MRI RBC:TP maps detected abnormalities not visible by CT, proving more sensitive for long COVID (Fig. 1).

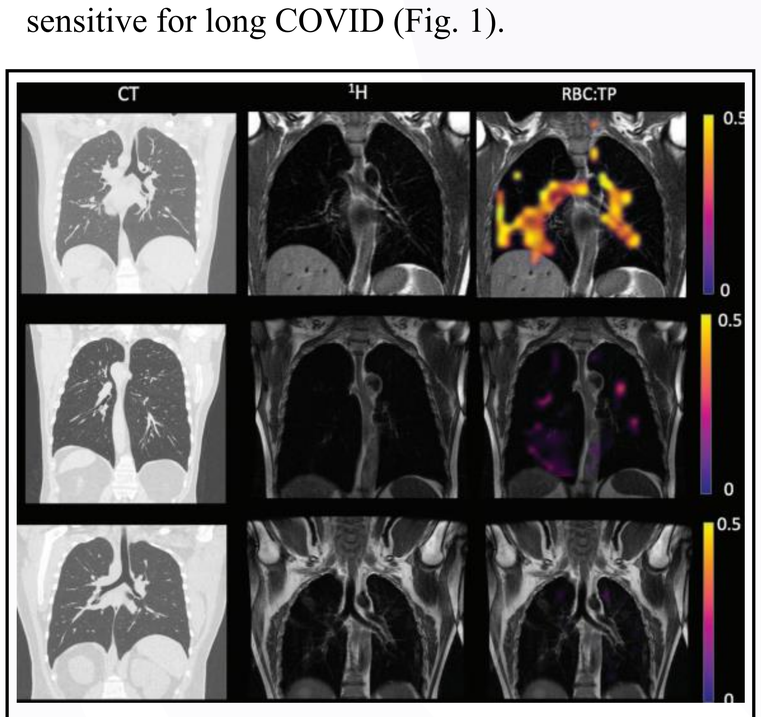


***Figure 1**: CT, ^{1}H MRI, and HP MRI RBC:TP images in hospitalised long COVID (HLC) participants, reproduced from Grist, J.T. et al, Radiology 2022; 305:3[1].*

- HP imaging revealed heterogeneous and low mean RBC:TP values (top row: 0.59, middle row: 0.31, bottom row: 0.16) in the lungs of HLC participants.
- Lower RBC:TP indicates breathing difficulties could be due to microstructural abnormalities.

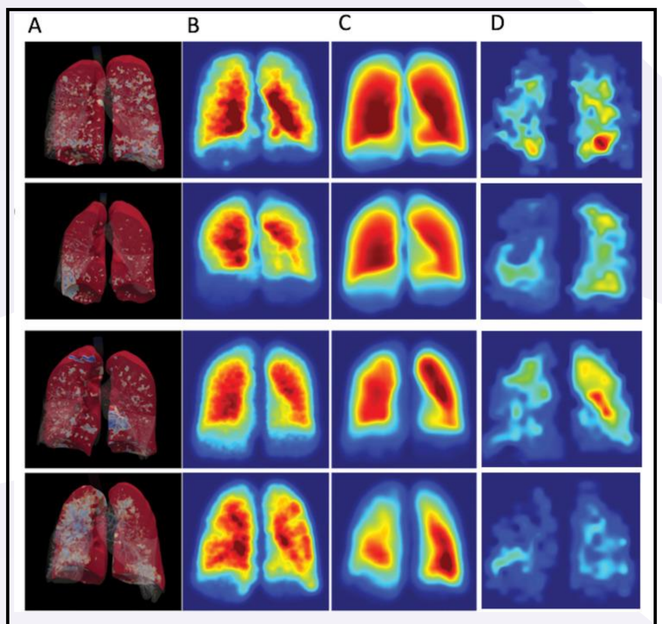


***Figure 2**: 3D (A) FAN, (B) FAN modelling, and HP imaging in NHLC (C) and HLC (D), reproduced from Grist, J.T. et al, Radiology 2022; 305:3[1].*

- FAN (full-scale airway network) modelling from CT images (Fig. 2), confirms no detectable ventilation changes and does not correlate with RBC:TP findings.
- It is unclear whether the detected abnormalities are clinically relevant or if HP Xe MRI is an overly sensitive test, but the correlation with lung function results indicates they likely are significant.

Discussion

Limitations and Challenges:

- The reviewed study was limited by small cohorts of similar ages, so extrapolation must be performed with caution.
- Clinical use of HP MRI faces challenges such as high costs, technical complexity, the need for specialised expertise, and regulatory approval[4].

Multi-Centre Studies:

- Other contrast agents, such as [1-^{13}C]pyruvate, are undergoing single-institution clinical trials to investigate tissue metabolism.
- Previously, contributors provided input through questionnaires and meetings to develop consensus on requirements for future multi-centre human studies[2].
- Areas of consensus for adoption to ensure standardisation across centres are listed in Figure 3[2].

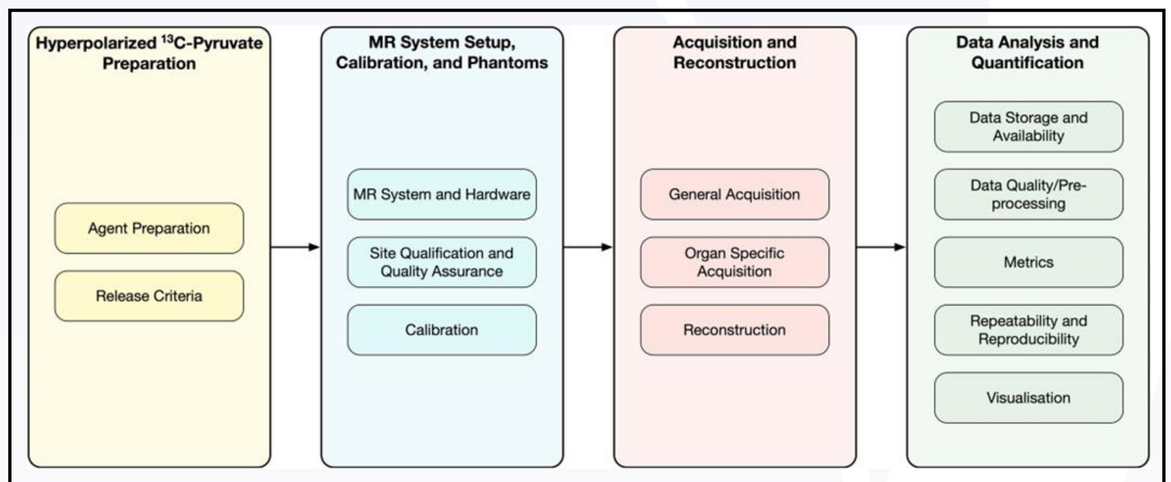


***Figure 3**: Illustration of the [1-^{13}C]pyruvate consensus process, covering key requirements for multi-centre human studies and clinical trials, reproduced from Punwani, S. et al, Magnetic Resonance in Medicine 2025; 94:4[2].*

Future Directions:

- Standardised phantoms are needed to capture the dynamics of agent administration for repeatability and reproducibility measurements.
- HP MRI results must be compared with accepted clinical standards such as proton (^{1}H) MRI or tissue/laboratory-based results, focusing on clinical outcomes.
- MRI scanner manufacturers must recognise the clinical potential of this technique to increase multinuclear capabilities, as well as improve the availability of regulatory-approved polarisation equipment[4].

References

[1] Grist, J.T. et al, Radiology 2022; 305:3.
[2] Punwani, S. et al, Magnetic Resonance in Medicine 2025; 94:4.
[3] Adamson, E.B. et al, Physics in Medicine and Biology 2017; 62:13.
[4] Stewart, N.J. et al, The British Journal of Radiology 2021; 95:1132.