**Pitfalls of blinded T1-map image analysis by human operator and impact on measured stress T1 responses**

Ambra Masi, Qiang Zhang, Raj Soundarajan, Joana Leal Pelado, Cassandra Baker, Stefan Neubauer, Vanessa M Ferreira, Stefan K Piechnik.

**Background**
Stress T1-mapping is a novel technique for ischaemia testing without the need for gadolinium-based contrast agents. We investigate pitfalls of simple blinded T1-map analysis, using inter-method agreement between MOLLI and ShMOLLI T1-maps as an illustrative example of their impact on stress T1 results.

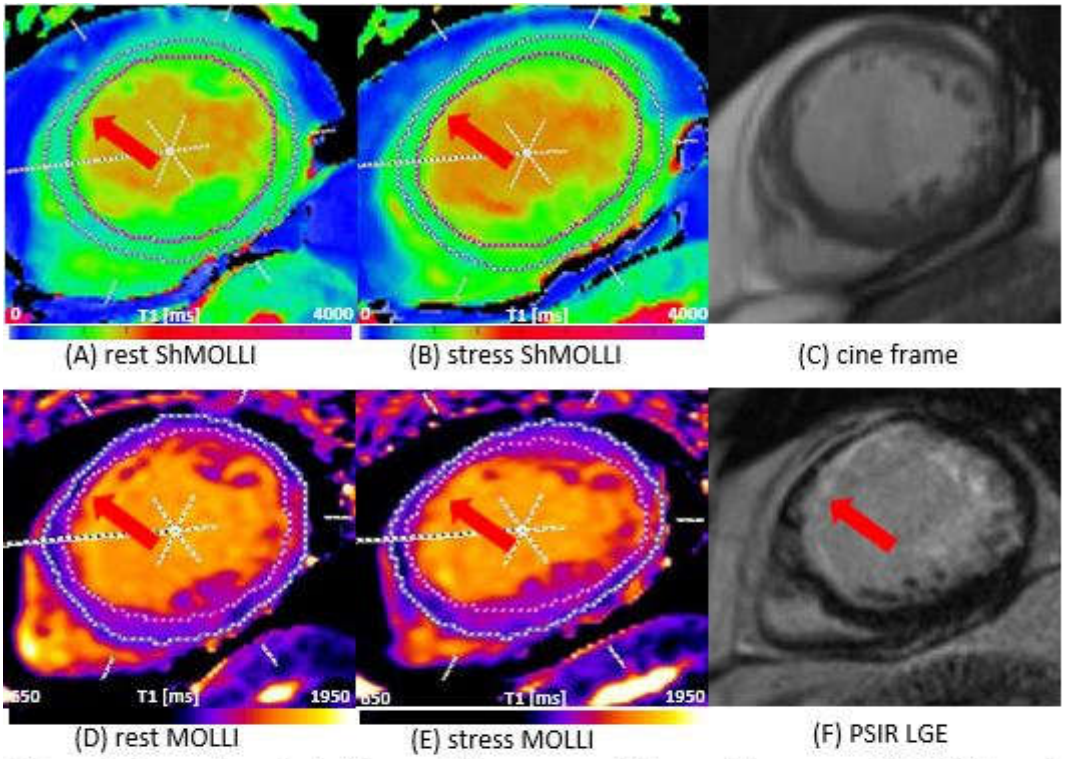
**Methods**
We prospectively scanned 18 patients (61±15 years; 72% male) referred for clinical stress CMR for inducible ischaemia, with varied pathology. All patients underwent CMR at 1.5 Tesla including cine, rest and Regadenoson stress T1-mapping using both ShMOLLI and MOLLI 5(3)3, perfusion and LGE imaging. Rest and stress T1-maps were analysed in the mid-ventricular short-axis view by a single human operator, blinded to other CMR images. T1 reactivity (T1stress - T1rest)/T1rest was analysed using original and eroded (mid-wall myocardium) contours on the segmental basis (n=108 segments).

**Results**
Stress T1 responses were clearly detectable (Table 1). ShMOLLI T1 measurements had a higher T1 reactivity (4%±4%) compared with MOLLI (3%±4%; $p<0.01$) in these patients, with both methods showing similar intragroup variability. Head-to-head comparison of ShMOLLI versus MOLLI revealed low positive correlation R=0.15. Minimizing the partial volume as one known source of noise in T1, improved inter-method correlation to R=0.27. Inevitably linked reduction in sample volumes increased the SD and slightly reduced the statistical significance of the apparent difference in reactivity between methods ($p<0.03$). Inspection of cases with major discrepancies, intended to shed light on unexpectedly weak inter-method correlation, revealed pitfalls in blinded T1-map analysis, such as significant variations in the ROI thickness and failures to include subendocardial infarctions at the blood-myocardium interface (Figure 1).

**Conclusion**
T1-map analysis blinded to LGE imaging by a human operator affects the stress T1 results using both ShMOLLI and MOLLI techniques. Clear pitfalls identified include significant variations in the ROI wall thickness and missing subendocardial infarctions. Multi-stage image analysis approaches with robust quality control are required to deliver more reliable stress T1-mapping for clinical applications.

**Table 1.** Comparison of segmental ShMOLLI and MOLLI rest-stress T1 (mean±SD) using Regadenoson in 18 patients referred for clinical stress CMR for inducible ischaemia.

| | Whole myocardium | | Mid-wall myocardium | |
|---|---|---|---|---|
| | ShMOLLI | MOLLI | ShMOLLI | MOLLI |
| T1 rest (ms) | 941 ± 74 | 982 ± 77 | 933 ± 75 | 1014 ± 58 |
| T1 stress (ms) | 982 ± 77 | 1025 ± 55 | 976 ± 79 | 1045 ± 61 |
| ΔT1 (%) | 4.5 ± 4.0 | 2.9 ± 4.0 | 4.7 ± 5.0 | 3.2 ± 5.0 |




(A) rest ShMOLLI (B) stress ShMOLLI (C) cine frame

(D) rest MOLLI (E) stress MOLLI (F) PSIR LGE

**Figure1**. Example of significant differences within and between ShMOLLI and MOLLI T1-map analysis by a single human operator, blinded to other CMR images. There are significant variations in ROI thickness within and between ShMOLLI and MOLLI at a representative mid-ventricular short-axis view. Blindly-drawn myocardial contours on either ShMOLLI or MOLLI T1-maps missed the subendocardial infarction, as seen on the LGE image (panel F, red arrow).