The effect of blood composition on T1 mapping

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Conflicts of interest: none

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Native myocardial T1 and extra-cellular volume (ECV) by cardiovascular magnetic resonance (CMR) are key biomarkers for assessing several heart muscle diseases. Their measurement is however influenced by blood T1, either due to myocardial vascular blood volume or via blood pool partial voluming. Different factors including Hematocrit (Hct), pH, temperature, gender, and oxygen pressure are known to affect blood T1 (1, 2) but the influence of blood biological constitutents such as iron, lipids or albumin is unknown.

We sought to assess this. With appropriate ethical approval and written informed consent, we prospectively recruited seventy-seven healthy volunteers free of cardiovascular disease or diabetes, with normal 12-lead ECG and normal CMR. T1 mapping was performed at 1.5T using all three primary approaches to the technique: MOdified Look-Locker Inversion Recovery (MOLLI) (3), Shortened Modified Look-Locker Inversion recovery (ShMOLLI) (4) and SAturation recovery Single-sHot Acquisition (SASHA) (5). Just prior to the scan, a blood sample was drawn and hemoglobin (Hb), Hct, N-terminal pro b-type natriuretic peptide (NT-proBNP), creatinine, estimated Glomerular Filtration Rate (eGFR), iron, total iron binding capacity (TIBC), ferritin, albumin, HbA1c, non-fasting lipid profile including triglycerides (TG), total cholesterol, low density lipoprotein (LDL) and high density lipoprotein (HDL) cholesterol were tested. T1 values were measured in blood and myocardium before and after administration of extracellular MR contrast medium (3). Univariable and multivariable linear regression analyses were performed to identify biochemical factors affecting blood T1.

The population mean age was 49±14 years old, range 20-76. 38/77 (49%) were male (mean age: males 50±14, females 49±15 years old). For MOLLI, ShMOLLI and SASHA respectively, myocardial T1s were 1027±38, 959±31 and 1144±48ms; and blood T1s were 1638±78ms, 1543±77ms, 1587±103ms. As expected, as Hct rose, blood T1 fell for all sequences (ShMOLLI r^2 0.530, $p<0.0001$), MOLLI (r^2 0.452, $p<0.0001$), and SASHA (r^2 0.375, $p<0.0001$).

However, univariable analysis (here ShMOLLI – other sequence concordant) showed additional correlations with iron bound to transferrin ($r^2=0.405$, $p<0.0001$), HDL-cholesterol ($r^2= 0.229$, $p<0.0001$), creatinine ($r^2= 0.115$, $p<0.002$), ferritin ($r^2=0.101$, $p=0.003$), TG ($r^2= 0.097$, $p=0.003$) and LDL-cholesterol ($r^2=0.031$, $p=0.069$). Albumin, total cholesterol, NT-proBNP, eGFR and HbA1c were not associated with blood T1 (by any sequences, log transformed where needed).

Multivariable analysis showed that blood T1 is largely determined by just three variables, in descending order of effect: Hct, iron and HDL-cholesterol regardless of sequences (MOLLI: cumulative $r^2=0.778$, ShMOLLI: $r^2=0.772$, SASHA: $r^2=0.567$, all $p<0.0001$), with SASHA performance slightly lower than MOLLI and ShMOLLI.

Measured blood T1 is associated with measured myocardial T1 (correlation $r^2=0.266$, $p=0.01$ by MOLLI; $r^2=0.374$, $p=0.001$ by ShMOLLI and $r^2=0.578$, $p<0.0001$ by SASHA). ECV is similarly associated by blood T1 ($r^2= 0.392$, $p= 0.001$ by MOLLI; $r^2= 0.464$ by ShMOLLI and $r^2= 0.457$ by SASHA with $p< 0.0001$ respectively).

To summarise, blood myocardial T1 is primarily determined by blood biology with three parameters, Hct, iron and HDL-cholesterol, out of the ones here investigated, explaining almost 80% measured variability in health. Anemia, iron deficiency and a high HDL-cholesterol, all more common in women, increase blood T1 and appear to explain this typical female longer blood T1. Native blood T1 is associated with

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myocardial T1 and ECV. This may be from the inclusion of blood signal in measured myocardial T1, but also potentially from biological processes (e.g. compensatory vasodilatation in anemia) – further work is required to understand this better.

Figure – **Correlation between ShMOLLI blood T1 and Hct, iron, HDL-cholesterol and albumin.**

Caption: Figure 1 shows significant correlations between blood T1 and Hct, blood T1 and iron and blood T1 and HDL-cholesterol while correlation between blood T1 and albumin was not significant.
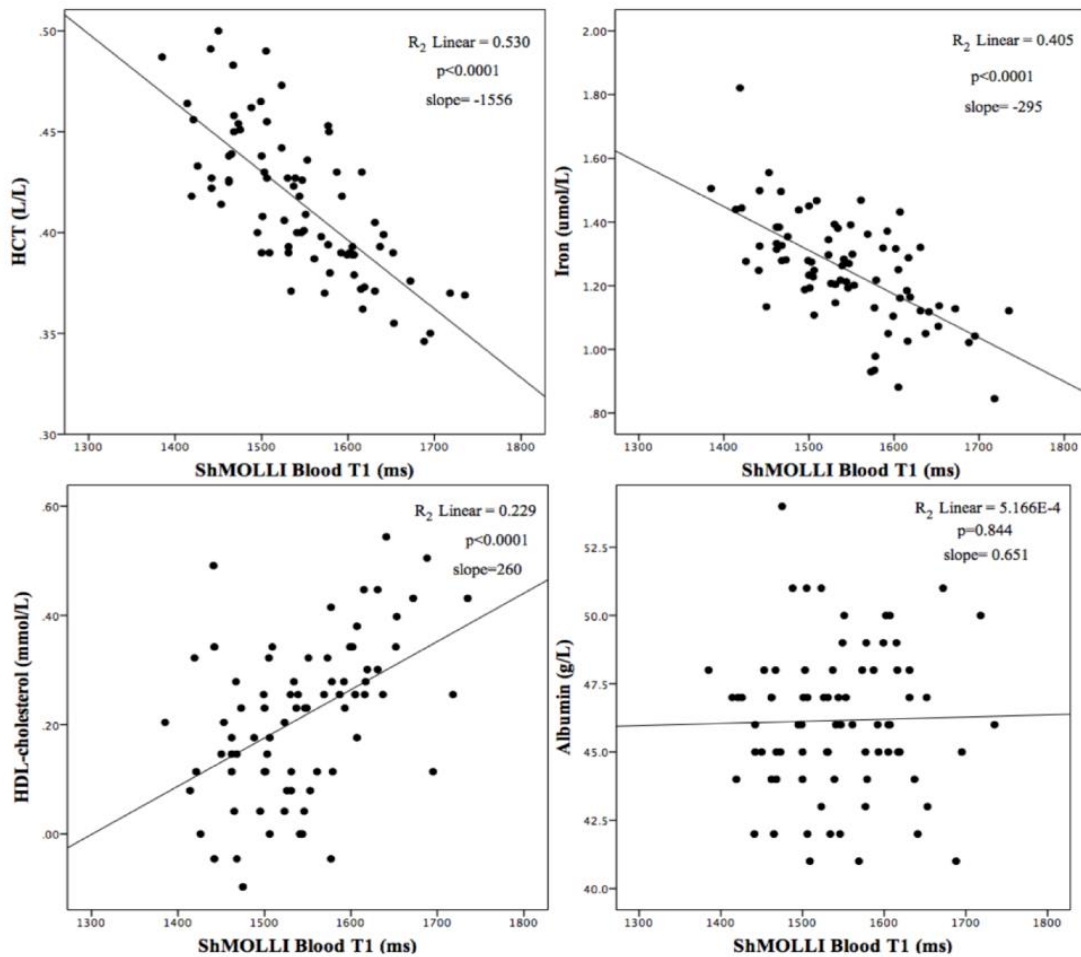
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