Equilibrium contrast MRI measurement of tissue extracellular volume of distribution in normal volunteers using ShMOLLI T1 quantification

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Background

Extracellular volume expansion occurs in a wide range of diseases and is often the result of diffuse fibrosis. In the liver examples include alcoholic liver disease and viral hepatitis. Equilibrium contrast MRI (EQ-MRI) is a new non-invasive technique that has been shown to accurately quantify myocardial extracellular volume[1], however the principals of this technique can be applied to other organs. Dynamic Contrast Enhanced MRI (DCE-MRI) is a commonly used technique and can provide a measure of extracellular volume fraction (Ve), but is prone to errors in estimation. In this study we measured the extracellular volume of distribution (Vd) within various abdominal tissues in normal subjects and compared our values to literature values measured using DCE-MRI.

Methods

45 normal volunteers were recruited from members of staff at our institution after giving informed consent according to local ethics procedures. Gadolinium contrast equilibrium was established using a bolus of 0.2ml/kg at 3ml/s followed 15 minutes later by an infusion of 0.133ml/hr for 30 minutes using the technique of Flett et al[1]. A blood sample was taken for measurement of the haematocrit. A shortened modified look-locker inversion recovery (ShMOLLI)[2] sequence was used for pre-contrast and equilibrium T1 mapping (single slice; slice thickness 8mm; flip angle 35°; TR 195.77; TE 1.05). Seven subjects were excluded from the analysis due to incomplete data or excessive image artefact. For the 38 remaining participants, regions of interest were drawn within the aorta, liver, spleen, stomach wall, fat and paravertebral muscle on pre-contrast and then transferred to the equilibrium T1 maps. Mean T1 values within each region were recorded for each map. Vd was calculated for each using the formula:

$Vd_{tissue} = (1\text{-haematocrit}) \times \Delta (1\text{-}T1)_{tissue} / \Delta (1\text{-}T1)_{blood}$

Mean Vd values were compared between tissues using the Kruskal Wallis test followed by Dunn's post-test to account for multiple comparisons.

Results

Figure 1 shows a representative pre-contrast and equilibrium T1 map in a single subject. Figure 2 summaries the median and interquartile range of Vd measured in the various tissues. No significant difference in Vd was demonstrated between liver, spleen and stomach wall ($p>0.05$), however the Vd of these tissues was significantly different from that measured in fat and muscle ($p<0.05$). There was no difference in Vd between fat and muscle ($p>0.05$). Literature values of Ve derived from DCE techniques are summarised in table 1.

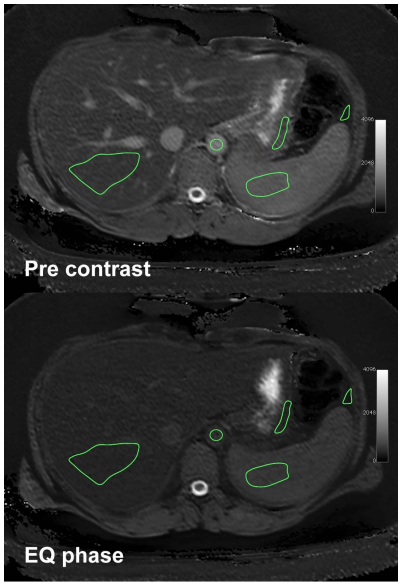

Figure 1. ShMOLLI T1 maps made pre and post Gadolinium equilibrium

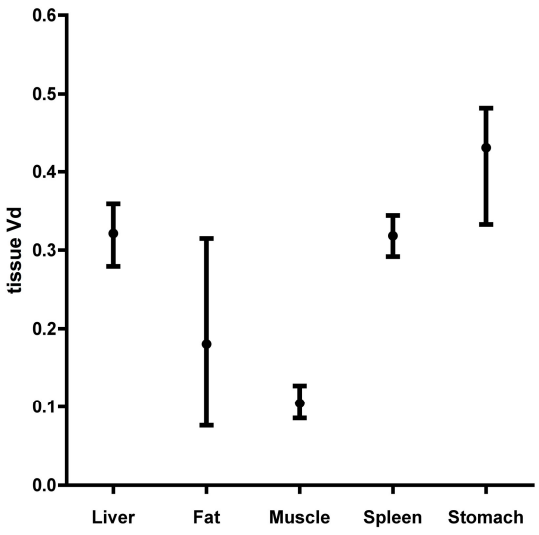

Figure 2. Vd median and interquartile range for tissues within the abdomen

Tissue	DCE-MRI Ve
Liver	*0.2-0.4[3]
Muscle	0.12 ± 0.03[4]
Fat	0.09 ± 0.02[4]

*values inferred from graphical data

Table 1. Literature DCE-MRI derived Ve values

Conclusion

Measured values for Vd in the liver; muscle and fat show good agreement with those quoted in the literature. Vd within the spleen and stomach wall have not been previously reported and are not significantly different from the liver. We found narrow interquartile ranges for all tissues except fat suggesting that Vd measurements may provide a useful tool for discrimination between normal and diseased tissue.

References

1. Flett AS, et al. Circulation 2010;122(2):138-44 2. Piechnik SK, et al. J Cardiovasc Magn Reson. 2010 Nov 19;12:69 3. Orton, M.R., et al., Phys Med Biol, 2009. 54(7): p. 2197-215 4. Padhani, A.R., et al., NMR Biomed, 2002. 15(2): p. 143-53.