Routine quantification of liver iron by MRI

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On biopsy, iron is detected by **Perl's** staining. Determination of the liver iron content (**LIC**) is done by biochemical analysis of the biopsy core and is normally **<2 mg/g or <36 µmol/g**.

$$1 \text{ mg/g} = 18 \mu\text{mol/g}$$

MRI is the best non-invasive method to estimate LIC. Excess of iron in the liver shortens its T2 and decreases the liver signal intensity. Gradient echo (GRE) sequences are more sensitive to iron and are widely used to detect and quantify iron overload. In case of steatosis, the signal of these sequences is also influenced by fat when TEs are not in-phase.

LIC assessment can be obtained ideally by calculating the **R2*** (or $T2^* = 1/R2^*$) but also by comparing the liver signal intensity to that of the paraspinal muscles (**SIR method**).

Rather than opposing these two methods, we must consider them as **complementary**.

This is particularly important at 3T where the iron effect is stronger. R2* is twice longer and could be difficult to assess.

Selected references:

1. Wood JC et al. Blood 2005.
2. Garbowski MW et al. J Cardiovasc Magn Reson 2014
3. d'Assignies G et al. Eur Radiol 2018
4. Gandon Y et al. Lancet 2004
5. Alústiza JM et al. Radiology 2004.
6. Rose C et al. Eur J Haematol 2006
7. Paisant A et al. Abdom Radiol 2017.

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R2*

The R2* is calculated by fitting a decreasing exponential curve on the different values of the liver signal intensity. The result is reliable as long as the signal is above the background noise on at least the first two or three echoes.

In case of collapse of the signal the value of R2* can be considerably underestimated.

The equation of the curve can be more complex and take into account the oscillating signal related to the variation of the phase between fat and water in case of steatosis.

With such complex equation, quantification stays accurate in the presence of steatosis but at the cost of increased risk of error in case of high iron overload.

Practically, to obtain R2* you can:

- get a 3D R2* map if you have bought the corresponding option (Ideal-IQ for GEMS, m-DIXON Quant for Philips or LiverLab for Siemens),
- or acquire a 2D multi-echo GRE sequence (example of protocols are provided on our university website) and then use a software like MRQuantif (freely downloadable on our website). If you use a body coil to acquire the signal you will have simultaneously R2* and SIR method, allowing a cross-check to ensure the results. MRQuantif checks the acquisition parameters to avoid technical errors.

How to convert R2* to LIC ?

At 1.5T, there are several papers providing a conversion formula with significant differences.

So, at 1.5T, we propose a simpler formula, between Wood¹ and Garbowski² results:

$$\text{LIC } \mu\text{mol/g} = R2^*/2$$

NB: divide this result by 18 to get it in mg/g

At 3T, we have published a formula³, but to avoid the risk of underestimation, we recommend you to acquire our protocol with the body coil and use MRQuantif to select optimal results between R2* and SIR.

MRQuantif screenshots showing similar results between 3D maps (T2*=6 ms, FF = 10%) and ME GRE with TE multiple of 1.2 ms but also multiple of 0.8 ms (T2*=6ms FF=7%). More details on comparison between 3D maps and MRQuantif results on Friday SS-13.