fluid, and determining from said comparison a value relating to the extracellular fluid in the subject's liver based on a normal iron content for the liver.

The methods, systems, apparatus and carriers of the present disclosure may also be applied to other organs or visceral tissues where biopsy is not routine or possible, for example the spleen and heart.

Therefore in a further embodiment the disclosure provides a method for processing MR relaxometry data of visceral tissue comprising: obtaining a measurement of relaxometry data of a subject's visceral tissue for extracellular fluid; determining an iron content for the visceral tissue; simulating a measurement of the subject's visceral tissue for extracellular fluid for the determined iron content; comparing the measurement of the subject's visceral tissue for extracellular fluid to the simulated measurement of the subject's visceral tissue for extracellular fluid; and determining from said comparison a value of extracellular fluid in the subject's visceral tissue based on a normal iron content for the visceral tissue.

Therefore, the disclosure provides a method for processing MR relaxometry data of visceral tissue of a subject, comprising:

a) obtaining a measurement of relaxometry data of a subject's visceral tissue for extracellular fluid;

b) determining an iron content for the visceral tissue;

c) simulating a measurement of the subject's visceral tissue for extracellular fluid for the determined iron content;

d) comparing the measurement of the subject's visceral tissue for extracellular fluid of step (a) to the simulated measurement of the subject's visceral tissue for extracellular fluid of step (c); and

e) determining from said comparison a value of extracellular fluid in the subject's visceral tissue based on a normal iron content for the visceral tissue, wherein the measurement of step (a) includes obtaining a T1 map of the visceral tissue, the simulation of step (c) includes determining a predicted T1 map associated with a particular extracellular fluid fraction of the visceral tissue for the iron content determined in step (b) and the comparison of step (d) includes comparing the measured T1 to the predicted T1, and determining a corrected T1 based on a normal iron content for the visceral tissue.

Another embodiment is a system or apparatus comprising at least one computing device and at least one application executable in the at least one

computing device, the at least one application comprising logic that obtains a measurement of relaxometry data of a subject's visceral tissue for extracellular fluid; measures the visceral tissue for iron content; simulates a measurement of the subject's visceral tissue for extracellular fluid for the determined iron content; compares the measurement of the subject's visceral tissue for extracellular fluid to the simulated measurement of the subject's visceral tissue for extracellular fluid; and determines from said comparison a value of extracellular fluid in the subject's visceral tissue based on a normal iron content for the visceral tissue.

In one aspect, there is provided a system, comprising:

at least one computing device;

at least one application executable in the at least one computing device, the at least one application comprising logic that:

a) obtains a measurement of relaxometry data of a subject's visceral tissue for extracellular fluid;

b) determines an iron content for the visceral tissue;

c) simulates a measurement of the subject's visceral tissue for extracellular fluid for the determined iron content;

d) compares the measurement of the subject's visceral tissue for extracellular fluid of step (a) to the simulated measurement of the subject's visceral tissue for extracellular fluid of step (c); and

e) determines from said comparison a value relating to the extracellular fluid in the subject's visceral tissue based on a normal iron content for the visceral tissue, wherein the measurement of step (a) includes obtaining a T1 map of the visceral tissue, wherein the measurement of step (a) includes obtaining a T1 map of the visceral tissue, the simulation of step (c) includes determining a predicted T1 map associated with a particular extracellular fluid fraction of the visceral tissue for the iron content determined in step (b) and the comparison of step (d) includes comparing the measured T1 to the predicted T1, and determining a corrected T1 based on a normal iron content for the visceral tissue.

Another embodiment is a carrier bearing software comprising instructions for configuring a processor to carry out the steps of obtaining a measurement of relaxometry data of a subject's visceral tissue for extracellular fluid, determining an iron content for the visceral tissue, simulating a measurement of the subject's visceral tissue for extracellular fluid for the determined iron content; comparing the measurement of the subject's visceral tissue for extracellular fluid to the simulated

value relating to the extracellular fluid in the subject's visceral tissue based on a normal iron content for the visceral tissue. In another aspect, there is provided a carrier bearing software comprising instructions for configuring a processor to carry out the steps of:

a) obtaining a measurement of relaxometry data of a subject's visceral tissue for extracellular fluid;

b) determining an iron content for the visceral tissue;

c) simulating a measurement of the subject's visceral tissue for extracellular fluid for the determined iron content;

d) comparing the measurement of the subject's visceral tissue for extracellular fluid of step (a) to the simulated measurement of the subject's visceral tissue for extracellular fluid of step (c); and

e) determining from said comparison a value of extracellular fluid in the subject's visceral tissue based on a normal iron content for the visceral tissue, wherein the measurement of step (a) includes obtaining a T1 map of the visceral tissue, the simulation of step (c) includes determining a predicted T1 map associated with a particular extracellular fluid fraction of the visceral tissue for the iron content determined in step (b) and the comparison of step (d) includes comparing the measured T1 to the predicted T1, and determining a corrected T1 based on a normal iron content for the visceral tissue.

The visceral tissue may be any internal organ of the body, preferably liver, heart or spleen, most preferably liver.

Any one or more of the embodiments can further include determining a corrected measured value of extracellular fluid from the comparison. The presence or absence of liver fibrosis can be determined from the measurements and comparison, as well as the extent of fibrosis.

In any one or more of the embodiments, the subject's liver can be measured using a medical imaging device, such as a magnetic resonance (MR) scanner. For example, a medical imaging device, such as a magnetic resonance imaging (MRI) device may be provided and a subject, such as a patient, positioned in association with the medical imaging device.

The measurement of relaxometry data may be obtained using the medical imaging device. In one or more aspects an MR scanner can be used, for example, to measure one or more characteristic relaxation time or times in the liver tissue. The liver can be measured for extracellular fluid content using an MR scanner. The liver can also be measured for iron content using an MR scanner. In particular, the subject's liver can be measured for extracellular fluid using MR relaxometry, for example, T1 mapping.

In any one or more of the embodiments, the subject's liver can also be measured for iron content using one or more of T2 mapping, T2* mapping, measuring one or more blood biomarkers, such as ferritin, transferrin, transferrin saturation, hepcidin, soluble transferrin receptor (sTfR) index (sTfR / log ferritin), or MR spectroscopy. For example, the width of the ^{1}H MRS spectra can indicate higher than normal iron loads.

In any one or more embodiments, the measurement of the subject's liver for extracellular fluid can include obtaining a T1 map of the liver, the simulation can include determining a predicted T1 map associated with a particular extracellular fluid fraction of the liver for the iron content determined and the comparison can include comparing the measured T1 to the predicted T1. A corrected T1 measurement can then be determined based on a normal iron content for the liver. Thesimulation can include multi-compartment modeling of various fractions of extracellular fluid in the liver and the impact of iron content in the liver on both the intra- and

Claims:

1. A system, comprising:

at least one computing device;

at least one application executable in the at least one computing device, the at least one application comprising logic that:

a) obtains a measurement of relaxometry data of a subject's visceral tissue for extracellular fluid;

b) determines an iron content for the visceral tissue;

c) simulates a measurement of the subject's visceral tissue for extracellular fluid for the determined iron content;

d) compares the measurement of the subject's visceral tissue for extracellular fluid of step (a) to the simulated measurement of the subject's visceral tissue for extracellular fluid of step (c); and

e) determines from said comparison a value relating to the extracellular fluid in the subject's visceral tissue based on a normal iron content for the visceral tissue, wherein the measurement of step (a) includes obtaining a T1 map of the visceral tissue, the simulation of step (c) includes determining a predicted T1 map associated with a particular extracellular fluid fraction of the visceral tissue for the iron content determined in step (b) and the comparison of step (d) includes comparing the measured T1 to the predicted T1, and determining a corrected T1 based on a normal iron content for the visceral tissue.

2. The system of claim 1, wherein the logic further determines from said measurements and comparison the presence or absence of visceral tissue fibrosis or inflammation.

3. The system of any one of claims 1 to 2, wherein the relaxometry data is obtained by use of a medical imaging device including a magnetic resonance (MR) scanner and the device is used to measure one or more characteristic relaxation time or times in the visceral tissue.

4. The system of any one of claims 1 to 3, wherein the visceral tissue is measured for extracellular fluid using T1 mapping and the visceral tissue is measured for iron content using one or more of one or more of T2 mapping, T2* mapping, magnetic resonance spectroscopy, or measuring one or more blood biomarkers.

5. The system of claim 4, wherein the T1 mapping is performed using a modified Look Locker inversion (MOLLI) recovery pulse sequence or a shortened modified Look Locker inversion recovery (Sh-MOLLI) sequence.

6. The system of any one of claims 1 to 5, wherein the simulation includes

(i) the impact of iron content in the visceral tissue on both the intra- and extracellular relaxation times in multi-compartment modeling of various fractions of extracellular fluid in the visceral tissue; and/or

(ii) the impact of iron content on both the intra- and extracellular fluid relaxation times and simulating a predicted measurement of the visceral tissue for various fractions of extracellular fluid in combination with a simulation of an imaging sequence.

7. The system of any one of claims 1 to 6, wherein the visceral tissue is liver, spleen or heart, preferably liver.

8. A carrier bearing software comprising instructions for configuring a processor to carry out the steps of:

a) obtaining a measurement of relaxometry data of a subject's visceral tissue for extracellular fluid;

b) determining an iron content for the visceral tissue;

c) simulating a measurement of the subject's visceral tissue for extracellular fluid for the determined iron content;

d) comparing the measurement of the subject's visceral tissue for extracellular fluid of step (a) to the simulated measurement of the subject's visceral tissue for extracellular fluid of step (c); and

e) determining from said comparison a value of extracellular fluid in the subject's visceral tissue based on a normal iron content for the visceral tissue, wherein the measurement of step (a) includes obtaining a T1 map of the visceral tissue, the simulation of step (c) includes determining a predicted T1 map associated with a particular extracellular fluid fraction of the visceral tissue for the iron content determined in step (b) and the comparison of step (d) includes comparing the measured T1 to the predicted T1, and determining a corrected T1 based on a normal iron content for the visceral tissue.