liver cirrhosis to determine whether or not they have portal hypertension. The invention can also be used to assess the portal pressure in patients with non-cirrhotic portal hypertension. The invention can also be used to assess the presence or degree of liver fibrosis.

The methods of the invention have significant advantages over the currently available methods since the MRI-based methods of the invention are quicker, completely non-invasive, do not require the patient to be admitted to hospital and also provide additional information on liver and spleen anatomy. The MRI scans could be performed on routine clinical MRI scanner without the installation of new hardware.

It is therefore an object of the invention to provide a non-invasive and accurate method of assessing portal pressure which may be useful for determining the presence or absence of portal hypertension in patients with liver cirrhosis.

It is another object of the invention to provide a non-invasive and accurate method of assessing portal pressure which may be useful for determining the presence or severity of liver fibrosis.

As disclosed, the invention provides a method of obtaining an indication of the vascular pressure in the blood vessels connecting a first organ to a second organ by obtaining an MRI measurement from the second organ, wherein the vascular pressure in the blood vessels between the two organs is correlated with the MRI measurement in the second organ, and wherein:

(a) the first organ is the liver and the second organ is the spleen; or

(b) the first organ is the heart and the second organ is the liver.

and wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms).

As disclosed, the invention provides a method of obtaining an indication of the vascular pressure in a splanchnic vein of a subject, the method comprising the steps of:

(a) correlating an MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom, with

(b) the pressure in a splanchnic vein of the subject,

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms), thereby obtaining an indication of the vascular pressure in the splanchnic vein of the subject.

thereby obtaining an indication of the vascular pressure in the splanchnic vein of the subject.

In a first aspect, the invention provides a method of obtaining an indication of the vascular pressure in a splanchnic vein of a subject, the method comprising the steps of:

(a) determining from an MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom, an indication of the pressure in the splanchnic vein of the subject,

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms) and wherein

the determining step comprises comparing the MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom, with corresponding MRI measurements obtained from one or more control subjects with defined splanchnic vein pressures, thereby obtaining an indication of the vascular pressure in the splanchnic vein of the subject.

In a second aspect, the invention provides a method of obtaining an indication of the pressure in the hepatic portal vein of a subject, the method comprising the steps of:

(a) obtaining an MRI measurement from the subject's spleen or liver, or a value derived therefrom; and

(b) correlating the measurement obtained in step (a) with the pressure in the hepatic portal vein.

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms),

and wherein the correlating step preferably comprises: (i) comparing the MRI measurement obtained from the subject's spleen or liver, or the value derived therefrom, with data previously obtained from corresponding MRI measurements or values from one or more control subjects with defined hepatic portal vein pressures;or

(ii) the correlating step preferably comprises comparing the MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom, with corresponding MRI measurements or values which have been obtained from one or more control subjects, wherein those control MRI measurements or values have been correlated with the hepatic portal vein pressures in those control subjects.

As disclosed, the invention provides a method of obtaining an indication of the pressure in the hepatic portal vein of a subject, the method comprising the steps of:

(a) obtaining an MRI measurement from the subject's spleen or liver, or a value derived therefrom; and
(b) determining from the MRI measurement or value in step (a) an indication of pressure in the hepatic portal vein.

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms).

In a further embodiment, the invention provides a method of obtaining an indication of hypertension in a splanchnic vein of a subject, the method comprising the steps of comparing:

(a) an MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom; and
(b) the corresponding measurement or value obtained in a control without hypertension in the splanchnic vein,

wherein an increase in the measurement or value obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of hypertension in the splanchnic vein of the subject.

More preferably, the method is for obtaining an indication of hypertension in the hepatic portal vein.

In some embodiments, the finding of hypertension is measured using the Hepatic Wedge Pressure (HWP), the Free Hepatic Vein Pressure (FHVP), or the Hepatic Vein Pressure Gradient (HVPG).

As disclosed, the invention provides a method of obtaining an indication of a change in pressure in a splanchnic vein of a subject, the method comprising the steps of comparing:

(a) an MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom; and
(b) a corresponding previously-obtained MRI measurement from the subject's spleen or liver, or a corresponding value derived therefrom,

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms),

wherein an increase in the measurement or value obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of an increase in pressure in the splanchnic vein of the subject,
and
wherein a decrease in the measurement or value obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of a decrease in pressure in the splanchnic vein of the subject.

More preferably, the method is for obtaining an indication of a change in pressure in the hepatic portal vein.

(a) obtaining an MRI measurement from the subject's liver or a value derived therefrom; and

(b) determining from the MRI measurement or value in step (a) an indication of central venous pressure.

In a further embodiment, the invention provides a method of obtaining an indication of increased central venous pressure in a subject, the method comprising the steps of comparing:

(a) an MRI measurement obtained from the subject's liver, or a value derived therefrom; and

(b) the corresponding measurement or value obtained from a control without increased central venous pressure,

wherein an increase in the measurement or value obtained in step (a) compared to the corresponding measurement or value obtained from the control is indicative increased central venous pressure in the subject.

In some embodiments, the increased central venous pressure in the subject is increased pressure in the hepatic vein, the inferior vena cava, the superior vena cava or the right atrium.

In a third aspect, the invention provides a method of obtaining an indication of a change in the central venous pressure of a subject, the method comprising the steps of comparing:

(a) an MRI measurement obtained from the subject's liver, or a value derived therefrom; and

(b) a corresponding measurement or value previously-obtained from the subject's liver,

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms),

wherein an increase in the measurement or value obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of an increase in the central venous pressure of the subject,
and
wherein a decrease in the measurement or value obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of a decrease in the central venous pressure of the subject, and

wherein the central venous pressure is the pressure in the hepatic vein, the inferior vena cava, the superior vena cava or the right atrium.

In a further embodiment, the invention provides a method of obtaining an indication of the prognosis of a subject with heart disease, the method comprising the steps of comparing:

(a) an MRI measurement obtained from the subject's liver, or a value derived therefrom, with
(b) a corresponding previously-obtained MRI measurement or value from the subject's liver,

wherein an increase in the measurement or value obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of a decline in the prognosis for the subject,
and
wherein a decrease in the measurement obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of an improvement in the prognosis for the subject.

CLAIMS

1. A method of obtaining an indication of the vascular pressure in a splanchnic vein of a subject, the method comprising the steps of:

(a) determining from an MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom, an indication of the pressure in the splanchnic vein of the subject,

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms), and
wherein the determining step comprises comparing the MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom, with corresponding MRI measurements obtained from one or more control subjects with defined splanchnic vein pressures, thereby obtaining an indication of the vascular pressure in the splanchnic vein of the subject.

2. A method of obtaining an indication of the pressure in the hepatic portal vein of a subject, the method comprising the steps of:

(a) obtaining an MRI measurement from the subject's spleen or liver, or a value derived therefrom; and
(b) correlating the measurement obtained in step (a) with the pressure in the hepatic portal vein,

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms),

wherein the correlating step comprises:

(i) comparing the MRI measurement obtained from the subject's spleen or liver, or the value derived therefrom, with data previously obtained from corresponding MRI measurements or values from one or more control subjects with defined hepatic portal vein pressures; or

(ii) comparing the MRI measurement obtained from the subject's spleen or liver, or a value derived therefrom, with corresponding MRI measurements or values which have been obtained from one or more control subjects, wherein those control MRI measurements or values have been correlated with the hepatic portal vein pressures in those control subjects.

3. A method of obtaining an indication of a change in the central venous pressure of a subject, the method comprising the steps of comparing:

(a) an MRI measurement obtained from the subject's liver, or a value derived therefrom; and

(b) a corresponding measurement or value previously-obtained from the subject's liver,

wherein the MRI measurement is T1 mapping or T1 relaxometry or T1 values (ms) or T2* imaging or T2* mapping or T2* values (ms) or T2 mapping or T2 relaxometry or T2 values (ms),

wherein an increase in the measurement or value obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of an increase in the central venous pressure of the subject,

and

wherein a decrease in the measurement or value obtained in step (a) compared to the corresponding measurement or value in step (b) is indicative of a decrease in the central venous pressure of the subject,

and wherein the central venous pressure is the pressure in the hepatic vein, the inferior vena cava, the superior vena cava or the right atrium.

4. A method as claimed in any one of the preceding claims, wherein the method further comprises the step of correction of the MRI measurement or value for iron overload or deficit from an MRI measurement of iron content obtained from the subject's liver or spleen or from an image of the subject's liver or spleen.

5. A method as claimed in any one of the preceding claims, wherein the measurement is obtained from a MRI image of the liver and/or spleen or the measurement is obtained from a previously-obtained MRI image of the liver and/or spleen.

6. A method as claimed in claim 1 or claim 2, wherein the value is derived from MRI measurements obtained from the subject's spleen and liver.

7. A method as claimed in any one of the preceding claims, wherein the MRI measurement or value derived therefrom which is previously-obtained or from a control subject is obtained from a graph, look-up table, database or mathematical equation.

8. A method as claimed in any one of the preceding claims, wherein the subject is a human.

9. A method as claimed in any one of the preceding claims, wherein the subject:

(i) has liver disease;

(ii) has liver disease and portal hypertension;

(iii) has portal hypertension;

(iv) has heart disease;

(v) has liver disease that is a consequence of heart disease; or

(vi) has increased central venous pressure.

10. A method as claimed in claim 9, wherein the subject:
(i) has liver fibrosis or liver cirrhosis;
(ii) has cirrhosis or liver fibrosis;
(iii) has non-cirrhotic portal hypertension or pre-hepatic portal hypertension or hepatic portal hypertension or post hepatic portal hypertension;
(iv) has right heart failure or congestive heart failure or congenital heart disease or constrictive pericarditis or tricuspid valve disease or valvular heart disease; or
(v) has cardiac liver cirrhosis.

11. A method as claimed in any one of the preceding claims, wherein the method is computer-implemented.

12. A system or apparatus comprising at least one processing means arranged to carry out the steps of a method as claimed in any one of claims 1 to 11.

13. A carrier bearing software comprising instructions for configuring a processor to carry out the steps of a method as claimed in any one of claims 1 to 11.