UK Biobank

Body (abdominal) MRI scan

Version 1.0

http://www.ukbiobank.ac.uk/

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This document details the procedure for the body (abdominal) MRI scan performed at an Imaging assessment centre for UK Biobank.

Contents

1. Introduction

1.1: This manual details the procedure for the body (abdominal) magnetic resonance imaging (MRI) scan measurement at a UK Biobank Imaging Assessment Centre.

Table 1: Sequence of assessment visit

	Visit station	**Assessments undertaken**
1	Reception	• Welcome & registration • Generating a USB key for Participants
2	Eligiblity Section	• Eligibility questionnaire • Consent
3	Imaging scans	• Cardiac MRI scan and pulse wave analysis • Body (abdominal) MRI scan • Brain MRI scan • Whole body DXA scan • Carotid ultrasound • 12-lead ECG
4	Touchscreen	• Touchscreen questionnaire • Hearing Test • Cognitive function tests
5	Interview & blood pressure	• Interviewer questionnaire • Blood pressure measurement • Measurement of arterial stiffness
6	Physical measurements	• Height (Standing and Sitting) • Hip & Waist measurement • Weight and Bio-impedance measurement • Hand-grip strength • Ultrasound Bone Densitometry • Spirometry (Lung function test)
7	Sample collection & exit	• Blood, urine and saliva sample collection

1.2: At the start of their visit, each participant is issued with a USB key at the Reception station. This contains Participant ID, name, date of birth and gender. As the participant progresses between stations the USB key acts as an identifying token. The USB key is encrypted so can only be read by assessment centre computers. None of the participant's

test data is transferred to the USB key. At the end of the assessment visit all identifying data on the USB key is removed.

1.3: This procedure is performed by a radiographer who has received suitable training and has been granted the relevant module permissions.

2. Participant Preparation

2.1: Electrodes (for the ECG measurement) are attached to the participant prior to the cardiac and body (abdominal) scan. Please see ECG explanatory documentation for further details of correct positioning of the leads.

2.2: The participant is fully informed prior to the scan of what the MRI scan entails and the importance of them keeping still whilst in the scanner. They are also given instructions on how to hold their breath in certain sections during the scan.

2.3: A pillow is placed underneath the participants' legs to minimise lumbar lordosis.

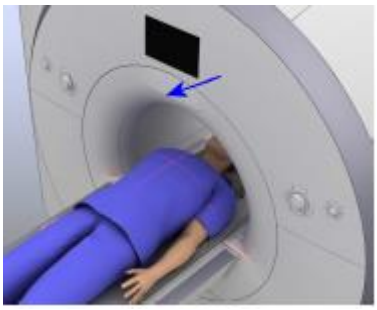
2.4: The participant is provided with a buzzer in order for them to contact the staff at any time during the scanning process.

2.5: The participant is provided with appropriate ear protection for the examination (earplugs and headphones).

2.6: The body coil is placed onto the participant's chest, covering the whole of the chest evenly (i.e. from the shoulders down so that the heart is well covered by the coil).

2.7: Velcro straps are clipped into the side of the table, with the participants' arms outside of the coil.

2.8: The laser light on the MRI scanner enables correct participant positioning (see figure).



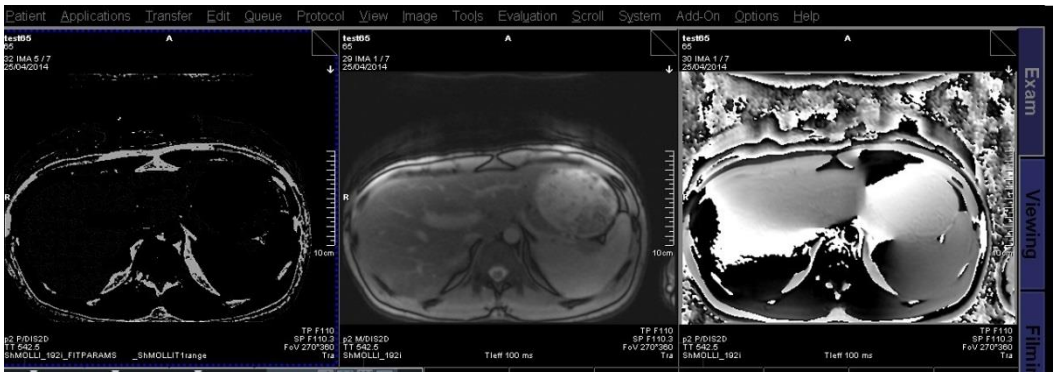
Correct position of the laser light

2.9: When the laser light localiser is switched on, a crosshair appears directly below the area. The table top is then moved in order to position the crosshairs directly over the area of interest.

3. Body (abdominal) MRI measurement

3.1: All measurements are performed using Siemens 1.5T MAGNETOM Aera.

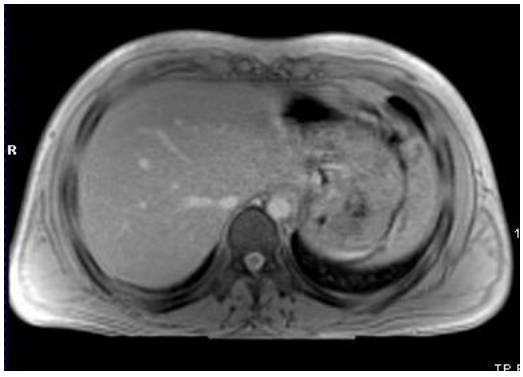
3.2: Liver*MultiScan*: A single transverse slice, located at the porta hepatis was chosen to represent the liver. Two sequences were used to acquire the necessary data. The first sequence consisted of a single breath-hold cardiac-gated T1-mapping Modified Look-Locker Inversion Recovery (MOLLI) sequence (typically 12 seconds), which acquires a series of seven images (8mm slice thickness, in-plane pixel spacing 9.3mm) each with a different T1 weighting.



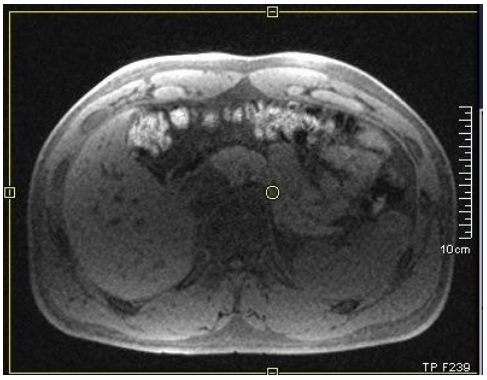
The results of the shMOLLI sequence

3.3: A second single-breath hold sequence (typically 14 seconds) using a multi-gradient echo approach was used to acquire 10 images (6mm slice thickness, in-plane pixel spacing 25mm).

3.4: Multi-echo liver and pancreas images were also generated.



An axial image showing the liver at its maximum size on axial image



An axial fat sat image showing the pancreas

3.5: In total, the Liver*MultiScan* component of the abdominal imaging protocol took 3 minutes.

4. Processing of data for derived liver measures

4.1: Derived measures of liver iron content, liver fat and liver inflammation factor were generated by Perspectum Diagnostics (www.perspectum-diagnostics.com/).

4.2: **T1:** The images acquired using the MOLLI sequence were used to determine a measurement of T1 ($T1_{LMS}$, units milliseconds), using an AMOEBA optimization, following a revised version of the method of Piechnik et al. (Piechnik, et al., 2010), using six of the acquired images.

4.3: **T2* and Iron**: T2* (units of milliseconds) was determined using the in-phase multi-gradient GRE data following the method of Bonny *et al* -this excludes pixels in which magnitude fails to exceed the background noise by 2-fold (Bonny, et al., 1996). The T2* of a tissue is affected by local magnetic susceptibility effects, including those caused by iron deposits. The presence of iron reduces the tissue T2*. Local iron concentration (Fe, units mg/g dry weight tissue) is estimated from T2* according to a previously determined model (St Pierre TG, et al., 2005).

4.4: **Corrected T1 and Liver Inflammation/Fibrosis (LIF) index:** The measurement of T1 can be affected by changes in T2*, with short T2*s (as are seen in the presence of local iron deposits) leading to an artificially reduced estimate of T1. Therefore, the T2* image is required to correct $T1_{LMS}$ values and generate a cT1 value (corrected $T1_{LMS)}$. This cT1 (units ms) has been shown to correlate with liver disease staging (Banerjee et al. (2014)). Typical values in the abdomen range from 0 to 4 seconds. Within the liver however, the range of focus is much smaller, even including variations due to disease, from about 600-1400ms. To simplify the scoring system for the liver, we introduced the LIF score, a continuum from 0 to 4, which represents the focus of cT1 values found in the liver.

4.5: Proton Density Fat Fraction: The 2nd, 3rd and 4th echos of the multi-gradient GRE data were used to calculate proton density fat and water images using the extended 3D-

DIXON sequence, as described elsewhere (Glover & Schneider, 1991). The Proton density fat fraction (PDFF) is calculated from the fat and water images by:

$$PDFF = \frac{Fat}{Fat + Water}$$

4.6: Validation of Liver*MultiScan* accuracy: To validate the accuracy of LiverMultiScan, phantom studies were conducted for T1, T2* and PDFF on a Siemens 1.5T Avanto at the University of Oxford Centre for Clinical Magnetic Resonance Research (OCMR). Similar phantom data was collected from the UK BioBank Siemens 1.5T Aera scanner.

5. Processing of data for derived body composition measures

5.1: Derived measures of body composition were developed by AMRA, details of which are found in a separate explanatory document (found in the 'Additional Resources' tab associated with these data-fields)

6. QC protocol

6.1: Fully automated software tools for analyses of body images are not currently available, but semi-automated tools scalable for use with very large datasets are being applied through collaborations with AMRA and Perspectum Diagnostics.

7. Data collected

The following data were collected and are available in Showcase:

Liver MRI:

- Liver images
- Liver fat percentage - steatosis
- Liver inflammation factor (LIF) - fibrosis
- Liver iron (Fe) - haemosiderosis

Derived from Perspectum Diagnostics (Rajarshi Banerjee). These data-fields will be made publicly available upon completion of the appropriate research application

Body composition measures:

- Abdominal subcutaneous adipose tissue (ASAT)
- Visceral adipose tissue (VAT)
- Posterior and anterior thigh muscle mass (right and left)

Derived from AMRA. These data-fields will be made publicly available upon completion of the appropriate research application

8. References

Banerjee R, Pavlides M, Tunnicliffe EM, et al. Multiparametric magnetic resonance for the non-invasive diagnosis of liver disease. *J Hepatol.* 2014; 60(1):69-77

Bonny JM, Zanca M, Boire JY & Veyre A. T2 maximum likelihood estimation from multiple spin-echo magnitude images. *Magn Reson Med*. 1996; 36(2):287-93.

Glover GH & Schneider E. Three-point Dixon technique for true water/fat decomposition with B0 inhomogeneity correction. Magn Reson Med. 1991; 18(2):371-83.

Piechnik SK, Ferreira VM, Dall'Armellina E, Cochlin LE, Greiser A, Neubauer S & Robson MD. Shortened Modified Look-Locker Inversion recovery (ShMOLLI) for clinical myocardial T1-mapping at 1.5 and 3 T within a 9 heartbeat breathhold. *Cardiovasc Magn Reson*. 2010, 12(69). doi: 10.1186/1532-429X-12-69.

St Pierre TG, Clark PR & Chua-Anusorn W. Measurement and mapping of liver iron concentrations using magnetic resonance imaging. *Ann N Y Acad Sci*. 2005; 1054: 379-85.