**MRI Variables – Descriptions, Methods & References**

**During the final portion of JHS Exam 2 and all of Exam 3, approximately 1800 cardiac MRI scans were performed. A subset of participants, approximately 150, had repeat MRIs about 3 years apart and a second subset of about 300 underwent contrast enhanced MRI.**

***Note: Recommended variables for each MRI data type are hilited in green***

**Data Set: mrib**

**MRI Structure/Function Variables –** LV Structure/function variables are common clinically significant measures of how well the heart is pumping blood and how healthy the muscle is. Measures are ejection fraction, end diastolic volume, end systolic volume, stroke volume, and LV mass. Three analysis platforms were used in JHS: MRV, QMASS and CIM. We recommend the use of CIM data. All structure/function data were analyzed by Dr. Jeff Carr’s Laboratory at Wake Forest (now located at Vanderbilt). The protocol used to acquire cardiac MR scans in JHS was developed for consistency with MESA. (Natori et al. 2006) LV Structure/function measures have been frequently reported in epidemiologic studies and clinical trials.(Natori et al. 2006; Shah et al. 2013; Turkbey et al. 2010)

**Analysis Software Used to Measure LV structure/function and Variable Names**

* **Pie Medical Imaging MRV (**Philipsweg 1, 6227 AJ Maastricht, 6201 BC Maastricht, The Netherlands; <www.piemedicalimaging.com>) was used initially to analyze LV structure/function on MRI scans acquired during V2. MRV uses a traditional analysis approach that requires defining the mitral valve plane, apex, end systole, trabeculation and epicardial contour. Although the Reading Center initially tested this software, its use is primarily clinical and other softwares are more often used in large population studies. All subjects with evaluable MRI scans acquired in V2 (n~261) have JHS results using MRV software.

***Variables***

**MRIB2** MRV Ejection Fraction (EF) *Percent of blood ejected from LV with each heartbeat, normal 55-70%*

**MRIB3** MRV End Diastolic Volume (EDV) *Volume of blood in LV at end of diastolic filling, normal 65-240 ml*

**MRIB4** MRV End Systolic Volume (ESV) *Volume of blood in LV at end of systolic emptying, normal 16-143 ml*

**MRIB5** MRV Stroke Volume (SV) *Volume of blood pumped by LV, SV=EDV-ESV, normal 55-100 ml*

**MRIB6** MRV Left Ventricle Mass (LVM) *Muscle mass of LV, normal 43-115 g*

* **Medis medical imaging systems QMASS** (Schuttersveld 9, 2316 XG Leiden, the Netherlands; [www.medis.nl](http://www.medis.nl)). QMASS software uses the same traditional approach as MRV, but is perhaps more user friendly and has been used in the MESA study. QMASS was used to analyze LV structure/function in a subset of participants in V2 and V3.

***Variables***

**MRIB7** Qmass Ejection Fraction (EF) *Percent of blood ejected from LV with each heartbeat, normal 55-70%*

**MRIB8** Qmass End Diastolic Volume (EDV) *Volume of blood in LV at end of diastolic filling, normal 65-240 ml*

**MRIB9** Qmass End Systolic Volume (ESV) *Volume of blood in LV at end of systolic emptying, normal 16-143 ml*

**MRIB10** Qmass Stroke Volume (SV) *Volume of blood pumped by LV, SV=EDV-ESV, normal 55-100 ml*

**MRIB11** Qmass Left Ventricle Mass (LVM) *Muscle mass of LV, normal 43-115 g*

* **Cardiac Image Modeling (CIM)** (Auckland Uniservices Ltd., Level 10, UniServices House, 70 Symonds Street, Auckland, NZ; [www.mri.auckland.ac.nz](http://www.mri.auckland.ac.nz/)). CIM analyses of LV structure/function are available on all evaluable JHS participant MRI scans (n~261 V2 and n~1530 V3). CIM allows 3-D analyses using a mathematical model approach to LV functional and structural analyses resulting increased analysis speed and reproducible results.

***Variables***

**MRIB12** CIM Ejection Fraction (EF) *Percent of blood ejected from LV with each heartbeat, normal 55-70%*

**MRIB13** CIM End Diastolic Volume (EDV) *Volume of blood in LV at end of diastolic filling, normal 65-240 ml*

**MRIB14** CIM End Systolic Volume (ESV) *Volume of blood in LV at end of systolic emptying, normal 16-143 ml*

**MRIB15** CIM Stroke Volume (SV) *Volume of blood pumped by LV, SV=EDV-ESV, normal 55-100 ml*

**MRIB16** CIM Left Ventricle Mass (g) (LVM) *Muscle mass of LV, normal 43-115 g*

**MRIB17** CIM Left Ventricle Mass (ml) (LVM) *Muscle mass of LV, normal 43-115 ml*

**MIMP Pulse Wave Velocity (PWV)** – Is a measure of aortic artery stiffness tracking the movement of the blood pulse wave from the ascending aorta through the aortic bifurcation in the lower abdomen. A faster PWV indicates stiffening or less healthy arteries. Wall thickness (WT), an indication of atherosclerosis, was also analyzed at the locations where PWV was measured. The MIMP software used is a MatLab based software developed by Drs. Craig Hamilton and Greg Hundley and Dr. Hundley’s laboratory analyzed PWV and WT for JHS at Wake Forest. PWV is available on all evaluable scans for V2 and V3. Increased PWV and reduced arterial distensibility (both markers of poorer arterial health) has been associated with heart failure, aging, glucose metabolism and hypertension.(Andersen et al. 2015; Hundley et al. 2001; Liu et al. 2015; Vasu et al. 2015) Increased aortic WT is associated aging, hypertension, and abdominal adipose deposition. (Andersen et al. 2015; Chughtai et al. 2011; Liu et al. 2015) Studies also show that cancer treatment may also adversely affect PWV and other structure/function measures. (Drafts et al. 2013)

***Variables***

**MRIB18** MIMP Pulse Wave Velocity Aortic Arch *PWV from ascending aorta through arch, normal 1-10 m/sec*

**MRIB19** MIMP Pulse Wave Velocity Status *PWV quality notes*

**MRIB20** MIMP Pulse Wave Velocity Aortic Arch ascending to descending *PWV from ascending aorta to descending, normal 1-10 m/sec*

**MRIB21** MIMP Pulse Wave Velocity Aortic Arch ascending to descending Status *PWV quality notes*

**MRIB22** MIMP Pulse Wave Velocity Aortic Arch ascending to descending (combined Var MRIB18 and MRIB20) *PWV from ascending aorta to descending for all subjects, normal 1-10 m/sec*

**MRIB23** MIMP Pulse Wave Velocity Aortic Arch ascending to descending (combined Var MRIB18 and MRIB20) Status *PWV quality notes*

**MRIB24** MIMP Pulse Wave Velocity Aorta diaphragm to bifurcation *PWV diaphragm to bifurcation*, *normal 1-10 m/sec*

**MRIB25** MIMP Pulse Wave Velocity Aorta diaphragm to bifurcation Status *PWV quality notes*

**MRIB26** MIMP Pulse Wave Velocity Aorta descending to bifurcation *PWV* descending to bifurcation, *normal 1-10 m/sec*

**MRIB27** MIMP Pulse Wave Velocity Aorta descending to bifurcation Status *PWV quality notes*

**MRIB28** MIMP Pulse Wave Velocity Aorta ascending to bifurcation *PWV* ascending to bifurcation, *normal 1-10 m/sec*

**MRIB29** MIMP Pulse Wave Velocity Aorta ascending to bifurcation Status *PWV quality notes*

**MRIB30** Mean wall thickness ascending aorta *WT in ascending aorta, normal 1-2 mm*

**MRIB31** Mean wall thickness descending aorta *WT in descending aorta, normal 1-2 mm*

**MRIB32** Mean wall thickness diaphragm *WT at diaphragm aorta level, normal 1-2 mm*

**MRIB33** Mean wall thickness bifurcation *WT at bifurcation aorta, normal 1-2 mm*

**MRIB34** Mean wall thickness renal *WT at renal level of aorta, normal 1-2 mm*

**HARP Eularian circumferential myocardial strain**- Strain is a measure of myocardial muscle deformation that indicates how well the heart muscle is contracting. Strain is thought to indicate risk of heart failure and show damage caused by infarct that is more sensitive than functional measures such as EF and CO. Strain is given as a negative percentage with more negative values (farther from zero) indicating healthier myocardium. Strain was measured in Dr. Carr’s laboratory. Strain as an outcome has been published many times. (Edvardsen et al. 2006; Verônica R S Fernandes et al. 2006; Verônica Rolim S Fernandes et al. 2008, 2011; Kishi et al. 2014; Rosen et al. 2007; Yan et al. 2010)

***Variables***

**MRIB35** Mean peak systolic Eularian strain overall *Peak circumferential strain overall, normal 15-25%*

**MRIB36** Mean peak systolic Eularian strain base *Peak circumferential strain LV base, normal 15- 25%*

**MRIB37** Mean peak systolic Eularian strain mid *Peak circumferential strain mid LV, normal 15- 25%*

**MRIB38** Mean peak systolic Eularian strain apex *Peak circumferential strain apex LV, normal 15- 25%*

**Housekeeping Variables***-* these variables indicate quality and completeness of MRI data

***Variables***

**MRIB39** Date of MRI Scan *Date scan acquired*

**MRIB40** JHS Visit *Visit scan acquired*

**MRIB43** Quality of Scan, *Subjective quality rating, higher is better*

**MRIB44** Quality of Scan, Noise *Subjective quality rating, higher is better*

**MRIB45** Quality of Scan, artifacts *Subjective quality rating, higher is better*

**MRIB46** Quality of Scan, overall *Subjective quality rating, higher is better*

**MRIB47** Cardiac surgery evidence *Signs of possible previous surgical interventions noted*

**MRIB48** Clinical report Status *Notes that clinical review was processed*

**MRIB49** MRV Status *Notes whether MRV analysis was done*

**MRIB50** HARP Status *Notes whether HARP analysis was done*

**MRIB51** QMass Status *Notes whether QMass analysis was done*

**MRIB53** CIM Status *Notes whether CIM analysis was done*

**MRIB54** Contrast Status *Notes whether contrast MRI study was done*

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