Mean wall thickness improves characterization and prognosis in left ventricular hypertrophy

Magnus Lundin[1], Einar Heiberg[2,3], David Nordlund[2], Tom Gyllenhammar[2], Katarina Steding-Ehrenborg[2,4], Henrik Engblom[2], Marcus Carlsson[2], Dan Atar[5], Jesper van der Pals[6], David Erlinge[7], Rasmus Borgquist[6], Ardavan Khoshnood[8], Ulf Ekelund[8], Jannike Nickander[1], Raquel Themudo[1], Sabrina Nordin[9], Rebecca Kozor[10], James C Moon[9], Eva Maret[1], Kenneth Caidahl[1], Andreas Sigfridsson[1], Peder Sörensson[11], Erik B Schelbert[12], Håkan Arheden[2], Martin Ugander[1]

[1] Department of Clinical Physiology, Karolinska University Hospital, and Karolinska Institutet, Stockholm, Sweden. [2] Department of Sciences Lund, Clinical Physiology, Lund University, Skåne University Hospital, Lund, Sweden. [3] Wallenberg Center for Molecular Medicine, Lund University, Lund, Sweden. [4] Department of Health Sciences, Physiotherapy, Lund University, Lund, Sweden. [5] Institute of Clinical Medicine, University of Oslo, and Oslo University Hospital, Dept. of Cardiology B, Oslo, Norway. [6] Arrhythmia clinic, Skåne University Hospital, and Department of Cardiology, Clinical Sciences, Lund University, Lund, Sweden. [7] Department of Cardiology, Clinical sciences, Skåne University. Hospital, and Lund University, Lund, Sweden. [8] Department of Clinical sciences, Emergency and internal medicine, Skåne University Hospital, and Lund University, Lund, Sweden. [9] Institute of Cardiovascular Science, University college London, London, United Kingdom. [10] Advanced cardiovascular imaging group, Sydney Medical School, University of Sydney, Sydney, New South Wales, Australia. [11] Department of Cardiology, Karolinska University Hospital, and Department of Clinical Physiology, Karolinska Institutet, Stockholm, Sweden. [12] University of Pittsburgh Medical Center, Pittsburgh, PA, USA.

Background

Cardiovascular magnetic resonance is the gold standard for measuring left ventricular volumes and mass, but would benefit from an improved measure of the balance between mass and volume in the evaluation of left ventricular hypertrophy. Our goal was therefore to derive a simple measure of mean left ventricular wall thickness, create normal reference ranges, and to evaluate its diagnostic and prognostic utility independently and incrementally over existing measures.

Methods

Subjects were examined at 1.5T and included healthy volunteers (*n*=99), athletes (*n*=86), and patients assessed for different heart diseases (*n*=2742). Mean wall thickness was measured using dedicated software, as the mean of 24 measurements in each short-axis slice covering the entire left ventricle. An equation using geometric assumptions was optimized to estimate mean wall thickness from left ventricular mass and end-diastolic volume.

Results

Estimated mean wall thickness agreed with measured mean wall thickness in an independent validation cohort (bias 0.01±0.23mm), and sex-specific normal ranges in healthy volunteers were determined. In patients without left ventricular dilatation, estimated mean wall thickness indexed to body surface area (WTI) was the measure that was most predictive of death or hospitalization for heart failure (log-rank 34.8, $p<0.0001$, Figure 1) compared to other previously reported anatomical measures of hypertrophy including left ventricular mass and mass-to-volume ratio.

The classification of patients as having eccentric or concentric hypertrophy is shown in Figure 2. Of patients with suspected heart disease but normal findings regarding left ventricular volumes and mass, 22% were found to have increased WTI corresponding to concentric remodeling.

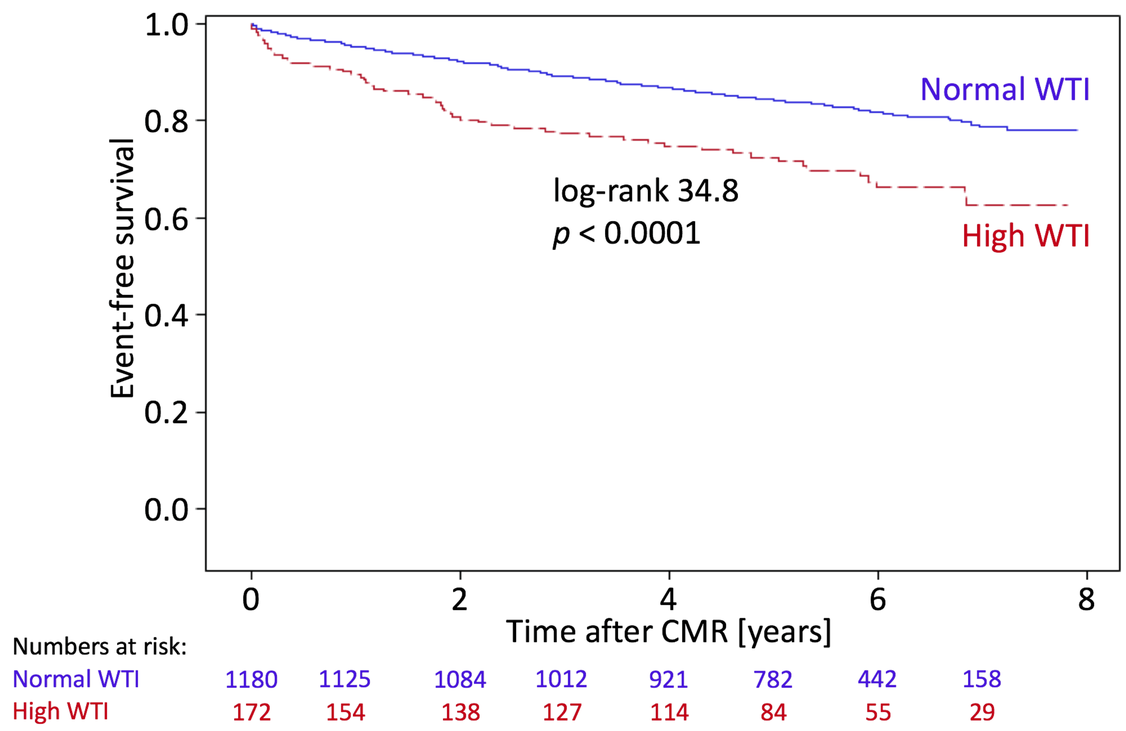

Figure 1. Kaplan–Meier curve showing survival free from hospitalization for heart failure or death in patients without left ventricular dilatation (normal EDVI), *n*=1352. Patients are stratified as having a WTI within (*n*=1180) or above (*n*=172) the sex-specific normal range.

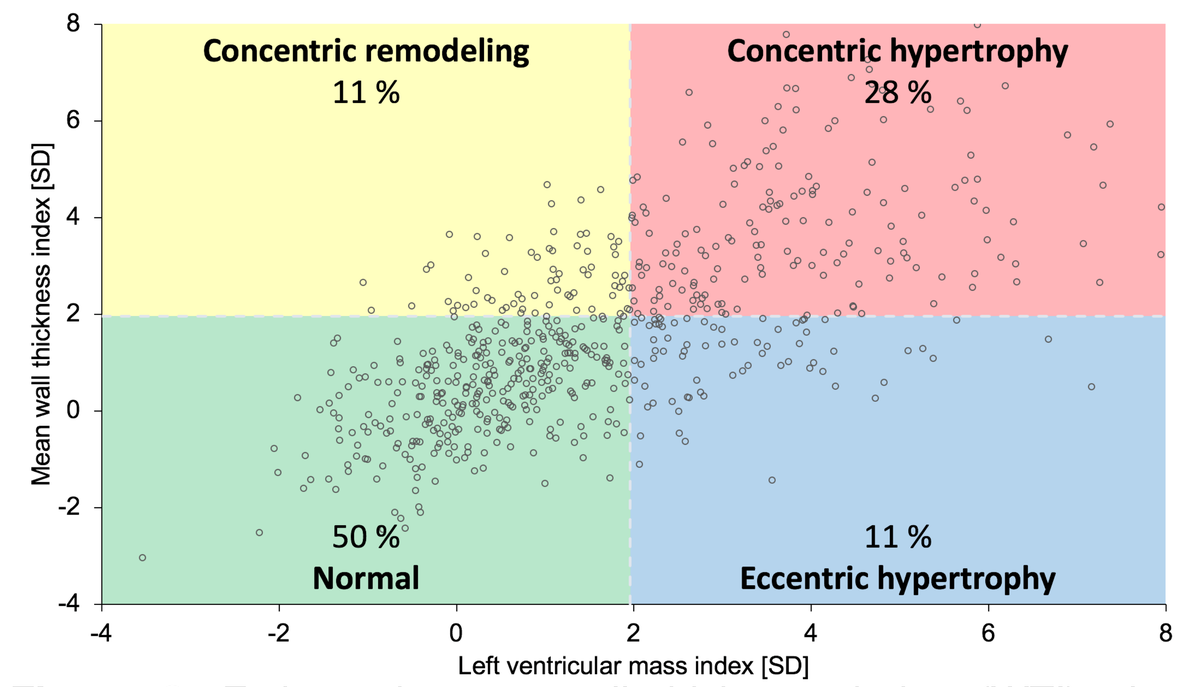

Figure 2. Estimated mean wall thickness index (WTI) plotted versus left ventricular mass index (LVMI) for an unselected clinical cohort (*n*=646). WTI and LVMI have been standardized to standard deviations (SD) from the sex-specific mean of healthy volunteers. Each black circle represents one patient and the borders between the colored fields are set at the upper limit of normal (+1.96 SD) for both WTI and LVMI. The colored fields show the classification of hypertrophy based on LVMI and WTI and the percentage of patients per class. The axes have been limited in order to reveal more detail, and 26 patients are therefore not shown.

Conclusions

Left ventricular mean wall thickness can be easily estimated from mass and volume with high accuracy. It agrees with measured mean left ventricular wall thickness and is the most prognostic measure compared to existing measures of hypertrophy in non-dilated left ventricles.

Magnus Lundin, MD PhD-student
Department of Clinical Physiology
Karolinska Institutet, Stockholm, Sweden

magnus.lundin@ki.se
www.karolinska-cmr.com

Karolinska Institutet