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ORIGINAL ARTICLE

# Left Ventricular Geometry and All-cause Mortality in Advanced Age

**Ruth O. Teh, PhD [a*], Ngaire M. Kerse, PhD [a], Elizabeth M. Robinson, MSc [b], Gillian A. Whalley, PhD [c], Martin J. Connolly, MD [d], Robert N. Doughty, MD [e]**

[a]Department of General Practice and Primary Health Care, University of Auckland
[b]Department of Epidemiology and Biostatistics, University of Auckland
[c]Faculty of Social and Health Sciences, Unitec Institute of Technology
[d]Freemasons' Department of Geriatric Medicine, University of Auckland
[e]Dept of Medicine and National Institute for Health Innovation, University of Auckland

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**Background** Abnormalities of cardiac structure and function are common in a wide range of populations including those with and without established clinical cardiovascular disease (CVD). This study reports the prevalence of left ventricular hypertrophy (LVH), the four patterns of LV geometry and establishes clinical characteristics and five-year outcomes of each group in people of advanced age.

**Method** A study conducted in general practices and Māori Health Services in three New Zealand North Island locations. One hundred participants had a full clinical echocardiogram performed and analysed in 2008 by one experienced cardiologist blinded to the participant's clinical history.

**Results** Two-thirds of the participants had CVD. Thirty-two participants had echocardiographic LVH. Those with LVH had higher left atrial area [median (IQR) 26.4 $cm^2$ (10.9) vs. 22.0 $cm^2$ (7.0), $p<0.01$] and E/e' [median (IQR) 13 (6.8) vs.10.8 (4.1), $p=0.01$] than those without LVH. Of those with LVH, 10 demonstrated concentric hypertrophy (CH) and 22 eccentric hypertrophy (EH); 12 concentric remodelling (CR) and 40 normal geometry (NG). Both CR and EH were independently associated with higher risk of all-cause mortality ($p<0.01$) and hospital admissions ($p<0.05$) than those with NG. Those with EH also had a higher risk of CVD events ($p=0.029$).

**Conclusions** Despite a high prevalence of CVD and hypertension in this sample, half had normal LV geometry. Concentric remodelling and eccentric hypertrophy were associated with higher mortality and adverse CVD outcomes in people of advanced age.

**Keywords** Aged • Left ventricular hypertrophy • Ventricular remodelling • Mortality • Cardiovascular diseases

## Introduction

The oldest old are the fastest growing population segment in New Zealand but have been under-represented in previous studies describing the prevalence and prognostic importance of abnormalities of cardiac structure and function [1,2]. Abnormalities of cardiac structure and function occur in a wide range of populations including those with and without established clinical cardiovascular disease (CVD). One of the most common adaptations is left ventricular hypertrophy (LVH) which

*Corresponding author at: Dept of General Practice and Primary Health Care, Faculty of Medical and Health Sciences, The University of Auckland, Private Bag 92019, Auckland Mail Centre, Auckland 1142 New Zealand. Tel.: +64 (09) 9237517; fax: +64 (09) 3737624, Emails: r.teh@auckland.ac.nz, ruthteh@hotmail.com

is also a well-recognised marker of adverse outcome in populations with and without hypertension and coronary artery disease [1,3].

LVH can be further subdivided into different geometric patterns using the relative wall thickness (RWT), which may be a better measure of LVH since it takes into account the overall size and wall thickness of the left ventricle [4]. Using this methodology, for those with LVH, two geometric patterns are defined: concentric hypertrophy (CH) and eccentric hypertrophy (EH). Those without LVH can be further categorised into normal geometry (NG) and concentric remodelling (CR), i.e. increased relative wall thickness without increase in LV mass. Concentric remodelling has been associated with adverse outcome in patients with hypertension [5] and importantly a reversal of the concentric remodelling pattern to NG has been associated with improved clinical outcome [6].

Understanding the prevalence of abnormalities of cardiac structure and function, and its implication among people of advanced age is important, as it cannot be assumed that similar prevalence and prognostic importance of such abnormalities will apply to this population as they do for younger populations. The aims of this study were to determine the prevalence of LVH and the four patterns of LV geometry among people of advanced age and establish the clinical characteristics and five-year outcomes (all-cause mortality, CVD events and hospital admissions) of each group.

# Methods

This study was initiated as part of the feasibility study [7] leading to the Life and Living to Advanced Age, a cohort study in New Zealand (LiLACS NZ) [8]. The study was initiated in January 2008 and data on hospital admission and mortality were collected in 2013. Participants were recruited through general practices and Māori Health Services from three New Zealand North Island locations and were stratified by ethnicity. The inclusion criteria were Māori born between 1929 and 1933 (aged 75 to 79 years in 2008) and all other ethnicities born in 1922 (aged 85 years in 2008). Māori participants were recruited at a younger age as there is an eight years gap in life expectancy between Māori and non-Māori [9]. The study was approved by the Multi-Region Ethics Committee, Ministry of Health New Zealand on 1 June 2007 (MEC/06/10/135). All study participants provided written informed consent.

## Measures

Socio-demographic, smoking status, use of prescribed medications and medical history were ascertained through a face-to-face interview. Physical assessments (height, weight and blood pressure) were completed by trained research nurses using standardised procedures. Fasting blood samples were collected and analysed for serum glucose, lipids and NT-proBNP. Echocardiography was performed by an experienced echocardiographer using a portable echocardiography machine (Sonosite MicroMaxx, Fuji Sonosite, Bothell, WA) according to the recommendations of the American Society of Echocardiography [4]. Images were recorded in digital format for offline analysis.

## Echocardiographic Measurements

All echocardiograms were analysed by one experienced cardiologist (who had no knowledge of the participant's clinical history) at the University of Auckland using an off-line workstation (Digiview®, Digisonics, Houston, TX). Each variable was measured in triplicate and the average of the three measurements used. The following measurements were made: i) LV mmode: LV end-diastolic dimension (LVEDD), LV end-systolic dimension (LVESD), interventricular wall (IVS) and posterior wall (PW) thickness both at end-diastole, ii) apical four-chamber left atrial area (LA area), iii) Mitral valve Doppler peak early filling velocity (E), iv) medial mitral annular tissue Doppler early diastolic (e') velocity. The following variables were calculated:

LV mass=0.8*[1.04[(LVEDD+PW+IVS)$^3$-(LVEDD)$^3$]]+0.6 g; relative wall thickness= (2xPW)/LVEDD; LV fractional shortening (LVEDD-LVESD)/LVEDDx100%; E/e'. LVM was indexed to height$^{2.7}$ (LVMi), and LV hypertrophy (LVH) defined as LVM/height$^{2.7}$ $\geq$44 g/m$^{2.7}$ for women and $\geq$48 g/m$^{2.7}$ for men. LVM was also indexed to body surface area (BSA), and LVH defined as LVM/BSA $\geq$95 g/m$^2$ for women and $\geq$115 g/m$^2$ for men [4]. LV geometry was categorised into four groups based on LVMi and RWT: normal geometry (NG: RWT$\leq$0.42 without LVH), concentric remodelling (CR: RWT>0.42 without LVH); concentric hypertrophy (CH: RWT>0.42 with LVH) and eccentric hypertrophy (EH: RWT$\leq$0.42 with LVH) [4].

Clinically manifest CVD was established by self-report CVD and from review of nationally held hospitalisation records [7]. Outcomes were ascertained through review of the nationally held mortality and hospitalisation records including and up to five years after initial assessment. Type 2 diabetes mellitus was ascertained from self-reported diabetes, records of glucose-lowering medications from the questionnaire, fasting serum glucose >7.0 mmol/L [10], or hospitalisation records of diabetes. Hypertension was defined as self-reported hypertension, records of prescribed medications indicated for hypertension from the questionnaire, an average of three seated blood pressure measurements with blood pressure >140/90 mmHg, isolated systolic hypertension (SBP>140 mmHg, DBP<90 mmHg) [11], or hospitalisation records of hypertension. Dyslipidaemia was defined as receiving treatment with lipid-lowering agents identified from the interview, hospitalisation records of hyperlipidaemia, or high fasting serum lipids for people aged 75+ according to the New Zealand Guidelines [12]. Medical records from the general practices were not available for viewing for the study.

## Statistical Analysis

Socio-demographic data are presented as frequencies and percentages. Continuous data was examined with histogram and box-plots, and are presented as mean and standard