ORIGINAL ARTICLE

Accuracy of Peguero-Lo Presti ECG Criteria for Left Ventricular Hypertrophy Diagnosis in Elderly Thai Patients Using Cardiovascular Magnetic Resonance as a Gold Standard

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Background: The conventional electrocardiogram (ECG) criteria have shown low sensitivity for LVH detection in the elderly.

Objective: To evaluate the diagnosis accuracy of the new ECG criteria proposed by Peguero-Lo Presti in this population using cardiovascular magnetic resonance (CMR) as a gold standard.

Materials and Methods: Patients older than 60 years that underwent CMR (1.5 T and 3 T, Philips) between 2012 and 2019 were included. Exclusion criteria were abnormal CMR findings and abnormal baseline ECG. Left ventricular mass index (LVMI) was calculated from short-axis slices covering the entire left ventricle. LVH was defined as LVMI of 63 g/m^2 or more in male patients and 48 g/m^2 or more in female patients. LVH by new ECG criteria was defined by the deepest S + SV4 of 2.8 or more in males and 2.3 or more in females. Sensitivity, specificity, and accuracy between the new criteria and the Cornell voltage criteria were compared.

Results: Five hundred fifty-nine patients were included with a mean age of 71±7 years old, and with 63.69% of female, 71.56% had hypertension, and 16.46% were octogenarian. Eighty patients (14.3%) had LVH detected by CMR. The new ECG criteria showed higher sensitivity compared with the Cornell voltage criteria especially in the octogenarian with a sensitivity of 15% versus 10% in overall and 31.25% versus 18.75% in octogenarian, but the AUC did not show significant difference at AUC of 0.56 versus 0.54 (p=0.67).

Conclusion: Using CMR as the gold standard, the new ECG criteria showed higher sensitivity than the Cornell voltage criteria, especially in the octogenarian, without significant different accuracy.

Keywords: Electrocardiography; Elderly population; Left ventricular hypertrophy; Cardiac magnetic resonance; Peguero-Lo Presti Criteria

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The size of the elderly population around the world has been increasing significantly during the past decades. Hypertension is a common disease in this group and left ventricular hypertrophy (LVH) is a major cause of morbidity[1]. In general, electrocardiogram (ECG) is the first diagnostic tool for LVH detection. Further, recent hypertension guideline has recommended ECG as a screening tool for LVH screening[2]. Among the many ECG criteria that have been proposed, the Cornell-voltage criteria have been accepted as one of the most accurate[3]. Previous studies have shown the low accuracy of ECG criteria for detecting LVH in elderly patients[4,5]. The changing electrical activity of an aging heart has been postulated as the reason for the low accuracy of current ECG criteria in this group of the population[6].

Recently, a study of the new ECG criteria, as proposed by Peguero-Lo Presti, was conducted for LVH detection[7]. The new criteria have defined LVH as the summation of maximum S wave in any ECG lead and the S wave in V4 (S_D + SV4) that exceeds 2.3 mV in women or 2.8 mV in men. It has demonstrated a higher sensitivity for LVH detection compared

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to conventional criteria, using echocardiography as a gold standard. However, the measurements from 2-dimensional echocardiography are operator-dependent and may lead to erroneous results, whereas cardiac magnetic resonance imaging (CMR) is less operator-dependent and more accurate[8,9]. Current practice guidelines recommend CMR as the gold standard for ventricular mass assessment, particularly in obese patients who have poor image quality by echocardiography. Studies exist that investigate the accuracy of the different ECG criteria for LVH detection by using CMR as the gold standard. However, none of these studies has been conducted in the elderly population[10,11]. The present study aimed to 1) investigate the diagnostic accuracy of the Peguero-Lo Presti ECG criteria for LVH detection in elderly Thai patients using CMR as the gold standard, and 2) compare the diagnosis accuracy between conventional Cornell voltage criteria and the new ECG criteria.

Materials and Methods

Population

Patients who underwent cardiac magnetic resonance imaging (MRI) between 2012 and 2019 at Ramathibodi Hospital were identified. Inclusion criteria were 1) 60-years-old or older and 2) 12-lead ECG and cardiac MRI performed on the same day. Exclusion criteria were 1) patients whose data were incomplete, 2) patients with abnormal cardiac MRI findings, including left ventricular dysfunction (EF of less than 55% by CMR, myocardial scar, congenital heart disease, pericardial disease, and 3) patients whose ECG manifested bundle branch block, atrial fibrillation, atrial flutter, Wolf Parkinson-White syndrome, and low-quality ECG. Octogenarian was defined as patients aged 80-years-old or older.

The present study was a retrospective cross-sectional study approved by the Ethics Committee of Ramathibodi Hospital, ethic number MURA2017/168/N_1.

CMR protocol and data analysis

All patients underwent CMR for the assessment of cardiac function, with left ventricular volume, mass, and ejection fraction. CMR studies were performed on a 1.5 T CMR scanner (Achieva 1.5 T, Philips Medical Systems, Best, The Netherlands) using a 32-channel SENSE Cardiac coil for signal reception. Cardiac function was evaluated by a steady-state free precession sequence (b-SSFP) with retrospective ECG gating: repetition time (TR) of 3 ms, echo time (TE) of 1.5 ms, flip angle (FA) at 60 degrees, field of view (FOV) at 340×340 mm^2, in-plane resolution at 1.8×1.8 mm, reconstruction matrix at 256×256, and slice thickness of 8 to 10 mm. All cine images in short-axis and three long-axis views of 4-chamber, 3-chamber, and 2-chamber, were acquired with 30 to 40 phases per cardiac cycle.

Analysis of CMR images

CMR Image analysis was performed using an independent workstation with dedicated software (Extended MR Workspace 2.6, Philips Healthcare). Left ventricular volume, mass and ejection fraction were analyzed by an experienced technician and two cardiologists with at least five years of experience in cardiac MRI and were blinded to the ECG results. The endocardial border of the left ventricle was automatically traced on the short-axis images in end-diastolic and end-systolic phases with additional manual adjustment. The left ventricle mass was measured in the end-diastolic phase and the papillary muscles were not included in the left ventricular mass calculation. Left ventricular ejection fraction (LVEF) was calculated automatically. The left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), and left ventricular mass (LVMASS) were indexed by body surface area (Mosteller formula). According to recently published data for normal cardiac MRI value in the Asian population, left ventricular hypertrophy was defined as LVMASSi of 63 g/m^2 or more in males and 48 g/m^2 or more in females[12].

12-lead ECG analysis

Standard 12-lead ECG was recorded at a 25 mm/second paper speed and a 1 mV/cm calibration carried out with patients in the supine position. Twelve-lead ECG was interpreted by an experienced investigator blinded to cardiac MRI results. Two ECG criteria for LVH diagnosis were evaluated in the present study, comprising the Peguero-Lo Presti and the Cornell voltage criteria. The criteria of LVH by Peguero-Lo Presti criteria was the sum of the deepest S in any lead plus S in V4 of 2.3 mV or greater in women and 2.8 mV or greater in men[7], whereas the criteria of LVH by the Cornell voltage was the sum of R in aVL plus S in V3 greater than 2.0 mV in women and greater than 2.8 mV in men[13].

Statistical analysis

Continuous data were presented as mean and standard deviation (SD), whereas categorical

Table 1. Baseline characteristics of patients with and without left ventricular hypertrophy defined by cardiac magnetic resonance

Characteristics	Overall (n=559)	LVH (n=80)	No LVH (n=479)	p-value
Female; n (%)	356 (63.69)	67 (83.75)	289 (60.33)	<0.001
Age (year); mean±SD	71±7	72±7	71±7	0.32
Body surface area (m^2); mean±SD	1.67±0.18	1.64±0.19	1.68±0.18	0.06
Body mass index (kg/m^2); mean±SD	25.74±4.30	26.33±4.28	25.64±4.30	0.19
Height (cm); mean±SD	158±8	154±8	158±8	<0.001
Hypercholesterolemia; n (%)	327 (58.50)	44 (55.0)	283 (59.08)	0.29
Diabetes mellitus; n (%)	146 (26.12)	21 (26.25)	125 (26.10)	0.54
Hypertension; n (%)	400 (71.56)	62 (77.50)	338 (70.56)	0.13
CMR variables; mean±SD				
LVEDVi (mL/m^2)	61.86±12.38	66.28±14.56	61.12±11.84	0.003
LVESVi (mL/m^2)	19.41±7.14	20.89±8.14	19.17±6.94	0.08
LVSVi (mL/m^2)	42.60±7.90	45.53±9.05	42.11±7.59	0.002
LVMI (g/m^2)	43.18±11.48	59.95±13.24	40.38±8.36	<0.001
LVEF (%)	69.42±7.07	68.96±7.77	69.50±6.96	0.56

SD=standard deviation; CMR=cardiac magnetic resonance; LVH=left ventricular hypertrophy; LVEDVi=left ventricular end-diastole index; LVESVi=left ventricular end-systole index; LVSVi=left ventricular stroke index; LVMI=left ventricular mass index; LVEF=left ventricular ejection fraction

Table 2. Sensitivity, specificity, positive predictive value and negative predictive value compared between Peguero-Lo Presti and Cornell voltage criteria in overall and octogenarian population

Age group	ECG criteria	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy
Overall	Cornell	10.0% (5 to 18)	97.49% (96 to 99)	40.0% (20 to 62)	86.64% (84 to 89)	84.97%
	Peguero-Lo Presti	15.0% (8 to 24)	93.53% (91 to 96)	27.91% (16 to 42)	86.82% (84 to 90)	82.29%
Age <80 years	Cornell	7.81% (3 to 16)	98.01% (96 to 99)	38.46% (16 to 65)	87.0% (84 to 90)	85.65%
	Peguero-Lo Presti	10.94% (5 to 18)	93.55% (91 to 96)	21.21% (10 to 37)	86.87% (84 to 90)	82.23%
Age ≥80 years	Cornell	18.75% (5 to 42)	94.74% (96 to 99)	42.86% (13 to 77)	84.71% (76 to 91)	81.52%
	Peguero-Lo Presti	31.25% (13 to 56)	93.42% (86 to 98)	50.0% (22 to 78)	86.56% (78 to 93)	82.61%

CI=confidence interval; ECG=electrocardiogram; PPV=positive predictive value; NPV=negative predictive value

data were presented as numbers and percentages. Comparison of continuous data was made by the student t-test for unpaired data and comparison of categorical data was made by the chi-square test. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive and negative likelihood ratio, and accuracy were calculated for both ECG criteria. A p-value of less than 0.05 was considered statistically significant. Using the ROC, the area under curve (AUC) was compared between Cornell and Peguero-Lo Presti criteria. IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA) was used for data analysis. All statistical analyses were performed using SPSS Statistics, version 17.0 (SPSS Inc., Chicago, IL, USA).

Results

Five hundred fifty-nine patients were included, with 356 patients (63.69%) being female. Mean age was 71±7 years. Of the 559 patients, 400 (71.56%) were diagnosed with hypertension. Left ventricular hypertrophy was diagnosed by CMR in 80 patients (14.3%), with 68 patients being female (85%). Mean blood pressure at the time of scanning was 129.7±15.5 mmHg. Baseline characteristics of the patients with and without LVH are shown in Table 1. There was a significantly higher number of females in the LVH group compared with the no LVH group. The left ventricular size, defined by LVEDVi and LVESVi, was also higher in the LVH group although the LVEF was not significantly different.

Twenty patients (3.58%) were diagnosed with LVH by Cornell criteria, whereas 46 patients (8.23%) were diagnosed by Peguero-Lo Presti criteria. Table 2 shows the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the two ECG criteria. Overall, the sensitivity of the Peguero-Lo Presti criteria was higher than the Cornell voltage criteria. The accuracy of the new criteria was

Table 3. Baseline characteristics of octogenarian and non-octogenarian patients

	Octogenarian (n=92)	Non-octogenarian (n=467)	p-value
Female; n (%)	63 (68.48)	293 (62.74)	0.18
Height (cm); mean±SD	155±8	158±9	<0.001
Body surface area (m^2); mean±SD	1.60±0.16	1.68±0.18	<0.01
Body mass index (kg/m^2); mean±SD	25.0±4.39	25.88±4.27	0.08
Hypercholesterolemia; n (%)	51 (55.43)	276 (59.10)	0.30
Diabetes mellitus; n (%)	26 (28.26)	120 (25.70)	0.35
Hypertension; n (%)	75 (81.52)	325 (69.59)	0.01
CMR variables; mean±SD			
LVEDVi (mL/m^2)	60.53±13.83	62.12±12.07	0.31
LVESVi (mL/m^2)	19.10±8.22	19.48±6.91	0.68
LVSVi (mL/m^2)	42.09±9.23	42.70±7.61	0.50
LVMI (g/m^2)	44.18±11.01	43.0±11.57	0.35
LVEF (%)	70.18±7.21	69.28±7.04	0.28
Patients with LVH; n (%)	16 (17.39)	64 (13.70)	0.22

SD=standard deviation; CMR=cardiac magnetic resonance; LVH=left ventricular hypertrophy; LVEDVi=left ventricular end-diastole index; LVESVi=left ventricular end-systole index; LVSVi=left ventricular stroke index; LVMI=left ventricular mass index; LVEF=left ventricular ejection fraction

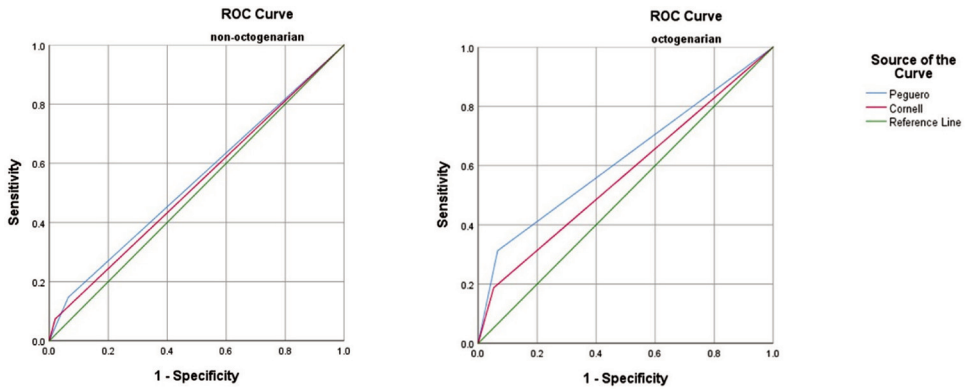

Figure 1. Compares area under curve (AUC) between Peguero-Lo Presti criteria and Cornell criteria in non-octogenarian (left) and octogenarian group (right). The AUC of Peguero-Lo Presti criteria were 0.52 and 0.62 in non-octogenarian and octogenarian patients respectively whereas the AUC of Cornell criteria were 0.53 and 0.57 respectively.

higher than the Cornell voltage criteria, but it did not reach statistical difference with AUC of 0.56 versus 0.54 (p=0.67).

There were 92 octogenarian patients with a mean age of 83±3 years and 63 were female (68.48%), and 16 patients demonstrated LVH by CMR. The LVEDVi, LVEF, and LV mass index were not significantly different between octogenarian and non-octogenarian populations (Table 3). Ten patients were diagnosed LVH by Peguero-Lo Presti criteria, whereas seven patients were diagnosed LVH by Cornell voltage criteria. The sensitivity of the Peguero-Lo Presti was higher than the Cornell voltage criteria at 31.25% versus 18.75% with similar specificity at 93.42% versus 94.74% as shown in Table 2. The AUC of the new criteria was higher than the Cornell criteria in the octogenarian group but did not reach statistical significance (Figure 1).

Discussion

The present study was a retrospective cross-sectional study aimed to investigate the accuracy of LVH detected by the new Peguero-Lo Presti ECG criteria and compare its accuracy with the conventional Cornell voltage criteria in the elderly population. The authors found the new ECG criteria had a higher sensitivity compared with the Cornell voltage criteria, especially in octogenarian group, although the specificity and accuracy were not significantly different in the overall.

The accuracy of ECG criteria for LVH detection in elderly patients is not as good as in the general

population[5,13]. In elderly patients with LVH, the chamber grows leftward, inferiorly, and posteriorly, which results in the change of direction and magnitude of the ECG vector[6]. Because of the vector changing, the Peguero-Lo Presti ECG criteria, which use the summation of deepest S wave in any lead and S wave in lead V4, could lead to better LVH detection compared with conventional criteria, which analyze the depth of R and S wave in fix leads. The QRS axis in the present study octogenarian patients was more leftward than the non-octogenarian at 9.5 versus 23 (p=0.06), and the sensitivity of the new criteria was especially higher than the conventional Cornell voltage criteria in the octogenarian population at 31.25% versus 18.75%. However, the overall sensitivity of the new criteria in the present study was much lower compared with the original study[7]. There are explanations for this difference. First, the authors used left ventricular measurements from CMR instead of 2D-echocardiography. Although CMR has been considered the gold standard imaging modality for ventricular mass measurements due to a better image quality and inter- and intra-observer measurement[14-16], the prevalence of LVH defined by CMR is lower than echocardiography[11]. Armstrong et al. performed a comparison study between CMR and echocardiography, found that the left ventricular mass was higher when assessed by echocardiography[9]. In addition, the cut-off value of LVH detection in the present study was different from the Peguero-Lo Presti study. The authors used the cut-off value for Asian population because, compared with the Caucasian population, the Asian Chinese population had lower left ventricular mass that remained even after normalizing to body surface area[12]. Hence, the different imaging modality and different cut-off left ventricular mass value can explain the different sensitivity of the new criteria between the present study and a previous one[7].

In addition, the population ethnicity has an impact on diagnosis accuracy. In the MESA study used CMR as the gold standard, the accuracy of ECG criteria for LVH detection was different between different ethnicities with the lowest sensitivity in the Chinese ethnicity[10]. The authors found similar accuracy of Cornell voltage criteria in the present study and the MESA-Chinese ethnicity with ROC of 0.53 and 0.56, respectively. This finding suggests that the accuracy of ECG for LVH detection is ethnic-dependent and could explain the lower accuracy of ECG criteria in the present study compared with the Caucasian population in the Peguero-Lo Presti study.

It should be noted that the Peguero-Lo Presti criteria is modeled on a hypertensive crisis population with high prevalence of LVH of 60% in the test group. A recent study from Sun et al. showed that, when applying the new criteria in the general Chinese population, its accuracy was lower than the conventional Cornell voltage or Sokolow-Lyon criteria[17]. The present study population had well-controlled blood pressure with mean blood pressure of 129.7±15.5 mmHg. Further, the sensitivity of the new criteria in the present study was not different from the sensitivity in the Sun et al. study at 31.25% versus 33%. Thus, the accuracy of Peguero-Lo Presti criteria in the general population might not be as high as demonstrated in the hypertensive crisis population.

Left ventricular hypertrophy is an independent risk factor for cardiovascular disease[18] and current guidelines for the management of patients with hypertension have recommended ECG as a screening tool for LVH detection[2]. ECG criteria with high sensitivity should be given the first priority as a screening tool for LVH detection. Because the Peguero-Lo Presti ECG criteria showed high sensitivity for LVH detection, especially among the octogenarian population, it should be considered as screening ECG criteria in this group of population.

Limitation

The present study included patients who were sent for stress CMR. Although the authors excluded patients with a history of coronary artery disease and abnormal CMR findings, the present study population did not reflect the healthy general population. In addition, most patients with LVH were female, meaning gender inequality should be considered. Also, the number of octogenarian patients in the present study was small at 92 patients. Finally, the left ventricular mass in the present study was indexed by body surface area because the authors used the cut-off value based on study of the Asian population[12]. Brumback et al. showed the prevalence of left ventricular hypertrophy differs between different body-adjustment methods with the highest prevalence in height indices method[19]. Therefore, the accuracy of the new criteria can be varied according to the body index adjustment.

Conclusion

Using CMR as the gold standard for LVH detection in elderly patients, the new ECG criteria, showed higher sensitivity than the Cornell voltage criteria, especially in octogenarian patients.

What is already known on this topic?

Previous study showed the high accuracy of Peguero-Lo Presti ECG criteria for LVH detection in the western population. However, a study in Chinese population, using echocardiography as the gold standard, demonstrated the accuracy of the new criteria was not significantly higher than the conventional criteria.

What this study adds?

This study showed that although the Peguero-Lo Presti criteria showed higher sensitivity than the Cornell voltage criteria, especially in the octogenarian, the accuracy of the new criteria was not significantly higher than the conventional criteria. Therefore, the present study data confirmed that the accuracy of the new criteria in the Asian population was not as high as the western population.

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Conflicts of interest

On behalf of all authors, the corresponding author states that there are no conflicts of interest.

References

1. Jissho S, Shimada K, Taguchi H, Yoshida K, Fukuda S, Tanaka H, et al. Impact of electrocardiographic left ventricular hypertrophy on the occurrence of cardiovascular events in elderly hypertensive patients. - The Japanese trial to assess optimal systolic blood pressure in elderly hypertensive patients (JATOS). Circ J 2010;74:938-45.
2. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur Heart J 2018;39:3021-104.
3. Krittayaphong R, Nomsawadi V, Muenkaew M, Miniphan M, Yindeengam A, Udompunturak S. Accuracy of ECG criteria for the diagnosis of left ventricular hypertrophy: a comparison with magnetic resonance imaging. J Med Assoc Thai 2013;96 Suppl 2:S124-32.
4. Casiglia E, Maniati G, Daskalakis C, Colangeli G, Tramontin P, Ginocchio G, et al. Left-ventricular hypertrophy in the elderly: unreliability of ECG criteria in 477 subjects aged 65 years or more. The CArdiovascular STudy in the ELderly (CASTEL). Cardiology 1996;87:429-35.
5. Laszlo R, Kunz K, Dallmeier D, Klenk J, Denkinger M, Koenig W, et al. Accuracy of ECG indices for diagnosis of left ventricular hypertrophy in people >65 years: results from the ActiFE study. Aging Clin Exp Res 2017;29:875-84.
6. Mihalick MJ, Fisch C. Electrocardiographic findings in the aged. Am Heart J 1974;87:117-28.
7. Peguero JG, Lo Presti S, Perez J, Issa O, Brenes JC, Tolentino A. Electrocardiographic criteria for the diagnosis of left ventricular hypertrophy. J Am Coll Cardiol 2017;69:1694-703.
8. Mor-Avi V, Sugeng L, Weinert L, MacEneaney P, Caiani EG, Koch R, et al. Fast measurement of left ventricular mass with real-time three-dimensional echocardiography: comparison with magnetic resonance imaging. Circulation 2004;110:1814-8.
9. Armstrong AC, Gidding S, Gjesdal O, Wu C, Bluemke DA, Lima JA. LV mass assessed by echocardiography and CMR, cardiovascular outcomes, and medical practice. JACC Cardiovasc Imaging 2012;5:837-48.
10. Jain A, Tandri H, Dalal D, Chahal H, Soliman EZ, Prineas RJ, et al. Diagnostic and prognostic utility of electrocardiography for left ventricular hypertrophy defined by magnetic resonance imaging in relationship to ethnicity: the Multi-Ethnic Study of Atherosclerosis (MESA). Am Heart J 2010;159:652-8.
11. Armstrong AC, Gjesdal O, Almeida A, Nacif M, Wu C, Bluemke DA, et al. Left ventricular mass and hypertrophy by echocardiography and cardiac magnetic resonance: the multi-ethnic study of atherosclerosis. Echocardiography 2014;31:12-20.
12. Le TT, Tan RS, De Deyn M, Goh EP, Han Y, Leong BR, et al. Cardiovascular magnetic resonance reference ranges for the heart and aorta in Chinese at 3T. J Cardiovasc Magn Reson 2016;18:21.
13. Casale PN, Devereux RB, Kligfield P, Eisenberg RR, Miller DH, Chaudhary BS, et al. Electrocardiographic detection of left ventricular hypertrophy: development and prospective validation of improved criteria. J Am Coll Cardiol 1985;6:572-80.
14. Myerson SG, Bellenger NG, Pennell DJ. Assessment of left ventricular mass by cardiovascular magnetic resonance. Hypertension 2002;39:750-5.
15. Bottini PB, Carr AA, Prisant LM, Flickinger FW, Allison JD, Gottdiener JS. Magnetic resonance imaging compared to echocardiography to assess left ventricular mass in the hypertensive patient. Am J Hypertens 1995;8:221-8.
16. Marwick TH, Neubauer S, Petersen SE. Use of cardiac magnetic resonance and echocardiography in population-based studies: why, where, and when? Circ Cardiovasc Imaging 2013;6:590-6.
17. Sun GZ, Wang HY, Ye N, Sun YX. Assessment of Novel Peguero-Lo Presti electrocardiographic left

ventricular hypertrophy criteria in a large Asian population: Newer may not be better. Can J Cardiol 2018;34:1153-7.
18. Yatsuya H, Matsunaga M, Li Y, Ota A. Risk factor of cardiovascular disease among older individuals. J Atheroscler Thromb 2017;24:258-61.
19. Brumback LC, Kronmal R, Heckbert SR, Ni H, Hundley WG, Lima JA, et al. Body size adjustments for left ventricular mass by cardiovascular magnetic resonance and their impact on left ventricular hypertrophy classification. Int J Cardiovasc Imaging 2010;26:459-68.