The Journal of Clinical Hypertension

WILEY

COMMENTARY OPEN ACCESS

Left Ventricular Geometry and Optimal Blood Pressure Target

Cesare Cuspidi[1] | Marijana Tadic[2] | Guido Grassi[1]

[1]Department of Medicine and Surgery, University of Milano-Bicocca, Milano, Italy | [2]University Heart Center Ulm, University Ulm, Ulm, Germany

Correspondence: Cesare Cuspidi (cesare.cuspidi@unimib.it)

Received: 4 May 2026 | **Revised:** 4 May 2026 | **Accepted:** 14 May 2026

Keywords: cardiovascular events | intensive blood pressure lowering | left ventricular geometry

Left ventricular hypertrophy (LVH), a cardinal marker of hypertensive mediated organ damage (HMOD), is a complex cardiac phenotype resulting from the response of myocyte and non-myocyte components to mechanical (i.e. pressure overload) and neuro-humoral stimuli [1]. LVH, assessed LVH by electrocardiography (ECG) or more accurately by echocardiography (ECHO), is a powerful predictor of cardiovascular(CV) prognosis over and beyond conventional risk factors in hypertensive cohorts and population-based samples as well as different clinical settings including diabetes, chronic renal disease, heart failure, and coronary artery disease [2–4]. Among noninvasive tools for evaluation of cardiac anatomy and function in hypertensive patients, transthoracic ECHO is the most largely used, and the reference metrics for LVH is LV mass (LVM) indexed to body surface area (BSA) or height to various allometric exponents [5].

A large body of evidence, collected over the last four decades, has shown a direct association between LVM index (LVMI) over a wide range of values and risk of CV events and all-cause death, suggesting a continuous relationship between LVMI and outcomes, starting even below the diagnostic threshold of LVH [6].

On the contrary, the clinical and prognostic relevance of LV geometry patterns has been less investigated and is still the subject of debate to date. Whether abnormal LV geometry patterns carry prognostic information beyond that provided by LVMI is still uncertain. Traditional classification of LV geometry, based on LVMI and relative wall thickness (the ratio of wall thickness to cavity diameter) encompasses four LV phenotypes, namely, normal geometry, concentric remodeling (CR), eccentric and concentric LVH [7]. These patterns differ in several respects, such as hemodynamic profile, plasma volume blood pressure (BP) levels, LV diastolic function, LV mechanics, and the extent of extracardiac HMOD [8]. A meta-analysis of height studies including 712 hypertensive patients (234 normal geometry, 97 CR, 176 eccentric LVH, and 205 concentric LVH) showed that global longitudinal strain gradually deteriorated from pariticipants with normal LV geometry (19.5±0.6%), across those with concentric remodeling (18.8±0.7%), eccentric (17.6±0.7%) and concentric LVH (16.5+0.6%, p<0.001), respectively [9]. More importantly, many studies have suggested that the assessment of LV geometry may improve CV risk stratification in patients with hypertension, and, in particular, concentric LVH has been reported to be associated with the highest risk [10, 11].

The study by Zhu et al. [12], published in this Journal, provides important new information into this complex research scenario by addressing several uninvestigated aspects such as the prevalence of LV patterns based on ethnicity specific diagnostic criteria compared to international guidelines; the value in predicting the CV outcomes, and, whether or not the impact of intensive BP control on prognosis can be influenced by LV geometry.

For this purpose, 7680 hypertensive patients (mean age 61 yrs, 20% obese, 18% active smoking) at high CV disease risk categorized into four LV geometry groups: normal geometry, CR, eccentric LVH, and concentric LVH were recruited and followed for a median follow-up of 3.5 years. At entry, the prevalence of the four LV geometric patterns, defined according to Echocardiographic Measurement in Normal Chinese Adults (EMINCA) [13] diagnostic thresholds was as follows: 68% normal geometry, 7.8% CR, 19.6% eccentric LVH, 4.6% concentric LVH and 29%, 28%, 15% and 25%, according to American Society of Echocardiography and

European Association of Cardiovascular Imaging (ASE/EACVI) guidelines, respectively [14]. This finding expands the view that the prevalence of abnormal LV geometric patterns in Chinese hypertensive patients is significantly lower with ethnic-specific reference diagnostic thresholds than that by the ASE/ EACVI criteria. Furthermore, eccentric LVH emerged as the prevalent type of LVH contrary to what is observed with ASE/ EACVI criteria. Despite these differences, both abnormal LV geometric patterns were significantly associated with the incident, the primary endpoint (i.e. CV death, myocardial infarction, stroke, hospitalization for coronary artery diseases and heart failure). However, this was not the case for secondary endpoints for which the EMINCA criteria performed better in stratifying the risk. More importantly, the study provides a novel contribution to the long-standing controversy regarding the benefits and risks of intensive antihypertensive therapy in patients with LVH.

Before further analyzing and discussing the results of the study by Zhu et al. [12], it's useful to briefly summarize previous evidence regarding the prognostic significance of LV geometric patterns and the differential impact of intensive BP lowering.

A growing evidence on the prognostic significance of LV geometric patterns has accumulated over the last 15 years thanks to the introduction of an updated classification that identifies four subtypes of LVH (i.e., eccentric non-dilated and eccentric dilated LVH, concentric non-dilated and concentric dilated LVH) providing a better graduation of CV risk. The Dallas Heart Study, carried out in a population-based sample of 2803 residents of Dallas County, reported that individuals with eccentric-non dilated LVH, at variance from the other LVH types, had similar levels of LV function and biomarkers of cardiac stress as compared to their counterparts without LVH, thus suggesting that a mild increase in LVMI, not associated to abnormal LV mass/end diastolic volume ratio, has a marginal impact on LV performance and CV prognosis [15]. The predictive value of this new classification was investigated in 1716 members of the Pressioni Monitorate E Loro Associazioni (PAMELA) population study in which only concentric-non-dilated LVH but not CR, eccentric-non-dilated, and dilated LVH remained a predictor of the ten-year risk of total and CV mortality independently of LVMI [16]. As for the hypertensive setting, Verdecchia et al. [17], studying a cohort of 3635 initially untreated patients over a 10-year period, demonstrated that the excess risk for CV disease associated with abnormal LV geometric patterns was no longer significant after adjusting for several confounders and baseline LVMI values.

A key open question remains the optimal antihypertensive strategy for hypertensive patients with LVH and, in particular, the protective role of intensive BP lowering. The researchers of the Cardio-Sis study, including 1111 nondiabetic patients randomly assigned to a systolic BP (SBP) target <140 mm Hg (standard control) or <130 mm Hg (tight control), stratified by absence or presence of established CV disease at entry, showed that ECG LVH occurred less frequently in the tight than in the standard control group in the patients without (10.8% vs. 15.2%) and with (14.1% vs. 23.5%) CV disease [18]. The data subsequently provided by the Strategy of BP Intervention in the Elderly Hypertensive Patients (STEP) trial carried out in 7141 older patients with hypertension were in line with those found in the Cardio-Sis trial [19]. That is intensive SBP lowering (110–130 mmHg) was associated with a significantly lower risk of new LVH occurrence (−24%, p = 0.001) and slower progression of the mean Peguero-Lo Presti index value compared to standard treatment (130–150 mmHg). A meta-analysis performed on data from four trials comprising a total of 20 747 hypertensive patients revealed that intensive BP lowering was linked with a diminished LVH incidence (−34%) and an increased likelihood of LVH regression (−21%), as well as with a reduced risk of CV disease (−29%) [20]. In contrast, a post hoc analysis of the Losartan Intervention for Endpoint Reduction (LIFE) Study showed that patients achieving an average SBP ≤130 mmHg had a 37% increase in all-cause mortality ($p = 0.005$) and a 32% increase in CV mortality ($p = 0.08$) compared to those who achieved an average SBP of ≥142 mmHg [21]. In line with the LIFE study, the Valsartan Antihypertensive Long-Term Use Evaluation (VALUE) trial documented that the ECG-LVH group achieving an average SBP <130 mmHg had higher cardiac mortality (hazard ratio, 1.98, $p = 0.032$) and all-cause mortality (hazard ratio, 1.74; $p = 0.007$) than their counterparts with higher on-treatment BP levels [22].

Unfortunately, ECHO-based evidence that could help clarify this controversial issue is limited to a very few studies. The largest of them, the Campania Salute Network Registry comprising 9511 hypertensive patients, demonstrated that the reduction of SBP < 130 mmHg in the subgroup with ECHO-LVH (i.e. > 50 g/h$^{2.7}$ in men and 47 g/h$^{2.7}$) was associated with significantly attenuated rates of CV events (a composite of fatal or non-fatal myocardial infarction and stroke, sudden cardiac death, and carotid stenting) which were no longer different from those without LVH [23]. The Japan Morning Surge-Home BP (J-HOP) Study showed participants with ECHO-LVH had higher incident rates of total CV events compared to those without LVH, but this was not the case in the controlled BP group (i.e. morning home SBP < 135/85 mmHg, average 125.4 mmHg) [24].

In this scenario characterized by conflicting and still lacking data, the study by Zhu et al. [12] offers an important contribution on the complex relationship between BP lowering targets CV outcomes and LV geometric patterns in the hypertensive setting, further highlighting the superiority the use of ethnic-specific ECHO diagnostic criteria in phenotyping cardiac HMOD in Asian populations. In agreement with the findings provided from previous observational ECHO studies [23, 24], but at the same time going a step further, these authors suggest that intensive SBP reduction (i.e <130 mmHg) improved CV prognosis exclusively in the subgroup of patients with concentric LVH and, conversely, the opposite occurred in patients with CR. Indeed, the relationship between SBP and CV events in this subgroup was characterized by a *J*-type curve, with an excess risk for the primary outcome and hospitalization for CAD, more evident for the patients aged over 50 years.

In conclusion, although the study by Zhu et al. [12] is worthy of attention, its potential clinical implications should be taken with caution as it based on a retrospective observational design, with a relatively short follow-up period (i.e. < 4 years), without taking into account serial changes in BP and ECHO parameters, and last, but not least, not applicable to non-Asian populations. Thus, the need to define the optimal BP target in patients with altered ventricular structure and geometry can no longer be postponed to make a step forward in CV protection of high-risk patients [25].

Author Contributions

Manuscript drafting: CC, MT, GG, Supervision: CC. Each author contributed significant intellectual content during the drafting or revision of the manuscript and accepted responsibility for the overall work by ensuring that any questions regarding the accuracy or integrity of any part of the work were thoroughly investigated and resolved.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. M. Tadic, C. Cuspidi, and T. H. Marwick, "Phenotyping the Hypertensive Heart," *European Heart Journal* 43, no. 38 (2022): 3794–3810.

2. H. Zhang, L. Hu, and X. Wei, "Prognostic Value of Left Ventricular Hypertrophy in Hypertensive Patients: A Meta-Analysis of Electrocardiographic Studies," *Journal of Clinical hypertension* 22 (2020): 254–260.

3. R. S. Vasan, E. M. Urbina, L. Jin, and V. Xanthakis, "Prognostic Significance of Echocardiographic Measures of Cardiac Remodeling in the Community," *Current Cardiology Reports* 23, no. 7 (2021): 86.

4. B. T. Özbek, D. Modin, R. Møgelvang, et al., "Echocardiographic Predictors of Long-Term Adverse Cardiovascular Outcomes in Participants With and Without Diabetes Mellitus: A Follow-up Analysis of the Copenhagen City Heart Study," *Diabetic Medicine* 38, no. 10 (2021): e14627.

5. J. W. McEvoy, C. P. McCarthy, R. M. Bruno, et al., "2024 ESC Guidelines for the Management of Elevated Blood Pressure and Hypertension," *European Heart Journal* 45 (2024): 3912–4018.

6. G. Schillaci, P. Verdecchia, C. Porcellati, O. Cuccurullo, C. Cosco, and F. Perticone, "Continuous Relation Between Left Ventricular Mass and Cardiovascular Risk in Essential Hypertension," *Hypertension* 35 (2000): 580–586.

7. A. Ganau, R. B. Devereux, M. J. Roman, et al., "Patterns of Left Ventricular Hypertrophy and Geometric Remodeling in Essential Hypertension," *Journal of the American College of Cardiology* 19 (1992): 1550–1558.

8. R. Maimaitiaili, J. Teliewubai, S. Zhao, et al., "Relationship Between Vascular Aging and Left Ventricular Concentric Geometry in Community-Dwelling Elderly: The Northern Shanghai Study," *Clinical Interventions in Aging* 15 (2020): 853–863.

9. M. Tadic, C. Sala, S. Carugo, G. Mancia, G. Grassi, and C. Cuspidi, "Myocardial Strain and Left Ventricular Geometry: A Meta-Analysis of Echocardiographic Studies in Systemic Hypertension," *Journal of Hypertension* 39 (2021): 2297–2306.

10. P. Verdecchia, G. Schillaci, C. Borgioni, et al., "Prognostic Value of Left Ventricular Mass and Geometry in Systemic Hypertension With Left Ventricular Hypertrophy," *American Journal of Cardiology* 78 (1996): 197–202.

11. W. Lieb, P. Gona, M. G. Larson, et al., "The Natural History of Left Ventricular Geometry in the Community: Clinical Correlates and Prognostic Significance of Change in LV Geometric Pattern," *JACC Cardiovasc Imaging* 7 (2014): 870–878.

12. Y. Zhu, Z. Nie, D. Zhou, et al., "Differential Influences of Achieved Blood Pressure on Cardiovascular Outcomes by Left Ventricular Geometries According to Chinese Ethnicity-Specitic Echocardiographic Criteria for Hypertensive Patients," *Journal of Clinical Hypertension* (2026).

13. Y. Sheng, M. Li, M. Xu, et al., "Left Ventricular and Atrial Remodelling in Hypertensive Patients Using Thresholds From International Guidelines and EMINCA Data," *European Heart Journal - Cardiovascular Imaging* 23 (2022): 166–174.

14. T. H. Marwick, T. C. Gillebert, G. Aurigemma, et al., "Recommendations on the use of Echocardiography in Adult Hypertension: A Report From the European Association of Cardiovascular Imaging (EACVI) and the American Society of Echocardiography (ASE)," *European Heart Journal – Cardiovascular Imaging* 16 (2015): 577–605.

15. C. N. Bang, E. Gerdts, G. P. Aurigemma, et al., "Four-Group Classification of Left Ventricular Hypertrophy Based on Ventricular Concentricity and Dilatation Identifies a low-Risk Subset of Eccentric Hypertrophy in Hypertensive Patients," *Circulation: Cardiovascular Imaging* 7 (2014): 422–429.

16. C. Cuspidi, R. Facchetti, M. Bombelli, et al., "Risk of Mortality in Relation to an Updated Classification of Left Ventricular Geometric Abnormalities in a General Population: The Pamela Study," *Journal of Hypertension* 33 (2015): 2133–2140.

17. P. Verdecchia, F. Angeli, G. Mazzotta, et al., "Impact of Chamber Dilatation on the Prognostic Value of Left Ventricular Geometry in Hypertension," *Journal of the American Heart Association* 6, no. 6 (2017): e005948, https://doi.org/10.1161/JAHA.117.005948.

18. G. Reboldi, F. Angeli, G. De Simone, J. A. Staessen, and P. Verdecchia, "Tight Versus Standard Blood Pressure Control in Patients With Hypertension With and Without Cardiovascular Disease," *Hypertension* 63 (2014): 475–482.

19. Y. Deng, W. Liu, X. Yang, et al., "Intensive Blood Pressure Lowering Improves Left Ventricular Hypertrophy in Older Patients With Hypertension: The STEP Trial," *Hypertension* 80 (2023): 1834–1842.

20. Y. Soliman, A. Nazir, M. Abuelazm, A. Seri, A. Mahmoud, and B. Abdelazeem, "The Effect of Intensive Blood Pressure Lowering on Left Ventricular Hypertrophy in Patients With Hypertension: A Systematic Review and Meta-Analysis of Randomized Controlled Trials," *Proceedings (Baylor University Medical Center)* 37 (2024): 700–704.

21. P. M. Okin, D. A. Hille, S. E. Kjeldsen, B. Dahlöf, and R. B. Devereux, "Impact of Lower Achieved Blood Pressure on Outcomes in Hypertensive Patients," *Journal of Hypertension* 30 (2012): 802–810.

22. S. Heimark, M. H. Mehlum, G. Mancia, et al., "Middle-Aged and Older Patients With Left Ventricular Hypertrophy: Higher Mortality With Drug Treated Systolic Blood Pressure Below 130 Mm Hg," *Hypertension* 80 (2023): 1739–1748.

23. M. Lembo, V. Trimarco, R. Izzo, et al., "Achieving a Systolic Blood Pressure Below 130 Mmhg Reduces the Incidence of Cardiovascular Events in Hypertensive Patients With Echocardiographic Left Ventricular Hypertrophy," *Journal of Pharmacology and Experimental Therapeutics* 390 (2024): 4–10.

24. T. Fujiwara, S. Hoshide, and K. Kario, "Association Between Home Blood Pressure Control Status and Cardiovascular Prognosis in Participants With Left Ventricular Hypertrophy: The J-HOP Study," *Journal of Hypertension* 43 (2025): 1793–1801.

25. S. E. Kjeldsen, B. Egan, G. Mancia, J. E. Mariampillai, S. Heimark, and M. Burnier, "Target Systolic Blood Pressure in Patients With Left Ventricular Hypertrophy," *European Journal of Internal Medicine* 146 (2026): 106760, https://doi.org/10.1016/j.ejim.2026.106760.