

Treating Visit-to-Visit Blood Pressure Variability to Improve Prognosis Is Amlodipine the Drug of Choice?

Anastasios Kollias, George S. Stergiou, Konstantinos G. Kyriakoulis, Grzegorz Bilo, Gianfranco Parati

Blood pressure (BP) levels are linearly associated with cardiovascular risk, and hypertension is the most common modifiable risk factor for cardiovascular disease.¹ Moreover, antihypertensive treatment-induced BP lowering has been associated with reduction in all outcomes (stroke, heart failure, coronary events, cardiovascular, and all-cause mortality).² Apart from the established knowledge regarding the importance of hypertension and its effective treatment, during the last years, there has been an increasing interest in the possibility that BP variability (BPV) might carry an additional contribution to cardiovascular risk, on top of the impact of mean BP levels. BP fluctuates constantly and its variability not only may have diagnostic implications regarding the accurate assessment of hypertension but also seems to exert additional stress on the cardiovascular system over and above average BP levels.³ Different components of BPV have been identified, characterized by BP fluctuations between hours, days, or months/years, respectively, termed as short-, mid-, and long-term components.³ All these types of BPV have been shown to carry an independent prognostic value in terms of cardiovascular events and all-cause and cardiovascular mortality.⁴⁻¹⁰

Three interesting articles have been recently published in this journal regarding long-term visit-to-visit BPV (VTV). Tedla et al¹¹ showed that an increased VTV among 1122 untreated individuals was predictive of arterial stiffness progression after 10 years of follow-up. The 2 remaining papers reported data on the prognostic value of systolic VTV coming from 2 major trials: the observational extension of the ADVANCE trial (Action in Diabetes and Vascular Disease: Preterax and Diamicon Modified Release Controlled Evaluation)¹² and the SPRINT (Systolic Blood Pressure Intervention Trial).¹³

However, it seems that at the present time, despite the accumulating evidence on the clinical relevance of VTV, the latter still remains a research tool failing to provide clinical application in practice.^{14,15}

Evidence on the Clinical Relevance of VTV

The first step for an index of BPV to be applied in clinical practice is the demonstration of its clinical relevance, in terms

of cardiovascular prognosis, as well as in terms of incremental value in risk stratification over and above average BP levels. Growing evidence suggests that BPV carries cardiovascular prognostic value independent of the average BP. A recent meta-analysis showed similar hazard ratios for all-cause mortality among all types of systolic BPV (VTV: 1.12 [95% confidence intervals, 1.05–1.20]; day-to-day home BPV: 1.15 [95% confidence intervals, 1.06–1.26]; 24-hour ambulatory BPV: 1.11 [95% confidence intervals, 1.04–1.18]).⁵ However, the strongest evidence has been provided for VTV.⁵ Recent meta-analyses of studies that used different methodologies (based on categorical or continuous analyses) showed that VTV—mainly assessed by standard deviation (SD) of BP values measured across repeated visits—is independently associated with total and cardiovascular mortality.⁴⁻⁶ In the last 2 years, several large studies (not included in the aforementioned meta-analyses) investigated the prognostic value of VTV in terms of mortality (Table).^{7,12,13,16,17} Interestingly, 4 of them included patients at high risk (Table).^{12,13,16,17} It is important to note that the ADVANCE-ON study (ADVANCE-Observational) showed that further to the independent prognostic value of the SD of systolic BP, its addition in the assessment of patients' cardiovascular risk significantly improved the 8-year risk classification beyond that provided by traditional risk factors, including average systolic BP.¹² This is highly relevant given that this study included subjects with diabetes mellitus and hypertension, which means that the incremental value of long-term BPV was evident despite the already high risk of these individuals.¹² Similar results were obtained also by considering other indices of VTV, such as the coefficient of variation, variation independent of mean, average successive variability, residual SD, and range of systolic BP values, which is reassuring for the consistency of the VTV clinical relevance.¹² On the contrary, the analysis of the SPRINT failed to show an independent prognostic value of systolic VTV regarding the primary end point, although a marginal association was found with all-cause mortality.¹³ It should be mentioned, however, that the latter trial presents different characteristics compared with the other trials, mainly regarding the office BP measurement methodology and the achieved BP levels which, along

From the Department of Cardiovascular, Neural and Metabolic Sciences, S. Luca Hospital, IRCCS, Istituto Auxologico Italiano, Milan; and Department of Medicine and Surgery, University of Milano-Bicocca, Italy (A.K., G.B., G.P.); and Hypertension Center STRIDE-7, National and Kapodistrian University of Athens, School of Medicine, Third Department of Medicine, Sotiria Hospital, Athens, Greece (A.K., G.S.S., K.G.K.).

Correspondence to Gianfranco Parati, Department of Cardiovascular, Neural and Metabolic Sciences, S. Luca Hospital, Istituto Auxologico Italiano & University of Milano-Bicocca, Piazzale Brescia 20, 20149 Milan, Italy. E-mail gianfranco.parati@unimib.it

(*Hypertension*. 2017;70:862-866. DOI: 10.1161/HYPERTENSIONAHA.117.10087.)

© 2017 American Heart Association, Inc.

Hypertension is available at <http://hyper.ahajournals.org>

DOI: 10.1161/HYPERTENSIONAHA.117.10087

Table. Recent Large Studies on the Prognostic Value of Visit-to-Visit Blood Pressure Variability

| Study | Study Characteristics | Index of Blood Pressure Variability | Results | |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-----------------------------|------------|
| | | | All-Cause Mortality | CVD Events |
| Chang et al ¹³ | Age >75 y or ≥50 y with ≥1 of the following: evidence of clinical/subclinical CVD, 10-year Framingham risk score for CVD events ≥15%, or CKD (n=7.879) | CV SBP | ± (adjusted <i>P</i> =0.07) | – |
| Vidal-Petiot et al ¹⁶ | CHD patients (n=13.794) | SD;ARV SBP/DBP | +; -/+; + | +; +/+; + |
| Bangalore et al ¹⁷ | MI patients (n=8.658) | ASV SBP/DBP | +/+ | +/+ |
| Ohkuma et al ¹² | Type 2 diabetic patients (n=9.114) | SD SBP | + | + |
| Gosmanova et al ⁷ | US Database-Veterans Affairs (n=2.865.157; 63% HTN) | SD SBP | + | +* |

ARV indicates average real variability; ASV, average successive variability; CHD, coronary heart disease; CKD, chronic kidney disease; CV, coefficient of variation; CVD, cardiovascular disease; DBP, diastolic blood pressure; HTN, hypertension; MI, myocardial infarction; SBP, systolic blood pressure; and SD, standard deviation.

*Coronary events.

with the relatively short period of follow-up, could have accounted, at least in part, for its results.

The prognostic importance of VVV in treated hypertensive individuals, might be, at least in part, attributed to the fact that VVV reflects the long-term degree of BP control and stability.^{18,19} A post hoc analysis of the ALLHAT (Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial) showed that VVV was higher among subjects reporting to take <80% of their antihypertensive medications at ≥1 study visits.²⁰ However, notwithstanding the significant association between medication nonadherence and VVV, nonadherence did not explain the association between VVV and cardiovascular and mortality outcomes.²⁰

Despite the accumulating and consistent evidence on the prognostic value of VVV, several unanswered questions still remain, including the optimal protocol to be used for office BP assessment, the methodology for the assessment of average BP levels and BPV, the thresholds to identify subjects at risk, and most importantly, the therapeutic implications of BPV management.

Meta-Analyses Regarding Therapeutic Implications: Is There a Specific Role for Calcium-Channel Blockers?

In the absence of large clinical intervention trials providing ad hoc evidence on the importance of using BPV as a treatment target and on potential drug class-specific effects in reducing BPV, evidence is derived from post hoc analyses of previous studies and, indirectly, from a historical meta-analysis.²¹ Webb et al²¹ performed a meta-analysis regarding the effect of antihypertensive drugs on interindividual BPV and risk of stroke. The authors based their analysis on interindividual BPV taking into account reports showing that ≈50% of group SD of systolic BP at any follow-up duration was the result of within-individual VVV rather than of differences between individuals in underlying average systolic BP levels.²¹ Their 2 main results were that (1) when performing between-drugs comparisons, interindividual systolic BPV was reduced by calcium-channel blockers (CCBs) and nonloop diuretic drugs, while it was increased by angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, and β-blockers, and (2) across all trials, the effects of treatment on both systolic BP average levels and systolic BPV accounted for the treatment effects

on stroke risk, with both parameters remaining significant in a combined model.²¹ It should be noted that most of the available evidence concerning the favorable effect of CCBs on VVV regarded amlodipine.²¹

Wang et al²² performed a meta-analysis using data on the treatment-induced changes in intraindividual BPV available from randomized clinical trials involving amlodipine and other comparators and showed amlodipine to be more effective in minimizing VVV.

Aiming to simulate the analysis by Webb et al—but by using intraindividual BPV—we used the data of Wang et al and plotted the between-group differences (amlodipine versus comparators) in coefficient of variation of systolic BP (least squares means obtained from visits performed from 12 weeks onwards for each study) against the odds ratios (amlodipine versus comparators) for each study primary end point, stroke, and all-cause mortality from the respective randomized clinical trials (ASCOT-BPLA [Anglo-Scandinavian Cardiac Outcomes Trial–Blood Pressure Lowering Arm], ALLHAT, and CAMELOT [The Comparison of Amlodipine Versus Enalapril to Limit Occurrences of Thrombosis]).^{23–25} In general, there was a trend toward greater reductions in odds ratios for each end point, with greater decreases in coefficient of variation of systolic BP achieved by amlodipine versus other comparators (Figure 1). Most importantly, although the data are derived from a smaller number of trials, the pattern of plot regarding the risk of stroke was similar to that published by Webb et al,²¹ which is reassuring for consistency of the results provided by both approaches.

Mechanisms Regarding VVV and the CCBs-Induced Reduction in VVV

VVV seems to be influenced by biological and behavioral factors (advanced age, female sex, history of cardiovascular disease, smoking, alarm reaction in the office visit, etc), by seasonal climatic changes, and by treatment-related parameters as previously reported.^{3,13,20} Arterial stiffness and endothelial and smooth muscle dysfunction have been proposed as mechanisms underlying the association between VVV and outcome.^{26,27} Furthermore, the underlying mechanisms accounting for the beneficial effect of CCBs—especially amlodipine—on VVV have not been clarified, but there are a few hypotheses. Zhang et al²⁸ investigated the effect of

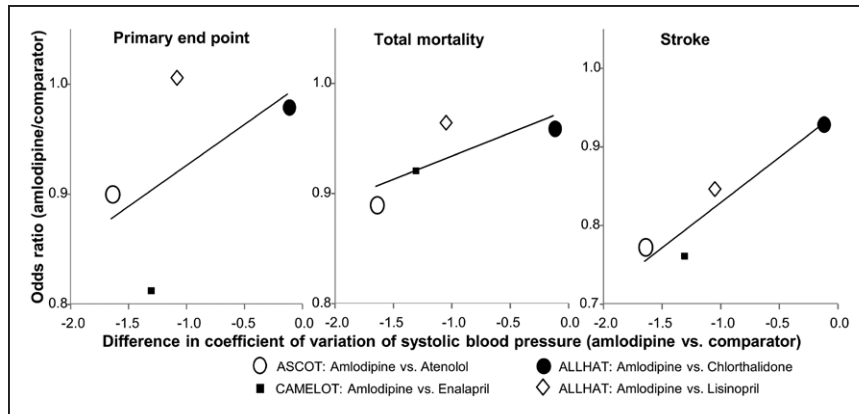


Figure 1. Plot of odds ratios (amlodipine/comparators) for several end points against the differences in coefficient of variation of systolic blood pressure between amlodipine and comparators. Size of symbols corresponds to the study sample size. ALLHAT indicates Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial; ASCOT, Anglo-Scandinavian Cardiac Outcomes Trial; and CAMELOT, The Comparison of Amlodipine Versus Enalapril to Limit Occurrences of Thrombosis.

candesartan, indapamide, and amlodipine on BPV using ambulatory BP data before and after 3 months of treatment. Both indapamide and amlodipine reduced systolic BPV, but the reduction induced by amlodipine was associated with reduction in both average BP levels and in heart rate variability, implying amelioration of the autonomic nervous system regulation.²⁸ Furthermore, other mechanisms related to the action of CCBs, including their profound vasodilatory effect, the potential improvements in arterial baroreflex sensitivity and arterial stiffness, as well as the attenuation of the myogenic response of vascular smooth muscle cells, may all contribute to the CCBs-induced reduction in VVV.^{29–31}

Hypothesis: Is There Any Contribution of BPV to the Findings of the ACCOMPLISH Trial?

The ACCOMPLISH trial (The Avoiding Cardiovascular Events Through Combination Therapy in Patients Living With Systolic Hypertension) was one of the landmark studies showing that an angiotensin-converting enzyme inhibitor-CCB (benazepril-amlodipine) combination is superior to an angiotensin-converting enzyme inhibitor-thiazide diuretic (benazepril-hydrochlorothiazide) combination in reducing cardiovascular events in patients with hypertension at high risk (high percentage of diabetics included).³² The risk reduction achieved with the benazepril-amlodipine combination could not be attributed to between-group differences in average BP levels (around 1 mmHg for systolic/diastolic BP).³²

We speculated that BPV may be more overtly reduced in the benazepril-amlodipine compared with the benazepril-hydrochlorothiazide arm. In one of the subanalyses of the ACCOMPLISH trial, according to body size, data on average

BP values, as well as on their SD, were given for both baseline and after 6 months of follow-up (titration completed at first 3 months).³³ We calculated the overall weighted (for sample size of body mass index subgroups) percent change ((follow-up minus baseline)/baseline) in coefficient of variation for systolic/diastolic BP corresponding to the changes in interindividual BPV for the 2 treatment arms. Although this approach does not exactly correspond to intraindividual VVV, as previously shown, it gives a rather rough estimate of this phenomenon.²¹ It appeared that interindividual BPV was increased in the benazepril-hydrochlorothiazide group as compared with the benazepril-amlodipine group, in which BPV values were decreased (Figure 2). A specific analysis of the raw study data would be desirable and could confirm whether a potential reduction of BPV induced by amlodipine did contribute, at least in part, to the outcome findings of this trial.

Regarding the available evidence on the comparison of CCBs versus diuretic-based combinations, it should be noted that in the COLM study (Combinations of OLMesartan), which included a smaller patient sample as compared with the ACCOMPLISH study, the olmesartan-CCB versus the olmesartan-diuretic combination was not found to be superior in terms of the primary end point, although the incidence of stroke tended to be lower in the elderly subjects of the former group.³⁴ Interestingly, in a subanalysis of this study, VVV of systolic BP was smaller in the olmesartan-CCB than in the olmesartan-diuretic group, especially in elderly patients, as well as in isolated systolic hypertensive patients.³⁵ Moreover, the incidence rate of the primary end point increased along with an increment in the SD of systolic BP in all of the age and treatment groups.³⁵ Furthermore, the study by Matsui et al²⁹ in

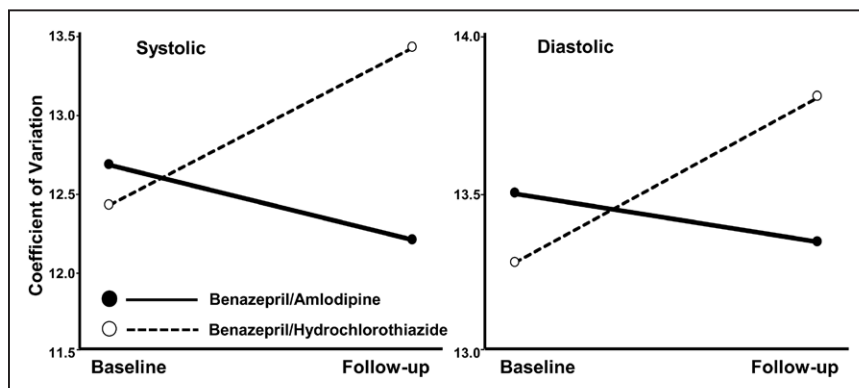


Figure 2. Change in coefficient of interindividual variation for systolic/diastolic blood pressure in the 2 treatment arms of the ACCOMPLISH trial (The Avoiding Cardiovascular Events Through Combination Therapy in Patients Living With Systolic Hypertension).

207 hypertensive subjects compared the olmesartan–azelnidipine combination versus the olmesartan–hydrochlorothiazide combination in terms of reduction of BPV and regression of arterial stiffness. Home BP monitoring was performed before each office visit (total of 7 visits during a 24-week period of follow-up). The authors concluded that for similar reduction in average home BP, the azelnidipine-based compared with the hydrochlorothiazide-based treatment reduced to a greater degree home BPV. Moreover, this change was associated with a reduction in arterial stiffness.²⁹

Perspectives

VVV seems to have an independent prognostic value over and above the impact of average BP. Accumulating evidence, mainly derived from post hoc analyses and meta-analyses of clinical trials, implies that CCBs—especially amlodipine—may have a more evident role in reducing VVV, which might lead to further risk reduction. Randomized outcome intervention trials are needed to explore whether a treatment-induced reduction in BPV using specific drug classes in specific patient categories is accompanied by an independent reduction in the cardiovascular events rate and mortality.

Disclosures

None.

References

- Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet*. 2002;360:1903–1913.
- Thomopoulos C, Parati G, Zanchetti A. Effects of blood pressure lowering on outcome incidence in hypertension. 1. Overview, meta-analyses, and meta-regression analyses of randomized trials. *J Hypertens*. 2014;32:2285–2295. doi: 10.1097/HJH.0000000000000378.
- Parati G, Ochoa JE, Lombardi C, Bilo G. Blood pressure variability: assessment, predictive value, and potential as a therapeutic target. *Curr Hypertens Rep*. 2015;17:537. doi: 10.1007/s11906-015-0537-1.
- Wang J, Shi X, Ma C, Zheng H, Xiao J, Bian H, Ma Z, Gong L. Visit-to-visit blood pressure variability is a risk factor for all-cause mortality and cardiovascular disease: a systematic review and meta-analysis. *J Hypertens*. 2017;35:10–17. doi: 10.1097/HJH.0000000000001159.
- Stevens SL, Wood S, Koshiaris C, Law K, Glasziou P, Stevens RJ, McManus RJ. Blood pressure variability and cardiovascular disease: systematic review and meta-analysis. *BMJ*. 2016;354:i4098.
- Diaz KM, Tanner RM, Falzon L, Levitan EB, Reynolds K, Shimbo D, Muntner P. Visit-to-visit variability of blood pressure and cardiovascular disease and all-cause mortality: a systematic review and meta-analysis. *Hypertension*. 2014;64:965–982. doi: 10.1161/HYPERTENSIONAHA.114.03903.
- Gosmanova EO, Mikkelsen MK, Molnar MZ, Lu JL, Yessayan LT, Kalantar-Zadeh K, Kovesdy CP. Association of systolic blood pressure variability with mortality, coronary heart disease, stroke, and renal disease. *J Am Coll Cardiol*. 2016;68:1375–1386. doi: 10.1016/j.jacc.2016.06.054.
- Juhanoja EP, Niiranen TJ, Johansson JK, Puukka PJ, Thijs L, Asayama K, Langén VL, Hozawa A, Aparicio LS, Ohkubo T, Tsuji I, Imai Y, Stergiou GS, Julia AM, Staessen JA; International Database on Home Blood Pressure in Relation to Cardiovascular Outcome (IDHOCO) Investigators. Outcome-driven thresholds for increased home blood pressure variability. *Hypertension*. 2017;69:599–607. doi: 10.1161/HYPERTENSIONAHA.116.08603.
- Palatini P, Reboldi G, Beilin LJ, Casiglia E, Eguchi K, Imai Y, Kario K, Ohkubo T, Pierdomenico SD, Schwartz JE, Wing L, Verdecchia P. Added predictive value of night-time blood pressure variability for cardiovascular events and mortality: the Ambulatory Blood Pressure-International Study. *Hypertension*. 2014;64:487–493. doi: 10.1161/HYPERTENSIONAHA.114.03694.

- Hansen TW, Thijs L, Li Y, et al; International Database on Ambulatory Blood Pressure in Relation to Cardiovascular Outcomes Investigators. Prognostic value of reading-to-reading blood pressure variability over 24 hours in 8938 subjects from 11 populations. *Hypertension*. 2010;55:1049–1057. doi: 10.1161/HYPERTENSIONAHA.109.140798.
- Tedla YG, Yano Y, Carnethon M, Greenland P. Association between long-term blood pressure variability and 10-year progression in arterial stiffness: the Multiethnic Study of Atherosclerosis. *Hypertension*. 2017;69:118–127. doi: 10.1161/HYPERTENSIONAHA.116.08427.
- Ohkuma T, Woodward M, Jun M, Muntner P, Hata J, Colagiuri S, Harrap S, Mancia G, Poulter N, Williams B, Rothwell P, Chalmers J; ADVANCE Collaborative Group. Prognostic value of variability in systolic blood pressure related to vascular events and premature death in type 2 diabetes mellitus: the ADVANCE-ON Study. *Hypertension*. 2017;70:461–468. doi: 10.1161/HYPERTENSIONAHA.117.09359.
- Chang TI, Reboussin DM, Chertow GM, et al; SPRINT Research Group. Visit-to-visit office blood pressure variability and cardiovascular outcomes in SPRINT (Systolic Blood Pressure Intervention Trial). *Hypertension*. 2017;70:7510–7518. doi: 10.1161/HYPERTENSIONAHA.117.09788.
- Whelton PK, Pollock BD. Is it time to employ a measure of visit-to-visit variability in clinical practice? *Hypertension*. 2017;70:227–228. doi: 10.1161/HYPERTENSIONAHA.117.09455.
- Whittle J. Blood pressure variability predicts clinical outcomes: now what? *Hypertension*. 2017;69:584–586. doi: 10.1161/HYPERTENSIONAHA.116.08806.
- Vidal-Petiot E, Stebbins A, Chiswell K, Ardissino D, Aylward PE, Cannon CP, Ramos Corrales MA, Held C, López-Sendón JL, Stewart RAH, Wallentin L, White HD, Steg PG; STABILITY Investigators. Visit-to-visit variability of blood pressure and cardiovascular outcomes in patients with stable coronary heart disease. Insights from the STABILITY trial [published online ahead of print May 27, 2017]. *Eur Heart J*. doi: 10.1093/eurheartj/ehx250. <https://www.ncbi.nlm.nih.gov/pubmed/28575274>.
- Bangalore S, Fayyad R, Messerli FH, Laskey R, DeMicco DA, Kastelein JJ, Waters DD. Relation of variability of low-density lipoprotein cholesterol and blood pressure to events in patients with previous myocardial infarction from the IDEAL Trial. *Am J Cardiol*. 2017;119:379–387. doi: 10.1016/j.amjcard.2016.10.037.
- Mancia G, Messerli F, Bakris G, Zhou Q, Champion A, Pepine CJ. Blood pressure control and improved cardiovascular outcomes in the International Verapamil SR-Trandolapril Study. *Hypertension*. 2007;50:299–305. doi: 10.1161/HYPERTENSIONAHA.107.090290.
- Mancia G. Visit-to-visit blood pressure variability: an insight into the mechanisms. *Hypertension*. 2016;68:32–33. doi: 10.1161/HYPERTENSIONAHA.116.07139.
- Kronish IM, Lynch AI, Oparil S, Whittle J, Davis BR, Simpson LM, Krousel-Wood M, Cushman WC, Chang TI, Muntner P. The association between antihypertensive medication nonadherence and visit-to-visit variability of blood pressure: findings from the Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial. *Hypertension*. 2016;68:39–45. doi: 10.1161/HYPERTENSIONAHA.115.06960.
- Webb AJ, Fischer U, Mehta Z, Rothwell PM. Effects of antihypertensive-drug class on interindividual variation in blood pressure and risk of stroke: a systematic review and meta-analysis. *Lancet*. 2010;375:906–915. doi: 10.1016/S0140-6736(10)60235-8.
- Wang JG, Yan P, Jeffers BW. Effects of amlodipine and other classes of antihypertensive drugs on long-term blood pressure variability: evidence from randomized controlled trials. *J Am Soc Hypertens*. 2014;8:340–349. doi: 10.1016/j.jash.2014.02.004.
- ALLHAT Officers and Coordinators for the ALLHAT Collaborative Research Group; The Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial. Major outcomes in high-risk hypertensive patients randomized to angiotensin-converting enzyme inhibitor or calcium channel blocker vs diuretic: The Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). *JAMA*. 2002;288:2981–2997. doi: 10.1001/jama.288.23.2981.
- Nissen SE, Tuzcu EM, Libby P, Thompson PD, Ghali M, Garza D, Berman L, Shi H, Buebendorf E, Topol EJ; CAMELOT Investigators. Effect of antihypertensive agents on cardiovascular events in patients with coronary disease and normal blood pressure: the CAMELOT study: a randomized controlled trial. *JAMA*. 2004;292:2217–2225. doi: 10.1001/jama.292.18.2217.
- Dahlöf B, Sever PS, Poulter NR, Wedel H, Beevers DG, Caulfield M, Collins R, Kjeldsen SE, Kristinsson A, McInnes GT, Mehlsen J, Nieminen M, O'Brien E, Ostergren J; ASCOT Investigators. Prevention of cardiovascular events with an antihypertensive regimen of amlodipine

- adding perindopril as required versus atenolol adding bendroflumethiazide as required, in the Anglo-Scandinavian Cardiac Outcomes Trial-Blood Pressure Lowering Arm (ASCOT-BPLA): a multicentre randomised controlled trial. *Lancet*. 2005;366:895–906. doi: 10.1016/S0140-6736(05)67185-1.
26. Shimbo D, Shea S, McClelland RL, Viera AJ, Mann D, Newman J, Lima J, Polak JF, Psaty BM, Muntner P. Associations of aortic distensibility and arterial elasticity with long-term visit-to-visit blood pressure variability: the Multi-Ethnic Study of Atherosclerosis (MESA). *Am J Hypertens*. 2013;26:896–902. doi: 10.1093/ajh/hpt040.
 27. Diaz KM, Veerabhadrapa P, Kashem MA, et al. Visit-to-visit and 24-h blood pressure variability: association with endothelial and smooth muscle function in African Americans. *J Hum Hypertens*. 2013;27:671–677. doi: 10.1038/jhh.2013.33.
 28. Zhang Y, Agnoletti D, Safar ME, Blacher J. Effect of antihypertensive agents on blood pressure variability: the Natrilix SR versus candesartan and amlodipine in the reduction of systolic blood pressure in hypertensive patients (X-CELLENT) study. *Hypertension*. 2011;58:155–160. doi: 10.1161/HYPERTENSIONAHA.111.174383.
 29. Matsui Y, O'Rourke MF, Hoshide S, Ishikawa J, Shimada K, Kario K. Combined effect of angiotensin II receptor blocker and either a calcium channel blocker or diuretic on day-by-day variability of home blood pressure: the Japan Combined Treatment With Olmesartan and a Calcium-Channel Blocker Versus Olmesartan and Diuretics Randomized Efficacy Study. *Hypertension*. 2012;59:1132–1138. doi: 10.1161/HYPERTENSIONAHA.111.189217.
 30. Julien C. Pharmacological attenuation of blood pressure variability. *Acta Pharmacol Sin*. 2005;26:1288–1289. doi: 10.1111/j.1745-7254.2005.00221.x.
 31. Eguchi K, Tomizawa H, Ishikawa J, Hoshide S, Fukuda T, Numao T, Shimada K, Kario K. Effects of new calcium channel blocker, azelnidipine, and amlodipine on baroreflex sensitivity and ambulatory blood pressure. *J Cardiovasc Pharmacol*. 2007;49:394–400. doi: 10.1097/FJC.0b013e31804d1cf1.
 32. Jamerson K, Weber MA, Bakris GL, Dahlöf B, Pitt B, Shi V, Hester A, Gupta J, Gatlin M, Velazquez EJ; ACCOMPLISH Trial Investigators. Benazepril plus amlodipine or hydrochlorothiazide for hypertension in high-risk patients. *N Engl J Med*. 2008;359:2417–2428. doi: 10.1056/NEJMoa0806182.
 33. Weber MA, Jamerson K, Bakris GL, Weir MR, Zappe D, Zhang Y, Dahlof B, Velazquez EJ, Pitt B. Effects of body size and hypertension treatments on cardiovascular event rates: subanalysis of the ACCOMPLISH randomised controlled trial. *Lancet*. 2013;381:537–545. doi: 10.1016/S0140-6736(12)61343-9.
 34. Ogihara T, Saruta T, Rakugi H, et al; COLM Investigators. Combinations of olmesartan and a calcium channel blocker or a diuretic in elderly hypertensive patients: a randomized, controlled trial. *J Hypertens*. 2014;32:2054–2063; discussion 2063. doi: 10.1097/HJH.0000000000000281.
 35. Rakugi H, Ogihara T, Saruta T, Kawai T, Saito I, Teramukai S, Shimada K, Katayama S, Higaki J, Odawara M, Tanahashi N, Kimura G; COLM Investigators. Preferable effects of olmesartan/calcium channel blocker to olmesartan/diuretic on blood pressure variability in very elderly hypertension: COLM study subanalysis. *J Hypertens*. 2015;33:2165–2172. doi: 10.1097/HJH.0000000000000668.

Treating Visit-to-Visit Blood Pressure Variability to Improve Prognosis: Is Amlodipine the Drug of Choice?

Anastasios Kollias, George S. Stergiou, Konstantinos G. Kyriakoulis, Grzegorz Bilo and Gianfranco Parati

Hypertension. 2017;70:862-866; originally published online September 25, 2017;
doi: 10.1161/HYPERTENSIONAHA.117.10087

Hypertension is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2017 American Heart Association, Inc. All rights reserved.
Print ISSN: 0194-911X. Online ISSN: 1524-4563

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://hyper.ahajournals.org/content/70/5/862>

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Hypertension* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the [Permissions and Rights Question and Answer](#) document.

Reprints: Information about reprints can be found online at:
<http://www.lww.com/reprints>

Subscriptions: Information about subscribing to *Hypertension* is online at:
<http://hyper.ahajournals.org/subscriptions/>