**Journal** of the
**American Geriatrics Society**

## LETTERS TO THE EDITOR

### RESEARCH

# Hypotensive episodes revealed by ambulatory blood pressure monitoring in nursing home residents

## INTRODUCTION

Susceptibility to hypotension increases at advanced age,[1,2] particularly in nursing home (NH) residents, a vulnerable population with multiple coexisting risk factors for low blood pressure (BP).

Hypotension may be responsible for symptoms such as dizziness, confusion, and drowsiness, which impair autonomy and quality of life. Moreover, hypotension in older people is a frequent cause of syncope and falls, which are more likely to occur in NH residents due to concomitant conditions such as dementia, gait, and balance disorders, which magnify the risk of falls and related complications.[3,4]

Ambulatory blood pressure monitoring (ABPM) is a valuable diagnostic tool to investigate low BP[5] and may be useful to detect hypotension in NH residents. However, ABPM is rarely used in this setting and data regarding ambulatory BP in NH residents are scarce.

This study aimed to assess the prevalence of hypotensive episodes in NH residents undergoing ABPM and to analyze the associated clinical features and ambulatory BP profile.

## METHODS

We retrospectively analyzed data from 100 subjects aged 60 or older consecutively admitted to the NH of the "Filippo Turati" Foundation in Gavinana, Pistoia, Italy, who underwent comprehensive geriatric assessment including ABPM (Spacelabs Healthcare, model 90207).

Hypotensive episodes on ABPM were defined as systolic BP (SBP) drops ≥20 mmHg between two consecutive measurements, reaching a minimum SBP of <100 mmHg. This cutoff is consistent with previous studies dealing with ambulatory hypotension.[1,2] We adopted a more conservative approach excluding individuals with only night-time hypotension, as very low BP values frequently occur during sleep and their prognostic value is questionable. Based on night-time BP dipping (i.e., difference between mean daytime and night-time SBP, expressed as percentage of daytime SBP), participants were classified as "dippers" (dipping >10%), "non-dippers" (dipping 0%–9%), and "reverse dippers" (nocturnal rise in BP). White coat effect was also assessed, defined as a difference of >20 mmHg between office SBP and mean daytime SBP on ABPM.

Multivariable logistic regression was used to identify clinical variables associated with hypotensive episodes among those showing an association with the outcome in univariate analysis ($p < 0.1$). To avoid multicollinearity in the multivariable regression model, the intercorrelations among variables were checked using a correlation matrix of two-sided Spearman rho correlation coefficients. Correlations of ≥0.50 were considered to be significant. Statistical significance was set at $p < 0.05$. Statistical analyses were performed using SPSS Statistics, version 26 (IBM Corp, Armonk, NY). The study was approved by the local institutional review board.

## RESULTS

The study sample included 91 residents (mean age 83, 56% female). Hypotensive episodes were observed in 50 residents (55%), with 35 (38%) reaching a minimum SBP of <90 mmHg. No clinical correlate of hypotensive episodes was recorded. Residents with hypotensive episodes had significantly lower ambulatory BP and more frequently showed a reverse dipping profile and a white coat effect. Office BP and prevalence of orthostatic hypotension were similar between the two groups (Table 1).

Residents with hypotensive episodes showed a higher prevalence of heart failure and atrial fibrillation and more commonly received digoxin and benzodiazepines, while antihypertensive prescriptions were similar

**TABLE 1** Clinical characteristics of the study sample according to the presence of hypotensive episodes on ABPM

| | Overall sample (n = 91) | Hypotensive episodes on ABPM (n = 50) | No hypotensive episodes on ABPM (n = 41) | p |
|---|---|---|---|---|
| Age (years), mean ± SD | 82.7 ± 9.6 | 83.9 ± 8.7 | 81.3 ± 10.4 | 0.198 |
| Female, n (%) | 56 (61.5) | 32 (64.0) | 24 (58.5) | 0.594 |
| BMI (kg/m$^2$), mean ± SD | 24.3 ± 3.3 | 23.8 ± 3.0 | 24.8 ± 3.5 | 0.133 |
| Barthel Index, median (IQR) | 30 (10–75) | 40.0 (5.0–81.25) | 30.0 (10.0–67.5) | 0.888 |
| Length of NH stay (days), median (IQR) | 346 (22.0–1357.0) | 518.5 (19.8–1648.3) | 315 (28.5–1086.5) | 0.696 |
| Syncope, n (%) | 6 (6.6) | 4 (7.4) | 3 (6.5) | 0.863 |
| Falls history, n (%) | 44 (48.4) | 28 (51.9) | 21 (45.7) | 0.537 |
| Comorbidities | | | | |
| Charlson Comorbidity Index | 5 (5–6) | 5 (5–6) | 5 (4.5–6) | 0.581 |
| Hypertension, n (%) | 46 (50.5) | 25 (50.0) | 21 (51.2) | 0.908 |
| Diabetes, n (%) | 9 (9.9) | 6 (12.0) | 3 (7.3) | 0.457 |
| Stroke/TIA, n (%) | 26 (28.6) | 12 (24.0) | 14 (34.1) | 0.286 |
| Coronary artery disease, n (%) | 14 (15.4) | 7 (14.0) | 7 (17.1) | 0.686 |
| Heart failure, n (%) | 16 (17.6) | 13 (26.0) | 3 (7.3) | 0.020 |
| Atrial fibrillation, n (%) | 15 (16.5) | 13 (26.0) | 2 (4.9) | 0.007 |
| Chronic kidney disease, n (%) | 4 (4.4) | 2 (4.0) | 2 (4.9) | 0.839 |
| Creatinine, mean ± SD | 0.93 ± 0.31 | 0.9 ± 0.3 | 1.0 ± 0.3 | 0.073 |
| Creatinine <1 mg/dl, n (%) | 61 (67.0) | 38 (76) | 23 (57.5) | 0.062 |
| Dementia, n (%) | 59 (64.8) | 35 (70.0) | 24 (58.5) | 0.254 |
| MMSE score, median (IQR) | 17 (3–25) | 15 (0–23.25) | 18 (9.5–25.5) | 0.188 |
| NPI, median (IQR) | 6 (0–16) | 10 (0–16) | 6 (0–12) | 0.098 |
| Parkinson, n (%) | 1 (1.9) | 1 (1.9) | 0 (0.0) | 0.354 |
| Hemoglobin, mean ± SD | 12.7 ± 1.5 | 12.5 ± 1.6 | 12.9 ± 1.5 | 0.287 |
| Serum protein, mean ± SD | 6.7 ± 0.8 | 6.6 ± 0.8 | 6.8 ± 0.8 | 0.280 |
| Albumin, mean ± SD | 3.8 ± 1.6 | 3.6 ± 0.5 | 4.1 ± 2.3 | 0.268 |
| Medications | | | | |
| Number of medications, median (IQR) | 3 (2–4) | 4 (2–4) | 3 (2–4) | 0.560 |
| Number of antihypertensives, median (IQR) | 1 (0–2) | 1 (0–2) | 1 (1–2) | 0.726 |
| ACE, n (%) | 36 (39.6) | 19 (38.0) | 17 (41.5) | 0.737 |
| ARB, n (%) | 2 (2.2) | 1 (2.0) | 1 (2.4) | 0.887 |
| Calcium antagonists, n (%) | 14 (15.4) | 9 (18.0) | 5 (12.2) | 0.445 |
| Diuretics, n (%) | 36 (39.6) | 21 (42.0) | 15 (36.6) | 0.599 |
| Beta-blockers, n (%) | 4 (4.4) | 2 (4.0) | 2 (4.9) | 0.839 |
| Alpha-blockers, n (%) | 4 (4.4) | 1 (2.0) | 3 (7.3) | 0.218 |
| Nitrates, n (%) | 9 (9.9) | 4 (8.0) | 5 (12.2) | 0.505 |
| Digoxin, n (%) | 15 (16.5) | 14 (28.0) | 1 (2.4) | 0.001 |
| Antiarrhythmics, n (%) | 3 (3.3) | 3 (5.6) | 0 (0.0) | 0.105 |
| Antidepressants, n (%) | 28 (30.8) | 13 (26.0) | 15 (36.6) | 0.276 |
| Benzodiazepines, n (%) | 37 (40.7) | 26 (52.0) | 11 (26.8) | 0.015 |
| Antipsychotics, n (%) | 19 (20.9) | 9 (18.0) | 10 (24.4) | 0.456 |
| Office blood pressure | | | | |
| Office SBP, mean ± SD | 134.1 ± 14.7 | 133.0 ± 14.0 | 135.5 ± 15.5 | 0.433 |
| Office DBP, mean ± SD | 80.0 ± 10.2 | 79.5 ± 10.2 | 80.6 ± 10.2 | 0.599 |
| Supine SBP, mean ± SD | 134.0 ± 16.4 | 131.3 ± 14.4 | 137.2 ± 18.1 | 0.088 |
| Supine DBP, mean ± SD | 77.3 ± 10.4 | 77.4 ± 10.7 | 77.3 ± 10.3 | 0.988 |
| Orthostatic hypotension[a], n (%) | 8/49 (16.3) | 4/28 (14.3) | 4/21 (19.0) | 0.655 |
| White coat effect, n (%) | 33 (36.3) | 27 (54.0) | 6 (14.6) | <0.001 |

(Continues)

**TABLE 1** (Continued)

| | Overall sample (n = 91) | Hypotensive episodes on ABPM (n = 50) | No hypotensive episodes on ABPM (n = 41) | p |
|---|---|---|---|---|
| ABPM | | | | |
| ABPM: 24 h SBP, mean ± SD | 121.5 ± 14.9 | 113.2 ± 10.7 | 131.5 ± 13.2 | <0.001 |
| ABPM: 24 h DBP, mean ± SD | 68.0 ± 10.9 | 62.6 ± 8.9 | 74.5 ± 9.7 | <0.001 |
| ABPM: daytime SBP, mean ± SD | 123.0 ± 15.9 | 114.1 ± 12.1 | 134.0 ± 12.7 | <0.001 |
| ABPM: daytime DBP, mean ± SD | 70.3 ± 11.8 | 64.5 ± 10.2 | 77.3 ± 9.7 | <0.001 |
| ABPM: night-time SBP, mean ± SD | 119.8 ± 16.1 | 112.2 ± 12.5 | 129.2 ± 15.1 | <0.001 |
| ABPM: night-time DBP, mean ± SD | 65.7 ± 11.6 | 60.6 ± 9.3 | 72.0 ± 11.1 | <0.001 |
| ABPM: daytime SD, mean ± SD | 13.4 ± 3.6 | 13.8 ± 3.5 | 12.8 ± 3.8 | 0.186 |
| Nocturnal dipping, n (%) | | | | |
| Dippers | 26 (28.6) | 14 (28.0) | 12 (29.3) | 0.894 |
| Non-dippers | 35 (38.5) | 14 (28.0) | 21 (51.2) | 0.023 |
| Reverse dippers | 30 (33.0) | 22 (44.0) | 8 (19.5) | 0.013 |

Abbreviations: ABPM, ambulatory blood pressure monitoring; ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blockers; BMI, body mass index; DBP, diastolic blood pressure; IQR, interquartile range; MMSE, Mini-Mental State Examination; NH, nursing home; NPI, Neuropsychiatric Inventory; SBP, systolic blood pressure; SD, standard deviation; TIA, transient ischemic attack.
[a]Orthostatic hypotension was assessed in 49 of 91 subjects who were able to stand.

between the two groups. No significant difference was observed in cognitive performance, functional status, and comorbidity burden (Table 1). At multivariable analysis, hypotensive episodes were independently associated with digoxin (OR 20.0, 95% CI 2.21–181.19, p = 0.008), benzodiazepines (OR 4.0, 95% CI 1.45–11.22, p = 0.007), and serum creatinine <1 mg/dl (OR 3.9, 95% CI 1.28–12.17, p = 0.017).

## DISCUSSION

In this sample of NH residents undergoing ABPM, hypotensive episodes were highly prevalent (55%) and related with a specific ABPM profile including lower mean BP values, reverse dipping, and white coat effect. This profile suggests that a certain degree of autonomic dysfunction may be present as a consequence of cardiovascular aging and comorbidities, leading to higher BP during the night-time and orthostatic/postprandial hypotension during the daytime. Second, overtreatment may contribute to hypotensive episodes, as white coat effect may determine excessive BP lowering in residents presenting with high office BP.

Hypotensive episodes were independently associated with benzodiazepines, consistently with previous studies describing a hypotensive effect of this class.[6] An independent association with digoxin was also observed, which may be related to comorbidities such as heart failure and atrial fibrillation. Moreover, chronic treatment with digoxin was found to lower BP in previous studies. Hypothesized mechanisms include increased baroreflex sensitivity, enhanced parasympathetic activity, and withdrawal of elevated sympathetic tone due to improved cardiac inotropism.[7,8] Finally, our study revealed an independent association between hypotensive episodes and low serum creatinine, which is common in older adults with sarcopenia.[9] This implies a link between low muscle mass and hypotensive risk, possibly deriving from the crucial role of muscle mass in the BP response to gravity stress.[10]

No clinical correlate of hypotensive episodes was recorded in our sample. Yet, symptoms of hypotension are frequently atypical in older individuals and subjects with cognitive impairment are less likely to report them.[3] Therefore, ABPM may reveal hypotensive episodes that would otherwise be unrecognized.

The present study confirms that NH residents have a significant predisposition for hypotensive episodes. ABPM can significantly contribute to hypotension diagnosis of subjects at risk in this vulnerable, older population.

## AUTHOR CONTRIBUTIONS
Conception and design: Giulia Rivasi, Enrico Mossello, and Andrea Ungar. Acquisition, analysis, and interpretation of data: all authors. Drafting the article: Giulia Rivasi,

Enrico Mossello, Michele Brignole, Andrea Ungar, and Ludovica Ceolin. Revising of the article for important intellectual content: all authors. Final approval of the version to be published: all authors.

Giulia Rivasi MD[1] 
Enrico Mossello PhD[1] 
Giada Turrin MD[1]
Maria Flora D'Andria MD[1]
Virginia Tortù MD[1]
Ludovica Ceolin MD[1]
Antonio Coscarelli MD[1]
Angela Fedeli MD[1]
Martina Rafanelli PhD[1]
Michele Brignole MD[2]
Andrea Ungar PhD[1]

[1]*Hypertension Clinic, Division of Geriatric and Intensive Care Medicine, Careggi Hospital and University of Florence, Florence, Italy*
[2]*IRCCS, Istituto Auxologico Italiano, Cardiology Unit and Department of Cardiovascular Neural and Metabolic Sciences, S. Luca Hospital, Milan, Italy*

**ORCID**
*Giulia Rivasi* https://orcid.org/0000-0002-2736-2242
*Enrico Mossello* https://orcid.org/0000-0002-7730-5836

**TWITTER**
*Giulia Rivasi* @RivasiGiulia

**REFERENCES**

1. Scuteri A, Modestino A, Frattari A, Di Daniele N, Tesauro M. Occurrence of hypotension in older participants. Which 24-hour ABPM parameter better correlate with? *J Gerontol A Biol Sci Med Sci*. 2012;67(7):804-810.
2. Divisón-Garrote JA, Ruilope LM, de la Cruz JJ, et al. Magnitude of hypotension based on office and ambulatory blood pressure monitoring: results from a cohort of 5066 treated hypertensive patients aged 80 years and older. *J Am Med Dir Assoc*. 2017; 18(5):452.e1-452.e6. doi:10.1016/j.jamda.2017.01.015
3. Freidenberg DL, Shaffer LET, Macalester S, Fannin EA. Orthostatic hypotension in patients with dementia: clinical features and response to treatment. *Cogn Behav Neurol*. 2013;26(3):105-120.
4. Mossello E, Ceccofiglio A, Rafanelli M, et al. Differential diagnosis of unexplained falls in dementia: results of "Syncope & Dementia" registry. *Eur J Intern Med*. 2018;50:41-46.
5. Brignole M, Moya A, De Lange FJ, et al. 2018 ESC guidelines for the diagnosis and management of syncope. *Eur Heart J*. 2018;39(21):1883-1948.
6. Rivasi G, Kenny RA, Ungar A, Romero-Ortuno R. Effects of benzodiazepines on orthostatic blood pressure in older people. *Eur J Intern Med*. 2020;72:73-78. doi:10.1016/j.ejim.2019.10.032
7. Grossmann M, Jamieson MJ, Kirch W. Effects of digoxin and digitoxin on circadian blood pressure profile in healthy volunteers. *Eur J Clin Invest*. 1998;28(9):701-706.
8. Krum H, Bigger T, Goldsmith RL, Packer M. Effect of long-term digoxin therapy on autonomic function in patients with chronic heart failure. *J Am Coll Cardiol*. 1995;25(2):289-294.
9. Stevens PE. Evaluation and management of chronic kidney disease: synopsis of the kidney disease: improving global outcomes 2012 clinical practice guideline. *Ann Intern Med*. 2013; 158:825-830. doi:10.7326/0003-4819-158-11-201306040-00007
10. Wieling W, Krediet CTP, van Dijk N, Linzer M, Tschakovsky ME. Initial orthostatic hypotension: review of a forgotten condition. *Clin Sci*. 2007;112(3):157-165.

# Effect of electronic clinical decision support on inappropriate prescriptions in older adults

## INTRODUCTION

In older adults, benzodiazepines and sedative-hypnotics (BSH) are associated with an increased risk of falls, hospitalizations, and all-cause mortality.[1] The American Geriatrics Society (AGS) publishes a Beers Criteria list of potentially inappropriate medications, with a strong recommendation to avoid BSH prescriptions in older adults.[2] Despite this, adult BSH prescriptions in the United States are rising, with patients aged 65–80 years accounting for the highest proportion.[3] Given these risks and disproportionate use of BSH prescriptions in older adults, the AGS identified BSH prescriptions as one of their top five questionable clinical practices in the Choosing Wisely campaign.[4] Electronic medical record (EMR)-based support systems represent a promising avenue to influence practice at the point of care for clinicians.[5,6] To address the rising rates of BSH prescriptions in older adults, we implemented and evaluated the impact of a best practice alert (BPA) on BSH prescribing practices