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The Effect of Meals at Different Mealtimes on Blood Pressure and Symptoms in Geriatric Patients With Postprandial Hypotension

Lilian C. M. Vloet, Rita Smits, and René W. M. M. Jansen

Department of Geriatric Medicine, University Medical Center, Nijmegen, the Netherlands.

Background. The variability of postprandial hypotension (PPH) during the day in elderly patients is unknown. We examined the effect of meals administered at different mealtimes on postprandial blood pressure (BP) responses in geriatric patients.

Methods. In 14 geriatric patients (6 men and 8 women, aged 66–97) previously diagnosed with PPH, standardized liquid test meals were given in random order at breakfast, lunchtime, or dinnertime on 3 separate days. Systolic BP (SBP), diastolic BP (DBP), and heart rate (HR) were measured with an ambulatory BP device every 10 minutes from 20 minutes before until 90 minutes after each meal. Postprandial symptoms were observed continuously.

Results. Significant decreases in SBP and DBP were present after each meal ($p < .050$). The maximum SBP decrease was significantly smaller at dinnertime (–18 ± 3 mmHg) than at breakfast (–29 ± 2 mmHg) or lunchtime (–34 ± 4 mmHg) ($p < .005$ between groups). Eight patients showed no PPH in the evening, whereas all patients had PPH after breakfast and lunch. The duration of PPH was significantly shorter ($p < .001$), and postprandial symptoms were less frequent and less severe after dinner compared to breakfast and lunch.

Conclusions. In geriatric patients, postprandial BP responses show a variation during the day, with significantly less PPH and fewer symptoms in the evening. Clinical implication is that, in the diagnostic process and management of PPH, the variation of the occurrence of PPH during the day should be taken into account. Through adjustment of BP decreasing activities to the time PPH is least prevalent, the risk of developing symptomatic PPH can be reduced.

IN elderly people, postprandial hypotension (PPH) is a very common and serious disorder (1). PPH is associated with dizziness, falls, syncope, coronary events, stroke, and total mortality (1–4). Nearly all elderly people show some decline in systolic blood pressure (BP) after eating a meal, and one-third of nursing home patients show postprandial declines ≥20 mmHg (3,5). Recently, we found PPH in 41% of healthy elderly participants, in 82% of geriatric patients with Parkinson's disease, and in 55% of elderly patients with heart failure (6,7).

Important mechanisms and age- and illness-related factors contributing to PPH have been discussed extensively elsewhere (1,8–12). Because pharmacological treatments of PPH are limited, nonpharmacological interventions become more important (1). Several empirical nonpharmacological treatments for PPH have been suggested, such as lying down after a meal for 1 to 2 hours to prevent falling (1). It has also been demonstrated that walking after a meal restores the postprandial BP declines, however, this compensatory effect on BP disappears immediately after the patient stops walking (13). Other measures in the treatment of PPH are adjustment of the size or composition of a meal; e.g., by reducing the amount of carbohydrates (14,15).

Most studies investigating the effects of meals on BP have been performed in the morning (6,7,14). For diagnosis and treatment of PPH, however, it is important to know whether there is a variation in postprandial BP changes during the day. From orthostatic hypotension (OH), it is known that the prevalence is highly variable over time (16). It has been shown that meals and physical activities are the major factors that influence the daytime variation in BP in elderly persons (17). Variability of PPH during the day could have clinical implications for the timing of tests to diagnose PPH and for the treatment of PPH. Therefore the aim of this study is to examine the effect of different mealtimes on postprandial BP responses in elderly patients with PPH.

METHODS

Participants

During their first week of admission to the Geriatric Department of the University Medical Center Nijmegen, the Netherlands, all patients are screened for OH and PPH as part of a standard geriatric evaluation. Patients with PPH defined as a postmeal reduction in systolic blood pressure (SBP) ≥20 mmHg were selected from this evaluation to participate in the present study. Preset inclusion criteria were ages ≥65 years, PPH, and possibility of complete medication withdrawal for 24 hours. Preset exclusion criteria were acute diseases, diabetes mellitus, chronic atrial fibrillation, pacemaker dependency, problems with oral food ingestion, and cognitive impairments such that a participant was unable to understand the study protocol. All participants gave their informed consent. The Ethics Committee for Research on Human Subjects of the University Medical Center Nijmegen, the Netherlands, approved this study.

A sample size of 14 patients was required to identify differences in postprandial BP responses between breakfast,

Table 1. Patient Characteristics

Parameter	Mean ± *SEM*
Gender (male/female)	6/8
Age (y)	82 ± 2
Systolic blood pressure (mmHg)	149 ± 5
Diastolic blood pressure (mmHg)	80 ± 5
Heart rate (bpm)	75 ± 3
Height (cm)	165 ± 3
Weight (kg)	63 ± 3
Body mass index (kg/m^2)	23 ± 1
Orthostatic hypotension	6
Cardiovascular disorders	8
Respiratory disorders	5
Neurological disorders	3
Gastrointestinal disorders	5
Psychiatric disorders	9
Total amount of prescriptions per patient	6 ± 1
Cardiovascular medication	8
Respiratory medication	4
Gastrointestinal medication	5
Neurological medication	1
Psychiatric medication	12
Analgesics	11

Note: *SEM* = standard error of mean.

lunch, or dinner of 10 mmHg or more (standard deviation of BP responses 10 mmHg, power 80%, significance level 5%). Sixteen consecutive patients with PPH started the series of 3 meal studies. One patient was discharged from the hospital and chose not to complete the protocol; one patient dropped out because of an intercurrent pneumonia between the tests. Fourteen patients completed the study.

On 3 separate days, a test meal was given in random order at breakfast, lunchtime, or dinnertime, at 8:30 AM, 1:00 PM, and 5:30 PM, respectively. Testing days were separated by an interval of 3 days (range, 2–5 days). All tests took place in a quiet room with an ambient temperature of 21–24°C. The participants had medication withdrawn from midnight the night before until after their test. For all tests at lunchtime or dinnertime, patients refrained from oral intake 4 hours before the test. For the test at breakfast, all participants had an overnight fast. For the lunchtime test, all patients ate a small breakfast consisting of 1 slice of bread, with butter and ham or cheese, 1 cup of milk, and 1 cup of tea without sugar, containing approximately 25 g of glucose, and approximately 210 kcal. For the dinnertime test, all participants ate a small breakfast and lunch as described in the breakfast test. Although recent studies showed that both tea and coffee do not prevent PPH, drinking coffee was not allowed on all testing days until the measurements were performed, to avoid any potential effects of caffeine on BP (18,19). Each test consisted of 20 minutes of rest, ingestion of a test meal within 10 minutes, and 90 minutes of rest after the start of the meal, all in the sitting position to simulate a common eating situation for most people (1).

The standardized liquid test meals consisted of 100 ml of Nutrical (Nutricia, Zoetermeer, the Netherlands), which is a liquid carbohydrate meal composed of glucose syrup, and 100 ml lactose-free whole milk, containing 292 kcal, 65 g carbohydrate, 2 g fat, and 4 g protein. This meal composition has been used as a diagnostic test for PPH (7). The meals were served at a temperature of 22°C to avoid potential temperature effects on BP (20).

SBP, diastolic BP (DBP), mean arterial pressure (MAP), and heart rate (HR) were measured every 10 minutes throughout the test with an ambulatory automatic BP device (Spacelab 90207, Spacelabs Medical, Inc., Redmond, WA) (21).

Patients were questioned about any complaints before the meal to document the patients' baseline condition. During the test, the researcher observed the patients continuously. A standardized list with symptoms related to PPH according to the literature was used (1–3). Symptoms were scored on a 4-point scale and coded (absent = 0, mild = 1, moderate = 2, and severe = 4). The exact times symptoms appeared and disappeared were recorded.

Statistical Analysis

Statistical analysis was performed using SPSS for Windows 10.0 (SPSS, Inc., Chicago, IL). A p value $<$ .050 was taken as the level of significance. The results are expressed as mean and standard error of the mean (*SEM*).

Baseline values of SBP, DBP, and HR were defined as the last value measured before meal ingestion. Differences in baseline values or maximum changes in BP between the tests were tested by paired t tests. Two-way repeated measures analysis of variance (ANOVA) was applied to examine the overall effects of time, time of meal ingestion, and the time-by-meal interaction on BP changes versus baseline over the 3 tests. Pearson's correlation test was used to determine the correlation between BP responses and patient characteristics.

RESULTS

The characteristics of participants of this study are summarized in Table 1.

Postprandial Hemodynamic Changes

Figure 1 shows the group-averaged changes in SBP, DBP, and HR. Group averages of the maximum individual hemodynamic changes are presented in Table 2.

After each meal, SBP decreased significantly over time ($p < .050$). The reduction in SBP was significantly smaller after evening meals compared to breakfast ($p = .001$) and lunchtime meals ($p = .004$). Eight of the 14 participants (57%) had no postprandial decrease $\geq$20 mmHg after dinner, whereas all patients showed PPH at breakfast and lunchtime. The maximum individual decrease in SBP after breakfast correlated significantly with baseline SBP ($r = -.595$, $p = .025$).

DBP decreased significantly after each meal ($p < .050$), with a significant difference in DBP decline after breakfast and dinner ($p = .031$). No significant differences in DBP decrease were present between breakfast and lunch ($p = .112$) or between lunch and dinner ($p = .292$). HR increased after any of the 3 meals, but did not change significantly. At the time of maximum decrease in SBP, HR increased significantly less after breakfast than after lunch ($p = .034$). HR tended to increase more after dinner than after lunch and breakfast ($p = .061$).

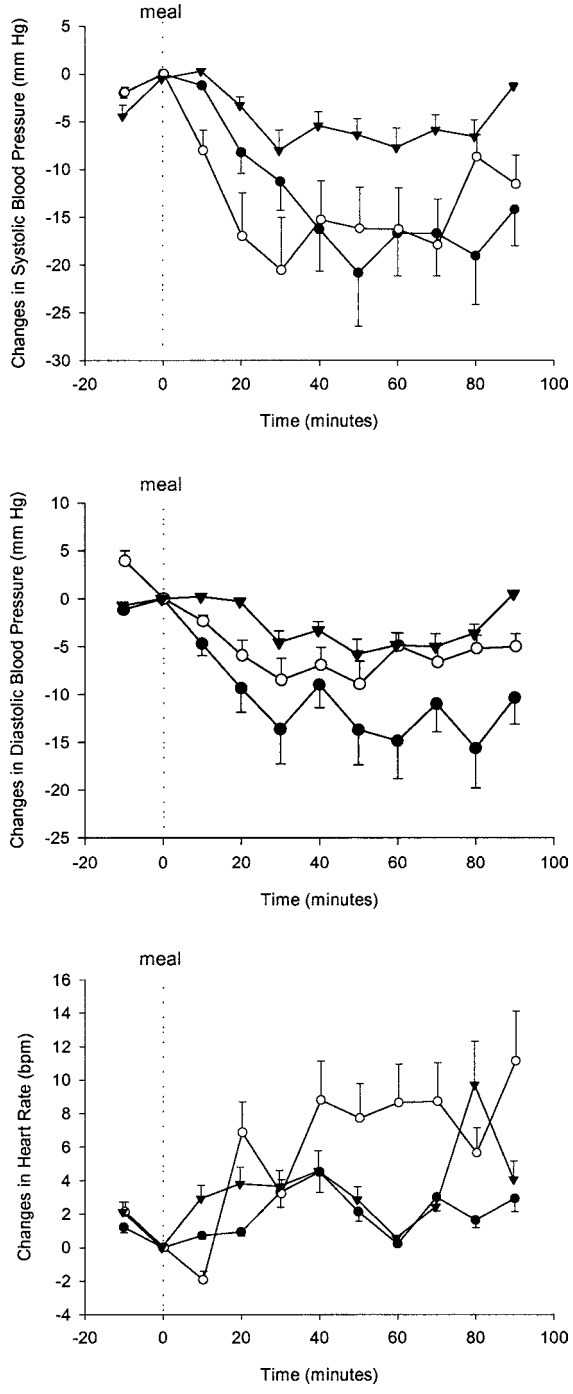

Figure 1. Mean changes in systolic blood pressure (SBP) (upper part), diastolic blood pressure (DBP) (middle part), and heart rate (HR) (lower part) in 14 geriatric patients with postprandial hypotension after ingestion of standardized liquid meals at breakfast (closed dots), lunchtime (open dots), and dinnertime (closed triangles). Data are presented as mean ± *SEM* (standard error of mean).

Duration of PPH

The PPH period was significantly shorter after dinnertime meals than after breakfast and lunch ($p < .010$, between groups) (Table 2). The mean maximum SBP decline after breakfast occurred at 50 minutes after the meal (–21 ± 2 mmHg), whereas SBP decreased maximally at 30 minutes after lunch (–21 ± 4 mmHg) and after dinner (–8 ± 3 mmHg). Significant correlation was found between maximum decrease in SBP and the duration of PPH after breakfast ($r = -.715$, $p = .004$) and dinner ($r = -.590$, $p = .026$).

Table 2. Maximum Individual Changes in Systolic Blood Pressure, Diastolic Blood Pressure, and Heart Rate, and Changes in Diastolic Blood Pressure and Heart Rate at the Time of Maximum SBP Decrease, and Duration of PPH (Mean ± *SEM*)

Time of Meal	ΔSBP (mmHg)	DBP (mmHg)	HR (bpm)	ΔDBP (mmHg)	ΔHR (mmHg)	Duration Minutes
8:30 AM	–29 ± 2*	–12 ± 3[‡]	3 ± 1[§]	–20 ± 3[‖]	9 ± 1	31 ± 5[¶]
1:00 PM	–34 ± 4[†]	–12 ± 2	6 ± 2	–16 ± 2	17 ± 4	31 ± 6**
5:30 PM	–18 ± 3	–6 ± 13	9 ± 4	–13 ± 3	13 ± 4	9 ± 4

Notes: *$p = .001$ breakfast (BK) vs dinner (DN).
[†]$p = .004$ lunch (LN) vs DN.
[‡]$p = .031$ BK vs DN.
[§]$p = .034$ BK vs LN.
[‖]$p = .031$ BK vs DN.
[¶]$p = .003$ BK vs DN.
**$p = < .000$ LN vs DN.
ΔSBP = change in systolic blood pressure; ΔDBP = change in diastolic blood pressure; HR = heart rate; PPH = postprandial hypotension; *SEM* = standard error of mean.

Symptoms

The postprandial symptoms varied in frequency and severity at different mealtimes. After breakfast, 5 patients had no symptoms and 6 patients felt sleepy. One patient was restless, one patient turned pale, a third patient had blurred vision. After lunch, 5 patients felt very tired, 4 participants were sleepy, 2 noted dizziness, and 1 patient looked pale. One person had disturbed speech, a headache, was sweating, and lost consciousness when SBP decreased with 74 mmHg, 20 minutes after lunch. A physical examination was performed, and the patient's wheelchair was tilted to a supine position. This patient, who had experienced syncope before, regained consciousness within 10 minutes, when BP returned to basal BP. Only 3 patients had no symptoms following lunch. After dinner, 6 patients noted sleepiness and 8 patients had no symptoms. All described symptoms were concurrent with SBP declines ≥20 mmHg, although at all mealtimes, 2 patients felt sleepy at the end of the test although their SBP had recovered again.

Discussion

The main finding of this study is that we demonstrated a clinically relevant variation of postprandial BP responses during the day in elderly patients with PPH. Postprandial declines in SBP were significantly larger at breakfast and lunchtime than at dinnertime. In more than half of our study population, PPH was absent after dinner. In addition, test meals at dinnertime induced significantly shorter hypotensive periods, and patients had almost no symptoms compared to meals at breakfast or lunchtime. This variation during the day has implications for the timing of diagnosis and treatment of PPH.

The diagnosis of PPH should be based on BP measurements around breakfast or lunchtime, because of the postprandial variation over the day and the frequent absence of

PPH after dinner. The postprandial SBP responses in the morning have been shown to be reproducible (22). Interventions such as BP-decreasing activities or cardiovascular medication should preferably be prescribed in the evening, to reduce the risk of developing symptomatic PPH in elderly persons.

Possible explanations for the differences in postprandial BP during the day include baseline SBP and impaired BP regulation (1). Kohara and colleagues found that hypertensive patients with PPH showed more profound awakening-related increases in SBP before breakfast, and therefore had larger postprandial SBP decreases, which can be explained by baroflex dysfunction (23). We found a significant correlation between baseline SBP and large postprandial SBP decreases after breakfast, indicating that higher baseline SBP and large postprandial decreases are both markers of impaired BP regulation. Although our population was very heterogeneous, Puisieux and colleagues confirmed that postprandial decreases in SBP in elderly people were higher after breakfast than after lunch and dinner (24). Unfortunately, they used nonstandardized meals and permitted medication at breakfast (24). Because we used identical test meals at all mealtimes and prohibited medication, meal composition or drugs cannot explain the differences in cardiovascular responses at different times of the day. Although the rate of nutrient delivery into the small intestine is a significant determinant of the postprandial fall in BP (25), the variation of PPH during the day cannot be explained by prior nutrient intake. A postprandial fall in BP is almost immediately evident (1). Our patients consumed a small comparable meal at both breakfast and lunch, and subsequently had a standardized period of fasting before both the lunchtime and dinnertime tests. Thus, it can be expected that the potential additional effect of food remaining in the small intestine is the same at lunch and dinner. The differences in postprandial BP decrease between lunch and dinner are significantly evident, and cannot be explained by the prior intake of nutrients. There is a substantial variation in the volume and duration of individual flow pulses in gastric emptying, which starts at approximately 1 minute after ingestion (26). Spiegel and colleagues (27) calculated a rate of gastric emptying after mixed (solid and liquid) meals of 2.2 ± 0.4 kcal/min, when patients were seated. In our study, it would take 133 minutes to empty the stomach. With an interval of more than 4 hours between the meals, we believe the additional effect of the previous meal on PPH is very small.

The study was carried out in a randomized fashion on 3 different days, but could not be blinded because all participants knew the time of the day the test was performed. Diagnosis of PPH can be difficult since most symptoms are nonspecific. Tiredness at the end of the test could also be due to the duration of the measurements. This study was performed on patients diagnosed with PPH based on BP measurements during admission to the geriatric ward. A few of these patients were asymptomatic. However, their postprandial BP decline in the evening was significantly less than after breakfast and lunch. Although postprandial declines in BP imply a period of risk in all patients, the results of this study can be even more important for symptomatic PPH patients.

Jansen and colleagues indicated previously that OH and PPH were distinct mechanisms (22). Although orthostatic changes in BP during prolonged sitting might contribute to the postprandial decreases in BP, we found it more physiologic to give patients their test meal in a sitting position. OH was not correlated with alterations in postprandial BP at all mealtimes. Accordingly, OH cannot explain the differences in PPH during the day.

Conclusion

This study showed a variation of postprandial BP responses during the day in elderly patients with PPH. After dinner, postprandial SBP declines were significantly smaller and the elderly participants experienced fewer and less severe symptoms than after breakfast or lunch. Furthermore, at dinnertime the duration of PPH was significantly shorter, which shortened the period at risk for hypotension and cerebral hypoperfusion. The clinical implication of these findings is that diagnostic tests and the treatment of symptomatic PPH should be adjusted to the variation of PPH during the day.

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Address correspondence to René W. M. M. Jansen, MD, PhD, UMC St Radboud, Department of Geriatric Medicine, 318, P.O. Box 9101, 6500 HB Nijmegen, the Netherlands. E-mail: r.jansen@ger.umcn.nl

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