The difference between the patients' initial and previously measured systolic blood pressure as predictor of mortality in older emergency department patients

Candel, B.G.J.; Ingen, I.B. van; Doormalen, I.P.H. van; Raven, W.; Mignot-Evers, L.A.A.; Jonge, E. de; Groot, B. de

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BRIEF REPORT

The difference between the patients' initial and previously measured systolic blood pressure as predictor of mortality in older emergency department patients

Bart G. J. Candel[1,2] · Iris B. van Ingen[2] · Iris P. H. van Doormalen[1] · Wouter Raven[2] · Lisette A. A. Mignot-Evers[1,3] · Evert de Jonge[4] · Bas de Groot[2]

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Key summary points

Aim To investigate whether a baseline systolic blood pressure (SBP) in older Emergency Department (ED) patients of ≥ 70 years has prognostic value, when compared with the initial SBP at presentation in the ED (= ΔSBP).

Findings A baseline SBP could be retrieved from the Electronic Health Record for most older ED patients (73.3%). A negative ΔSBP was associated with 30-day mortality. In 20% of the patients with a normal initial SBP in the ED, the ΔSBP was negative, with a high mortality rate.

Message A baseline SBP value could be retrieved from the Electronic Health Record in most hospitalized ED patients ≥ 70 years. In addition, the 21% with a normal SBP at ED presentation had a negative ΔSBP and these patients had an increased risk for 30-day mortality. As a result, ΔSBP may contribute to improved risk stratification and may help to recognize hypotension in older patients.

Abstract

Purpose To assess how often baseline systolic blood pressure (SBP) could be retrieved from the Electronic Health Record (EHR) in older Emergency Department (ED) patients. Second, to assess whether the difference between baseline SBP and initial SBP in the ED (ΔSBP) was associated with 30-day mortality.

Methods A multicenter hypothesis-generating cohort study including patients ≥ 70 years. EHRs were searched for baseline SBPs. The association between ΔSBP and 30-day mortality was investigated.

Results Baseline SBP was found in 220 out of 300 patients (73.3%; 95%CI 68.1–78.0%). In 72 patients with normal initial SBPs (133–166 mmHg) in the ED, fifteen (20.8%) had a negative ΔSBP with 20.0% mortality. A negative ΔSBP was associated with 30-day mortality (AHR 4.7; 1.7–12.7).

Conclusion Baseline SBPs are often available in older ED patients. The ΔSBP has prognostic value and could be used as an extra variable to recognize hypotension in older ED patients. Future studies should clarify whether the ΔSBP improves risk stratification in the ED.

Keywords Electronic health records · Emergency medical services · Geriatric emergency medicine · Aging · Hypotension

Iris B. van Ingen and Iris P. H. van Doormalen contributed equally.

✉ Bart G. J. Candel
bartcandel@gmail.com

[1] Department of Emergency Medicine, Máxima Medical Center, De Run 4600, 5504DB Veldhoven, The Netherlands

[2] Department of Emergency Medicine, Leiden University Medical Center, Leiden, The Netherlands

[3] Department of Health Services Research, CAPHRI School for Public Health and Primary Care, Maastricht University, Maastricht, The Netherlands

[4] Department of Intensive Care Medicine, Leiden University Medical Center, Leiden, The Netherlands

Introduction

Due to higher prevalence of hypertension in older patients [1, 2], a seemingly normal blood pressure in older Emergency Department (ED) patients may in fact be relative hypotension and may not be recognized as such, possibly leading to under-treatment and higher mortality.

Therefore, knowledge of an individual ED patient's baseline systolic blood pressure (SBP) may be essential to assess whether the initial SBP reflects hypotension or normotension. Unfortunately, baseline SBP may often not be available in the ED as the Electronic Health Record (EHR) is not routinely shared among general practitioners and hospitals [3], due to privacy laws and under registration.

Therefore, the aim of the present hypothesis-generating study is two-fold: first, to assess how often individual baseline SBPs are available in older ED patients, and second, to evaluate whether the absolute reduction of SBP compared to the patients' baseline SBP value (ΔSBP) is associated with 30-day mortality. The prognostic value of ΔSBP has not been studied before using the patients' individual baseline SBP values. If baseline SBPs are often available and the ΔSBP is associated with 30-day mortality, this variable may contribute to better risk stratification leading to better recognition of vital threads in ED patients.

Methods

Study design and setting

This multicenter retrospective cohort study was conducted in two EDs in the Netherlands: a tertiary care center with approximately 25,000 ED visits annually and an urban care center with approximately 20,000 ED visits annually. Data were collected from 1 to 27 January 2018. The study was approved by the medical ethics committee of the MMC. The study was registered in the Netherlands Trials Register: NL9029.

Patient selection

During the study period, all consecutive ED patients ≥ 70 years who were subsequently hospitalized were included (the prevalence of hypertension increases above this age, according to Statistics Netherlands (www.cbs.nl)). Patients were excluded if non-urgently triaged according to the Manchester or Dutch Triage System or transferred to another hospital.

Outcomes

The primary outcome was the number (*N*) (%) of patients with an SBP documented (objective 1) and 30-day mortality (objective 2). If patients were discharged alive and 30-day mortality was not known, they were considered alive after 30 days.

Sample size

See Supplementary file 1.

Data collection

Data were collected from the EHR. One researcher in each hospital (IvI, IvD) extracted the data. No clear definition exists in the literature of a baseline SBP. In our study, the baseline SBP was defined as the mean of a maximum of the three most recent SBP values from the General Practitioner (GP) referral letters and the three most recent SBP values from the outpatient clinical records. SBP values were not considered as a baseline value if the notes or records described signs for acute illness (i.e., pneumonia, urinary tract infection or fever) or acute pain (i.e., trauma, acute abdominal pain), or if patients were referred to the ED at the same day. The ΔSBP was calculated by subtracting the baseline SBP from the initial SBP in the ED. Thus, a negative ΔSBP indicated that the SBP in the ED was lower than the patients' baseline SBP.

Statistical analyses

Patient characteristics were described for survivors and non-survivors as mean (standard deviation (SD)), median (interquartile range (IQR)) or number (*N*, (%)) as appropriate. Paired Student's *t* tests, Wilcoxon signed-rank test and Pearson's χ^2 tests were used to compare patient characteristics. The ΔSBP and initial SBP in the ED were categorized in tertiles based on their distribution. The categorized ΔSBP could be negative, normal, and positive. The categorized initial SBP in the ED was considered low, normal, and high. A Cox regression analysis was used to assess the crude and adjusted association between ΔSBP, the initial SBP in the ED, and 30-day mortality, adjusted for age, sex, and triage category (urgent or very urgent/immediate) as a measure of disease severity. The Kaplan–Meier method was employed to generate survival plots, using the log-rank test, for 30-day mortality.

A sensitivity analysis was performed which included patients who had baseline SBP values documented within 5 years prior to ED-presentation, to limit the chance that

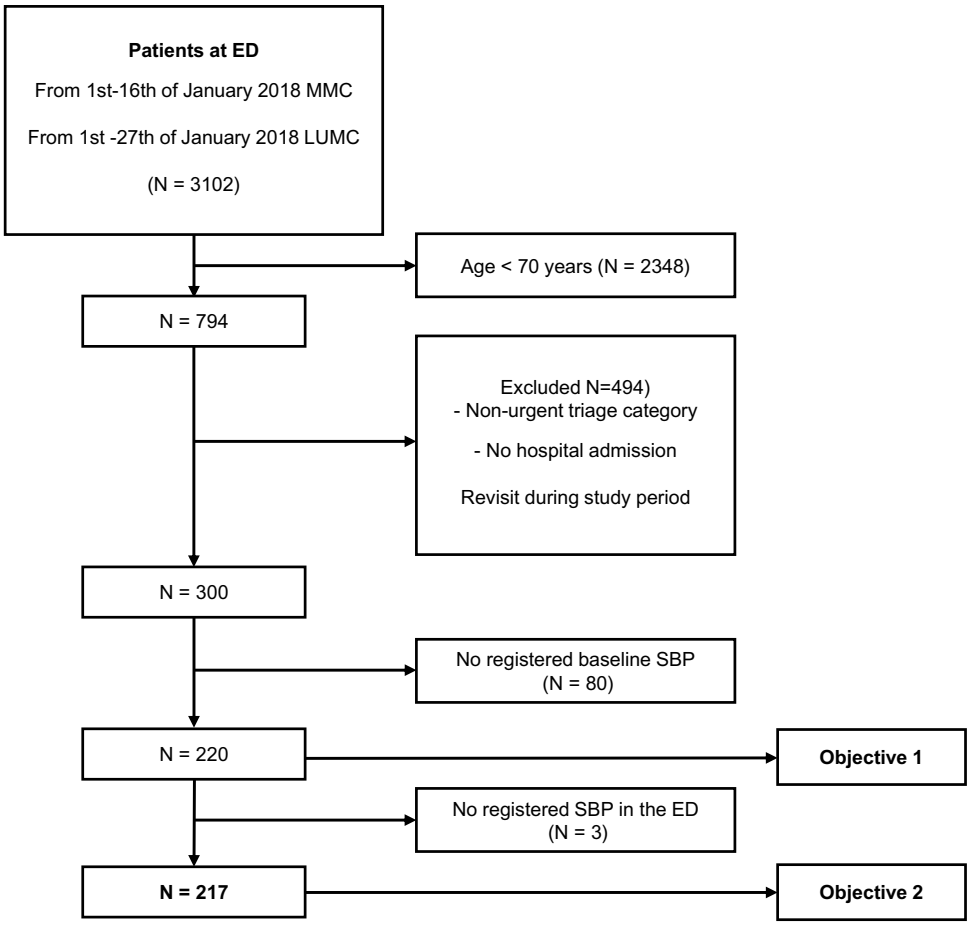

Fig. 1 Patient flow and inclusion through the study. The Electronical Patient Records were used to retrospectively include patients in two hospitals starting at 1 January 2018

antihypertensive drugs were prescribed and because individual baseline values may have changed by aging [4].

Adjusted Hazard Ratio's (AHRs) are presented with 95% confidence intervals (95% CIs).

An α of 0.05 was considered as statistically significant. Data were analyzed using SPSS (version 25.0, IBM, New York, USA).

Results

During the study period, 3102 patients presented to the ED of which 300 patients met the inclusion criteria (Fig. 1). Baseline SBP values were found in 220 patients (73.3%; 95% CI 68.1–78.0%). In the urban care center, a baseline SBP was found in 117 out of 141 patients (83.0%; 75.7–88.8%) compared to 103 out of 159 patients (64.8%; 56.8–72.2%) in the tertiary care center (difference: 18.2%; 8.5–27.9%).

30-day mortality was 14.3% (10.3–19.6%). Differences in patient characteristics existed between survivors and non-survivors (see Table 1).

A cross table between the categorized ΔSBP and the initial SBP in the ED showed that 15 out of 72 patients (20.8%; 13.1–31.6%) with a negative ΔSBP had a normal (mid-tertile) initial SBP in the ED (see Table 2). Mortality was highest if the ΔSBP was negative and the initial SBP in the ED was low, with 15 out of 57 deceased patients (26.3%).

Table 3 shows the crude and adjusted association for the ΔSBP and the initial SBP in the ED and 30-day mortality. Kaplan–Meier survival curves confirm the prognostic role of ΔSBP in ED patients ≥ 70 years (Fig. 2).

The sensitivity analysis showed similar results (Supplementary file 2).

Discussion

In this hypothesis-generating study, a baseline SBP value could be retrieved from the EHR in most hospitalized ED patients ≥ 70 years. In addition, the 21% with a normal SBP at ED presentation had a negative ΔSBP and these patients had an increased risk for 30-day mortality.

Low SBP is a well-known risk factor for mortality in older ED patients [5, 6]. Due to the high prevalence of hypertension in the elderly [1, 7], a seemingly normal SBP may, in fact, be relative hypotension. Consequently, this may

Table 1 Patients characteristics

	Total cohort $N=217$ (100%)	Survivors $N=196$ (90.3%)	Non-survivors $N=21$ (9.7%)	*P* value
Demographics				
Age, years, mean (SD)	79 (6.6)	79 (6.4)	82 (7.6)	0.04
Females, *N* (%)	108 (49.8)	100 (51.0)	8 (38.1)	0.36
Tertiary care center, *N* (%)	100 (46.1)	90 (45.9)	10 (47.6)	1.0
Baseline SBP[a]				
Baseline SBP, mmHg, mean (SD)	142 (16.8)	142 (16.4)	143 (20.9)	0.74
Months till ED visit, median [IQR]	33 [16–56]	32 [16–53]	40 [18–77]	0.27
Δ SBP, *N* (%)[b]				0.01
Negative (< − 6.5 mmHg)	73 (33.6)	59 (30.1)	13 (61.9)	
Normal (6.5–21.7 mmHg)	72 (33.2)	70 (35.7)	3 (14.3)	
Positive (> 21.7 mmHg)	72 (33.2)	67 (34.2)	5 (23.8)	
Comorbidity				
CCI, mean (SD)	5 (3.1)	5 (3.1)	5 (2.9)	0.87
Use of antihypertensive agents, *N* (%)	161 (74.2)	145 (74.0)	16 (76.2)	0.88
Arrival by ambulance, *N* (%)	127 (58.5)	112 (57.1)	15 (71.4)	0.26
Triage category				< 0.01
Urgent, *N* (%)	128 (59.0)	121 (61.7)	7 (33.3)	
Very-urgent, *N* (%)	76 (35.0)	67 (34.2)	9 (42.9)	
Immediate, *N* (%)	9 (4.1)	4 (2.0)	5 (23.8)	
Specialty				0.48
Internal medicine, *N* (%)	78 (35.9)	68 (34.7)	10 (47.6)	
Pulmonary medicine, *N* (%)	53 (24.4)	49 (25.0)	4 (19.0)	
Neurology, *N* (%)	40 (18.4)	39 (19.9)	1 (4.8)	
Cardiology, *N* (%)	16 (7.4)	13 (6.6)	3 (14.3)	
Other, *N* (%)	29 (13.4)	26 (13.3)	3 (14.3)	
Top three chief complaints				0.87
Feeling unwell, *N* (%)	55 (25.3)	51 (26.0)	4 (19.0)	
Dyspnea, *N* (%)	50 (23.0)	41 (20.9)	9 (42.9)	
Abdominal pain, *N* (%)	14 (6.5)	13 (6.6)	1 (4.8)	
Other, *N* (%)	54 (24.9)	50 (25.5)	4 (19.0)	
Initial vital signs in the ED				
SBP, mmHg, mean (SD)	150 (35.4)	151 (34.8)	137 (39.8)	0.07
SBP, categorized, mmHg, *N* (%)				0.03
Low (< 133 mmHg)	76 (35.0)	63 (32.1)	13 (61.9)	
Normal (133–166 mmHg)	71 (32.7)	67 (34.2)	4 (19.0)	
High (> 166 mmHg)	70 (32.3)	66 (33.7)	4 (19.0)	
HR bpm, median [IQR]	86 [75–104]	85 [75–103]	98 [72–107]	0.27
RR/min, median [IQR]	20 [16–28]	18 [16–25]	28 [22–32]	< 0.01
SPO_2, %, median [IQR]	96 [94–97]	96 [94–97]	94 [90–97]	0.03
O_2 administration, *N* (%)	102 (47.0)	83 (42.3)	19 (90.5)	< 0.01
O_2, L/min, median [IQR]	0.0 [0.0–4.0]	0.0 [0.0–3.0]	4.0 [0.0–6.0]	< 0.01
Body temperature, °C, median, [IQR] (26)	37.3 [36.6–38.4]	37.2 [36.7–38.4]	37.5 [36.0–38.4]	0.89
NRS 1–10, median [IQR]	1 [0–3]	1 [0 -3]	0 [0–2]	0.07
Administered fluid in ED, *N* (%)	75 (34.6)	64 (32.7)	11 (52.4)	0.08
Disposition				< 0.01
Admission to a ward, *N* (%)	171 (78.8)	158 (80.6)	13 (61.9)	
Admission to MCU, *N* (%)	5 (2.3)	5 (2.6)	0 (0)	
Admission to ICU, *N* (%)	10 (4.6)	4 (2.0)	6 (28.6)	
Admission to CCU, *N* (%)	9 (4.1)	8 (4.1)	1 (4.8)	

Table 1 (continued)

	Total cohort $N=217$ (100%)	Survivors $N=196$ (90.3%)	Non-survivors $N=21$ (9.7%)	*P* value
Admission to neurocare, *N* (%)	22 (10.1)	21 (10.7)	1 (4.8)	
Length of hospital stay				
Days, median [IQR]	5 [2–9]	5 [2–9]	3 [2–9]	0.44

Missing values (survivors; non-survivors) = Use of antihypertensive agents (2;0), Arrival by ambulance (5;0), Triage category (4;0), responsible specialism (1;0), Presenting complaints (41;3), HR (8;1), RR (34;2), SPO_2 (16;2), O_2 administration (59;6), Body temperature (23;3), NRS (51;7), Administered fluid in Ed (4;0), Admission to (3;1)

N number; *SD* standard deviation; *IQR* interquartile range; *CCI* Charlson Comorbidity Index; *ED* emergency department; *SBP* systolic blood pressure; *mmHg* millimeter mercury; *Δ* delta; *DBP* diastolic blood pressure; *HR* heart rate; *RR* respiratory rate; SPO_2 peripheral oxygen saturation; O_2 oxygen; *°C* degree Celsius; *NRS (0–10)* numeric rating scale for pain; *MCU* medium care unit; *ICU* intensive care unit; *CCU* cardiac care unit; *Neurocare* high dependency care unit for neurology patients

[a]The baseline SBP was defined as a mean of SBP values which included a maximum of the three most recent SBP values from referral letters of the General Practitioner and the three most recent SBP values from the outpatient clinical records. SBP values were not considered as a baseline value if the letters or records described signs for acute illness (i.e., pneumonia, urinary tract infection or fever) or acute pain (i.e., trauma, acute abdominal pain), or if patients were referred to the ED at the same day. The mean time from the measured baseline SBP till ED visit is presented

[b]The ΔSBP was calculated by subtracting the baseline SBP from the first measured SBP in the ED. A negative ΔSBP therefore indicated that the SBP in the ED was lower than the patients' baseline SBP. The ΔSBP was categorized in tertiles based on distribution

Table 2 A cross table of categorized ΔSystolic Blood Pressure (SBP) and the initial SBP in the Emergency Department with numbers of 30-day mortality

	Initial SBP in the ED			Total (*N*)
	Low, < 133 mmHg, (*N*)	Normal, 133-166 mmHg, (*N*)	High, > 166 mmHg, (*N*)	
Δ SBP (categorized) negative (< − 6.5 mmHg)	57 15† (26.3%)	15 3† (20.0%)	0 0† (0.0%)	72
Normal (− 6.5–21.7 mmHg)	18 2† (11.1%)	43 2† (4.7%)	12 1† (8.3%)	73
Positive (> 21.7 mmHg)	1 0† (0.0%)	13 2† (15.4%)	58 6† (10.3%)	72
Total (*N*)	76	71	70	217

The ΔSBP and the initial SBP in the ED were categorized in tertiles based on their distribution

SBP systolic blood pressure; *ED* emergency department; *Δ* delta

†Number of patients who died in 30 days, with percentages in that group

lead to an underestimation of the risk and a lower urgency to initiate treatment. Thus, the deviation from a patients' normal SBP may be relevant. This hypothesis is supported by a study in patients undergoing abdominal surgery, in which an individualized, targeted SBP reduced the risk of postoperative organ dysfunction compared to standard management [8]. This study suggests that individualized treatment using the baseline SBP as a target may improve outcomes. In another study in patients with septic shock, a higher target mean arterial pressure resulted in less kidney injury among patients known with chronic hypertension [9].

We are not aware of earlier studies on the association between the difference in SBP between baseline values and SBP at presentation in the ED and outcome in acutely ill patients. However, using another definition, ΔSBP showed prognostic value in trauma patients in the ED [10–12]. In these studies, the ΔSBP was calculated as the difference between the initial SBP in the ED and the prehospital SBP on the same day. A declining SBP in the hours before ED admission was associated with increased mortality, as was also shown for hospitalized patients [13, 14]. In our study, we did not attempt to study short-term SBP trends, but we assessed whether a lower SBP in the ED compared to a baseline SBP was associated with 30-day mortality in older patients. Although baseline SBP in our study could have been measured years before the ED visit, we hypothesized that this SBP would provide important information about the patients' normal value.

Our study was not designed to study whether the ΔSBP was a better predictor for mortality than the initial SBP in the ED. Nonetheless, our study may have implications for clinical practice. We found that even if SBP at admission

Table 3 The association between a delta systolic blood pressure and 30-day mortality in hospitalized Emergency Department patients ≥ 70 years

	30-day mortality			
	Univariable HR (95% CI)	*P* value	Multivariable AHR (95% CI)	*P* value
ΔSBP (categorized)				
Negative (< − 6.5 mmHg)	4.2 (1.5–11.2)	0.01	4.7 (1.7–12.7)	< 0.01
Normal (− 6.5–21.7 mmHg)	1.0		1.0	
Positive (> 21.7 mmHg)	1.7 (0.55–5.1)	0.37	2.0 (0.63–6.1)	0.25
Initial SBP in the ED (categorized)				
Low (< 133 mmHg)	2.5 (1.0–5.9)	0.05	2.5 (1.0–6.0)	0.04
Normal (133-166 mmHg)	1.0		1.0	
High (> 166 mmHg)	1.0 (0.35–2.9)	0.99	1.1 (0.38–3.1)	0.90

The association between ΔSBP and 30-day mortality, and initial SBP in the ED and 30-day mortality, were both adjusted for age, sex, and triage category (urgent, or very urgent/immediate). Because of multi-collinearity, we did not include the initial SBP in the model with delta SBP and mortality

The ΔSBP was calculated by subtracting the baseline SBP from the first measured SBP in the ED. A negative ΔSBP, therefore, indicated that the SBP in the ED was lower than the patients' baseline SBP. The ΔSBP and the initial SBP in the ED were categorized in tertiles based on their distribution

HR hazard ratio; *AHR* adjusted hazard ratio; *95% CI* 95% confidence interval; *SBP* systolic blood pressure; *ED* emergency department; *Δ* delta

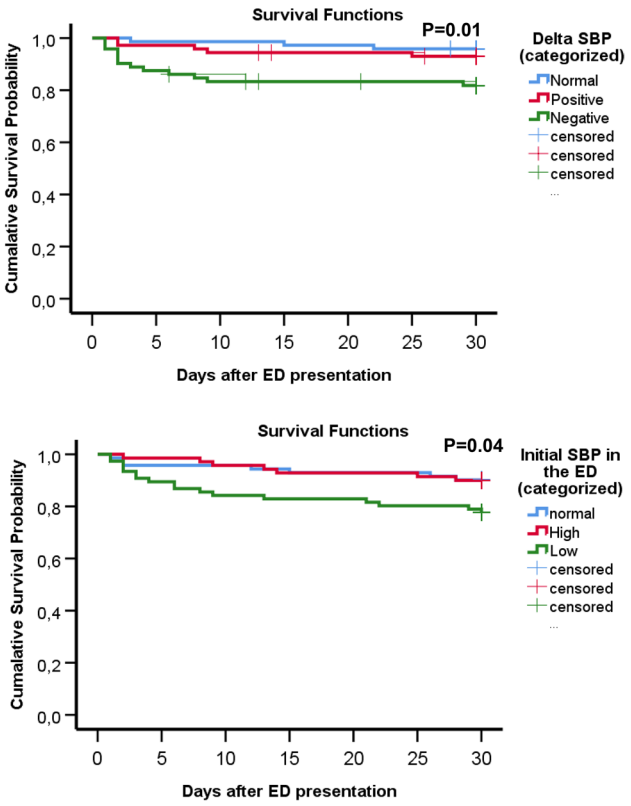

Fig. 2 A Kaplan–Meier curve is shown for categorized delta systolic blood pressure and 30-day mortality, and for the initial systolic blood pressure in the Emergency Department and 30-day mortality

is normal (> 133 mmHg), some patients had relative hypotension. Future studies should assess whether using the ΔSBP in risk stratification tools like, i.e., the National Early Warning Score has added value to the SBP alone. Also, many challenges are reported regarding health information exchange among hospitals and primary care centers [3, 15]. Because baseline SBPs may have significant prognostic value, our findings argue in favor of promoting health information exchange among hospitals and primary care centers to have baseline vital signs available in the ED.

Our study has several limitations. First, the baseline SBP was defined as a mean of values found in referral letters of GPs and outpatient clinical records. No information existed on how these SBPs were measured. Also, the median time of the measured baseline SBP till ED visit was substantial. Furthermore, antihypertensive agents could have been prescribed in the meantime, or baseline SBPs could have been changed by (patho)physiological changes [4]. We tried to overcome this with a sensitivity analysis using only baseline SBPs measured < 5 years from ED visit, which showed similar results. In addition, baseline SBP should be unaffected by pain, psychological stress, or acute illness. We cannot rule out the possibility that this was not always documented in the files, which could have influenced baseline SBP. Secondly, 30-day mortality was missing in seven patients who were discharged alive. However, five of these patients had a negative ΔSBP and therefore we do not expect this would have affected our results. Lastly, the limited sample size of

this study and the two-center design limit the generalizability of our findings and may lead to overestimation of the effect size. Nonetheless, we believe that the ΔSBP needs further investigation in larger prospective studies because it may improve recognition of hypotension.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s41999-021-00588-z.

Author contributions BC and BDG devised and designed the study, contributed to the analyses, and edited the manuscript. IvI and IvD collected and analyzed data, and wrote the manuscript. EDJ, WR and LAAM-E edited the manuscript. BdG takes full responsibility for the study. All authors have read and approved the manuscript.

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Availability of data and material Data are available upon reasonable request.

Declarations

Conflict of interest All authors declare no conflicts of interest.

Ethics approval The medical ethical committee of Máxima MC reviewed the research proposal and concluded that the anonymized data were not subject to the Dutch Research on Humans Subjects Act (in Dutch "WMO") and waived the need for informed consent. The study was approved with registration number (N20.052).

Informed consent Due to the retrospective design, informed consent was not required.

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