Inter-Arm Blood Pressure Difference in Hospitalized Elderly Patients Is Not Associated With Excess Mortality

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Inter-arm blood pressure difference (IAD) has been found to be associated with cardiovascular mortality. Its clinical significance and association with mortality in the elderly is not well defined. This study evaluated the association of IAD with mortality in a cohort of hospitalized elderly individuals. Blood pressure (BP) was measured simultaneously in both arms in elderly individuals (older than 65 years) hospitalized in a geriatric ward from October 2012 to July 2014. During the study period, 445 patients, mostly women (54.8%) with a mean age of 85±5 years, were recruited. Systolic and diastolic IAD were >10 mm Hg in 102 (22.9%) and 76 (17.1%) patients, respectively. Patients were followed for an average of 342±201 days. During follow-up, 102 patients (22.9%) died. Mortality was not associated with systolic or diastolic IAD. It is therefore questionable whether BP should be routinely measured in both arms in the elderly. *J Clin Hypertens (Greenwich).* 2015;17:786–791. © 2015 Wiley Periodicals, Inc.

It is recommended to measure blood pressure (BP) in both arms at the initial evaluation because differences exist in BP values measured in both arms and measurement in only one arm may lead to underdiagnosis of hypertension.[1,2] Inter-arm BP difference (IAD) is associated with peripheral vascular disease.[3] Whereas some consider it a risk factor for cardiovascular mortality,[4–8] others believe that because it so prevalent in the general population including in young healthy individuals,[9] its association with mortality is merely incidental. The prevalence of systolic IAD >10 mm Hg in the general population ranges between 12% and 23.6%.[6,8,9] Several reports have demonstrated no association between IAD with age.[9–11] IAD has been found to be associated with increased mortality in the elderly comparable to the general population[12]; however, its significance in the very old and in hospitalized elderly individuals, probably representing those with the most significant burden of atherosclerosis, has not been evaluated. This study prospectively followed a cohort of elderly individuals hospitalized in a geriatric ward in order to evaluate the association between IAD and overall mortality in this population.

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METHODS

Study Population

All elderly individuals hospitalized in the Department of Geriatrics, Rabin Medical Center between October 2012 and July 2014, were screened for eligibility for inclusion. The geriatric ward contains 30 beds, admitting patients 65 years and older with various acute medical problems. Patients who were expected to survive <24 hours from admission and patients with systolic BP <90 mm Hg on admission, were excluded from the study. Also excluded were patients in whom simultaneous BP measurements could not be performed.

The study was approved by the ethics committee of the Rabin Medical Center, and all patients or their legal guardians gave informed consent.

BP Measurement and Data Collection

BP measurement was performed by designated technicians in a quiet room while the patient lay in a supine position following at least 5 minutes of rest. BP was measured simultaneously in both arms using two different BP devices that were operated by two operators at the same time. Measurements were performed at noon prior to lunch in order to minimize the effect of meals on BP. BP was measured simultaneously in both arms with an automatic sphygmomanometer (Vital Signs Monitor 52 NTP model; Welch Allyn Protocol, Inc, Beaverton, OR) calibrated according to the manufacturer's recommendations. Standard or large cuffs were used as appropriate. During hospitalization, two measurements were performed: one during admission or within 24 hours of admission and the second during the course of hospitalization (2–7 days after the first measurement). For analysis of the association between IAD

and mortality, we used the IAD determined on initial measurement.

Medical history and patients' characteristics retrieved from the patients' medical records included age, sex, treatment, and comorbidities. Laboratory parameters evaluated included fasting serum glucose levels, lipid profile, and renal functions. Data on mortality were available for all participants from the Israeli Ministry of Internal Affairs registry.

Statistical Analysis

Data were analyzed with SPSS software version 22.0. (SPSS Inc, Chicago, IL). Significance levels were set at 0.05. Baseline characteristics of the study population were presented as means and standard deviations for continuous variables and as frequencies and percentages for categorical variables. Chi-square tests and independent *t* tests were performed to compare the two groups (male/female and survived/died) for categorical and continuous variables, respectively. Kaplan–Meier survival analysis was performed to examine the distribution of survival time between the two groups, using data that include some censored cases.

RESULTS

Patients' Characteristics

During the study period, 1891 elderly patients were hospitalized in the geriatric ward. Of these, 445 patients (244 women) with a mean age of 85±5 years were included in the study and gave informed consent. Patients' characteristics are presented in Table I. Most patients had hypertension (78%), and diabetes mellitus was present in 37% and ischemic heart disease in 33% of patients. Women had a higher prevalence of diastolic IAD >10 mm Hg, a lower prevalence of ischemic heart disease, and higher levels of total and high-density lipoprotein (HDL) cholesterol. The most common antihypertensive medications used were β-blockers and calcium antagonists. Women were more likely to have

TABLE I. Baseline Characteristics of Study Population by Sex

	All	Men	Women	*P* Value[a]
No.	445	201	244	–
Age, y	85±5	85±5	85±5	.936
SBP right hand, mm Hg	134±22	133±21	135±22	.397
SBP left hand, mm Hg	133±21	132±20	135±21	.147
DBP right hand, mm Hg	69±13	69±13	68±12	.564
DBP left hand, mm Hg	68±12	69±12	68±12	.354
Heart rate, beats per min	73±14	72±15	73±12	.530
Systolic IAD, mm Hg	7.2±7.6	7.0±6.1	8.1±8.0	.116
Diastolic IAD, mm Hg	6.1±5.7	5.4±5.6	6.5±5.7	.046
Systolic IAD >10, mm Hg, No. (%)	102 (22.9)	42 (21.0)	60 (24.6)	.356
Diastolic IAD >10, mm Hg, No. (%)	76 (17.1)	24 (11.9)	52 (21.3)	.009
Associated diseases				
Hypertension, No. (%)	348 (78)	153 (76)	195 (80)	.334
Diabetes, No. (%)	167 (37.5)	78 (39)	89 (36.5)	.613
Ischemic heart disease, No. (%)	146 (33)	86 (43)	60 (24.6)	<.001
Stroke, No. (%)	95 (21)	51 (25)	44 (18)	.060
Laboratory parameters				
Serum creatinine, mg/dL	1.12±0.66	1.33±0.83	0.95±0.39	<.001
Serum glucose, mg/dL	139±58	140±62	139±55	.885
Serum cholesterol, mg/dL	165±44	155±37	176±49	.002
Serum HDL cholesterol, mg/dL	49±15	43±12	55±15	<.001
Serum LDL cholesterol, mg/dL	90±28	87±28	94±29	.129
Treatment				
β-Blockers, No. (%)	204 (46)	86 (43)	118 (49)	.224
α-Blockers, No. (%)	95 (21.3)	82 (41)	13 (5)	<.001
Calcium antagonists, No. (%)	193 (43.4)	77 (38)	116 (48)	.046
Diuretics, No. (%)	166 (37.3)	76 (38)	90 (37)	.867
ACE inhibitor, No. (%)	177 (39.8)	87 (43)	90 (37)	.181
ARB, No. (%)	73 (16.4)	24 (12)	49 (20)	.020
Lipid-lowering agents, No. (%)	258 (58)	115 (57)	143 (59)	.767
Aspirin, No. (%)	203 (45)	106 (53)	97 (40)	.007
Clopidogril, No. (%)	60 (13.5)	32 (16)	28 (11.5)	.171

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; DBP, diastolic blood pressure; HDL, high-density lipoprotein; IAD, inter-arm blood pressure difference; LDL, low-density lipoprotein; SBP, systolic blood pressure. [a]*P* for men vs women.

been treated with calcium antagonists and angiotensin receptor blockers and less likely to have been treated with α-blockers and aspirin.

Inter-Arm BP Differences

Average systolic BP and diastolic BP were similar in both hands (Table I). The absolute systolic and diastolic IAD was 7.6±7.2 mm Hg and 6.1±5.7 mm Hg, respectively. A systolic and diastolic IAD >10 mm Hg were present in 102 (22.9%) and 76 (17.1%) patients, respectively. The prevalence of systolic IAD >10 mm Hg was similar in both men and women. Patients with systolic IAD >10 mm Hg had similar baseline parameters as those with IAD ≤10 mm Hg except for higher baseline systolic BP levels (Table II). Patients with diastolic IAD >10 mm Hg had higher baseline fasting glucose levels and were more likely to use diuretics and lipid-lowering agents than those with IAD ≤10 mm Hg (Table II).

Inter-Arm BP Differences and Mortality

During a follow-up period of 342±201 days (ranging from 5 to 659), 102 patients (22.9%) died. Those who died had a lower admission systolic BP, a higher admission heart rate, and lower HDL cholesterol levels and were more likely to use diuretics and less likely to use aspirin than those who survived (Table III). Mortality rate was the same among those with systolic IAD >10 mm Hg (22 of 102 [21.6%]) and those with IAD ≤10 mm Hg (80 of 343 [23.3%]) (*P*=.711). Similarly, the mortality rate was 21% (16 of 76) among patients with diastolic IAD >10 mm Hg and 23.3% (86 of 369) in patients with diastolic IAD ≤10 mm Hg (*P*=.67). Mortality was not associated with either systolic or diastolic IAD. Compared with the mortality rate in those with IAD ≤10 mm Hg, the hazard ratio for mortality was 0.89 (0.55–1.42) for systolic IAD >10 mm Hg and 0.89 (0.52–1.52) for diastolic IAD >10 mm Hg (Figure).

In 394 patients, IAD was measured on two separate occasions during hospitalization. Of these, systolic IAD was >10 mm Hg in both measurements in 34 patients and diastolic IAD >10 mm Hg in 15 patients. Mortality rate was the same in those with systolic and diastolic IAD >10 mm Hg twice and those with IAD ≤10 mm Hg twice (Table IV).

TABLE II. Baseline Characteristics of Study Population by IAD

	Systolic IAD			Diastolic IAD		
	≤10 mm Hg (n=343)	>10 mm Hg (n=102)	*P* Value	≤10 mm Hg (n=369)	>10 mm Hg (n=76)	*P* Value
Age, y	85±5.5	85±4.9	.969	85±5.3	85±5.3	.545
SBP right hand, mm Hg	133±21	139±24	.005	134±22	137±19	.244
DBP right hand, mm Hg	68±12	71±14	.060	68±12	69±16	.563
Heart rate, beats per min	73±14	74±15	.733	73±14	76±15	.058
Systolic IAD, mm Hg	4.6±3.1	17.7±8.0	<.001	6.8±6.8	11.5±7.9	<.001
Diastolic IAD, mm Hg	5.3±5.4	8.6±6.1	<.001	4.04±2.9	15.8±5.9	<.001
Associated diseases						
Hypertension, No. (%)	272 (79)	76 (75)	.304	294 (80)	54 (71)	.097
Diabetes, No. (%)	136 (40)	31 (30)	.090	136 (37)	31 (41)	.519
Ischemic heart disease, No. (%)	112 (33)	34 (33)	.898	121 (33)	25 (33)	.986
Stroke, No. (%)	76 (22)	19 (19)	.493	82 (22)	13 (17)	.322
Laboratory parameters						
Serum creatinine, mg/dL	1.13±0.69	1.10±0.51	.669	1.12±0.68	1.13±0.54	.943
Serum glucose, mg/dL	139±57	142±63	.644	136±54	156±72	.024
Serum cholesterol, mg/dL	164±37	168±65	.622	167±46	156±39	.199
Serum HDL cholesterol, mg/dL	48±15	51±16	.320	49±16	47±12	.382
Serum LDL cholesterol, mg/dL	92±29	83±25	.079	91±28	85±33	.304
Treatment						
β-Blockers, No. (%)	160 (47)	44 (43)	.517	168 (46)	36 (47)	.785
α-Blockers, No. (%)	74 (22)	21 (21)	.821	83 (23)	12 (16)	.190
Calcium antagonists, No. (%)	141 (41)	52 (51)	.081	159 (43)	34 (45)	.806
Diuretics, No. (%)	124 (36)	42 (41)	.367	129 (35)	37 (49)	.025
ACE inhibitor, No. (%)	135 (40)	42 (41)	.758	141 (38)	36 (47)	.142
ARB, No. (%)	52 (15)	21 (21)	.198	61 (17)	12 (16)	.866
Lipid-lowering agents, No. (%)	200 (58)	58 (57)	.795	205 (56)	53 (70)	.023
Aspirin, No. (%)	154 (45)	49 (48)	.592	163 (44)	40 (53)	.184
Clopidogril, No. (%)	49 (13)	11 (15)	.755	71 (21)	13 (13)	.070

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; DBP, diastolic blood pressure; HDL, high-density lipoprotein; IAD, inter-arm blood pressure difference; LDL, low-density lipoprotein; SBP, systolic blood pressure.

TABLE III. Baseline Characteristics of Study Population by Survivors

	Survived	Died	*P* Value[a]
No.	343	102	–
Sex (male/female)	157/186	44/58	.639
Age, y	85±5	86±5	.149
SBP right hand, mm Hg	136±22	129±21	.012
SBP left hand, mm Hg	135±21	129±21	.014
DBP right hand, mm Hg	69±12	68±14	.357
DBP left hand, mm Hg	69±12	67±13	.127
Heart rate, beats per min	73±14	76±13	.032
Systolic IAD, mm Hg	7.4±6.7	8.3±8.9	.276
Diastolic IAD, mm Hg	6.1±5.6	5.9±6	.785
Systolic IAD >10 mm Hg, No. (%)	80 (23.3)	22 (21.6)	.711
Diastolic IAD >10 mm Hg, No. (%)	60 (17.5)	16 (15.7)	.670
Associated diseases			
Hypertension, No. (%)	271 (79)	77 (76)	.450
Diabetes, No. (%)	130 (37.1)	37 (36.3)	.766
Ischemic heart disease, No. (%)	115 (33)	31 (30)	.554
Stroke, No. (%)	71 (21)	24 (23)	.540
Laboratory parameters			
Serum creatinine, mg/dL	1.09±0.65	1.21±0.67	.126
Serum glucose, mg/dL	138±58	145±60	.265
Serum cholesterol, mg/dL	166±34	163±65	.687
Serum HDL cholesterol, mg/dL	51±15	44±15	.014
Serum LDL cholesterol, mg/dL	92±28	86±29	.262
Treatment			
β-Blockers, No. (%)	157 (46)	47 (46)	.976
α-Blockers, No. (%)	74 (22)	21 (21)	.821
Calcium antagonists, No. (%)	156 (46)	37 (36)	.095
Diuretics, No. (%)	118 (34.5)	48 (47)	.021
ACE inhibitors, No. (%)	138 (40)	39 (38)	.702
ARBs, No. (%)	61 (18)	12 (12)	.147
Lipid-lowering agents, No. (%)	205 (59.8)	53 (52)	.172
Aspirin, No. (%)	165 (48)	38 (37)	.051
Clopidogril, No. (%)	48 (14)	12 (12)	.549

Abbreviations: ACE, angiotensin-converting enzyme; ARBs, angiotensin receptor blockers; DBP, diastolic blood pressure; HDL, high-density lipoprotein; IAD, inter-arm blood pressure difference; LDL, low-density lipoproteins; SBP, systolic blood pressure. [a]*P* died vs survivors.

DISCUSSION

Although the prevalence of IAD >10 mm Hg was very high and in accordance with previous reports in similar cohorts,[12] it was not found to be associated with increased mortality. IAD >10 mm Hg has been found to predict cardiovascular morbidity and mortality in various populations, including patients with diabetes[7,8] and patients with stroke.[13] Similar BP in both arms probably represents a finely tuned homeostasis of the circulation, whereas IAD >10 mm Hg may represent some form of disturbed homeostasis of the circulation that may be caused by endothelial dysfunction and consequent arterial stiffness resulting in the increased morbidity and mortality associated with IAD >10 mm Hg.[14] Atherosclerosis is probably more prevalent in elderly individuals[15,16] and the high prevalence of IAD >10 mm Hg in our cohort may serve as evidence for the high prevalence of atherosclerosis.

In a recent study we demonstrated that in very elderly patients, IAD is inconsistent.[17] Therefore, in the present study, we also evaluated the mortality rate in those who had IAD >10 mm Hg on two different occasions. Even in this subgroup, the IAD >10 mm Hg was not associated with increased mortality. The lack of association of IAD >10 mm Hg with mortality in our cohort may have resulted from the high morbidity of our patients and the various potential causes of death in these very elderly patients. Indeed, a previous large study reported an association between IAD >10 mm Hg and mortality in elderly individuals.[12] However, this study included younger (mean age of 69 years) and ambulatory elderly patients and, therefore, does not represent the true typical study of elderly patients.

We included very elderly patients (mean age of 85 years) with multiple comorbidities. We found that IAD >10 mm Hg was not associated with mortality. Another study reported no association of IAD with mortality in young individuals after taking into account traditional risk factors.[18] Because the prevalence of traditional risk factors in our cohort was very high, as expected in

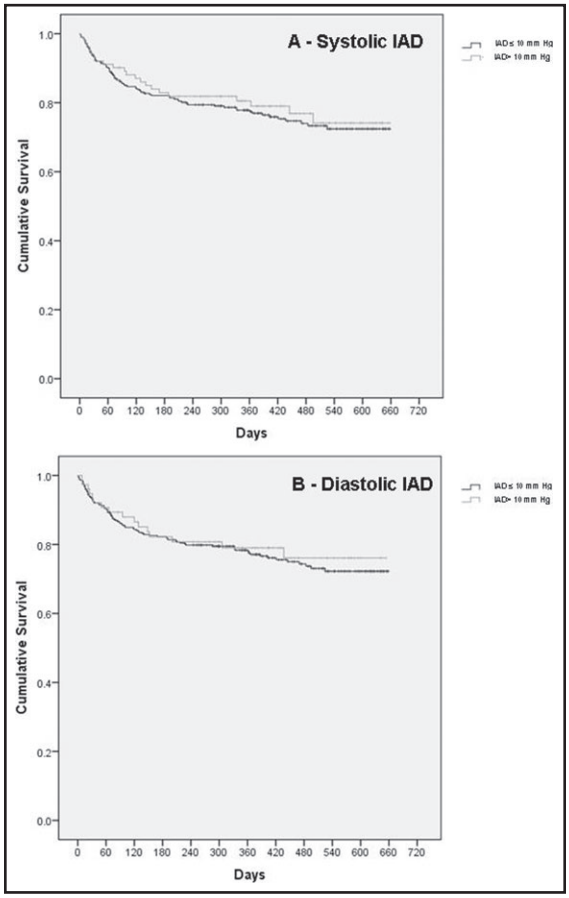

FIGURE. Kaplan–Meier survival curve by category of systolic (A) and diastolic (B) inter-arm blood pressure difference (IAD).

TABLE IV. Mortality Rate in Patients With Two Inter-Arm Blood Pressure Measurements (n=394)

Inter-Arm Difference	>10 mm Hg Both	>10 mm Hg Once	≤10 mm Hg Both	*P* Value
Systolic blood pressure				
No.	34	140	220	
Mortality, No. (%)	7 (20.6)	31 (22.1)	52 (23.6)	.89
Diastolic blood pressure				
No.	15	92	287	
Mortality, No. (%)	4 (26.7)	20 (21.7)	66 (23.0)	.91

elderly hospitalized patients, these risk factors may have "neutralized" the influence of IAD. It is also possible that very old patients have a "survival advantage" irrespective of their burden of atherosclerosis and thus surrogate markers of atherosclerosis have scarce influence on their mortality. In addition, it is also possible that despite the high prevalence of hypertension in this cohort (78%), a large proportion of the patients were medically treated and particularly well-controlled, thus eliminating the potential vascular injury resulting from the atherosclerotic process. As IAD was not found to be associated with mortality and because of the low probability of identifying significant and potentially treatable conditions by measuring BP in both arms, such routine measurement seems unnecessary in the elderly.

STUDY LIMITATIONS

This study has several limitations. First, it was conducted on hospitalized patients in whom the acute condition leading to their hospitalization may have influenced their BP values. In order to minimize the effect of hemodynamic instability on IAD, we excluded all patients with admission systolic BP <90 mm Hg. Indeed, one study reported a very high prevalence of IAD in critically ill patients[19] but our cohort included patients hospitalized in a general ward and not in an intensive care setting. We excluded patients with low admission BP. Moreover, the patient characteristics in our study and the prevalence of IAD >10 mm Hg were similar to those of previous studies of the elderly. Therefore, we believe that the cohort can represent very elderly ambulatory patients. In order to evaluate mortality unrelated to hospitalization, we excluded patients who were expected to survive <24 hours from admission. Our cohort was certainly at high risk for mortality based on the participants' age and comorbidities. Yet, we believe that because of the prespecified limitations of the cohort, the results are applicable to this particular population.

Second, follow-up was relatively short, but since the patients were very old, mortality rates were high enough to evaluate the association with IAD. Indeed the high mortality rate in our cohort may be responsible for the negative findings, but this rate is probably representative of the expected mortality in such a cohort of hospitalized elderly individuals. Moreover, IAD was almost the same in those who died and those who survived, therefore it is unlikely that the results would be different if the sample size were larger and the follow-up longer.

CONCLUSIONS

Neither systolic nor diastolic IAD >10 mm Hg is associated with mortality in hospitalized elderly individuals. Considering the lack of association with mortality in this population, it is questionable whether BP should be routinely measured in both arms in the elderly.

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