

ORIGINAL ARTICLE

The Influence of Seasonal Temperature Variation on Blood Pressure Behavior

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Abstract

Background: Hypertension in Brazil affects 32.5% of the population, accounting for 50% of deaths due to cardiovascular disease. The correct measurement and interpretation of blood pressure are essential for attaining an adequate disease diagnosis and management.

Objective: To verify the correlation between the seasonal temperature variation during 2016 and blood pressure variation in 902 patients of a private Cardiology Service in the city of Porto Alegre/RS.

Method: A total of 902 ambulatory blood pressure monitoring (ABPM) results were analyzed in 2016. Pearson's Correlation Coefficient was used to correlate blood pressure levels with the values of temperature and relative air humidity; the Kolmogorov-Smirnov and Shapiro-Wilk tests were adopted for significance values, assuming an alpha error < 0.05 and a 95% confidence interval. The Analysis of Variance compared the 902 ABPM results with the continuous variables obtained for this study.

Results: No statistically significant differences were found when the blood pressure values obtained from the 902 ABPM results were correlated with the minimum, mean and maximum values of temperature and relative air humidity, and also when each of the continuous variables obtained for this study were compared with these same pressure measurements.

Conclusion: Despite the great variation in temperature and relative air humidity throughout the year in the region, there was no significant influence on the systemic arterial pressure in the study population. New comparative studies in the same population with different thermal variations may provide further clarification on this subject. (Int J Cardiovasc Sci. 2019; [online].ahead print, PP.0-0)

Keywords: Blood Pressure; Climate Change; Risk Factors; Risk Assessment; Seasons; Humidity.

Introduction

According to data obtained from the 7th Brazilian Guideline of Arterial Hypertension, Arterial Hypertension (AH) in Brazil affects 32.5% of the adult population (36 million), and more than 60% of this population consists of elderly individuals. This condition contributes directly or indirectly to 50% of deaths from cardiovascular disease, and for this reason it is considered a public health problem. Due to this fact, the correct measurement and interpretation of systemic arterial pressure are essential for the adequate diagnosis and management of hypertension.¹

Risk factors such as age, overweight and obesity, socioeconomic factors, excessive salt intake, chronic and high consumption of alcoholic beverages and sedentary lifestyle effectively contribute to the development of AH. The influence of climatic factors (seasonality, temperature, relative air humidity and others) as a risk factor for AH development is not well established. Few studies have been carried out to verify the influence of temperature variation throughout the year on the development of arterial hypertension, but this correlation is still unclear and requires further studies.¹⁻⁴ Amoah et al.,⁵ reported that an increase in the sympathetic system activity is correlated with higher blood pressure readings

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during winter and that blood pressure decreases in summer due to blood vessel dilation, associated with loss of salt and water through perspiration, so that lower BP values are recorded during that season.

Considering that the city of Porto Alegre, capital of the state of Rio Grande do Sul, Brazil, is characterized by quite different climatic conditions during the year, the aim of the present study was to verify the correlation between the seasonal variation of temperature and relative humidity of the air during the year 2016 and the systemic arterial pressure variation in a sample assessed through ambulatory blood pressure monitoring (ABPM) of 902 patients from a private Cardiology Service of the aforementioned city.

Methods

This was a retrospective longitudinal study of a convenience sample, in which we analyzed 902 results of patients submitted to ABPM, after indication of their attending physicians, from January to December 2016, in a private Cardiology Service in the city of Porto Alegre/RS.

The sample consisted of individuals older than 18 years of age, of both genders, divided into three groups: the first group included all 902 patients in the sample; the second group included 186 patients using one or more antihypertensive drugs of different classes, and the third group included 716 patients who did not use any type of antihypertensive medication. We analyzed the diagnostic and follow-up examinations of all patients who underwent ABPM at the clinic during the specified period. A Cardios ABPM device was used. The values for systolic and diastolic blood pressure levels were obtained from the respective ABPM of each individual, and the daily values for temperature and relative humidity of the air were obtained from INMET (National Institute of Meteorology) website from December to January 2016 and were divided by the four seasons of the year (summer, fall, winter and spring).

Statistical analysis

The collected data were organized into a database using the software Statistical Package for Social Sciences (SPSS).²² For the continuous variables, mean, standard deviation and 95% confidence intervals were used, as well as minimum and maximum values of each variable after assessment of their normality using the Shapiro-Wilks test.

Pearson's Correlation Coefficient was applied to correlate the mean awake systolic and diastolic blood pressure (MASBP/MADBP) and the mean resting systolic and diastolic blood pressure (MRSBP/MRDBP), minimum (MIN SBP) and maximum (MAX SBP) systolic blood pressure, 24-hour mean systolic and diastolic blood pressure (24HMSBP/24HMDBP), systolic and diastolic dipping in relation to the minimum, mean and maximum temperature values, and relative humidity of the air stratified by the users of antihypertensive medication (Table 2) or non-use of medication (Table 3).

The analysis of variance (one-way ANOVA) was applied to compare the levels of SBP obtained in ABPM, age, temperature and relative humidity between the 4 seasons of the year 2016.

For statistical significance, an alpha error < 0.05 and a 95% confidence interval were admitted.

Results

The results of 902 ABPM from different individuals were included in the study. The data obtained regarding the mean, standard deviation and 95% confidence interval, as well as minimum and maximum values of the patient's age, the results related to the systolic and diastolic blood pressure levels, temperature and relative humidity are shown in Table 1.

No significant associations were found when the variables obtained through ABPM were correlated with the minimum, mean and maximum values of temperature and relative air humidity, both in group 2, which used antihypertensive medications and in group 3, which did not use antihypertensive medications (Table 2 and Table 3, respectively).

Also, no significant differences were found when all three patient groups (total of patients, users and non-users of antihypertensive drugs) were compared with each of the continuous obtained variables – age, minimum, mean and maximum values of MASBP, MADBP, MRSBP, MRDBP, MIN SBP, MAX SBP, 24HMSBP, 24HMDBP, systolic and diastolic dipping, temperature and relative humidity (Table 4) (Figures 1 and 2).

Discussion

Hypertension is an important factor for cardiovascular morbidity and mortality, being an independent risk factor for myocardial infarction, chronic kidney disease,

Table 1 - Values obtained in the ABPM of 902 patients (January to December / 2016)

	Mean ± SD (95%CI)	Minimum value	Maximum value
Age	57.47 ± 15.429	18	94
MASBP	129.12 ± 12.940	94	185
MADBP	81.56 ± 10.745	51	118
MRSBP	116.73 ± 14.643	82	174
MRDBP	68.81 ± 10.364	43	105
MAX SBP	163.95 ± 21.566	114	255
MIN SBP	102.72 ± 12.435	68	152
24HMSBP	126.14 ± 12.641	93	180
24HMDBP	78.54 ± 10.210	50	115
Systolic dipping	9.50 ± 7.766	-27	28
Diastolic dipping	15.52 ± 9.215	-16	42
Maximum temperature	23.929 ± 5.930	13.0	39.0
Minimum temperature	14.759 ± 5.191	3.0	25.4
Mean temperature	18.493 ± 5.281	8.0	29.0
Relative air humidity	77.149 ± 10.164	49.2	97.25

ABPM: ambulatory blood pressure monitoring; SD: standard deviation; CI: confidence interval; MASBP/MADBP: mean awake systolic and diastolic blood pressure; MRSBP/MRDBP: mean resting systolic and diastolic blood pressure; MAX SBP/MIN SBP: maximum and minimum systolic blood pressure; 24HMSBP/24HMDBP: 24H mean systolic and diastolic blood pressure.

ischemic and hemorrhagic strokes, and premature death. It should not be treated alone, and the approach should include lifestyle changes (LSC) for these patients and the use of antihypertensive medications. In Brazil, it is considered a public health problem, requiring public policy strategies aimed at preventing the development of AH.¹⁻³ In a study entitled ELSA-BRASIL - Longitudinal Study of Adult Health (*Estudo Longitudinal de Saúde do Adulto*)⁶ carried out between 2008 and 2010, involving 15,105 individuals between the ages of 35 and 74, the authors found almost 36% of hypertensive individuals in the study population, corroborating the fact that AH

is a serious problem, requiring early intervention and prevention measures. Guimarães et al.,⁷ in an ecological time-series study on mortality due to cardiovascular diseases in Brazil, observed that there was a reduction in mortality coefficients from ischemic heart disease and cerebrovascular disease in Brazil between 1980 and 2012, but the regions that showed the highest coefficients for both conditions were the southeast and south regions, which draws attention to the region in which the present study was carried out.

Several studies have addressed and shown the association of risk factors such as age,⁸⁻⁹ socioeconomic factor,¹⁰ obesity,¹¹⁻¹⁴ sedentary lifestyle,¹⁴ excessive intake of salt^{13,15,16} and alcoholic beverages¹⁷ with the development of AH. Moreira et al.,⁸ in a cohort study carried out in the city of Porto Alegre, involving 1,089 individuals aged 40 to 49 years, concluded that age and waist-to-height ratio are independent factors for hypertension and that the incidence of hypertension in Brazil tends to be higher than in developed countries. Picon et al.,⁹ in a meta-analysis, also reports that the prevalence of hypertension in the elderly in Brazil is quite high; therefore, both authors corroborate that the age factor has influence on blood pressure behavior.

In the study by Bassanesi et al.,¹⁰ also carried out in Porto Alegre, premature mortality (between 45 and 64 years of age) from cardiovascular diseases was 163% higher in districts located in the worst socioeconomic quartile compared to those located in the best quartile. In this same study, almost half of the mortality from cardiovascular diseases before the age of 65 years was associated with poverty and socioeconomic factors.

Regarding the association between obesity / sedentary lifestyle and AH, there are many studies on this subject.¹¹⁻¹⁴ Galve et al.,¹⁴ reported that excess weight and sedentary lifestyle are among the leading causes of hypertension in both developed and developing countries.

Salt intake is considered to be one of the main causes of elevated blood pressure according to Trieu et al.,¹⁵ and Frohlich et al.,¹⁶ and its restriction can prevent cardiovascular and renal injuries. Regarding alcohol abuse, Briassoulis et al.,¹⁷ concluded in a meta-analysis that its excessive intake, regardless of gender, also greatly increases the risk of AH.

Regarding the influence of climate / temperature on blood pressure behavior, the studies, mainly in Brazil, are scarce. Worldwide, the vast majority of studies was carried out in China, with large population samples.

Table 2 - Values obtained from 186 ABPM in group 2 (patients taking antihypertensive medications) – Pearson's Correlation Coefficient

Pearson's Correlation Coefficient	Maximum temperature	Minimum temperature	Mean temperature	Relative air humidity
MASBP	-.081	-.072	-.078	.069
MADBP	-.043	.022	.001	-.037
MRSBP	.063	.073	.078	-.123
MRDBP	.065	.117	.111	-.105
MAX SBP	-.038	-.062	-.053	-.042
MIN SBP	-.027	-.004	-.012	-.058
24HMSBP	-.024	-.011	-.014	-.093
24HMDBP	.000	.072	-.051	-.054
Systolic dipping	-.193	-.192	-.209	.113
Diastolic dipping	-.175	-.165	-.186	.127

ABPM: ambulatory blood pressure monitoring; MASBP/MADBP: mean awake systolic and diastolic blood pressure; MRSBP/MRDBP: mean resting systolic and diastolic blood pressure; MAX SBP/MIN SBP: maximum and minimum systolic blood pressure; 24HMSBP/24HMDBP: 24H mean systolic and diastolic blood pressure.

Table 3 - Values obtained from 716 ABPM in group 3 (patients without antihypertensive medication) - Pearson's Correlation Coefficient

Pearson's Correlation Coefficient	Maximum temperature	Minimum temperature	Mean Temperature	Relative air humidity
MASBP	-.158	-.188	-.191	.001
MADBP	-.113	-.134	-.137	.029
MRSBP	-.033	-.030	-.041	-.028
MRDBP	-.042	-.042	-.050	.035
MAX SBP	-.154	-.187	-.189	.008
MIN SBP	-.127	-.121	-.140	-.008
24HMSBP	-.145	-.155	-.168	.017
24HMDBP	-.089	-.103	-.107	.019
Systolic dipping	-.138	-.172	-.162	-.028
Diastolic dipping	-.083	-.100	-.097	.001

ABPM: ambulatory blood pressure monitoring; MASBP/MADBP: mean awake systolic and diastolic blood pressure; MRSBP/MRDBP: mean resting systolic and diastolic blood pressure; MAX SBP/MIN SBP: maximum and minimum systolic blood pressure; 24HMSBP/24HMDBP: 24H mean systolic and diastolic blood pressure.

Regarding the pathophysiology, Amoah et al⁵ states that an increase in sympathetic tonus during winter increases BP levels, whereas vasodilation and loss of

salt and water through summer perspiration causes BP levels to decrease. In 2013, in a study carried out in China, the authors¹⁸ concluded that blood

Table 4 - Values obtained at the ABPM in the 3 groups of patients (January to December / 2016) - Analysis of variance

ANOVA	Group 1 (n = 902)*	Group 2 (n = 186)†	Group 3 (n = 716)‡
Age	.477	.172	.501
MASBP	.000	.738	.000
MADBP	.013	.476	.012
MRSBP	.552	.265	.402
MRDBP	.485	.119	.496
MAX SBP	.003	.727	.001
MIN SBP	.053	.553	.006
24HMSBP	.002	.610	.000
24HMDBP	.073	.202	.081
Systolic dipping	.006	.151	.020
Diastolic dipping	.204	.377	.337
Maximum temperature	.000	.000	.000
Minimum temperature	.000	.000	.000
Mean temperature	.000	.000	.000
Relative air humidity	.000	.000	.000

ABPM: ambulatory blood pressure monitoring; MASBP/MADBP: mean awake systolic and diastolic blood pressure; MRSBP/MRDBP: mean resting systolic and diastolic blood pressure; MAX SBP/MIN SBP: maximum and minimum systolic blood pressure; 24HMSBP/24HMDBP: 24H mean systolic and diastolic blood pressure; () total group of patients; (†) group of patients taking antihypertensive medications; (‡) group of patients without antihypertensive medications.*

pressure levels are strongly and inversely associated with external temperature and suggest that seasonal variations in blood pressure should be considered in the patients' assessment. In another study, carried out in a rural area of China, in which more than 57,000 individuals between 30 and 79 years old participated, Su et al.,¹⁹ also concluded that a lower external temperature is strongly associated with higher mean arterial pressure and the prevalence of hypertension, as well as poorer control of hypertension, and that this factor should be considered when performing population studies of hypertension.

Yang et al.,²⁰ in a sample of 23,000 Chinese individuals with a history of cardiovascular disease,

showed that there is an increase in blood pressure and cardiovascular mortality in winter. They concluded that careful monitoring and a more aggressive treatment are needed to decrease blood pressure during the cold months and reduce mortality from cardiovascular causes in high-risk individuals.

Lewington et al.,²¹ and Wang et al.,²² carried out surveys with population samples of more than 500,000 and 430,000 individuals, respectively, with the first study sample consisting of individuals from several Chinese rural regions, and the second one of patients from a university hospital linked to Zhejiang University (Zhejiang University School of Medicine). The authors of both studies also concluded that a low external temperature increases blood pressure levels, and similarly, suggest that the seasonal variation in blood pressure should be considered in the patients' clinical assessment.

In an American study, Amoah et al.,⁵ recently investigated the seasonal variation of blood pressure monitoring but correlated the control of blood pressure levels with the use of electronic equipment in the different climatic seasons, and concluded this control is performed cyclically, being higher during the winter period. However, they did not report the results of this variation in absolute numbers of blood pressure.

In Brazil, there have been some studies that associated seasonal temperature variation with gestational hypertension,^{4,23} symptoms of stroke,^{24,25} respiratory diseases,²⁶ epistaxis²⁷ and others that investigated the association between climate and mortality from different diseases in elderly individuals.²⁸ Only one study²⁹ approached the subject, when it investigated the effect of water temperature on cardiovascular responses: heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) during exercise at different temperatures (29° C, 33° C and 37° C). The authors found a HR increase and DBP decrease at 37° C; they did not find a significant effect on SBP. At the end, they suggest that, when therapeutic swimming pools are used for water-walking exercises, the choice of the water temperature should be considered as a way to decrease cardiovascular stress.

Studies that are similar to the present work, assessing the temperature seasonal variation in association to blood pressure behavior, were not found. This fact indicates the need for further investigations, since studies with large population bases, such as the Chinese studies, have shown that temperature variation does in fact influence blood pressure behavior.

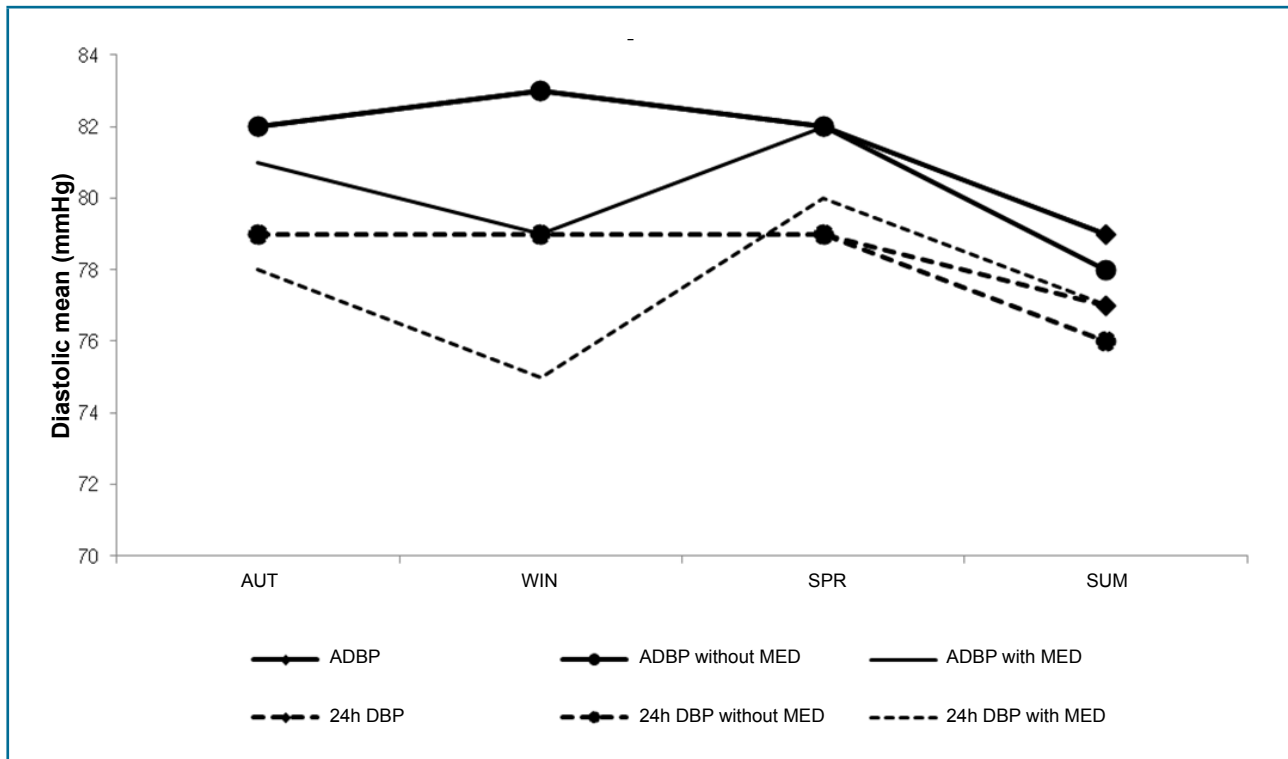


Figure 1 - Mean diastolic blood pressures at ABPM compared between the climatic seasons in the total group and according to antihypertensive drug use (January to December / 2016).

ADBP: awake diastolic blood pressure; ADBP with MED.: awake diastolic blood pressure with medication; ADBP without MED: awake diastolic blood pressure without medication; 24h DBP: 24-hour diastolic blood pressure in the entire group.

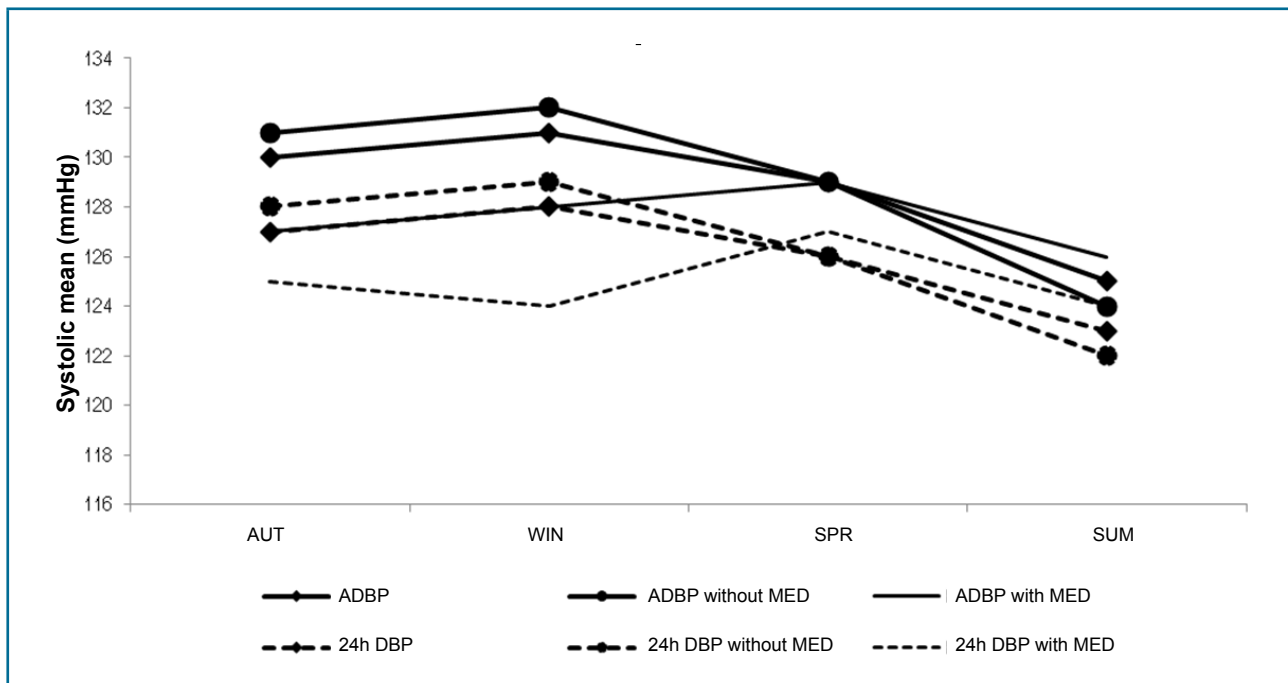


Figure 2 - Mean systolic pressures at ABPM compared between climatic seasons in the entire group and according to antihypertensive drug use (January to December / 2016).

ASBP: awake systolic blood pressure; ASBP with MED.: awake systolic blood pressure with medication; ASBP without MED: awake systolic blood pressure without medication; 24h SBP: 24-hour systolic blood pressure in the entire group; 24-h SBP without MED: 24-hour SBP without medication.

This study has limitations, as it consists of a population sample that had exams requested according to the attending physicians' individual criteria and no evaluation of other risk factors for AH, such as weight, ethnicity and family history of SAH.

Conclusion

The influence of climatic factors on blood pressure behavior is still controversial. There are not enough data in Brazil and in its South region because the studies related to the subject are scarce or nonexistent.

With four well-defined climatic seasons, mean air temperature and relative humidity in Porto Alegre show great variation throughout the year; however, this variation did not show a significant influence on systemic arterial pressure behavior in the assessed population. New comparative studies carried out in the same population with different thermal variations can provide further clarification on this subject.

Author contributions

Conception and design of the research: Escosteguy JR, Beskow M, Van Der Sand CR. Acquisition of data:

Escosteguy JR, Beskow M, Van Der Sand CR. Analysis and interpretation of the data: Van Der Sand CR. Statistical analysis: Van Der Sand CR. Writing of the manuscript: Escosteguy JR, Beskow M, Van Der Sand CR. Critical revision of the manuscript for intellectual content: Escosteguy JR, Van Der Sand CR.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

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