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ORIGINAL ARTICLES

Interrelation between severity of seasonal changes of blood pressure at night and in the morning and life quality characteristics in patients with arterial hypertension

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Summary

Objective

To identify the interrelation between the severity of seasonal changes of blood pressure (BP) at night and in the morning and life quality (LQ) characteristics in patients with AH.

Materials and methods

We analyzed databases of different studies that had been hold in our Center during the period from 1996 to 2011 and included the results of 953 24-h BP monitoring (24h-BPM) tests. We analyzed the results of studies with similar design and inclusion criteria. We estimated 24h-BMP in patients without serious concomitant diseases who underwent BP monitoring during one week withdrawal of antihypertensive therapy.

Results

We demonstrated that seasonal dynamics of diastolic BP (DBP) measured at night and in the morning was similar: maximal values of DBP were registered in winter and minimal ones – in summer, and it was typical for seasonal dynamics of DBP in general. The values of systolic BP (SBP) measured in the morning were minimal in winter and

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maximal in autumn, but there were no significant differences between seasons. Average values of night SBP were minimal in spring and maximal in autumn (p<0,05).
Statistical analysis of obtained results performed using generalized linear models and Fisher criterion (F) demonstrated that severity of seasonal BP changes was reversely correlated with the level of social support for seasonal changes of SBP measured at night and in the morning and for DBP measured in the morning. Apart from it, seasonal SBP changes depended on sex and gender: males and elderly people had more evident seasonal changes of SBP (F=5,01, p<0,03 and F=5,05, p<0,03, respectively).

Conclusions

We demonstrated that severity of seasonal changes of SBP and DBP in the morning and at night was reversely correlated with characteristics of AH patients' social support provided by relatives, friends, colleagues (one of LQ elements). Seasonal dynamics of DBP measured in the morning and at night was typical: BP levels were maximal in winter and minimal in summer. The highest values of morning SBP were detected in autumn, and the lowest ones were measured in winter. The values of night SBP were minimal in spring and maximal in autumn.

Key words

Arterial hypertension, seasonal dynamics of blood pressure, life quality

It is well known that climatic factors have much influence on humans. The change of seasons leads to functional changes in many organs and organ systems, behavior and mood [1-3]. Numerous studies conducted in Europe during the last years demonstrated seasonal fluctuations of clinical and home-measured levels of blood pressure (BP) [4] registered using automatic gadgets for 24-h BP monitoring (24h BPM) and BP self-monitoring (BPSM). It has been shown that clinical, average 24-hour (measured at home) and daily levels of BP are maximal in winter and minimal in summer, and average night BP is maximal in summer and minimal in winter [5, 6, 7, 8]. According with several studies, the degree of night BP reduction was the most evident in winter and the less noticeable in summer [9]. Another major study demonstrated that morning levels of BP (during awakening and 2 hours after it) were the highest at cold time of the year [10].

In this study we estimated seasonal dynamics of average night and morning BP levels (measured between 6 and 8 a.m.). It is necessary to mention that the features characterizing the degree of morning increase and night decrease of BP, absolute values of morning and night BP have prognostic value for cardiovascular complications and mortality, target organ lesions, and increase of carotid arteries' intima-media thickness [11-21]. Life quality (LQ) of patients is one of the main factors connected with BP levels. Numerous studies demonstrated that clinical levels of BP (degree of BP reduction at night, BP variability) correlated with several elements of LQ of patients with AH. The objective of this study was to identify the interrelation between the severity of seasonal changes of BP at night and in the morning and life quality (LQ) characteristics in patients with AH living in Moscow region.

Materials and methods

We analyzed a database of different studies that had been hold in our Center during the period from 1996 to 2011 and had similar inclusion criteria and study protocols. We selected 953 24-h BPM tests performed with the use of SpaceLabs equipment in patients with AH and without severe concomitant diseases after withdrawal of antihypertensive therapy. We included just the results of 24h-BPM that satisfied the following criteria: 1) the number of effective BP measurements was not less than 50; 2) there were no pauses longer than 1h in 24h-BPM protocols; 3) 24-h BPM device was fitted in the morning between 09.15 and 10.15 a.m. and it was removed the day after at the same time; 4) the age of patients was between 20 and 80 years; 5) average daytime BP was >135/85 mm Hg and ≤160/110 mm Hg, and patients with white coat hypertension (WCH) had BP>140/90 mm Hg measured in clinical setting (the percentage of WCH patients did not exceed 10-15% in total and for each season in particular); 6) patients had not been receiving antihypertensive therapy for 1 week at the moment of monitor fitting; 7) 24h-BMP was performed using SpaceLab90207 and 90317 devices.

We analyzed 953 24h-BPM that met the inclusion criteria. According with the results of 24h-BMP, we quantified average BP values in the following time periods: morning (m) — from 6 a.m. to 8 a.m.; night (n) — from 0 a.m. to 6 a.m.; daytime (d) — from 8 a.m. to 22 p.m.; 24 hours (24).

After 24h BPM patients underwent LQ estimation. We used "General Well-Being Questionnaire" (GWBQ) developed by the research group from Marburg university (Siegrist J et al, 1989) and further adapted for Russian population [29, 30]. The questionnaire is based on self-estimation of personal condition by patient and it includes 8 clinical scales: I — physical well-being (complaints), II — work capacity, III — positive (III) or IV — negative psychological well-being, V — psychological capacities, VI — social well-being, VII — ability to make social contacts, VIII – sexual capacity in men. Estimating the dynamics of GWBQ scales, we considered that reduction of the values of scales I-IV and increase of the values of all other scales corresponded to improved LQ. The scale VIII was not analyzed since both men and women took part in this study.

Statistical analysis of the results was done using SAS (version 6.15) software. Fisher's criterion (F) was quantified using generalized linear model. Severity of seasonal BP increase was quantified as the value characterizing the increase of BP at one exact day comparing with the reference (average annual) BP level. 24h-BPM values were quantified using APBM-FIT software [31].

Results

Average annual BP values in patients with AH detected with 24h BPM. We analyzed results of 953 24h BPM that met the inclusion criteria. 51% of 24h-BPM results belonged to female patients, and 49% of results were male ones. The average age of the patients was 55,2±12,3 years, the average duration of AH was 11,97±10,7 years, the average height was 168,3±8,1 cm, the average weight was 81,7±14,2 kg.

The average annual values of systolic BP (SBP) were the following (Table 1): the average daytime SBP (dSBP) was 141,5±15,5 mm Hg, the average night SBP (nSBP) was 124,9±16,4 mm Hg, the average 24h SBP (SBP24) was 137,7±15,0 mm Hg. Diastolic BP (DBP) had the following values: the average daytime DBP (dDBP) was 89,1,5±10,7 mm Hg, the average night SBP (nSBP) was 74.3,9±10,9 mm Hg, the average 24h SBP (SBP24) was 85,7±10,4 mm Hg.

Table 1. **Average annual SBP and DBP levels in patients with stable AH (M±SD)**

Time intervals	DBP (mm Hg)	SBP (mm Hg)
24 h	85.7±10.4	137.7±15,0
Daytime	89.1±10.7	141.5±15.5
Nighttime	74.3±10.9	124.9±16.4
TI for 24h	38.6±28.1	48.4±30.1
TI for daytime	46.3±32.6	50.4±33.2
TI for night	30.3±30.5	56.5±36.6
HR	74.9±9.5	

Comment: DBP, SBP – average diastolic/systolic BP, TI – time index, HR – heart rate.

Comparison of social-demographic characteristics of patients who participated in 24h BPM at different seasons did not reveal any significant differences of sex, age, height, weight and AH duration in all four groups. We analyzed the results of 953 24h-BPM, between them 230, 262, 208, 253 24h-BPM were performed in winter, spring, summer and autumn periods, respectively (Table 2).

Seasonal changes of home-measured BP values. Average home-measured *mDBP* had minimal values in summer and maximal ones in winter, but there were no significant differences between seasons.

We identified that average dDBP and DBP24 of patients with AH were maximal in winter and minimal in summer ($p<0,05$). Average home-measured nDBP levels had the same trend of seasonal changes, but there were no statistically significant changes between seasons (Table 3, Figure 1).

Average home-measured mSBP had the lowest and the highest values in winter and in autumn, respectively, but there were no significant changes between seasons.

Analysis of seasonal changes of main SBP characteristics (Table 3, Figure 1) measured in patients with

Table 2. **Characteristic of patients who underwent 24h-BPM during different seasons**

Characteristics	Demographic characteristics of patients who participated in 24h-BPM in winter (n=230) (M±SD)	Demographic characteristics of patients who participated in 24h-BPM in spring (n=262) (M±SD)	Demographic characteristics of patients who participated in 24h-BPM in summer (n=208) (M±SD)	Demographic characteristics of patients who participated in 24h-BPM in autumn (n=253) (M±SD)	Significance of differences (p<0,05)
Age (years)	55.7±12.4	56.1±10.9	54.4±12.5	55.3±11.9	Ns
Height (cm)	168.6±7.9	168.1±14.0	166.9±8.9	168.7±15.1	Ns
Weight (kg)	82.6±13.3	81.1±14.7	80.0±14.2	82.8±15.2	Ns
AH duration	12.8±11.3	11.1±11.24	11.7±10.1	12.0±10.3	Ns
Gender %(m/f)	49/51	50/50	50/50	49/51	Ns

Comment: ns – not significant

Table 3. **Seasonal changes of home-measured BP (M±SD)**

Seasons / 24h-BPM results	Winter	Spring	Summer	Autumn	Significance of differences p< 0.05
Seasonal changes of main home-measured BP characteristics					
DBP24	87.5±10.8	85.5±10.4	84.1±9.9	86.2±9.7	** - between winter and summer
dDBP	91.4±11.4	89.0±10.7	86.3±10.0	89.8±10.6	***- between winter and summer
nDBP	75.6±14.1	73.6±10.4	72.5±10.4	75.2±11.5	Ns
SBP24	138.5±15.2	137.3±14.9	136.0±15.0	138.6±14.8	Ns
dSBP	142.6±15.6	141.3±15.2	139.3±15.6	142.4±15.3	Ns
nSBP	125.2±15.7	123.0±15.8	124.6±15.8	126.3±16.9	** - between spring and autumn
Seasonal changes of morning home-measured BP characteristics					
mSBP	131.8±17.6	132.4±14.8	132.8±19.2	133.3±18.7	Ns
mDBP	83.5±13.7	81.5±13.4	80.2±11.5	82.25±12.3	Ns

Comment: Ns – not significant ** - p<0,05, *** - p<0,01.

AH demonstrated that average dSBP and SBP24 levels were maximal in winter and minimal in summer. The differences between seasons were not significant. Average home-measured nSBP were minimal in spring and maximal in autumn (p<0,05).

Concluding the results mentioned above (Figure 1), we can say that mSBP levels were maximal in autumn and minimal in winter. The highest values of mDBP were detected in summer and the lowest ones were detected in winter. Seasonal changes of BP24, dBP, and nBP in patients with AH who did not receive antihypertensive therapy were similar, with maximal BP levels in winter and minimal BP values in summer. The lowest levels of nSBP were registered in spring and the highest ones were detected in autumn.

We estimated influence of several independent variables on the severity of seasonal changes of 24h-BM using dispersion analysis and generalized linear models and quantifying Fisher's criterion (F) for these variables.

As can be seen at the Table 4, age and gender were important for morning seasonal SBP changes (F=5,01, p<0,03 and F=5,05, p<0,03, respectively).

We observed reverse correlation between several LQ features and severity of SBP fluctuations during year. Improved social support from family, friends, colleagues (scale VI — social well-being) was connected with reduced severity of SBP seasonal changes at day, night and in the morning (Table 4).

Seasonal DBP changes did not depend on gender and age. Several components of patients' LQ correlated reversely with the severity of DPB seasonal changes. Increased social support (Scale VI) correlated with decreased severity of seasonal changes of DBP in the morning, at daytime and during 24h (Table 5).

Therefore, decreased social support (one of LQ components) was combined with increased severity of seasonal DBP and SBP changes in the morning and at night in patients with AH. Seasonal mSBP changes were more evident in men and elderly pa-

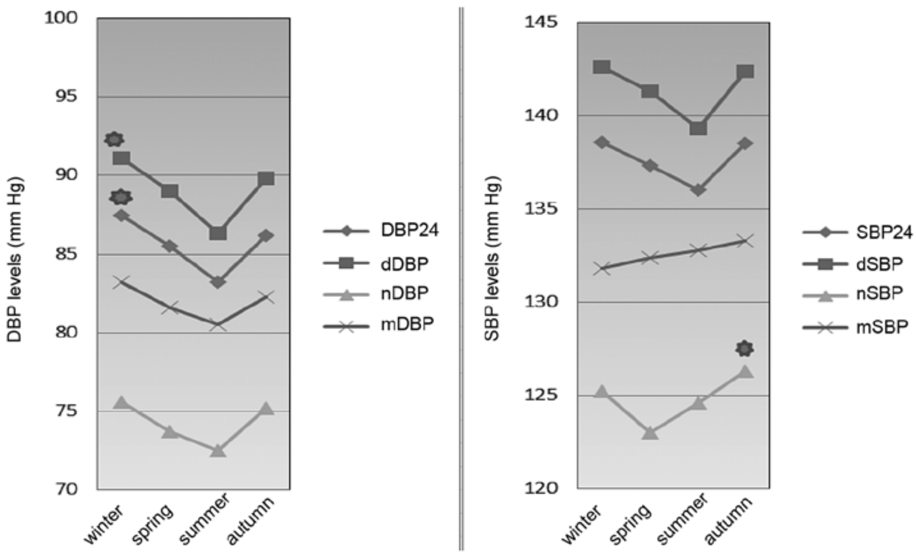

Figure 1. Comparison of seasonal changes of morning and night BP in patients with AH
* - significant differences (p<0,05)

Table 4. **Interrelation between LQ, age, gender and severity of seasonal SBP changes (based on Fisher's criterion (F))**

24h-BPM / Social-demographic characteristics	Age	Gender	LQ characteristics (Scale VI)
SBP24	Ns	Ns	F=11,34, (p<0,001)(-)
dSBP	Ns	Ns	F=11,91, (p<0,001)(-)
nSBP	F=4,13, (p<0,04)(+)	Ns	F=5,04, (p<0,002) (-)
mSBP	F=5,01,(p<0,03)(+)	F=5,05, (p<0,03)	F=11,29, (p<0,001)(-)

Comment: Ns – not significant; F – Fisher's criterion; SBP24 – average SBP measured within 24h, dSBP – average daytime SBP, nSBP – average night SBP, mSBP – average morning SBP; The scales of LQ-estimating questionnaire: VI – social well-being, + positive connections, - negative connections.

Table 5. **Interrelation between LQ, age, gender and severity of seasonal DBP changes (based on Fisher's criterion (F))**

24h-BPM / Social-demographic characteristics	Age	Gender	LQ characteristics (Scale VI)
DBP24	Ns	ns	F=4,06, (p,<0,04)(-)
dDBP	Ns	ns	F=5,17, (p,<0,02)(-)
nDBP	Ns	ns	Ns
mDBP	Ns	Ns	F=4,29, (p<0,04)(-)

Comment: Ns – not significant; F – Fisher's criterion; DBP24 – average DBP measured within 24h, dDBP – average daytime DBP, nDBP – average night DBP, mDBP – average morning DBP; The scales of LQ-estimating questionnaire: VI – social well-being, + positive connections, - negative connections.

tients. Seasonal mDBP dynamics was typical: BP levels were maximal in winter and minimal in summer. At the same time, the highest values of mSBP were registered in autumn and the lowest ones were detected in winter.

Discussion

In our study we estimated a new additional parameter that characterized morning BP levels measured at home (mBP) apart from well-known ones. mBP was quantified as average value of BP measured between 6 and 8 a.m. We selected this time period because it corresponds to the first time period associated with increased general and cardiovascular mortality [23]. Apart from it, this time period was associated with highest mortality in hospitals without intensive care units (ICU) (In case of ICU presence mortality peaks have different timing) [24]. Our approach of BP evaluation (average BP values measured between 6 and 8 a.m.) in the morning is enough simple to perform, since many devices for 24h-BPM have settings that allow to choose a distinct time interval and quantify average values of BP measurements made at this time period. As we have already mentioned before, parameters that characterize the severity of mBP increase, absolute values of mBP and night BP (nBP) have a prognostic value for estimation of the risk of stroke development, cardiovascular complications and mortality, and also for target organs lesions and increased thickness of carotid arteries' intima-media [11-21].

Our study demonstrated that low levels of social support (one of LQ elements) correlated with increased severity of seasonal variations of mBP and nBP in patients with AH. Many studies demonstrated that social support is one of the main psychosocial factors influencing the prognosis of cardiovascular diseases [32]. More than that, social support is also connected with some characteristics of home-measured BP. The study of Fortmann A.L. et al reported the association between the level of social support and the degree of BP dipping at night (comparative analysis of 297 studies [33]. Another study proved the important role of social support in BP dipping at night. This study involved 171 persons, both people with normal BP and AH [34]. Our results suggest that patients with low social support (lonely people or people living in retirement homes) should undergo more detailed estimation of BP and antihypertensive therapy efficiency during periods of seasonal BP fluctuations in order to improve the efficacy of complex antihypertensive treatment.

This study demonstrated that average home-measured systolic and diastolic values of BP24, dBP, nBP, and mBP had similar seasonal variations: maximal BP levels were registered in winter, and minimal BP levels were detected in summer. Numerous studies that had been conducted in Europe during the last years demonstrated that clinical [4] and home-measured BP levels obtained using 24h-BPM and blood pressure self-monitoring (BPSM) were characterized with increased BP levels during cold periods of the year [5, 6, 7, 8]. In our research center we also estimated seasonal changes of BP in different regions of European Russia (Ivanovo, Saratov, Moscow) and received similar results [35, 36]. Seasonal variations of BP characteristics differ between nighttime and daytime periods. Many studies demonstrated that average nBP levels were maximal not in winter, but in summer, and they had the lowest values in winter [5, 6, 7]. Another major study reported that mBP levels (measured before awakening and 2 hours after it) were the highest during the cold period of the year [10]. In our study nSBP and mSBP were minimal in spring and winter, respectively, and maximal in autumn. It is possible that such differences between our study and the works of our foreign colleagues may be explained by the fact that in the Moscow region the weather of the beginning and in the middle of spring is similar with the winter one. Possibly, if we had performed analysis of seasonal BP changes taking into account not formal change of seasons but real weather changes, our results would have been more similar with the results of other studies.

Conclusions

1) Severity of seasonal changes of SBP and DBP in the morning and at night was reversely correlated with characteristics of AH patients' social support provided by relatives, friends, colleagues (one of LQ elements).

2) Seasonal dynamics of mDBP was typical: BP levels were maximal in winter and minimal in summer. The highest values of mSBP were detected in autumn, and the lowest ones were measured in winter. Gender and age were significant just for seasonal variations of mSBP

3) The values of nDBP were maximal in winter and minimal in simmer, whereas the levels of nSBP were maximal in autumn and minimal in spring

Conflict of interest: None declared.

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