The Influence of Arterial Stiffness on Seasonal Variation of Blood Pressure in Hypertensive Patients

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The Influence of Arterial Stiffness on Seasonal Variation of Blood Pressure in Hypertensive Patients

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석사 논문이 의학자로서의 아주 소박한 첫 걸음이라면 이 소박한 출발을 가능케 하신 하나님께 무엇보다 감사를 드립니다. 긴 세월 동안 헌신적인 사랑으로 저를 길러내신 어머님과 늘 사랑으로 아껴 주시는 외가 어른들, 그리고 저를 아들처럼 대해 주시는 장인 장모님께 감사의 말씀을 전합니다. 복음이 무엇이며 신자가 어떻게 살아야 하는 지를 가르쳐 주신 누가회 간사님들과 백금산 목사님, 김은주 사모님, 그리고 예수 가족 교회 식구들에게도 깊은 감사를 드립니다. 마지막으로 모든 것을 함께 해온 사랑하는 아내와 어려운 환경 속에서도 건강하게 태어나고 잘 자라주어서 큰 기쁨을 주는 귀한 딸 예빈이에게 감사의 마음을 전합니다.

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ABSTRACT

The influence of arterial stiffness on seasonal variation of blood pressure in hypertensive patients

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Seasonal variation in blood pressure (BP) in hypertensive patients may be related to the higher cardiovascular mortality in winter. However, it is not clear what factors are relevant to the seasonal BP changes. We hypothesized that arterial stiffness is related to the BP changes between summer and winter. Eighty five eldery (>55 years) patients with essential hypertension (33 males, 64±6.0 years) were enrolled. Seasonal BP profiles for at least 2 years were studied along with arterial stiffness (brachial-ankle pulse wave velocity (PWV) measured by oscillometric technique) and clinical variables (age, gender, smoking, duration of hypertension, anti-hypertensive medications and body mass index). Both systolic and diastolic BP were significantly higher during winter compared to three other seasons (spring; 128±10.0/79±7.3mmHg, summer; 127±9.8/78±7.1mmHg, autumn; 127±10.3/78±8.0 mmHg, winter; 136±12.5/81±7.6mmHg, systolic BP changes; p <0.001, diastolic BP changes; p <0.001). There were no significant seasonal difference among spring, summer, and autumn. PWV was correlated with winter - summer differences in systolic BP (r=0.272, p=0.012), but not in diastolic BP (r=0.188, p=0.085). Age, which was correlated with PWV strongly (p<0.001), were not significantly related to the seasonal changes in BP (systolic BP changes; p=0.114, diastolic BP changes; p=0.298). No other clinical variables had a significant correlation with seasonal BP changes. Multivariate regression analysis revealed that PWV is an only significant predictor for winter-summer systolic BP changes. Our results established a feasible link between arterial stiffness and seasonal BP variation. These findings may be partly explanatory of higher cardiovascular risk in patients with increased arterial stiffness.

Key words: arterial stiffness, hypertension, seasonal variation

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I. INTRODUCTION

Seasonal changes in cardiovascular disease have been well documented, usually with an increase in winter[1-3]. Acute myocardial infarction exhibits a seasonal pattern with an increased incidence during winter. Data from the US National Registry of Myocardial Infarction report approximately 53% more cases in winter than during the summer, and in-hospital case fatality rate shows a peak of 9% in winter[1]. Moreover, a winter peak in occurrence has been reported for ischemic and hemorrhagic stroke[2], and rupture or dissection of aortic aneurysms[3].

Several factors may play a role in the winter preference for increased cardiovascular events. Cold exposure, for example, results in an increase in sympathetic activity and blood pressure levels, and a significant negative correlation between ambient temperature and blood pressure has been reported[4]. Winter is also characterized by a pro-thrombotic state. Fibrinogen levels show wide seasonal variation, increasing up to 23% during the colder months[5], and also a mild surface cooling is capable to increase platelet and red cell count, and consequently blood viscosity[6]. Probably, such an unfavorable constellation of underlying factors may affect the increased cardiovascular disease in winter.

Among these, augmented seasonal variation of blood pressure is one of the most important contributing factors to increased cardiovascular events. Seasonal variation of blood pressure has been documented in normal population[7], in hypertensive patients[4,8], in elderly[9,10], and in dialysis patients[11]. Ambient temperature[7,10], age[9], body mass index (BMI)[9,12], smoking[13], and interdialytic body weight gain[11] are reported to be related to the seasonal variation of blood pressure. However, there is no single important affecting factor underlying the seasonal variation of blood pressure which are consistently observed in various studies[4,7,9-13].

Recently arterial stiffness, which can be evaluated by several measurements including pulse wave velocity (PWV), has been shown to be a strong independent predictor of cardiovascular and all cause mortality in patients with essential hypertension[14], older subjects over 70 years[15] as well as in patients with end stage renal disease on hemodialysis[16]. However, underlying mechanisms between arterial stiffness and increased cardiovascular mortality are not well known. Blood pressure variation which was known to be related to the increased cardiovascular event[17] could be the bridging point which can explain the increased cardiovascular mortality in patients with increased arterial stiffness. Recent study[18] suggested the possibilities that arterial stiffness is related to the weekly variation of blood pressure. Therefore, we hypothesized that arterial stiffness is related to augmented seasonal variation of blood pressure and subsequently related to increased cardiovascular events during winter.

II. MATERIALS AND METHODS

1. Subjects

The analyzed subjects were 85 hypertensive elderly patients (> 55 years) who are on regular follow up at Severance Hospital, Yonsei University College of Medicine between April 2002 and March 2005. Hypertension was defined according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report[19]. The inclusion criteria were as follows: (1) Patients who were followed regularly more than two years who can show the seasonal profile of the blood pressure (2) Age 55 years or more. Exclusion criteria were as follows: (1) Recent myocardial infarction, unstable angina, congestive heart failure, previous cerebrovascular accident, malignant debilitating disease, severe respiratory disease, renal failure (creatinine > 1.4 mg/dL), anemia (hemoglobin < 12g%), secondary hypertension, hyper- or hypothyroidism and severe dementia. (2) Patients with any kind of changes in hypertensive medication during the follow up period which can influence the seasonal profile of blood pressure

2. Method

A. Blood pressure measurements

After the patients had sat down and rested for 15min, two consecutive readings were recorded by a mercury sphygmomanometer with a standard sized cuff (12 x 35 cm), and their mean values were calculated. Korotkoff 5 sounds were recorded as the level of diastolic pressure. The average indoor temperature was maintained by an air conditioner at 23~25℃, irrespective of outdoor environment.

B. Arterial stiffness

Arterial stiffness was estimated by brachial-ankle pulse wave velocity (baPWV), which was measured using a volume-plethymographic apparatus (from PWV/ABI, VP-2000®; Colin, Co., Ltd., Komaki, Japan). The details of this measurement method have been reported elsewhere[20]. To avoid the interobserver variation, one experienced examiner measured all the baPWV of analyzed patients.

C. Clinical variables

Age, gender, smoking, BMI, duration of hypertension, types of anti-hypertensive medications, laboratory data, and echocardiographic data are reviewed as well as the seasonal blood pressure profile.

D. Statistic analysis

The statistical analysis was performed using SPSS statistical analysis program (ver. 12.0, SPSS Inc., Chicago, IL, USA). Values are expressed as mean±S.D. Data were analyzed by independent t-test, paired t-test, correlation analysis, and multivariate linear regression. A p value of less than 0.05 was considered to be statistically significant.

III. RESULT

1. The characteristics of the study group

Age, sex, smoking, duration of hypertension, body weight, BMI, laboratory parameters, echocardiographic data, and brachial-ankle pulse wave velocity (baPWV) are studied (Table 1).

Table 1. The characteristics of the study group

Characteristics	Values
Age	64 ± 6.0 (55-77)
Sex	33:52
Smoking	5
Duration of HTN (years)	11 ± 9.3 (2-38)
Bwt (Kg)	63 ± 9.2 (42-85)
BMI (Kg/m^2)	24.8 ± 2.70 (18.5-31.2)
BUN (mg/dL)	15.8 ± 3.90 (9.6-24.8)
Cr (mg/dL)	0.9 ± 0.9 (0.6-1.3)
LVEF (%)	72 ± 6.3 (60-86)
baPWV	1589 ± 286.2 (928-2355)

Data are mean ± S.D., HTN; hypertension, Bwt; body weight, BMI; body mass index, BUN; blood urea nitrogen, Cr; creatinine, LVEF; left ventricular ejection fraction, baPWV; brachial-ankle pulse wave velocity

2. Seasonal mean systolic blood pressure (SBP) and mean diastolic blood pressure (DBP): absolute values and their differences (Δ)

We took the mean of four each seasonal BP profiles at least 2 years. The results of SBP and DBP measurements during the different seasons are shown in Table 2. Both SBP and DBP were markedly increased in winter compared with three other seasons. The winter-summer SBP difference was 9±10.7 mmHg (p<0.001) during the follow up period, whereas the indoor temperature was maintained 23-25℃ level. The winter-autumn SBP difference was

9±11.4 mmHg ($p<0.001$) and winter-spring SBP difference was 8±10.9 mmHg ($p<0.001$), while the summer-spring, summer-autumn and spring-autumn SBP differences were not significant.

The winter-summer DBP difference was 3±7.3 mmHg ($p<0.001$). The winter-spring DBP was 2±6.8 mmHg ($p=0.002$) and the winter-autumn DBP was 3±8.0 mmHg ($p<0.001$). There were no significant seasonal differences between spring-autumn, summer-spring, and summer-autumn DBP differences.

3. Correlation analysis of mean difference between winter and summer systolic blood pressure (SBP) and diastolic blood pressure (DBP); age, BMI, PWV

Pearson correlation analysis of mean difference between winter and summer SBP and DBP with age, BMI, and PWV are shown in Table 3. PWV was correlated with winter - summer differences in systolic BP (r=0.272, $p=0.012$), but not in diastolic BP (r=0.188, $p=0.085$) (Fig. 1). Age, which was correlated with PWV strongly ($p<0.001$), were not significantly related to the seasonal changes in BP (systolic BP changes; $p=0.114$, diastolic BP changes; $p=0.298$). No other clinical variables had a significant correlation with seasonal BP changes.

4. Multivariate regression analysis taking systolic, diastolic BP changes as a dependent variable; age, BMI, PWV

Multivariate regression analysis taking systolic, diastolic BP changes as a dependent variable with age, BMI, PWV as an independent factor revealed that PWV is an only predicting factor for seasonal systolic BP changes (Table 4).

Table 2. Seasonal systolic blood pressure (SBP) and diastolic blood pressure (DBP): absolute values and their differences (Δ)

	BP, mean ± S.D.	BP range (mmHg)
SBP spring	128 ± 10.0	93-145
SBP summer	127 ± 9.8	99-150
SBP autumn	127 ± 10.3	98-155
SBP winter	136 ± 12.5	101-160
DBP spring	79 ± 7.3	57-90
DBP summer	78 ± 7.2	55-98
DBP autumn	78 ± 8.0	45-95
DBP winter	81 ± 7.6	55-96

	BP, mean ± SD	*p*-value
ΔSBP winter-summer	9 ± 10.7	< 0.001
ΔSBP winter-spring	8 ± 10.9	< 0.001
ΔSBP winter-autumn	9 ± 11.4	< 0.001
ΔSBP summer-spring	1 ± 10.4	0.303
ΔSBP summer-autumn	0 ± 10.6	0.789
ΔSBP spring-autumn	0 ± 9.0	0.382
ΔDBP winter-summer	3 ± 7.3	< 0.001
ΔDBP winter-spring	2 ± 6.8	0.002
ΔDBP winter-autumn	3 ± 8.0	< 0.001
ΔDBP summer-spring	0 ± 7.3	0.222
ΔDBP summer-autumn	0 ± 8.3	0.941
ΔDBP spring-autumn	1 ± 7.8	0.225

Table 3. Correlation analysis of Mean difference between winter and summer systolic blood pressure (SBP) and diastolic blood pressure (DBP); age, BMI, PWV

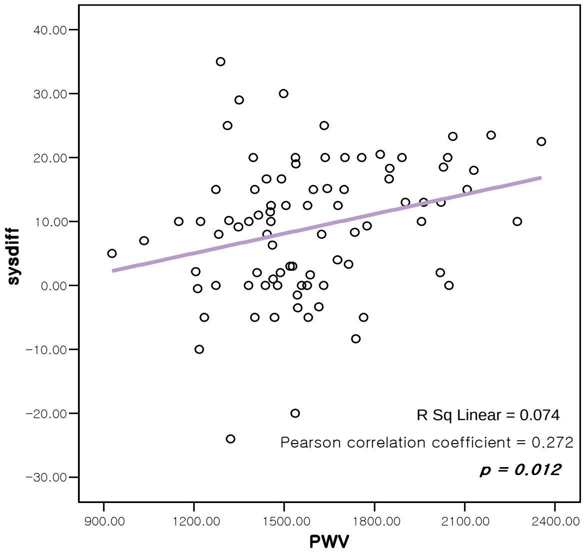
(N=85)

	Age	BMI	PWV	Sys-Diff	Dia-Diff
Age	1.000	-0.103	0.447	0.173	0.114
		0.349	***< 0.001***	*0.114*	*0.298*
BMI	-0.103	1.000	-0.029	0.061	0.139
	0.349		*0.790*	*0.577*	*0.203*
PWV	0.447	-0.029	1.000	0.272	0.188
	< 0.001	*0.790*		***0.012***	***0.085***
Sys-Diff	0.173	0.061	0.272	1.000	0.463
	0.114	*0.577*	***0.012***		***< 0.001***
Dia-Diff	0.114	0.139	0.188	0.463	1.000
	0.298	*0.203*	***0.085***	***< 0.001***	

Data are value of Pearson correlation coefficient, while *p*-value are shown in *italic type letter*

Sys-Diff; winter-summer systolic BP difference, Dia-Diff; winter-summer diastolic BP difference

Figure 1. Mean difference between winter-summer systolic blood pressure (SBP) and diastolic blood pressure (DBP); Correlation analysis with PWV



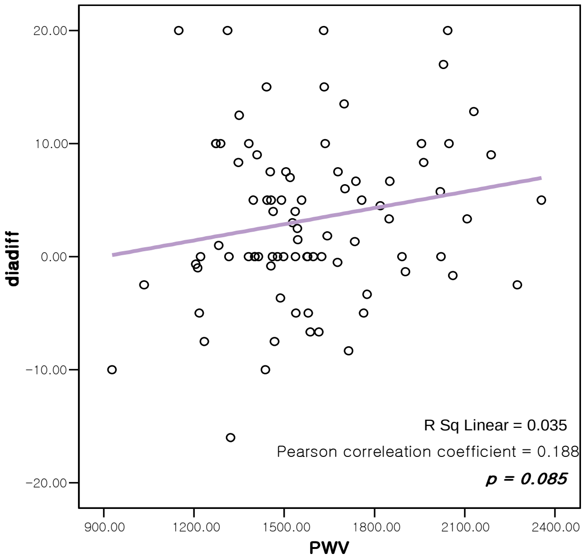


Table 4. Multivariate regression analysis taking systolic, diastolic BP changes as a dependent variable; age, BMI, PWV

Dependent variable; Winter-Summer SBP changes, Adjusted R square; 0.049

	ß	Standard Error	*p*-value
Age	0.129	0.214	0.549
BMI	0.301	0.424	0.480
PWV	0.009	0.004	0.045

Dependent variable; Winter-Summer DBP changes, Adjusted R square; 0.024

	ß	Standard Error	*p*-value
Age	0.066	0.147	0.655
BMI	0.403	0.291	0.170
PWV	0.004	0.003	0.167

IV. DISCUSSION

Relationship between arterial stiffness and seasonal blood pressure variation

We presented the relationship between arterial stiffness and seasonal blood pressure variation in hypertensive elderly patients. Multivariate regression analysis taking systolic, diastolic BP changes as a dependent variable with age, BMI, PWV as an independent factor revealed that PWV is an only predicting factor for seasonal systolic BP changes. Our results established a feasible link between arterial stiffness and seasonal BP variation.

Seasonal variation of blood pressure, which was previously found in various subsets of patients, is also well documented in our study group. We found both systolic and diastolic blood pressures were significantly higher during winter compared to three other seasons. The degree of seasonal differences in blood pressure that we found were similar with those reports in previous studies on hypertensive or elderly populations[4,8,10].

Theoretically as arterial stiffness increases, systolic blood pressure rises up while diastolic blood pressure goes down. This idea was consistent with our findings. Increased arterial stiffness was related to the winter-summer SBP changes, but not to the DBP changes. Moreover, augmented SBP changes compared with DBP changes are well documented in our study because of the inclusion criteria of over 55 year old patients. SBP increases steadily with age, whereas DBP increases until about age 55 and then declines when increased large-vessel stiffness alters the flow contours such that systolic pressure is increased and diastolic pressure is decreased[21].

Age[9], BMI[9,12], smoking[13] which were previously known to be related to the seasonal variation of blood pressure, were not shown to be related in our study. As for the smoking, the fact that smoking results in peripheral vasoconstriction may be related with the augmented blood pressure response in winter. However, because the number of smoker in the study group was relatively small - only five, the effects of smoking on blood pressure variations could be masked in our results. Kristal-Boneh et al.[12] reported the inverse relationship between BMI and seasonal SBP changes, that is augmented seasonal variation of blood pressure in leaner patients. However, probably due to the differences of study population – lower BMI in our study group compared with previous study[12], there was no significant relationship between BMI and seasonal variation of blood pressure.

It should be noted that age, BMI, smoking, which were known to be related to the seasonal variation of blood pressure are also influencing factors on the arterial stiffness, itself[22,23]. Therefore increased arterial stiffness more clearly explain the relationship between previously known influencing factors – age, BMI, smoking and seasonal variation of blood pressure and this could be a more fundamental mechanism.

Relationship between arterial stiffness and cardiovascular events

Epidemiologic and clinical studies have shown that increased pulse pressure is an independent cardiovascular risk factor in general population[24]. Theoretically pulse pressure is influenced by left ventricular ejection (stroke volume and ejection time) and arterial stiffness (principally that of the aorta and large central arteries). Because left ventricular ejection remain stable or even decrease with age, arterial stiffness is the principal factor responsible for increased pulse pressure in various subsets of patients with increased cardiovascular risk[24]. Recently arterial stiffness itself, which can be evaluated by several measurements including pulse wave velocity (PWV), has been shown to be a strong independent predictor of cardiovascular and all cause mortality in patients with essential hypertension[14], older subjects over 70 years[15] as well as in patients with end stage renal disease on hemodialysis[16]. However, underlying mechanisms between arterial stiffness and increased cardiovascular mortality are not well known. Blood pressure variation which was known to be related to the increased cardiovascular event[17] could be the bridging point which can explain the increased cardiovascular mortality in patients with increased arterial stiffness. Here we presented the feasible mechanism of increased cardiovascular mortality in patients with increased arterial stiffness by demonstrating the relationship between arterial stiffness and seasonal variation of blood pressure.

Clinical Implications

These findings could give a meaningful contribution to the treatment of elderly hypertensive patients. Physicians should not overlook the BP surge during winter as an insignificant common finding. Based on our results we can find high risk patients who require more strict BP control during winter. To reduce the cardiovascular event it is necessary to treat more carefully during winter, especially in high risk patients with increased arterial stiffness. Moreover even as for the normotensive patients, it is important to assess hypertension during winter not in other seasons if they have increased arterial stiffness or other cardiovascular risk factors.

Limitations

The present study has several potential limitations. First, our study population was relatively small. Second, PWV is influenced by BP for the times when PWV is measured. However, it is still controversial whether PWV is necessary to be corrected by BP. Third, the season which PWV measured were not same among study population. Prospective studies in a large population are needed to reveal more clear relationship among arterial stiffness, augmented seasonal blood pressure variation, and major adverse cardiovascular event.

V. CONCLUSION

In conclusion, retrospective study of 85 elderly hypertensive patients revealed a significant increase of blood pressure in winter. In this population arterial stiffness, which was known as an independent cardiovascular risk factor, was related to augmented seasonal variation of blood pressure. These findings may be partly explanatory of higher cardiovascular risk in patients with increased arterial stiffness.

REFERENCES

1. Spencer FA, Goldberg RJ, Becker RC, Gore JM Seasonal distribution of acute myocardial infarction in the second National Registry of Myocardial Infarction. J Am Coll Cardiol 1998;31:1226-1233.
2. Gallerani M, Portaluppi F, Maida G, Chieregato A, Calzolari F, Trapella G, et al. Circadian and circannual rhythmicity in the occurrence of subarachnoid hemorrhage. Stroke 1996;27:1793-1797.
3. Mehta RH, Manfredini R, Hassan F, Sechtem U, Bossone E, Oh JK, et al. Chronobiological patterns of acute aortic dissection. Circulation 2002;106:1110-1115.
4. Hata T, Ogihara T, Maruyama A, Mikami H, Nakamaru M, Naka T, et al. The seasonal variation of blood pressure in patients with essential hypertension. Clin Exp Hypertens 1982;4:341-354.
5. Woodhouse PR, Khaw KT, Plummer M, Foley A, Meade TW Seasonal variations of plasma fibrinogen and factor VII activity in the elderly: winter infections and death from cardiovascular disease. Lancet 1994;343:435-439.
6. Keatinge WR, Coleshaw SR, Cotter F, Mattock M, Murphy M, Chelliah R Increases in platelet and red cell counts, blood viscosity, and arterial pressure during mild surface cooling: factors in mortality from coronary and cerebral thrombosis in winter. Br Med J (Clin Res Ed) 1984;289:1405-1408.
7. Jansen PM, Leineweber MJ, Thien T The effect of a change in ambient temperature on blood pressure in normotensives. Journal of Human Hypertension 2001;15:113-117.
8. Brennan PJ, Greenberg G, Miall WE, Thompson SG Seasonal variation in arterial blood pressure. Br Med J (Clin Res Ed) 1982;285:919-923.
9. Charach G, Rabinovich PD, Weintraub M Seasonal Changes in Blood Pressure and Frequency of Related Complications in Elderly Israeli Patients with Essential Hypertension. Gerontology 2004;50:315-321.

10. Woodhouse PR, Khaw KT, Plummer M Seasonal variation of blood pressure and its relationship to ambient temperature in an elderly population. J Hypertens 1993;11:1267-1274.
11. Argiles A, Lorho R, Servel MF, Chong G, Kerr PG, Mourad G Seasonal modifications in blood pressure are mainly related to interdialytic body weight gain in dialysis patients. Kidney International 2004;65:1795-1801.
12. Kristal-Boneh E, Harari G, Green MS, Ribak J Body mass index is associated with differential seasonal change in ambulatory blood pressure levels. American Journal of Hypertension 1996;9:1179-1185.
13. Kristal-Boneh E, Harari G, Green MS Seasonal change in 24-hour blood pressure and heart rate is greater among smokers than nonsmokers. Hypertension 1997;30:436-441.
14. Laurent S, Boutouyrie P, Asmar R, Gautier I, Laloux B, Guize L, et al. Aortic stiffness is an independent predictor of all-cause and cardiovascular mortality in hypertensive patients. Hypertension 2001;37:1236-1241.
15. Meaume S, Rudnichi A, Lynch A, Bussy C, Sebban C, Benetos A, et al. Aortic pulse wave velocity as a marker of cardiovascular disease in subjects over 70 years old. J Hypertens 2001;19:871-877.
16. Blacher J, Guerin AP, Pannier B, Marchais SJ, Safar ME, London GM Impact of aortic stiffness on survival in end-stage renal disease. Circulation 1999;99:2434-2439.
17. Matsui Y, Kario K, Ishikawa J, Eguchi K, Hoshide S, Shimada K Reproducibility of arterial stiffness indices (pulse wave velocity and augmentation index) simultaneously assessed by automated pulse wave analysis and their associated risk factors in essential hypertensive patients. Hypertens Res 2004;27:851-857.
18. Ohwaki K, Yano E, Murakami H, Nagashima H, Nakagomi T Meteorological factors and the onset of hypertensive intracerebral hemorrhage. International Journal of Biometeorology 2004;49:86-90.
19. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL,

Jr., et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. Jama 2003;289:2560-2572.

20. Yamashina A, Tomiyama H, Takeda K, Tsuda H, Arai T, Hirose K, et al. Validity, reproducibility, and clinical significance of noninvasive brachial-ankle pulse wave velocity measurement. Hypertens Res 2002;25:359-364.
21. Izzo JL, Jr., Shykoff BE Arterial stiffness: clinical relevance, measurement, and treatment. Rev Cardiovasc Med 2001;2:29-34, 37-40.
22. Rehill N, Beck CR, Yeo KR, Yeo WW The effect of chronic tobacco smoking on arterial stiffness. Br J Clin Pharmacol 2006;61:767-773.
23. Achimastos A, Benetos A, Stergiou G, Argyraki K, Karmaniolas K, Thomas F, et al. Determinants of arterial stiffness in Greek and French hypertensive men. Blood Press 2002;11:218-222.
24. London GM, Cohn JN Prognostic application of arterial stiffness: task forces. Am J Hypertens 2002;15:754-758.

ABSTRACT (IN KOREAN)

동맥경직도가 고혈압 환자의 계절별 혈압 변화에 미치는 영향

지도교수 임세중
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겨울철에 심혈관계 질환의 발병률과 사망률이 높다는 것은 이미 잘 알려져 있는 사실이다. 이러한 현상에 대한 가능한 설명으로 교감신경계 활성도의 변화, 심근 산소 소모량의 증가, 적혈구나 혈소판, 피브리노겐 등 혈액 성분의 변화 그리고 혈압의 계절별 변화 등을 들 수 있다. 이 중 혈압의 연중 변화는 정상인에서나 단순 고혈압 환자, 혹은 만성 신부전 환자 등에서 비교적 일관되게 관찰되는 현상으로 통상적으로 겨울에 혈압이 높고 여름에 혈압이 낮은 양상을 띤다. 그러나 혈압의 연중 변화가 발생하는 기전이나 관련된 인자에 대하여는 아직까지 그 이해가 부족한 상황이다. 혈압의 변화는 이론적으로는 대동맥 탄성과 관련이 있는 것으로 알려져 있다. 이에 본 연구에서는 동맥 경직도가 혈압의 연중 변화에 미치는 영향에 대해 확인하고자 하였다. 신촌 세브란스병원에 내원한 단순 고혈압 환자 중 추적기간이 2년 이상이고 적어도 3개월 이내의 간격으로 혈압을 측정하여 혈압의 계절별 변화를 알 수 있는 55세 이상의 환자 중 동맥 경직도의 지표인 baPWV를 측정했던 환자 85명에 대해 분석하였다 (남:여=33:52, 평균연령=64±6.0세). 분석 결과 겨울철에 다른 세 계절에 비하여 수축기 및 이완기 혈압이 모두 유의미하게 높은 것으로 나타났다 (봄; 128±10.0/ 79±7.3mmHg, 여름; 127±9.8/ 78±7.1mmHg, 가을; 127±10.3/ 78±8.0mmHg, 겨울; 136±12.5/ 81±7.6mmHg, 여름-겨울간 수축기 혈압차 *p* <0.001, 여름-겨울간 이완기 혈압차 *p* <0.001). 그러나 다른 세 계절 사이에는 통계적으로 의미 있는 혈압차이는 없었다. 동맥 경직도의 지표인

baPWV는 여름-겨울간 수축기 혈압차이와는 관련이 있었으나 (r=0.272, p=0.012) 이완기 혈압차이와는 관련이 없었다 (r=0.188, p=0.085). baPWV와 높은 상관관계를 보인 연령 (p<0.001)은 여름-겨울 혈압차이와는 관련이 없는 것으로 나타났다. (수축기 혈압차이; p=0.114, 이완기 혈압차이; p=0.298) baPWV이외에 다른 인자들은 여름-겨울 혈압차이와 연관이 없는 것으로 나타났다. 다중 회귀 분석 상에서도 baPWV만이 수축기 혈압차이에 대한 예측 인자로 확인되었다 (p=0.045). 이러한 결과는 동맥 경직도가 높을수록 계절별 혈압차이가 크다는 것으로 동맥 경직도가 높은 환자에서 심혈관계 위험성이 높다는 사실을 뒷받침해 준다.

핵심되는 말: 동맥경직도, 고혈압, 계절별 혈압 변화