Original Article

Epidemiology

Higher Prevalence and Awareness, but Lower Control Rate of Hypertension in Patients with Diabetes than General Population: The Fifth Korean National Health and Nutrition Examination Survey in 2011

Seung-Hyun Ko[1], Hyuk-Sang Kwon[1], Dae Jung Kim[2], Jae Hyeon Kim[3], Nan Hee Kim[4], Chul Sik Kim[5], Kee-Ho Song[6], Jong Chul Won[7], Soo Lim[8], Sung Hee Choi[8], Kyungdo Han[9], Yong-Moon Park[10,11], Bong-Yun Cha[1], on behalf of the Taskforce Team of Diabetes Fact Sheet of the Korean Diabetes Association

[1]Division of Endocrinology and Metabolism, Department of Internal Medicine, The Catholic University of Korea College of Medicine, Seoul,
[2]Department of Endocrinology and Metabolism, Ajou University School of Medicine, Suwon,
[3]Division of Endocrinology and Metabolism, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul,
[4]Division of Endocrinology and Metabolism, Department of Internal Medicine, Korea University College of Medicine, Seoul,
[5]Division of Endocrinology and Metabolism, Department of Internal Medicine, Hallym University Sacred Heart Hospital, Hallym University College of Medicine, Anyang,
[6]Department of Internal Medicine, Konkuk University School of Medicine, Seoul,
[7]Department of Internal Medicine, Mitochondrial Research Group, Inje University Sanggye Paik Hospital, Inje University College of Medicine, Seoul,
[8]Department of Internal Medicine, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam,
[9]Departments of Biostatistics, [10]Preventive Medicine, The Catholic University of Korea College of Medicine, Seoul, Korea;
[11]Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA

Background: We investigated the prevalence, awareness, treatment, and control rate of hypertension in Korean adults with diabetes using nationally representative data.

Methods: Using data of 5,105 adults from the fifth Korea National Health and Nutrition Examination Survey in 2011 (4,389 nondiabetes mellitus [non-DM]), 242 newly diagnosed with DM (new-DM), and 474 previously diagnosed with DM (known-DM), we analyzed the prevalence of hypertension (mean systolic blood pressure $\geq$140 mm Hg, diastolic blood pressure $\geq$90 mm Hg, or use of antihypertensive medication) and control rate of hypertension (blood pressure [BP] <130/80 mm Hg).

Results: The prevalence of hypertension in diabetic adults was 54.6% (44.4% in new-DM and 62.6% in known-DM, $P<0.0001$ and $P<0.0001$, respectively) compared with non-DM adults (26.2%). Compared to non-DM, awareness (85.7%, $P<0.001$) and treatment (97.0%, $P=0.020$) rates were higher in known-DM, whereas no differences were found between new-DM and non-DM. Control rate among all hypertensive subjects was lower in new-DM (14.9%), compared to non-DM (35.1%, $P<0.001$) and known-DM (33.3%, $P=0.004$). Control rate among treated subjects was also lower in new-DM (25.2%), compared to non-DM (68.4%, $P<0.0001$) and known-DM (39.9%, $P<0.0001$).

Conclusion: Higher prevalence and low control rate of hypertension in adults with diabetes suggest that stringent efforts are needed to control BP in patients with diabetes, particularly in newly diagnosed diabetic patients.

Keywords: Blood pressure; Diabetes mellitus; Hypertension; Korea National Health and Nutrition Examination Survey

Corresponding authors:
Yong-Moon Park
Department of Preventive Medicine, The Catholic University of Korea College of Medicine, 222 Banpo-daero, Seocho-gu, Seoul 137-701, Korea;
Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, 800 Sumter St, Columbia, SC 29208, USA
E-mail: markYMpark@gmail.com

Bong-Yun Cha
Division of Endocrinology and Metabolism, Department of Internal Medicine, Seoul St. Mary's Hospital, The Catholic University of Korea College of Medicine, 222 Banpo-daero, Seocho-gu, Seoul 137-701, Korea
E-mail: bycha@catholic.ac.kr

INTRODUCTION

The treatment of hypertension and achievement of target blood pressure (BP) in type 2 diabetes is important in cardiovascular outcomes and mortality [1]. According to the United Kingdom Prospective Diabetes Study (UKPDS), a linear relationship exists between mean systolic blood pressure (SBP) and the risk of macrovascular and microvascular complications [1,2]. Conversely, several epidemiological studies and clinical trials have also demonstrated that control of hypertension can significantly reduce mortality and microvascular or macrovascular complications in patients with type 2 diabetes [3-5]. Based on these results, the current treatment guideline and expert opinions have consistently stated the target BP levlel as <130/80 mm Hg in patients with type 2 diabetes. The Seventh Report of the Joint National Committee on the Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7), the American Diabetes Association (ADA), the International Diabetes Federation (IDF), and the Korean Diabetes Association (KDA) treatment guidelines recommend that BP in type 2 diabetes should be maintained below 130/80 mm Hg [6-9]. However, several epidemiological studies of achieved BP in hypertension trials have suggested no benefits associated with an achieved lower SBP [10-12]. One observational subgroup analysis of 6,400 patients with diabetes and 22,576 participants with coronary artery disease (CAD) in the International Verapamil SR-Trandolapril Study showed that tight control of SBP (<130 mm Hg) among patients with diabetes and CAD was not associated with improved cardiovascular outcomes compared with normal controls (achieved SBP 130 to 140 mm Hg) [12]. Based on these results, ADA has recommended in 2013 that people with diabetes and hypertension should be treated to achieve SBP of <140 mm Hg and diastolic blood pressure (DBP) <80 mm Hg [11]. Based on recent large epidemiological analyses, randomized clinical trials, and clinical recommendations of other countries, KDA adopted also in 2013 the treatment goal of BP <140/80 mm Hg in type 2 diabetes (unpublished data). Optimal BP control is essential in patients with type 2 diabetes; however, the clinical benefits of target BP goal of <140/80 mm Hg rather than <130/80 mm Hg for the Asian population with type 2 diabetes requires further investigation because Asians are at a much greater risk of stroke than the risk of myocardial infarction [13].

In this study we investigated the prevalence of hypertension and BP control among patients with diabetes from nationally representative samples. We analyzed the BP levels in Korean adults, using data from the fifth Korea National Health and Nutrition Examination Survey (KNHANES-V) in 2011 to explore the prevalence, awareness, and control rate of hypertension.

METHODS

Study design

This study used the data from the fifth KNHANES-V conducted by the Korean Ministry of Health and Welfare. This survey was a nationally representative study of noninstitutionalized civilians using a stratified, multistage probability sampling design. Sampling units were defined based on the data of household registries, including geographical area, gender, and age groups. The KNHANES was composed of a health interview survey, a health examination survey and a nutrition survey conducted by trained investigators. Additional details regarding the study design and methods are provided elsewhere [14,15]. A total of 8,055 out of 10,589 subjects (76.1%) participated in all three surveys in 2011. After excluding subjects younger than 30 years of age, pregnant women and subjects with missing BP data, 5,105 diabetic adults were eligible for the present analysis (4,389 nondiabetes mellitus [non-DM], 242 newly diagnosed DM; new-DM and 474 previously diagnosed DM; known-DM). This study was approved by the Institutional Review Board of The Catholic University of Korea.

Definition of diabetes and hypertension

Subjects previously diagnosed with diabetes by a physician or those taking insulin or oral hypoglycemic agents were classified as known-DM. New-DM was defined as individuals with fasting plasma glucose ≥126 mg/dL and/or hemoglobin A1c (HbA1c) ≥6.5% in the absence of previous diagnosis of diabetes [16].

Hypertension was defined as a SBP ≥140 mm Hg, a DBP ≥90 mm Hg, or a self-reported current use of antihypertensive medications [15,17,18]. Participants with hypertension who were told that they had hypertension were classified as having a positive awareness of their disease. Patients were considered to be under treatment if they had hypertension and simultaneously reported currently taking antihypertensive medications [15,17,18]. Subjects were considered to have controlled hypertension if they had an average SBP <130 mm Hg and an average DBP <80 mm Hg, as recommended by the JNC-7, ADA, IDF, and the KDA [6-9]. Although the recent target BP goal has

been changed from BP <130/80 mm Hg to <140/90 mm Hg [11], we used the previous target BP goal (BP <130/80 mm Hg) in this analysis for comparison with previously published data.

Measurements

Anthropometric measurements of the participants were performed by specially trained examiners. BP was measured three times in subjects seated for at least 5 minutes using a mercury sphygmomanometer on the right arm (Baumanometer; Baum, Copiague, NY, USA). The mean value of three separate BP readings was used for data analysis. Waist circumference was measured to the nearest 0.1 cm in a horizontal plane at the midpoint between the iliac crest and the costal margin at the end of a normal expiration. The body mass index was calculated as the individual's weight in kilograms divided by the square of the individual's height in meters.

Blood samples were obtained after a minimum fasting time of 8 hours. HbA1c values were measured using a high-performance liquid chromatography 723 G7 (Tosoh, Tokyo, Japan). The serum fasting glucose levels, total cholesterol, high density lipoprotein cholesterol, triglycerides, and creatinine were measured enzymatically in a central laboratory using an automatic analyzer 7600 (Hitachi, Tokyo, Japan). Lifestyle-related or other characteristics, including duration and treatment of diabetes and subjects' comorbidities were investigated using a structured questionnaire.

Statistical analysis

The data were analyzed using the appropriate sample weights provided by the Korea Centers for Disease Control and Prevention. All data were presented as the mean±standard error (SE) for continuous variables and as a frequency percentage (SE) for categorical variables. Statistical analyses were performed using the SAS version 9.2 (SAS Institute, Cary, NC, USA) survey procedure to account for the complex sampling design and to provide a nationally representative prevalence estimate. Prevalence, awareness, treatment, and control rate of hypertension were compared between non-DM and new-DM or known-DM, using Bonferroni correction. A P value less than 0.05 was considered statistically significant.

RESULTS

Prevalence

The mean age of the subjects showed significant differences be-

tween groups (48.9±0.4 years in non-DM, 54.9±0.9 years in new-DM, and 61.2±0.8 years in known-DM; $P<0.0001$). Mean duration of diabetes in the known-DM group was 8 years.

The prevalence of hypertension in diabetic adults was 54.6% (44.4% in new-DM and 62.6% in known-DM; $P<0.0001$ and $P<0.0001$, respectively) compared with non-DM adults (26.2%), indicating the prevalence of hypertension was significantly higher in subjects with diabetes (Table 1). Additionally, 44.4% of patients who were diagnosed with diabetes for the first time had hypertension simultaneously. Mean SBP level was also significantly higher in patients with diabetes (118.1±0.4 mm Hg in non-DM, 126.1±1.5 mm Hg in new-DM, and 127.7± 12.1 mm Hg in known-DM; $P<0.0001$). However, mean DBP

Table 1. Clinical characteristics according to diabetes status

Characteristic	Non-DM	New-DM	Known-DM	P value
No.	4,389	242	474	
Age, yr	48.9±0.4	54.9±0.9	61.2±0.8	<0.0001
Gender, % female	48 (0.7)	60.3 (3.6)	55.6 (2.8)	0.0004
Body mass index, kg/m²	23.7±0.1	26.2±0.3	24.6±0.2	<0.0001
Waist circumference, cm	81.5±0.2	90.0±0.7	86.7±0.6	<0.0001
Diabetes duration, yr	NA	0±0	8.1±0.4	<0.0001
Current smoker, %	23.4 (0.8)	30 (4)	26.3 (2.6)	0.1267
Heavy drinker, %	11.1 (0.7)	13.4 (2.9)	10 (1.9)	0.6013
Mean SBP, mm Hg	118.1±0.4	126.1±1.5	127.7±1.1	<0.0001
Mean DBP, mm Hg	77.0±0.2	79.6±0.8	75.6±0.6	0.0006
Hypertension, yes	26.2 (0.8)	44.4 (4.2)	62.6 (2.9)	<0.0001
Diabetes treatment, yes	NA	NA	89.6 (1.5)	
Laboratory data				
Glucose, mg/dL	92.7±0.2	139.7±3.7	139.9±2.6	<0.0001
Creatinine, mg/dL	0.84±0.00	0.87±0.01	0.91±0.01	<0.0001
eGFR, mL/min/1.73 m²	92.6±0.4	91.5±1.5	85.1±1.1	<0.0001
Total cholesterol, mg/dL	192.5±0.7	204.7±3.2	181.8±2.2	<0.0001
Triglycerides, mg/dL	135.3±2.3	188.2±9.9	168.7±7.1	<0.0001
HbA1c, %	5.5±0	7.2±0.1	7.4±0.1	<0.0001

Values are presented as mean±standard error or percentage (standard error).

DM, diabetes mellitus; NA, not available; SBP, systolic blood pressure; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; HbA1c, hemoglobin A1c.

level was highest in the new-DM group ($P=0.0006$). Mean HbA1c levels of new-DM and known-DM were 7.2%±0.1% and 7.4%±0.1%, respectively.

Awareness, treatment, and control rate of hypertension

The awareness of hypertension was significantly different between non-DM and known-DM group (Fig. 1). Compared to non-DM, awareness (85.7%, $P<0.001$) and treatment (97.0%, $P=0.02$) rates were higher in known-DM, whereas no differences were found between new-DM and non-DM groups. Control rate among all hypertensive subjects was lower in new-DM (14.9%), compared to non-DM (35.1%, $P<0.001$) and known-DM (33.3%, $P=0.004$). Control rate among treated

subjects was also lower in new-DM (25.2%), compared to non-DM (68.4%, $P<0.0001$) and known-DM (39.9%, $P<0.0001$).

The prevalence of hypertension showed an increased tendency according to the increase in age (all P for linear trend <0.05). In addition, compared to patients with diabetes, the prevalence of hypertension was lower in the non-DM population across all age categories (all $P<0.05$) (Fig. 2).

We also analyzed the treatment and control rates between non-DM and DM (new-DM and known-DM) groups. Treatment rate was not significantly different between the two groups across all age categories (Fig. 3A). However, control rate of hypertension among treated participants was significantly lower in the younger-aged population. Compared to the control rate
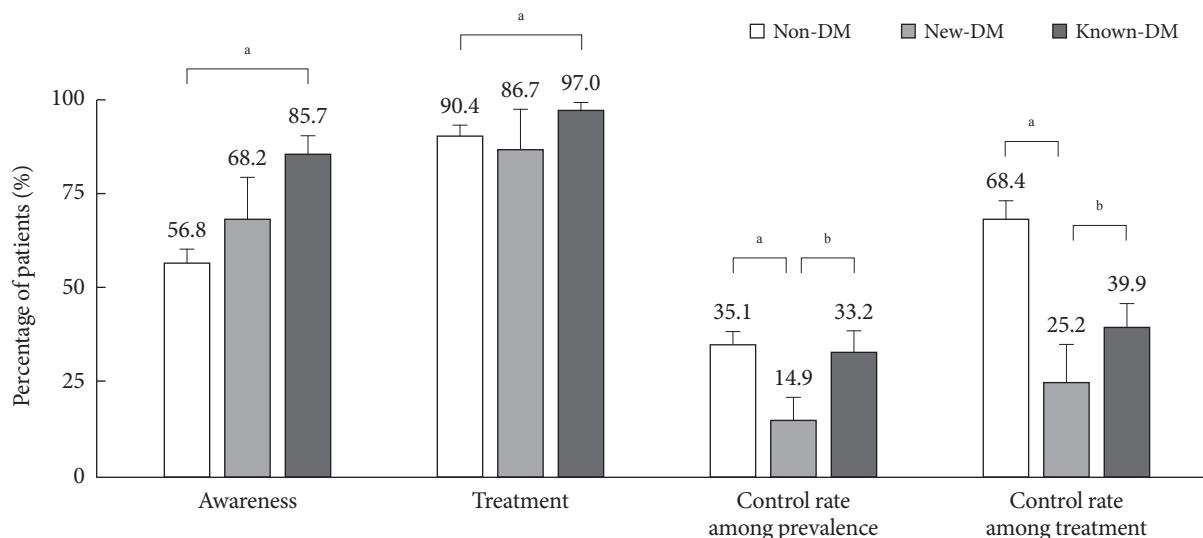

Fig. 1. Awareness, treatment and control of hypertension according to diabetes status. [a]$P<0.05$ vs. nondiabetes mellitus (non-DM), [b]$P<0.05$ vs. known-DM.
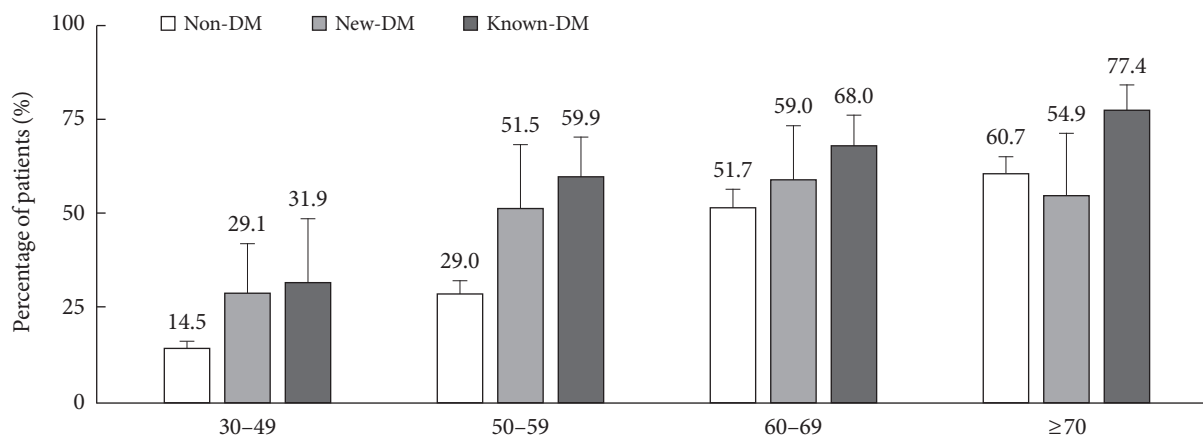

Fig. 2. Comparison of hypertension prevalence according to diabetes status by age group (all P for linear trend <0.05).

of hypertension in the 50 years and older age group, the rate was less than half in the 30 to 49 years age group in patients with diabetes (Fig. 3C).
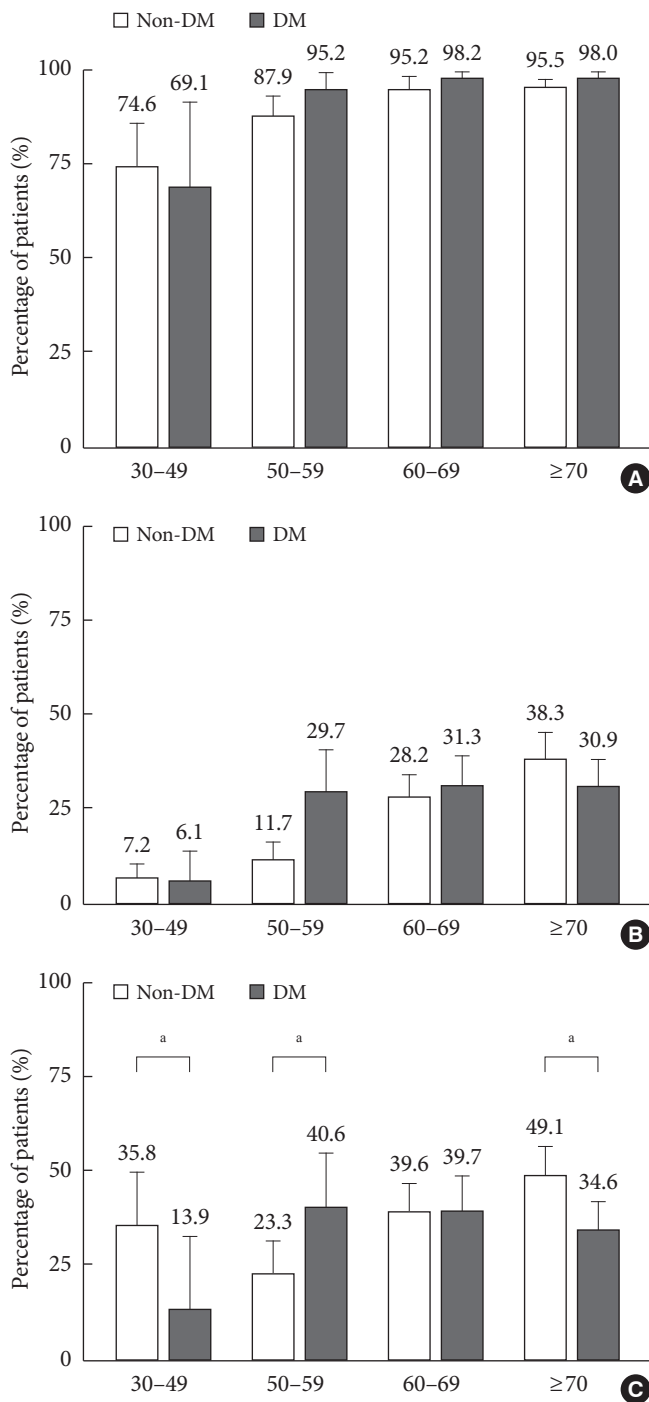

Fig. 3. Comparison of (A) treatment rate, (B) control rate among prevalence, and (C) control rate among treatment according to presence of diabetes by age group. [a]$P<0.05$ between nondiabetes mellitus (non-DM) and DM population.

We classified BP into four stages according to severity in patients with diabetes. The proportion of diabetic patients with stage 1 and 2 hypertension, as defined by the JNC-7 criteria (SBP ≥140 mm Hg or DBP ≥90 mm Hg), was significantly higher in the new-DM population ($P<0.001$). However, the proportion of subjects with an SBP <130 mm Hg and a DBP <80 mm Hg was significantly higher in known-DM subjects ($P<0.001$) (Fig. 3).

DISCUSSION

According to 2011 KNHANES, the prevalence of hypertension in patients with diabetes was 54.6%, which was approximately 2-fold higher than nondiabetic adults (26.2%) in Korea. In spite of higher prevalence, awareness, and treatment rates, control rate of hypertension in patients with diabetes remains unsatisfactory compared to the nondiabetic population. The control rate was more significant, especially in newly diagnosed subjects with diabetes.

The appropriate treatment of hypertension, especially in patients with diabetes is important clinically because of its effects on clinical outcomes and health burden. Among adults with diabetes enrolled in the UKPDS, each 10-mm Hg decrease in SBP was associated with a decrease of 12% in diabetes-related complications, 15% in deaths related to diabetes, 11% in myocardial infarctions, and 13% in microvascular complications [1]. Similar to other countries, except for malignancy, cardiovascular disease is the leading cause of death in Korea [19]. Cardiovascular disease has been a major cause of death for patients with diabetes and in the general population. Therefore, adequate control of hypertension in subjects with hypertension is an important health concern.

After the International Expert Committee recommended the use of the HbA1c with a threshold ≥6.5% to diagnose diabetes in 2009, ADA has adopted this recommendation [20]. In 2011, Committee of Clinical Practice Guideline of KDA also adopted HbA1c as diagnostic criteria for diabetes [8]. HbA1c has been measured in all participants aged ≥10 years since 2011, the second year of the 5th KNHANES, regardless of fasting glucose level or presence of diagnosed diabetes. Therefore, HbA1c was available as diagnostic criteria for diabetes in Korea using KNHANES-V since 2011. When HbA1c ≥6.5% was added to the diagnostic measurement, the prevalence of diabetes was increased from 10.5% to 12.4% (male, 23.8%; female, 10.4%) in KNHANES-V 2011 analysis [16]. According to

this change in prevalence of diabetes, the prevalence of hypertension in diabetic subjects was also increased from 51.7% in 2008 (KNHANES-IV) to 54.6% in 2011.

Generally, the prevalence of hypertension is higher in the diabetic population compared to general population. Hypertension is up to three times more common in patients with type 2 diabetes than in nondiabetic subjects and is frequent in type 1 diabetic subjects [21]. From 1988 to 1994, 71% of the United States adult population with diabetes had elevated BP. The awareness and treatment of elevated BP were higher among people with diabetes than among United States adult population (82% vs. 69% for awareness and 71% vs. 53% for treatment, respectively) [3]. However, high awareness and treatment rate of hypertension did not reflect appropriate control of hypertension. In our analysis, we found that less than half of the population that treated hypertension attained target BP goals both in the new-DM and known-DM groups. Compared to control rate of hypertension in the nondiabetic population, the rates in new-DM and known-DM subjects were remarkably low. Previous studies also found that only 12% to 35% of diabetic patients with hypertension controlled their BP below 130/80 mm Hg [22].

The reason why prevalence of hypertension is higher in people with diabetes than in nondiabetic subjects remains unclear. The suggested pathogenesis of hypertension in diabetic subjects includes genetic factors, combined abdominal obesity, insulin resistance, autonomic dysfunction, premature arterial stiffness, and endothelial dysfunction [23]. Notably, patients with diabetes have more isolated systolic hypertension, higher basal heart rates, enhanced variability in BP, and hypertension more resistant to treatment compared to patients without diabetes [24-27]. Moreover, their target BP level is lower than the general population and more attention is needed for hypertensive patients with diabetes.

In this study, approximately 45% of the new-DM subjects had hypertension, which was equivalent to approximately twice the nondiabetic population. In addition, new-DM patients were more unaware of having hypertension and had a significantly lower control rate of hypertension compared to known-DM subjects.

When we divided the subjects based on age categories, the prevalence of hypertension was significantly higher according to increased age both in nondiabetic and diabetic adults. The younger aged group (30 to 49 years) showed significantly lower control rates among all age categories both in the nondiabetic and diabetic population. Therefore, urgent actions are needed to improve the control rate in patients with diabetes, especially in the younger-aged population.

In conclusion, approximately half of Korean adults diagnosed with diabetes had hypertension, and diabetic patients with hypertension are not adequately controlled. The considerably low control rate of hypertension suggests that intensive interventions and increased clinical attention should be urgently initiated to reach target BP levels in patients with diabetes, especially in newly diagnosed subjects with diabetes. Active adaptation of the guidelines, increased education and implementation support should be started to improve the management of hypertension. In addition, to improve BP control, strict adherence to antihypertensive medication, lifestyle modifications such as weight loss, reduction in sodium intake, increased physical activity and avoidance of smoking should be emphasized for diabetic individuals.

CONFLICTS OF INTEREST

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

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