Sex Differences

Gender Difference in Blood Pressure Control and Cardiovascular Risk Factors in Americans With Diagnosed Hypertension

Kwok Leung Ong, Annette W.K. Tso, Karen S.L. Lam, Bernard M.Y. Cheung

Abstract—Hypertension is an important risk factor for cardiovascular disease, which is the leading cause of death in women. We, therefore, analyzed gender-specific trends in the control of blood pressure and prevalence of 5 other cardiovascular risk factors (central obesity, elevated total cholesterol, low high-density lipoprotein cholesterol, hyperglycemia, and smoking) among adults with diagnosed hypertension in the United States. We included 3475 participants aged ≥18 years with diagnosed hypertension in the National Health and Nutrition Examination Survey 1999–2004. The age-adjusted prevalence of uncontrolled blood pressure was 50.8±2.1% in men and 55.9±1.5% in women, which were not significantly different and had not changed significantly with time. Central obesity, elevated total cholesterol level, and low high-density lipoprotein cholesterol were significantly more prevalent in women than in men (79.0±1.0%, 61.3±1.6%, and 39.7±1.6% versus 63.9±1.6%, 48.1±1.8%, and 35.6±1.7%, respectively; \( P < 0.05 \)). The age-adjusted proportion with ≥3 of the 6 risk factors studied was higher in women than in men (52.5±1.4% versus 40.9±1.8%; \( P < 0.001 \)), and this proportion decreased significantly by 7.7% in women from 1999–2000 to 2003–2004 (\( P < 0.05 \)) but not in men. Our study shows that blood pressure control in women with diagnosed hypertension was not significantly inferior compared with men and had not changed significantly in 1999–2004. However, women had higher prevalence of other concomitant cardiovascular risk factors. Although there is room for improvement in blood pressure control, our study has highlighted the importance of addressing concomitant cardiovascular risk factors in women with hypertension. (Hypertension. 2008;51:1142-1148.)

Key Words: cardiovascular risk factors ■ control ■ gender difference ■ hypertension ■ United States

Hypertension is a disease of complex etiology, affecting 972 million people worldwide.\(^1\) It is estimated that the worldwide prevalence of hypertension would increase from 26.4% in 2000 to 29.2% in 2025.\(^1\) Hypertension is an important risk factor for cardiovascular disease and has become a major global burden on public health.\(^2\) In 2003–2004, 76.9% US adults with cardiovascular disease comorbidities had hypertension.\(^3\) Because cardiovascular disease is the leading cause of death in women,\(^4,5\) there is a need to improve our understanding of the factors that influence blood pressure control in women with hypertension.

Other than hypertension, cigarette smoking, hypercholesterolemia, low high-density lipoprotein cholesterol (HDL), and diabetes are also major risk factors for cardiovascular diseases.\(^6,7\) Hypertension clusters with obesity, dyslipidemia, and elevated glucose level. The presence of these metabolic risk factors correlates with uncontrolled blood pressure and augments the cardiovascular risk in hypertensive individuals.\(^8\)

Therefore, blood pressure control needs to be considered in conjunction with the control of other concomitant cardiovascular risk factors. We previously reported an improvement in blood pressure control rates among all adults with hypertension and among those with drug treatment in the United States from 1999–2000 to 2003–2004.\(^9\) However, blood pressure control rates among people with diagnosed hypertension were not examined in previous reports,\(^9–11\) and there are few reports on the prevalence of other cardiovascular risk factors in people in a large, nationally representative sample population. In this study, we used the latest data from the US National Health and Nutrition Examination Survey (NHANES) 1999–2004 to determine, among people with diagnosed hypertension, the gender difference in blood pressure control, prevalence of other concomitant cardiovascular risk factors, and factors that may influence blood pressure control.

Methods

Study Design

NHANES was conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention to monitor the...
health and nutritional status of the civilian, noninstitutionalized US population. All of the participants gave informed consent, and the study received approval from the Centers for Disease Control and Prevention Institutional Review Board. Participants were defined to have diagnosed hypertension if they self-reported diagnosed hypertension and had a blood pressure $\geq 140/90$ mm Hg or were taking antihypertensive medications. In NHANES 1999–2004, there were 8307 women and 7564 men aged $\geq$ 18 years who were both interviewed and examined in the mobile examination center. After excluding 862 pregnant women and 788 subjects with missing blood pressure data, there were 6989 women and 7232 men. Among them, 2501 women and 2335 men had hypertension, of whom 1858 women and 1617 men had been diagnosed previously and were aware of their hypertension. Therefore, a total of 3475 participants with diagnosed hypertension were included in the analysis. Additional details are described in the supplementary Methods section (please see http://hyper.ahajournals.org).

Blood Pressure Control
Uncontrolled blood pressure was defined as blood pressure $\geq 140/90$ mm Hg in nondiabetic persons and $\geq 130/80$ mm Hg in diabetic persons according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7). In a separate analysis, we assessed the prevalence of uncontrolled blood pressure using the cut points of blood pressure $\geq 140/90$ mm Hg for nondiabetic persons and $\geq 130/85$ mm Hg for diabetic persons according to the previous JNC 6 guidelines. Participants were considered to have diabetes if they had been diagnosed previously by a doctor or if they were receiving insulin or oral antidiabetic medications.

Cardiovascular Risk Factors
Central obesity was defined according to the National Cholesterol Education Program-Adult Treatment Panel III. In a separate analysis, central obesity was also assessed using the ethnic-specific waist circumference cut points according to the International Diabetes Federation. Low HDL was defined as a level $<50$ mg/dL in men and $<40$ mg/dL in women. Because data on fasting glucose, triglycerides, and low-density lipoprotein cholesterol were available only in a subsample of fasting subjects, we assessed glycosylated hemoglobin level ($\text{HbA}_1c$) and total cholesterol level instead. Elevated $\text{HbA}_1c$ was defined as a level $\geq 7.0\%$. Elevated total cholesterol level was defined as a level $\geq 200$ mg/dL. Additional details are described in the supplementary Methods section.

Other Variables of Interest
Information on race/ethnicity, education, health insurance, smoking, and history of hypertension, including blood pressure control methods, was obtained from self-reported questionnaires. Body mass index was calculated as weight in kilograms divided by the square of height in meters. Pregnancy was determined by a self-reported questionnaire and a urine pregnancy test. Women not having a menstrual period in the past 12 months were defined as having had menopause. Albuminuria was defined as a urinary albumin:creatinine ratio $\geq 30$ mg/g. Additional details are described in the supplementary Methods section.

Statistical Analysis
Data were analyzed using the complex sample function of SPSS version 15.0 (SPSS Inc) and SAS version 9.0 (SAS Institute Inc). The blood pressure control rates and prevalence of cardiovascular risk factors were age adjusted by direct standardization to the NHANES 1999–2004 population with diagnosed hypertension. To analyze the trends over time, multiple linear or logistic regression models were used, and the survey (NHANES 1999–2000, 2001–2002, and 2003–2004) was included as an independent ordinal variable. Multiple logistic regression was used to assess the independent associations of potential factors with blood pressure control. Interactions between potential factors and gender for blood pressure control were assessed by including each multiplicative interaction term in the multivariate logistic regression models in the full sample after adjusting for the main effects of confounding factors. Additional details are described in the supplementary Methods section.

Results
Among people with diagnosed hypertension in NHANES 1999–2004, 54.9 $\pm$ 1.2% (mean $\pm$ SE) were women. The age-adjusted proportion of women did not change significantly in this period, from 54.4 $\pm$ 1.9% in 1999–2000 to 58.3 $\pm$ 1.9% in 2001–2002 and to 50.7 $\pm$ 2.1% in 2003–2004 (P for trend=0.061 after adjusting for age and race or ethnicity). Table 1 shows the gender-specific characteristics of people with diagnosed hypertension in NHANES 1999–2004. Compared with men, women were older, more likely to have a higher body mass index and be non-Hispanic black and less likely to be non-Hispanic white. There was an increase in the level of education in both men and women between 1999–2000 and 2003–2004. There had been a significant increase in the prevalence of diabetes in women over the period 1999–2004 so that, overall, the prevalence of diabetes was not significantly different in men and women. The prevalence of microalbuminuria was significantly lower in women and decreased significantly in women but not men during the study period. Women were more likely than men to have their blood pressure checked by a doctor in the last 6 months. Men were more likely to use reduction of alcohol intake to control blood pressure, although this percentage had decreased significantly between 1999–2000 and 2003–2004. The use of other methods for blood pressure control did not differ by gender nor change with time. A detailed version of Table 1 is given in supplementary Table S1.

Table 2 shows the gender-specific blood pressure control rates and prevalence of cardiovascular risk factors among people with diagnosed hypertension in NHANES 1999–2004. In NHANES 1999–2004, women had higher mean systolic but lower mean diastolic blood pressure than men. During this period, diastolic blood pressure decreased significantly in both men and women, whereas systolic blood pressure decreased significantly in women only. However, the age-adjusted prevalences of uncontrolled blood pressure, 50.8 $\pm$ 2.1% in men and 55.9 $\pm$ 1.5% in women, were not significantly different and had not changed significantly with time. If blood pressure targets in the JNC 6 guidelines were used, then the prevalence of uncontrolled blood pressure among all of the people with diagnosed hypertension decreased significantly with time after adjustment (P for trend$=0.04$ after adjusting for age, sex, and race or ethnicity; Table S2).

The prevalence of central obesity (either National Cholesterol Education Program-Adult Treatment Panel III or International Diabetes Federation definition), elevated total cholesterol level, and low HDL was significantly higher in women than in men (P$<0.001$, $P<0.001$, and $P=0.042$ after adjusting for age and race or ethnicity, respectively; Table 2). The prevalence of central obesity did not change significantly with time in either gender. However, total cholesterol decreased significantly among all of the people, particularly in women (Table S2). In 1999–2004, the mean HDL increased and the prevalence of low HDL decreased among all of the
Elevated total cholesterol (unadjusted prevalence: 64.1% in women versus 48.9% in men) was significantly higher in women than in men (52.5 vs. 45.0; \( P = 0.049 \) after adjusting for age and race or ethnicity) but not in men (52.5 vs. 45.0; \( P = 0.049 \) after adjusting for age and race or ethnicity). However, only age and exercise showed significant interactions with gender for blood pressure control among all of the subjects (\( P = 0.023 \) and 0.038 for time trend after adjusting for age (except for age-specific estimates) and race or ethnicity (except for race or ethnicity-specific estimates).)

### Discussion

This study reported the recent trends in blood pressure control and prevalence of cardiovascular risk factors among people with diagnosed hypertension in NHANES 1999–2004. In this study, we found that blood pressure control rates were not significantly lower in women and have excluded a large gender difference in this respect.
However, women tended to have more cardiovascular risk factors than men, including central obesity, elevated total cholesterol, and low HDL. Although on average, women had a lower diastolic blood pressure than men, women had a higher systolic blood pressure, which is a better predictor of the risk of cardiovascular and renal disease than diastolic blood pressure.18 On the positive side, along with decreases in systolic and diastolic blood pressures, there have been improvements in microalbuminuria, total cholesterol, HDL, and also the number of cardiovascular risk factors present. These changes were especially notable in women.

In NHANES III (1988–1994), the male gender was associated with uncontrolled blood pressure and lack of awareness of hypertension in multivariate analysis.19 Although women had higher awareness and control rates than men in 1988–1994, these differences were no longer significant in 1999–2000.10 There was an increase in the use of any hypertensive medications in men but not women between 1988–1994 and 1999–2000.10 These may account for the observation that the male gender was not associated with uncontrolled blood pressure in the period 1999–2004. Our finding differs from some reports showing gender difference in blood pressure control.21 It has been suggested that sex hormones may contribute to the gender difference in blood pressure regulation.22 It is likely that androgens but not estrogens are the major contributing factor, because androgens could increase blood pressure, whereas studies on hormone replacement therapy shows no or slight effect on blood pressure in postmenopausal women.22 In the Rancho Bernardo Study, the total serum testosterone increased with age in women with intact ovaries, demonstrating that testosterone may have a

<table>
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<tr>
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<tbody>
<tr>
<td><strong>Blood pressure</strong></td>
<td></td>
<td></td>
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<tr>
<td>n</td>
<td>1617</td>
<td>1858</td>
</tr>
<tr>
<td>Systolic, mean (SE), mm Hg</td>
<td>136.0 (0.7)‡</td>
<td>−2.7 (−6.2 to 0.7)§</td>
</tr>
<tr>
<td>Diastolic, mean (SE), mm Hg</td>
<td>75.6 (0.5)‡</td>
<td>−3.1 (−5.3 to −0.9)§</td>
</tr>
<tr>
<td>Uncontrolled blood pressure, % (SE)¶</td>
<td>50.8 (2.1)</td>
<td>−3.3 (−14.0 to 7.4)</td>
</tr>
<tr>
<td>Waist circumference</td>
<td></td>
<td></td>
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<tr>
<td>n</td>
<td>1544</td>
<td>1768</td>
</tr>
<tr>
<td>Mean (SE), cm</td>
<td>107.9 (0.5)‡</td>
<td>1.7 (−0.6 to 4.0)</td>
</tr>
<tr>
<td>Central obesity, % (SE)</td>
<td>63.9 (1.6)‡</td>
<td>8.8 (0.8 to 16.8)</td>
</tr>
<tr>
<td>NCEP-ATP III definition</td>
<td>86.2 (1.0)‡</td>
<td>−1.4 (−5.2 to 2.5)</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td></td>
<td></td>
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<tr>
<td>n</td>
<td>1544</td>
<td>1726</td>
</tr>
<tr>
<td>Mean (SE), mg/dL</td>
<td>201.8 (1.6)‡</td>
<td>−6.7 (−13.2 to −0.2)§</td>
</tr>
<tr>
<td>≥200 mg/dL%, % (SE)</td>
<td>48.1 (1.8)‡</td>
<td>−9.9 (−18.5 to −1.3)§</td>
</tr>
<tr>
<td>HDL</td>
<td></td>
<td></td>
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<tr>
<td>n</td>
<td>1544</td>
<td>1727</td>
</tr>
<tr>
<td>Mean (SE), mg/dL</td>
<td>46.0 (0.4)‡</td>
<td>2.1 (−0.1 to 4.4)</td>
</tr>
<tr>
<td>&lt;40 mg/dL in men or &lt;50 mg/dL in women, % (SE)§</td>
<td>35.6 (1.7)</td>
<td>−13.2 (−21.4 to −5.0)§</td>
</tr>
<tr>
<td>HbA1c</td>
<td></td>
<td></td>
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<tr>
<td>n</td>
<td>1559</td>
<td>1777</td>
</tr>
<tr>
<td>Mean (SE), %</td>
<td>5.89 (0.04)</td>
<td>0.05 (−0.14 to 0.23)§</td>
</tr>
<tr>
<td>≥7.0%, % (SE)</td>
<td>11.1 (0.9)</td>
<td>−2.9 (−6.3 to 0.5)</td>
</tr>
<tr>
<td>Current smoking</td>
<td></td>
<td></td>
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<tr>
<td>n</td>
<td>1615</td>
<td>1858</td>
</tr>
<tr>
<td>% (SE)</td>
<td>18.7 (1.3)</td>
<td>4.5 (−2.1 to 11.0)</td>
</tr>
</tbody>
</table>

Data are age-adjusted by direct standardization to the NHANES 1999–2004 population with diagnosed hypertension. NA indicates not applicable; NCEP-ATP III, National Cholesterol Education Program-Adult Treatment Panel III; IDF, International Diabetes Federation.

P<0.05, †P<0.01, and ‡P<0.001 for gender difference and §P<0.05 and ||P<0.01 for time trend after adjusting for age and race/ethnicity.

|=Blood pressure ≥140/90 mm Hg in nondiabetic patients and ≥130/80 mm Hg in diabetic patients according to JNC 7 guidelines.
physiological role in very elderly women.21 The nonsignificant difference in blood pressure control rate between premenopausal and postmenopausal women in our analysis could also be because of the limited sample size, because >82% of the women with diagnosed hypertension were postmenopausal.

Because aging is a risk factor for hypertension, it is expected that increasing age would be associated with uncontrolled blood pressure. In the Framingham Study, the incidence of cardiovascular diseases in women increased with age and became higher than that in men after menopause.24 Both chronological and ovarian age may play a role in the increases in waist circumference and fat mass and the decrease in skeletal muscle mass in women at midlife.25 This change in body composition may explain the association of increasing age with uncontrolled blood pressure in women.

Our study also highlighted the high prevalence of central obesity in people with hypertension, especially in women (>79%). Obesity is a well-known risk factor for hypertension.21 The association of weight control with uncontrolled blood pressure in women could be explained by the fact that most of the people practicing weight control are obese and, therefore, have poorer control.

Given the greater prevalence of cardiovascular risk factors in women, it is encouraging that more women had their blood pressure reading checked by doctors within the past 6 months, which was significantly associated with good blood pressure control. Improved detection of hypertension in women can also lead to better detection of other cardiovascular risk factors, which may explain the greater improvement in concomitant cardiovascular risk factors than men in the period 1999–2004. We found an alarming increase in the prevalence of diabetes among women with hypertension. This may be because of increased detection rate, because the mean HbA1c did not change significantly with time. Blood pressure control is extremely important in people with diabetes, because hypertensive people with diabetes have >2-fold risks of cardiovascular morbidity and mortality.26 We found that diabetes was associated with uncontrolled blood pressure. This might be because of obesity, a more stringent blood pressure target in people with diabetes, or renal involvement.

The higher rate of uncontrolled blood pressure and prevalence of other cardiovascular risk factors in non-Hispanic black Americans could be because of genetic, cultural, and social factors, including insurance, access to care, and medications.27,28 It is interesting that current smoking was associated with better blood pressure control, especially in men. Smoking is recognized to be associated with weight loss, and weight gain often occurs after smoking cessation.29 It has been reported in epidemiologic studies that smokers had lower blood pressure than nonsmokers, and cessation of smoking results in higher blood pressure and risk of hypertension.30,31 The reason for this paradox is uncertain.
previous report on an elderly community-based population in Norway shows a positive correlation of nonsmoking or smoking cessation with a greater use of blood pressure- and cholesterol-lowering drugs, probably because of higher awareness of health status among smokers.\textsuperscript{32}

We have previously reported improved blood pressure control rates among all of the hypertensive persons in NHANES and among all of those on treatment for hypertension.\textsuperscript{9} Although there were significant decreases in systolic and diastolic blood pressures in the present study, the decrease in the proportion with uncontrolled blood pressure did not reach statistical significance. This might be because of the inclusion of individuals diagnosed to have hypertension who were not on drug treatment.

This study made use of the NHANES database with its large sample sizes that can provide nationally representative estimates, good sampling design, and quality control. Subjects with undiagnosed hypertension were excluded from this study, because these subjects were not aware of their hypertension and might, therefore, not have taken any actions to control blood pressure and related cardiovascular risks. However, there were also several limitations in this study. The prevalence of diabetes reported did not include undiagnosed persons. Our definition of hypertension excluded hypertensive subjects with blood pressure successfully controlled by nonpharmacological means. There may be unrecognized variables causing residual confounding that explains the observed gender differences. Duration of hypertension and treatment may account for some of the gender differences, but this information was not available in the database. Also, the cross-sectional survey design makes it difficult to analyze trends over time, which may simply reflect population trends in how hypertension is diagnosed, as well as the different lifestyle and pharmacological treatments available.

Perspectives
Our study indicated that there was no significant difference in blood pressure control between men and women in the period 1999–2004. The prevalence of central obesity, elevated total cholesterol, low HDL, and the mean number of cardiovascular risk factors were higher in women. Women have more risk factors than men, which may be because of their higher prevalence of central obesity. Although there is still room for improvement in blood pressure control, our study has highlighted the importance of addressing other concomitant cardiovascular risk factors in women, especially those related to central obesity.

Disclosures
None.

References


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