International Journal of Cardiology 166 (2013) 633–639

Contents lists available at SciVerse ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Increased prevalence of metabolic syndrome among hypertensive population Ten years' trend of the Korean National Health and Nutrition Examination Survey

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ARTICLE INFO

Article history:
Received 17 April 2011
Received in revised form 26 October 2011
Accepted 26 November 2011
Available online 20 December 2011

Keywords:
Hypertension
Metabolic syndrome
Target organ damage

ABSTRACT

Purpose: The implication of metabolic syndrome (MetS) in the hypertensive population has not been known. The prevalence and the risk factors of MetS among the hypertensive population were investigated.
Method: The first to the fourth Korean National Health and Nutrition Examination Survey (KNHANES) held from 1998 to 2008, nationally representative cross-sectional survey, were analyzed. MetS was defined following NCEP-ATP III guideline.
Results: In the general population, MetS prevalence was about 27%, however, it was doubled in the hypertensive population, reaching almost 60%. This trend was consistent through the first to the fourth KNHANES. Moreover, although the prevalence of hypertension as well as MetS among the general population has been slightly decreasing, MetS prevalence among the hypertensive population continues to rise which is more obvious among younger patients than the general population both in men and in women. In a multivariate analysis, high BMI, menopause, smoking and daily alcohol intake were suggested as independent risk factors of MetS in hypertensive population. Finally, the presence of MetS was associated with increased prevalence of target organ damage, such as stroke, coronary artery disease and chronic renal disease.
Conclusion: MetS prevalence among hypertensives was much higher than expected. Moreover, MetS increased target organ damage in hypertensives. Investigation of metabolic status when initiating hypertension control could help establish more effective overall risk control.

1. Introduction

The treatment of hypertension no longer remains in merely controlling blood pressure alone, but targets overall risk control [1–4]. More than 80% of hypertensive patients had multiple cardiovascular risk factors or co-morbidities [1]. For example, in the Framingham Heart Study, 30% of men and 32% of women with hypertension had more than 3 additional risk factors [2]. This rate of clustering was four times higher than expected by chance alone, which suggested a metabolic connection between hypertension and other cardiovascular risk factors. Metabolic syndrome (MetS) represents a cluster of cardiovascular risk factors such as hyperglycemia, hypertension, obesity and dyslipidemia, which are all closely linked to insulin resistance [5].

The prevalence of MetS is rapidly increasing, ranging from 10% to 30% of the adult population in industrialized countries [6,7]. Since hypertension is a key component of MetS, it is not surprising that more than 50% of MetS patients have hypertension. Conversely, the prevalence of MetS is also higher in hypertensive patients than in general population [8]. MetS is also suggested to amplify cardiovascular risk associated with high blood pressure, independent of the several established cardiovascular risk factors [9]. Finally, hypertension is rapidly increasing in middle-income to low-income countries and obesity is also emerging epidemic in all regions of the world across the high-income to middle-income countries [10–12]. However, the temporal trend of the prevalence and the risk factors of MetS combination among hypertensive populations have not been fully studied yet. Hence, we investigated the ten years' trend regarding the prevalence and the clinical characteristics of MetS among hypertensive population by analyzing the first to the fourth Korean National Health and Nutrition Examination Survey (KNHANES) performed in 1998–2008.

2. Materials and methods

2.1. Population

We analyzed the participants of the first to the fourth Korean National Health and Nutrition Examination Survey (KNHANES) which were conducted in 1998, 2001, 2005 and 2008, respectively. The KNHANES, a cross-sectional study, was a nationally representative survey on nutrition and health based on a comprehensive questionnaire. The KNHANES was comprised of four components of the health interview survey, the health behavior survey, the health examination survey, and the nutrition survey. The target population of the KNHANES included all civilian non-institutionalized Korean individuals of at least 1 year of age. A stratified multi-stage probability sampling design was employed. The subjects were selected from sampling units predicated on

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doi:10.1016/j.ijcard.2011.11.095

geographical area, sex and age, determined using household registries. Each of the population was assigned a weighted value on the basis of geographical and demographic characteristics to allow estimates to be calculated for the entirety of the Korean population. Nurses were trained for recording anthropometric measurements, blood collection, blood pressure measurement and questionnaire management. The questionnaires used in this study included questions which addressed the demographic, socioeconomic, dietary and medical history of each respondent [13].

The target population of this research was those whose information could provide sufficient data in diagnosing hypertension, MetS and obesity. The sample included people who were 20 years or older at the time of KNHANES evaluation for whose anthropometric variables (i.e. waist circumference, weight, height), blood pressure, spot urinalysis and blood studies (i.e. glucose, HDL cholesterol, and triglyceride levels) had been measured.

Among the 4594 of the participants of the fourth KNHANES, 2940 were selected by the criteria. We also obtained samples from the first to the third KNHANES to evaluate temporal trend. Using the same criteria, 7962 out of 39,331 samples from the first, 6477 out of 37,769 from the second and 5442 out of 34,152 from the third KNHANES were selected. And the analysis was done with the weighted value of each subject for the entirety of the Korean population.

3. Definition

3.1. Metabolic syndrome (MetS)

The NCEP-ATP III definition of the MetS requires the presence of 3 or more of the following [14], with exception of the waist circumference which was adjusted for Korean by Korean Society for the Study of Obesity [15]; (i) central obesity, waist circumference of more than 90 cm in men and 85 cm in women; (ii) hypertriglyceridemia, fasting plasma triglycerides more than 150 mg/dL; (iii) low HDL-cholesterol, fasting HDL-cholesterol less than 40 mg/dL for men and less than 50 mg/dL for women; (iv) hypertension, systolic and/or diastolic blood pressure more than 130 mm Hg and/or 85 mm Hg or known treatment of hypertension; and (v) high fasting plasma glucose concentration more than 100 mg/dL or known treatment of diabetes.

3.2. Hypertension

Blood pressure categories were defined according to JNC-7 report. The subjects were defined as hypertensive if systolic pressure was 140 mm Hg and higher or diastolic pressure was 90 mm Hg and higher or already taking hypertensive medication. Prehypertensive group were those who do not belong to hypertensive range but those whose systolic pressure was between 120 mm Hg and 139 mm Hg or diastolic pressure between 80 mm Hg and 89 mm Hg.

3.3. Obesity

Obesity was defined when the body mass index (BMI), calculated as the weight in kilograms divided by the height in meters squared, was higher than 25 [16].

3.4. Insulin resistance

Impaired fasting glucose (IFG) was defined as fasting glucose levels between 100 mg/dL and 125 mg/dL by WHO criteria. Diabetes mellitus was defined as fasting plasma glucose (FPG) more than 126 mg/dL or already taking hyperglycemic medication [17].

3.5. Hypertension related target organ damage (TOD)

Hypertension related TOD was defined as the previous cardiovascular events such as angina, myocardial infarction and stroke in which development hypertension had been known to play an important role [4]. In addition, chronic renal disease which was defined as chronic kidney disease (CKD) stage 3 or more (Glomerular filtration rate (GFR) $<$60 ml/min/1.73 m^2) was also defined as hypertension related TOD [18]. GFR was estimated by Modification of Diet in Renal Disease (MDRD) equation.

3.6. Statistics analysis

Categorical variables were analyzed using the Chi-square test and continuous variables were tested using Student's *t*-test. Also, the contribution of the risk factors for MetS combination was analyzed using multiple logistic regression analysis. For all analyses, a p value less than 0.05 was considered statistically significant. Statistical analysis was performed by the SPSS system. (SPSS Inc. version 13.0).

4. Results

4.1. The prevalence of metabolic syndrome (MetS) among hypertensive population

The age-adjusted prevalence of MetS among Korean population over 20 years old was estimated around 25%. The prevalence of MetS increased parallel to blood pressure level. In prehypertensive range, the prevalence was similar to general population, about 27%, however, it was doubled in hypertensive population, reaching almost 60% (Fig. 1A). And this trend was consistent through the first to the fourth KNHANES, performed over 10 years' interval. Moreover, though the prevalence of MetS in the overall population remained stable, MetS prevalence among the hypertensive population has been increasing during the last 10 years. Regardless of gender, the prevalence of MetS among hypertensive population increased by about 10% from the first to the fourth KNHANES, which even reached to 63% in males and even to above 70% in females.

As consistent with the pathogenesis of MetS that it is based on the insulin resistance, the age-adjusted prevalence of impaired fasting glucose and even diabetes mellitus was more than double among hypertensive population compared with that of general population. It suggests that the high prevalence of MetS is not caused by the laboratory error in a certain assay, but is really emerging epidemics of insulin resistance (Fig. 1B).

4.2. The effect of aging and gender on MetS prevalence

In order to investigate the reason of this strong association between hypertension and MetS far beyond the laws of probability, we dissected the impact of age and gender. The prevalence of MetS was increased associated with aging in overall population, which began to rise from the fourth decade, peaking at the seventh decade. However in hypertensive population, MetS prevalence rose from the earlier, third decade and remained high thereafter (Fig. 2A). Then, we evaluated the combined effect of gender and aging on MetS prevalence. In men, MetS prevalence gradually rose following aging, whereas in women its rise was accelerated from the fifth decade, suggesting the effect of menopause. However in the hypertensive population, the prevalence rose from the earlier ages from the third decade both in men and women. In the male hypertensive population, MetS prevalence was already as high as 60% from the third decade and remained stably high thereafter (Fig. 2B). In the female hypertensive population, MetS prevalence began to rise from the younger ages of the third decade which might probably be prior to menopause (Fig. 2C). As a result, large difference in MetS prevalence was found between normotensive and hypertensive women in premenopausal ages.

4.3. Distribution of the metabolic risk component among hypertensive population

The pattern of distribution of the metabolic risk component in hypertensive population was similar to that of overall population (Fig. 3). The most notable finding was that the high blood pressure component had gradually decreased from 39% in the first to 29% in the fourth KNHANES, whereas the prevalence of low HDL cholesterolemia