Association Between Raised Blood Pressure and Dysglycemia in Hong Kong Chinese

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OBJECTIVE — To investigate the association between raised blood pressure and dysglycemia.

RESEARCH DESIGN AND METHODS — We studied the association between raised blood pressure and dysglycemia in 1,862 subjects in the Hong Kong Cardiovascular Risk Factor Prevalence Study cohort. We determined the factors predicting the development of diabetes and hypertension in 1,496 subjects who did not have either condition at baseline.

RESULTS — Diabetes and hypertension were both related to age, obesity indexes, blood pressure, glucose, HDL cholesterol, and triglycerides. Of subjects with diabetes, 58% had raised blood pressure. Of subjects with hypertension, 56% had dysglycemia. BMI and blood glucose 2 h after a 75-g oral glucose load were independent predictors of new-onset diabetes. Age, systolic blood pressure, and 2-h glucose were independent predictors of new-onset hypertension. BMI, systolic blood pressure, and 2-h glucose were independent predictors of the development of diabetes and hypertension together.

CONCLUSIONS — Diabetes and hypertension share common etiological factors. Patients with diabetes or hypertension should be screened and managed for the precursor of the other condition.

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In the U.S., ~29.3 and 7.8% of the general population have hypertension or diabetes, respectively (1). In Hong Kong, ~20 and 9.6% of adults have hypertension and diabetes, respectively (2,3). Obesity is as an important precursor of both hypertension and diabetes in Hong Kong (2,3). Therefore, we investigated the association between raised blood pressure and dysglycemia in the Hong Kong Cardiovascular Risk Factor Prevalence Study cohort.

RESEARCH DESIGN AND METHODS

— In 1995, 2,895 Chinese adults (1,412 men and 1,483 women, aged 25–74 years) were recruited from the general population in Hong Kong through random telephone numbers. From 2000–2004, 1,944 of them participated in the follow-up study, the Hong Kong Cardiovascular Risk Factor Prevalence Study-2 (CRISPS2) (2,3). The study protocol was approved by the University of Hong Kong Faculty of Medicine ethics committee. All participants gave written informed consent. Details of the protocol have been previously reported (2,3). In this study, raised blood pressure included both high-normal blood pressure and hypertension (4). Dysglycemia, which includes impaired fasting glucose, impaired glucose tolerance, and diabetes, was diagnosed with a 75-g oral glucose tolerance test (5). Pre-diabetes includes impaired fasting glucose and impaired glucose tolerance. We analyzed both the 5.6 and 6.1 mmol/l (100 and 110 mg/dl, respectively) cut points for fasting glucose (5,6).

Data analysis was performed using SPSS 15.0 for Windows (SPSS, Chicago, IL). A Cox proportional hazards model was used to identify independent factors predicting the development of diabetes, hypertension, or both. Age, sex, smoking status, alcohol use, and exercise habits were entered into the model. Other variables were included stepwise if $P < 0.05$. Variables that distinguished the development of hypertension from diabetes were identified using discriminant analysis.

RESULTS

— Of the 1,944 subjects studied from 2000 to 2004, oral glucose tolerance test results or diagnosis of diabetes were available for 1,862 subjects. Flow of subjects and baseline characteristics of these men and women with different degrees of dysglycemia and hypertension are shown in an online appendix (available at http://dx.doi.org/10.2337/dc08-0405). Dysglycemia and raised blood pressure were both related to age, waist circumference, waist-to-hip ratio, systolic and diastolic blood pressure, fasting and 2-h blood glucose, homeostasis model assessment estimate of insulin resistance, HDL cholesterol, and triglycerides. Men and women with prediabetes already had obesity, blood pressure, and lipid abnormalities resembling those in diabetes.

Among the 1,862 subjects, 5.0% had diabetes only, 12.5% had hypertension only, and 3.9% had both conditions; 15.3% had dysglycemia only, 13.9% had raised blood pressure only, and 13.9% had both dysglycemia and raised blood

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Table 1—*Characteristics of subjects* (n = *1,496) with no diabetes or hypertension at baseline who developed diabetes, hypertension, or both*

Status at follow-up	No diabetes or hypertension	Diabetes only	Hypertension only	Diabetes and hypertension
n	1,201	67	194	34
Age (years)	42 ± 11	46.1 ± 12.7*	50.0 ± 11.1**	47.8 ± 10.4*
Male (%)	43.6	50.7*	52.1*	64.7*
Diabetes in either parent (%)	16.2	20.9	17.0	27.3
Hypertension in either parent (%)	28.8	20.9	30.6	44.1
BMI (kg/m^2)	23.2 ± 3.2	25.9 ± 4.3**	24.6 ± 3.3**	26.2 ± 3.2**
Waist circumference (cm)	76.0 ± 8.9	83.1 ± 10.4**	80.1 ± 8.7**	84.1 ± 9.9**
Waist-to-hip ratio	0.82 ± 0.08	0.87 ± 0.07**	0.85 ± 0.07**	0.88 ± 0.06**
Systolic blood pressure (mmHg)	110 ± 11	114 ± 13*	123 ± 11**	122 ± 10**
Diastolic blood pressure (mmHg)	70 ± 8	73 ± 9	77 ± 8**	78 ± 8**
Fasting glucose (mmol/l)	5.0 ± 0.4	5.5 ± 0.6**	5.2 ± 0.4**	5.3 ± 0.4**
OGTT 2-h glucose (mmol/l)	5.9 ± 1.5	7.8 ± 1.6**	6.2 ± 1.4†	7.2 ± 1.6**
HOMA-IR	1.0 (0.7–1.5)	1.5 (1.0–2.4)**	1.2 (0.8–1.7)	1.6 (1.1–2.4)
Fasting insulin (mIU/l)	4.3 (2.9–6.4)	6.3 (3.9–9.9)*	5.1 (3.6–7.1)	6.7 (4.4–10.5)
Total cholesterol (mmol/l)	4.9 ± 0.9	5.3 ± 1.1*	5.2 ± 1.2**	5.1 ± 0.9
LDL cholesterol (mmol/l)	3.1 ± 0.8	3.4 ± 1.1*	3.3 ± 0.9*	3.3 ± 0.7
HDL cholesterol (mmol/l)	1.3 ± 0.3	1.2 ± 0.3**	1.2 ± 0.3	1.1 ± 0.3**
Triglycerides (mmol/l)	1.0 ± 0.6	1.5 ± 0.9**	1.3 ± 0.8**	1.6 ± 0.9**
Tobacco use (%)‡	22.4	23.9	27.3	32.4
Regular alcohol consumption (%)§	11.4	10.4	14.5	20.6†
Physically active (%)‖	34.5	28.4	37.1	23.5

Data are means ± SD, median (interquartile range), or percent. Dunnett *t* test or χ^2 test were used, as appropriate. *$P < 0.01$; **$P < 0.001$; †$P < 0.05$ compared with subjects with no diabetes or hypertension. ‡Ever been a smoker. §At least once a week. ‖Exercising at least once a week in the past month. Hypertension was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or if the subject had been previously diagnosed with hypertension and was taking antihypertensive medications. Diabetes was defined as having a fasting plasma glucose concentration ≥7.0 mmol/l (126 mg/dl), having a 2-h OGTT plasma glucose concentration ≥11.1 mmol/l (200 mg/dl), or if the subject had been previously diagnosed with diabetes and was receiving medications for diabetes. HOMA-IR was calculated as follows: [fasting plasma glucose (mmol/l) × fasting insulin (mIU/l)]/22.5. To convert mmol/l to mg/dl, divide by 0.056 for glucose, 0.026 for cholesterol, and 0.011 for triglycerides. HOMA-IR, homeostasis model assessment estimate of insulin resistance; OGTT, oral glucose tolerance test.

pressure. Of the people with diabetes, 58% had raised blood pressure. Of people with hypertension, 58% had dysglycemia, 23.7% had diabetes, and 32.2% had pre-diabetes.

Table 1 shows the characteristics of the 1,496 analyzable subjects who had neither diabetes nor hypertension at baseline. During a median follow-up interval of 6.4 years, 67, 194, and 34 subjects developed diabetes only, hypertension only, or both, respectively. Diabetes and hypertension shared similar predictive factors. Age, male sex, BMI, waist circumference, waist-to-hip ratio, systolic blood pressure, fasting and 2-h blood glucose, and triglycerides were related to the development of diabetes, hypertension, or both. Pre-diabetes (5) was associated with a hazard ratio (HR) of 13.2 (95% CI 7.5–23.5) for new-onset diabetes. A 1-cm increase in waist circumference increases the likelihood of new-onset hypertension by 4.2% (0.9–7.7).

In multivariate analysis, BMI (HR 1.11 [95% CI 1.03–1.19]; $P = 0.005$) and 2-h glucose (2.61 [2.12–3.22]; $P < 0.001$) were independent predictors of new-onset diabetes. Age (1.05 [1.04–1.07]; $P < 0.001$), systolic blood pressure (1.07 [1.05–1.08]; $P < 0.001$), and 2-h glucose (1.16 [1.04–1.30]; $P = 0.008$) were independent predictors of new-onset hypertension. The independent predictors of the development of diabetes and hypertension together were BMI (1.17 [1.05–1.30]; $P = 0.005$), systolic blood pressure (1.05 [1.01–1.09]; $P = 0.011$), and 2-h glucose (1.83 [1.39–2.40]; $P < 0.001$). Systolic blood pressure (standardized discriminant coefficient 0.63), 2-h glucose (−0.51), fasting glucose (−0.43), family history of hypertension (0.32), age (0.29), and homeostasis model assessment estimate of insulin resistance (−0.22) distinguished between those who developed hypertension only from those who developed diabetes only.

CONCLUSIONS — The overlap between diabetes and hypertension is substantial, but that between dysglycemia and raised blood pressure is even greater. Over one-half of people with diabetes have raised blood pressure, and over one-half of people with hypertension have dysglycemia. The overlap between diabetes and hypertension is not accidental; both are components of the metabolic syndrome (7). In cross-sectional analysis, the characteristics of people with diabetes and hypertension showed many similarities. Furthermore, these factors predict prospectively the development of diabetes and hypertension.

Are there factors that distinguish between the development of hypertension and diabetes? Our analysis suggested that high baseline blood pressure, family history of hypertension, and advanced age favored new-onset hypertension, whereas elevated 2-h glucose, elevated fasting glucose, and insulin resistance favored new-onset diabetes.

In conclusion, the majority of people with diabetes have raised blood pressure, and the majority of people with hypertension have dysglycemia. This has important implications in the clinical setting and the delivery of care. Patients with either condition need to be screened and managed for the precursor of the other condition.

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