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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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 pressure.
Raised blood pressure and dysglycemia association

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 (%) | 11.4 10.4 14.5 20.6† |
| Tobacco use (%)‡    | 22.4                        | 23.9         | 27.3             | 32.4                     |
| Hypertension in either parent (%) | 28.8 20.9 |
| BMI (kg/m²)         | 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 χ² 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 ≥1.17 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) x 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 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.
References
1. Ong KL, Cheung BMY, Man YB, Lau CP, Lam KSL: Prevalence, awareness, treatment, and control of hypertension among United States adults 1999–2004. Hypertension 49:69–75, 2007
2. Cheung BMY, Wat NMW, Man YB, Tam S, Thomas GN, Leung GM, Cheng CH, Woo J, Janus ED, Lau CP, Lam TH, Lam KSL: Development of diabetes in Chinese with the metabolic syndrome: a six year prospective study. Diabetes Care 30:1430–1436, 2007
3. Cheung BMY, Wat NMW, Man YB, Tam S, Cheng CH, Leung GM, Woo J, Janus ED, Lau CP, Lam TH, Lam KSL: Relationship between metabolic syndrome and the development of hypertension in the Hong Kong Cardiovascular Risk Factor Prevalence Study 2. Am J Hypertens 21:17–22, 2008
4. 2003 European Society of Hypertension-European Society of Cardiology guidelines for the management of arterial hypertension. J Hypertens 21:1011–1153, 2003
5. American Diabetes Association: Diagnosis and classification of diabetes mellitus. Diabetes Care 31 (Suppl. 1):S55–S60, 2008
6. World Health Organization: Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia: report of a WHO/IDF consultation [article online], 2006. Available from http://www.who.int/diabetes/publications/en/. Accessed 24 April 2008
7. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ, Smith SC Jr, Sper- tus JA, Costa F: Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. Circulation 112:2735–2752, 2005
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