Original Article

Association between Hypertension and Hyperglycemic States among Northeastern Thais

Praew Kotruchin MD[1], Chatlert Pongchaiyakul MD[2]

[1] Department of Emergency Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand
[2] Division of Endocrinology and Metabolism, Department of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

Background: The coexistence of hypertension [HT] and hyperglycemic states is becoming a major health problem in developing countries. However, there are not sufficient data on the prevalence and the association between HT and impaired fasting glucose [IFG]/diabetes [DM] among rural Thais.

Objective: The present study aimed to determine the prevalence of IFG and DM and the association between HT and IFG/DM.

Materials and Methods: This cross-sectional study was conducted at a health-check up clinic of Srinagarind Hospital, Khon Kaen, Thailand. Blood pressure and fasting plasma glucose measurements were done in all subjects. Frequencies of HT, IFG and DM were calculated, and the differences in characteristics between men and women, HT and non-HT individuals were tested. Logistic regression model was used to determine the association between HT and IFG/DM.

Results: A total of 4,247 Thai participants, the prevalence of HT was 25.8%. The prevalence of IFG and DM was found higher in men than in women (15.1% vs. 8.4% for IFG and 7.5% vs. 3.7% for DM in men and women, respectively). Men and women with HT had an increased risk of IFG (odds ratio [OR] 1.77, 95% CI: 1.34, 2.34 for men and OR 3.14, 95% CI: 2.35, 4.19 for women) and DM (OR 1.78, 95% CI: 1.23, 2.57 for men and OR 3.94, 95% CI: 2.60, 5.98 for women). After adjustment for age and body mass index, the risks of IFG were unchanged in both hypertensive men and women, but the risk for DM was associated with HT in women (OR 1.92, 95% CI: 1.21, 3.03) but not in men (OR 1.26, 95% CI: 0.86, 1.86).

Conclusion: Hyperglycemic states including IFG and DM are common among hypertensive rural Thais. Routine assessment for glucose metabolism abnormalities are recommended for patients with hypertension, in order to aid in early detection and treatment.

Keywords: Diabetes; Hypertension; Impaired fasting glucose

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The prevalence of hypertension [HT] and hyperglycemic states are increasing worldwide. They are often coexisting, and are recognized as major risk factors of cardiovascular disease [CVD][1-3]. It has been accepted that HT was associated with insulin resistance[4,5]. Previous studies have shown that hypertensive individuals are more predisposed to develop impaired fasting glucose [IFG] and diabetes [DM] than individuals with normal blood pressure[6,7]. Impaired fasting glucose, which is recognized as an early metabolic abnormality, is also an independent risk predictor for incident DM, CVD, premature CVD and all-cause mortality[8-12]. However, the current data is not sufficient to determine the association among HT, IFG, and DM in Thai populations living in rural areas.

The burden of DM is one of the greatest challenges of the 21st century[13]. Parallel with the rapid urbanization that is taking place in Thailand, the prevalence of both IFG and DM is increasing to the level of a public health concern[14,15]. There is, thus, an urgent need to identify the risk of IFG/DM in hypertensive individuals for encouraging the early prevention. Therefore, the present study was aimed to determine the prevalence of glucose abnormalities (IFG

Correspondence to:
Pongchaiyakul C. Division of Endocrinology and Metabolism Department of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.
Phone: +66-81-5446694, **Fax:** +66-43-366870
E-mail: pchat@kku.ac.th

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and DM) and examine the association between HT and IFG/DM among rural Thais.

Materials and Methods

Setting and population

This was a cross-sectional study, taken place at a health-check up clinic of Srinagarind Hospital, a tertiary care university hospital in Khon Kaen province, Thailand. Data was collected between January 1, 2005 and December 31, 2006, a total of 4,293 patients were recruited. All participants were Thai, aged 14 years old or more. Patients with underlying diseases as well as those who were taking drugs that affect their glycemic and blood pressure [BP] profile were excluded. The study protocol was approved by the Khon Kaen University Ethics Committee for Human Research, and written informed consent was obtained from each individual before enrollment.

Measurements

The participants were invited to meet with a research nurse. After they completed a consent form and a questionnaire, a full clinical history was obtained and a physical examination was performed. Body weight (including light indoor clothing) was measured using an electronic scale (accuracy 0.1 kilogram [kg]) and standing height (without shoes) was measured using a stadiometer (nearest 0.1 cm). Body mass index [BMI] was calculated using the ratio of weight in kg divided by height in square meter [m^2]. Blood pressure data were recorded using a calibrated electronic sphygmomanometer after five-minutes' rest in sitting position, and the average of two such measurements was then used for all analysis.

Laboratory measurements

Blood samples were collected from the antecubital vein in the morning (7:30 and 8:30 hours) after a 12-hour overnight fasting period prior to the clinical visit and were immediately centrifuged. Fasting plasma glucose (FPG) was measured in the central laboratory of our institution using the enzymatic hexokinase method (Cobas c501 analyzer, Roche Diagnostics GMbH, Mannheim, Germany).

Operation definition

Hypertension was diagnosed if the patient's office systolic BP [SBP] was more than 140 mmHg and/or diastolic BP [DBP] was more than 90 mmHg[16]. Impaired fasting glucose was defined as an FPG level between 100 and 125 mg/dl. Diagnosis of DM was based on the ADA criteria using FPG $\geq$126 mg/dl on repeated measurements within one week[17].

Statistical analysis

Continuous variables are presented as mean and standard deviation [SD] and categorical variables as observed number and percentage. Descriptive statistics were computed for each sex separately. The prevalence was expressed as a percentage. The differences in baseline characteristics between men and women, hypertensive and non-hypertensive patients were tested using an unpaired t-test once normality was demonstrated. Otherwise, a nonparametric test (Mann-Whitney test) was used. A logistic regression model was used to determine the association between HT and IFG/DM. Statistical significance was defined as a *p*-value <0.05. All data analyses were performed using SPSS, version 16 (SPSS Inc, Chicago) with the right of Khon Kaen univesity.

Results

A total of 4,247 Thai participants, aged between 14 and 83 years (mean age of 49.4 and 46.9 years for men and women, respectively) were included for analysis. Mean BMIs were 24.6$\pm$3.4 and 23.7$\pm$3.8 in men and women, respectively. Men in this study were, on average, significantly taller, heavier and had a higher BMI than women. SBP, DBP and FPG were also significantly higher in men than in women (Table 1).

Thirty-six percent of the participants were obese (BMI $\geq$25 kg/m^2; 42.8% in men vs. 31.7% in women), and the prevalence of HT was 25.8% (n = 1,096/4,247; 32.3% in men and 21.6% in women, respectively). The prevalence of IFG and DM were significantly higher in men than in women (15.1 vs. 8.4% for IFG and 7.5 vs. 3.7% for DM; Table 2). We found that the prevalence of HT, IFG and DM increased with age and higher BMI in both gender. Hypertensive men and women were, on average, older, had a higher BMI and FPG than those without HT (Table 3). The prevalence of IFG and DM were significantly higher in both hypertensive men (19.7 and 10.4%) and women (16.3 and 8.1%) compared with non-hypertensive individuals (Table 4). Moreover, the prevalence IFG and DM were also higher in individuals with stage I hypertension than in those with stage II hypertension (10.6 and 22.2 for IFG, and 8.5 and 11.7% for DM in stage I and II hypertensive groups, respectively; data not shown).

A logistic regression model was used to quantify the effect of predictive variables for IFG and

DM (Table 4). Men and women with HT had an increased risk of IFG (odds ratio [OR] 1.77, 95% CI: 1.34, 2.34 and OR 3.14, 95% CI: 2.35, 4.19, respectively) and DM (OR 1.78, 95% CI: 1.23, 2.57 and OR 3.94, 95% CI: 2.60, 5.98, respectively). In this study, age, BMI and HT were associated with IFG and DM in both gender. After adjustment for age and BMI; HT increased the risks of IFG in both men (OR 1.35, 95% CI: 1.01, 1.81) and women (OR 1.78, 95% CI: 1.29, 2.45). However, HT increased the risk of DM in women (OR 1.92, 95% CI: 1.21, 3.03) but not in men (OR 1.26, 95% CI: 0.86, 1.86).

Discussion

Epidemiologic data examining the glycemic status in hypertensive Thai individuals is limited, particularly in the rural population. The present study adds to the epidemiologic data regarding the association between HT and hyperglycemic states in this particular population. From our results, the overall prevalence of IFG and DM was 11% and 5.2%, respectively, which was comparable with the results of the survey-based studies by Aekplakorn et al in 2004 and 2009, which stated that the prevalence of IFG and

Table 1. Baseline characteristics

Characters	Men (n = 1,664)	Women (n = 2,583)
Age (yr)	49.4±11.0*	46.9±10.4
Body weight (kg)	67.3±10.2*	56.9±9.3
Height (cm)	165.5±5.8*	155.1±5.5
Body mass index (kg/m^2)	24.6±3.4*	23.7±3.8
Systolic blood pressure (mmHg)	122.0±15.8*	117.3±16.2
Diastolic blood pressure (mmHg)	80.4±11.0*	76.1±10.9
Fasting plasma glucose (mg/dl)	96.3±31.2*	88.9±20.5

* The *p*-value <0.01 for the difference of values between men and women

Table 2. Prevalence of obesity, hypertension, impaired fasting glucose and diabetes according to sex

Metabolic risks	% (n)		
	Total (n = 4,247)	Men (n = 1,664)	Women (n = 2,583)
Obesity (BMI ≥25 kg/m^2)	36.1 (1533)	42.8 (713)*	31.7 (820)
Hypertension	25.8 (1096)	32.3 (538)*	21.6 (558)
Impaired fasting glucose	11.0 (469)	15.1 (251)*	8.4 (218)
Diabetes	5.2 (220)	7.5 (125)*	3.7 (95)

* The *p*-value <0.01 for the difference of prevalence between men and women
BMI = body mass index

Table 3. Comparison of age, body mass index [BMI] and fasting plasma glucose [FPG] between hypertension [HT] and non-HT individuals according to sex

	Men		Women	
	HT (n = 538)	Non-HT (n = 1126)	HT (n = 558)	Non-HT (n = 2,025)
Age (yr)	53.0±11.1*	47.6±10.6	53.4±10.2*	45.1±9.7
BMI (kg/m^2)	25.4±3.4*	24.2±3.3	25.8±4.2*	23.1±3.4
FPG (mg/dl)	100.2±33.9*	94.5±29.6	95.3±27.4*	87.1±17.8

* The *p*-value <0.01 for the difference between values between HT and non-HT subjects of each sexs

Table 4. Prevalence and risk of impaired fasting glucose [IFG] and diabetes [DM] according to hypertension [HT]

Sex	IFG/DM	HT% (n/total)	Non-HT% (n/total)	Unadjusted OR (95% CI)	Adjust OR+ (95% CI)
Total	IFG	18.0 (197/1096)	8.6 (272/3151)	2.51 (2.05 to 3.06)	1.60 (1.29 to 1.98)
	DM	9.2 (101/1096)	3.8 (119/3151)	2.73 (2.07 to 3.59)	1.56** (1.16 to 2.10)
Men	IFG	19.7 (106/538)	12.9 (145/1126)	1.77 (1.34 to 2.34)	1.35* (1.01 to 1.81)
	DM	10.4 (56/538)	6.1 (69/1126)	1.78** (1.23 to 2.57)	1.26 (0.86 to 1.86)
Women	IFG	16.3 (91/558)	6.3 (127/2025)	3.14 (2.35 to 4.19)	1.78 (1.29 to 2.45)
	DM	8.1 (45/558)	2.5 (50/2025)	3.94* (2.60 to 5.98)	1.92** (1.21 to 3.03)

* $p<0.001$, ** $p<0.05$

[+] Adjusted for age and body mass index

DM in the general Thai population were 12.5% and 9.6%, in 2004 and 10.6% and 7.5%, in 2009[14,18]. The prevalence of DM in the present study was lower than in an earlier Asian survey-based study conducted in 2000 (5.2% vs. 9.6%). However, the prevalence of IFG in our study was higher (11% vs. 5.4%)[19]. This discrepancy can be explained by the difference in the populations studied. The previous Asian studies mentioned above recruited the subjects ≥35 years old and included patients who had been diagnosed with DM. Furthermore, the criteria for IFG diagnosis was not uniform[14,18,19].

The present study indicated a high prevalence of hyperglycemic states (IFG or DM) among individuals with HT (27.2%), with a 30.1% prevalence rate in men and 24.4% in women. The prevalence of IFG was 18% and the prevalence of DM was 9.2%. These findings were evident despite the exclusion of patients previously diagnosed with DM. The result was consistent with the previous studies. Sun et al, reported a 26% IFG prevalence and a 10% DM prevalence among 6,412 hypertensive individuals in rural China, while the overall prevalence of DM in rural China was only 6%[20]. In addition, the prevalence of diabetes was 16.5% and 4.3% in Turkish subjects with and without HT, respectively[21].

The authors found that individual with hypertension had higher risk of IFG (OR 2.51, 95% CI: 2.05, 3.06) and DM (OR 2.94, 95% CI: 2.23, 3.87) compared with those without HT. This finding was consistent with a study conducted by Yu et al, which found that for every millimeter of mercury of systolic blood pressure elevation, the OR of DM was 1.01 (95% CI 1.003, 1.013)[22]. Many studies have reported age, sex, obesity and HT as risk factors for IFG and DM[23-25]. In present study, we found that the prevalence of IFG and DM increased with age and BMI. However, the association between hypertension and IFG/DM in our study remained unchanged even after adjusting for age and BMI.

The authors found that the prevalence of IFG and DM was higher in men. The associations between gender and IFG/DM have been controversial. Two national Thai surveys showed the higher prevalence of IFG but the lower prevalence of DM in men than in women[19]. Our findings were consistent with the Chinese study[20]. However, a study in American population showed higher prevalence of both IFG and DM in men than in women[26], while a study in Turkish population reported that the prevalence of DM in men and women was equivalent[24]. The men recruited in

our study were older and had higher BMI, which may influence the sex-related differences in prevalence rates of IFG and DM.

The major strengths of the present study were as follows: 1) it dealt with a large sample size of 4,247 participants, 2) physical examinations, including weight, height, and blood pressure measurement, as well as blood sample collection for laboratory analysis were thoroughly conducted by educated nurses, which justified the reliability of process, 3) the diagnoses of IFG and DM were based on repeated FPG measurement, which minimized any possibility of misdiagnosis, 4) there was a formal control group taken from the same population, and 5) we excluded patients with previous history hypertension and DM, as well as patients on BP-lowering drugs (i.e., thiazide, beta-blockers) or any drugs affecting their glycemic profiles.

However, there are a number of limitations to the present findings. First, the hemoglobin A1c was not tested nor was the oral glucose tolerance test [OGTT]. Secondly, other potential factors, including family history of DM, dyslipidemia, educational and socioeconomic status, were not taken into account in this analysis. Third, the cross-sectional nature of the study limits our defining casual relationship. Fourth, it could be argued that patients with high blood pressure in a medical setting might merely be cases of white coat hypertension. Finally, this study was conducted in a single center in northeast Thailand. To extrapolate our results on other ethnicity might not be appropriate.

In conclusion, hyperglycemic states including IFG and DM are common among hypertensive rural Thais. Routine assessment for glucose metabolism abnormalities are recommended for patients with HT, in order for early detection, as well as initiate the lifestyles modification to prevent the emergence of IFG and DM and reduce future CVD.

What is already known on this topic?

The coexistence of hypertension [HT] and hyperglycemic states is becoming a major health problem in developing countries.

What this study adds?

This study adds to the epidemiologic data regarding the association between HT and hyperglycemic state in rural Thai population. The IFG and DM are not uncommon and hypertension is an independent risk factor for IFG and DM among hypertensive rural Thais.

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Potential conflicts of interest

The authors declare no conflict of interest.

References

1. Stamler J, Vaccaro O, Neaton JD, Wentworth D. Diabetes, other risk factors, and 12-yr cardiovascular mortality for men screened in the Multiple Risk Factor Intervention Trial. Diabetes Care 1993;16:434-44.
2. Buse JB, Ginsberg HN, Bakris GL, Clark NG, Costa F, Eckel R, et al. Primary prevention of cardiovascular diseases in people with diabetes mellitus: a scientific statement from the American Heart Association and the American Diabetes Association. Diabetes Care 2007;30:162-72.
3. Alderman MH, Cohen H, Madhavan S. Diabetes and cardiovascular events in hypertensive patients. Hypertension 1999;33:1130-4.
4. Ferrannini E, Buzzigoli G, Bonadonna R, Giorico MA, Oleggini M, Graziadei L, et al. Insulin resistance in essential hypertension. N Engl J Med 1987;317:350-7.
5. Shen DC, Shieh SM, Fuh MM, Wu DA, Chen YD, Reaven GM. Resistance to insulin-stimulated-glucose uptake in patients with hypertension. J Clin Endocrinol Metab 1988;66:580-3.
6. Gress TW, Nieto FJ, Shahar E, Wofford MR, Brancati FL. Hypertension and antihypertensive therapy as risk factors for type 2 diabetes mellitus. Atherosclerosis Risk in Communities Study. N Engl J Med 2000;342:905-12.
7. Drivsholm T, Ibsen H, Schroll M, Davidsen M, Borch-Johnsen K. Increasing prevalence of diabetes mellitus and impaired glucose tolerance among 60-year-old Danes. Diabet Med 2001;18:126-32.
8. Shaw JE, Zimmet PZ, de Court, Dowse GK, Chitson P, Gareeboo H, et al. Impaired fasting glucose or impaired glucose tolerance. What best predicts future diabetes in Mauritius? Diabetes Care 1999;22:399-402.
9. de Vegt F, Dekker JM, Jager A, Hienkens E, Kostense PJ, Stehouwer CD, et al. Relation of impaired fasting and postload glucose with

incident type 2 diabetes in a Dutch population: The Hoorn Study. JAMA 2001;285:2109-13.
10. Meigs JB, Nathan DM, D'Agostino RB Sr, Wilson PW. Fasting and postchallenge glycemia and cardiovascular disease risk: the Framingham Offspring Study. Diabetes Care 2002;25:1845-50.
11. DECODE Study Group, European Diabetes Epidemiology Group. Is the current definition for diabetes relevant to mortality risk from all causes and cardiovascular and noncardiovascular diseases? Diabetes Care 2003;26:688-96.
12. Heldgaard PE, Olivarius NF, Hindsberger C, Henriksen JE. Impaired fasting glycaemia resembles impaired glucose tolerance with regard to cardiovascular risk factors: population-based, cross-sectional study of risk factors for cardiovascular disease. Diabet Med 2004;21:363-70.
13. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Res Clin Pract 2010;87:4-14.
14. Aekplakorn W, Chariyalertsak S, Kessomboon P, Sangthong R, Inthawong R, Putwatana P, et al. Prevalence and management of diabetes and metabolic risk factors in Thai adults: the Thai National Health Examination Survey IV, 2009. Diabetes Care 2011;34:1980-5.
15. Deerochanawong C, Ferrario A. Diabetes management in Thailand: a literature review of the burden, costs, and outcomes. Global Health 2013;9:11.
16. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, et al. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. JAMA; 289*:* 2560-72.
17. Genuth S, Alberti KG, Bennett P, Buse J, Defronzo R, Kahn R, et al. Follow-up report on the diagnosis of diabetes mellitus. Diabetes Care 2003;26:3160-7.
18. Aekplakorn W, Abbott-Klafter J, Premgamone A, Dhanamun B, Chaikittiporn C, Chongsuvivatwong V, et al. Prevalence and management of diabetes and associated risk factors by regions of Thailand: Third National Health Examination Survey 2004. Diabetes Care 2007;30:2007-12.
19. Aekplakorn W, Stolk RP, Neal B, Suriyawongpaisal P, Chongsuvivatwong V, Cheepudomwit S, et al. The prevalence and management of diabetes in Thai adults: the international collaborative study of cardiovascular disease in Asia. Diabetes Care 2003;26:2758-63.
20. Sun Z, Zheng L, Xu C, Zhang X, Li J, Liu S, et al. Prevalence of diabetes and impaired fasting glucose in hypertensive adults in rural China. Acta Cardiol 2009;64:351-6.
21. Ozdemir L, Topcu S, Nadir I, Nur N, Arslan S, Sumer H. The prevalence of diabetes and impaired glucose tolerance in Sivas, Central Anatolia, Turkey. Diabetes Care 2005;28:795-8.
22. Yu S, Sun Z, Zheng L, Guo X, Yang H, Sun Y. Prevalence of diabetes and impaired fasting glucose in hypertensive adults in rural China: far from leveling-off. Int J Environ Res Public Health 2015;12:14764-79.
23. Baltazar JC, Ancheta CA, Aban IB, Fernando RE, Baquilod MM. Prevalence and correlates of diabetes mellitus and impaired glucose tolerance among adults in Luzon, Philippines. Diabetes Res Clin Pract 2004;64:107-15.
24. Kelestimur F, Cetin M, Pasaoglu H, Coksevim B, Cetinkaya F, Unluhizarci K, et al. The prevalence and identification of risk factors for type 2 diabetes mellitus and impaired glucose tolerance in Kayseri, central Anatolia, Turkey. Acta Diabetol 1999;36:85-91.
25. Kim SM, Lee JS, Lee J, Na JK, Han JH, Yoon DK, et al. Prevalence of diabetes and impaired fasting glucose in Korea: Korean National Health and Nutrition Survey 2001. Diabetes Care 2006;29:226-31.
26. Cowie CC, Rust KF, Byrd-Holt DD, Eberhardt MS, Flegal KM, Engelgau MM, et al. Prevalence of diabetes and impaired fasting glucose in adults in the U.S. population: National Health And Nutrition Examination Survey 1999-2002. Diabetes Care 2006;29:1263-8.