Prevalence of thyroid disorders and associated risk factors with various glycemic status in North China

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ABSTRACT
The aim of this cross-sectional study was to investigate whether abnormal glycemic status (diabetes and prediabetes) is associated with increased prevalence of thyroid disorders in North China. A total of 10,860 adult participants were enrolled based on the REACTION study [Ning G. J Diabetes. 2012;4(2):172–173]. They were divided into three groups by glucose levels according to the American Diabetes Association 2010 criteria. The basic characteristics of the study population were analyzed. The prevalence and effects of thyroid disorders, cardio-cerebrovascular disease, and risk factors of thyroid disorders, among the study groups, were investigated. The study population comprised 2994 diabetic patients (27.57%) and 6386 prediabetic patients (58.80%), with the mean age of 55.37 ± 8.82 years. Compared to those subjects with normal glucose status (8.11%), thyroid disorders were more common in the diabetic (15.97%) and prediabetic patients (13.48%) ($P < 0.001$). Impacts of female gender related to the presence of thyroid disorders were even more profound in the diabetic patients than in those with other glucose status. The results indicate that screening for thyroid disorders among patients with diabetes or prediabetes should be regularly performed, especially in females.

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Introduction
Diabetes mellitus is a noncommunicable chronic disease, which is one of the leading causes of mortality, causing burden for families and the society throughout the world, including China [1, 2]. Among the adults older than 20 years, the cases of diabetes are projected to rise from 135 million in 1995 to 300 million in 2025 worldwide. On the other hand, in China, the total number of people with diabetes will have increased from 20.8 million in 2000 to 42.3 million in 2030 [3].

It is known that the insulin metabolism disorders can result in thyroid functional abnormalities, and in turn, the thyroid hormone imbalance acts on the insulin metabolism [4–6]. Recent studies have confirmed that patients with diabetes with uncontrolled hyperthyroidism may suffer from hyperglycemic crisis and recurrent hypoglycemia episodes [7]. Celani et al. [8] have reported high frequencies of thyroid function abnormalities in acute cases with poor glycemic control at admission.

In recent years, more and more attention has been paid to the thyroid disorder prevalence among diabetic patients, rather than among prediabetic subjects, who have been ignored due to the obscure symptoms. Compared with normal glycemia subjects, patients with type 2 diabetes mellitus (T2DM) have higher serum levels of free tri-iodothyronine and thyroid-stimulating hormone (TSH), and suffer from higher prevalence of primary hypothyroidism. Among the parameters of the glucose metabolism, there are only higher glucose levels under fasting condition in the patients with hyperthyroidism [9]. A clinical trial study has found that prediabetes mellitus is associated with adverse cardiovascular outcomes [10]. China is one of the most populous countries, in which the prevalence of diabetes and prediabetes is as high as 11.6 and 50.1%, respectively, in adults [11]. However, few studies have investigated the prevalence of thyroid disorders in prediabetic subjects, and even fewer concern its risk factors among this population.

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In this study, the prevalence of thyroid disorders among patients with diabetes or prediabetes, and the related risk factors, were investigated, in North China. Moreover, in order to reduce the risk of cardio-cerebrovascular disease (CCVD), the necessity of frequent screening on the thyroid function among the hyperglycemic population was also analyzed.

Subjects and methods

Study population

This study was a large-scale, population-based, observational, cross-sectional study. The study population was derived from the REACTION study [12], which was conducted across China in 2011. All eligible residents no younger than 18 years who had been living in the communities or villages for no less than 5 years, received the screening examination (with a response rate of over 85%).

Exclusion criteria were as follows: (1) subjects for whom some of the needed data were missing, such as the results from the serum glucose or thyroid function analysis; (2) subjects intaking medication that would influence the thyroid function (including the thyroid hormones and anti-thyroid drugs) during the past 3 months; (3) subjects in pregnancy, or within six months after delivery; (4) subjects with history of renal impairment or hepatic failure; and (5) subjects having cardiovascular diseases, including the myocardial infarction (MI), stroke, coronary heart disease (CHD), or hypertension, in the euglycemia group. Ultimately, 10,860 cases were included herein.

Ethics statement

The study protocol was approved by the ethics committee of Shanghai Jiao Tong University [12], and written informed consent forms were obtained from all participants before collecting the data.

Data collection

A standard questionnaire was applied to obtain information concerning the demographic characteristics. The interview included questions related to the information on diabetes mellitus, thyroid disorders, cardiovascular events (CVEs), and other severe diseases. Clinical staff were trained to measure the blood pressure, and obtain the anthropometric measurements and blood specimens, according to standard protocols.

Waist circumference (cm) was measured on standing participants, midway between the costal arch lower edge and the iliac crest upper edge. The waist–hip ratios (WHRs) were obtained. Body mass index (BMI) was calculated as the weight (kg) divided by the square of height (m). The blood pressure was measured at the non-dominant arm in replicates with a 3-min interval, with an electronic sphygmomanometer (HEM-7117; Omron, Kyoto, Japan).

Blood samples were obtained between 08:00 AM and 10:00 AM after overnight fasting (> 10 h). Subjects without history of diabetes accepted the 75-g oral glucose tolerance test, and the plasma glucose level was measured at 0 h and 2 h after administration. The following indicators were obtained: the serum lipid profile, fasting and 2-h-postprandial glycemia, HbA1c, (FT3), free thyroxine (FT4), and TSH. Intra- and inter-assay coefficients of variation should be less than 5% for all these parameters.

Disease diagnosis

According to the American Diabetes Association 2010 criteria [13], diabetes was diagnosed when one or more of the following criteria were met: (1) self-reported previous diagnosis based on health care professionals; (2) fasting blood glucose (FBG) level of no less than 126 mg/dL; (3) 2-h plasma glucose level of no less than 200 mg/dL; and (4) HbA1c concentration of no less than 6.5%. Prediabetes or categories of increased risk of diabetes were defined as: (1) FBG levels between 100 mg/dL and 125 mg/dL; (2) 2-h plasma glucose levels between 140 mg/dL and 199 mg/dL; or (3) HbA1c concentrations between 5.7 and 6.4%, in participants without prior diabetes diagnosis. The laboratory reference ranges were as follows: TSH, 0.27–4.20 mIU/L; FT3, 3.1–6.8 pmol/L; and FT4, 12–22 pmol/L. Thyroid disorders occurred when the thyroid hormone levels were outside the reference range. Subclinical hypothyroidism (SCH) was defined in the cases when the TSH levels were greater than 4.20 mIU/L, while the FT4 levels were within the normal range.

Statistical analysis

Statistical Package for the Social Sciences (SPSS, version 18.0) software was used for statistical analysis. Categorical variables were described as frequency (percentage), and numerical variables with normal distribution were expressed as mean ± SD. The χ² test (categorical variables), and Student’s t-test and analysis of variance (numerical variables), were used when indicated. Multiple logistic regression analysis was used to
Determine which factors were most strongly related to thyroid disorders in subjects with different glucose levels. The mean difference was significant at the 0.05 level (two-tailed).

**Results and discussion**

**Basic characteristics of study population**

In total, 10,860 subjects, 4437 males (40.86%) and 6423 females (59.14%), with the mean age of 55.37 ± 8.82 years, were included in this study. Among these subjects, 2994 (27.57%) cases were diagnosed as pre-diabetes. There were differences among people with only diabetic patients, females accounted for 54.37% (P < 0.01). Furthermore, patients with thyroid disorders obtained significantly higher HbA1c compared to those without thyroid disorders (7.71 ± 1.76% vs. 7.36 ± 1.77%; P < 0.001). In addition, diabetic patients without thyroid disorders had higher serum creatine levels compared to those with thyroid disorders (67.44 ± 12.00 vs. 65.40 ± 11.33; P < 0.001) (Table 2). There were no differences in BMI (25.13 ± 3.67 and 25.16 ± 3.56; P = 0.842) and WHR (0.91 ± 0.26; P = 0.116).

On the other hand, among prediabetic patients with or without thyroid disorders, similar differences were observed in age (55.68 ± 8.39 vs. 55.04 ± 8.71 years; P < 0.05), female proportion (76.99% vs. 57.05%; P < 0.01), HbA1c (5.87 ± 0.30% vs. 5.82 ± 0.31%; P < 0.01) (Table 3). There were no differences in BMI (28.23 ± 104.2 and 26.27 ± 5.89) and WHR (0.92 ± 0.19 and 0.91 ± 0.06) (P < 0.236). Taken together, these results suggest that thyroid disorders

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**Table 1. Demographic information and clinical data of study population.**

|                 | Normal group (n = 1480) | Pre-DM group (n = 6386) | DM group (n = 2994) | P    |
|-----------------|------------------------|------------------------|---------------------|------|
| Gender, n (%)   | 890 (60.14)            | 3815 (59.74)           | 1718 (57.38)        | 0.068|
| Age            | 51.67 ± 8.61           | 55.13 ± 8.66           | 57.70 ± 8.57        | 0.000**|
| TD, n (%)      | 120 (8.11)             | 861 (13.48)            | 478 (15.97)         | 0.000**|
| SCH, n (%)     | 95 (6.42)              | 751 (11.76)            | 421 (14.06)         | 0.000**|
| BMI (kg/m²)    | 24.41 ± 3.83           | 25.13 ± 3.65           | 25.84 ± 3.75        | 0.000**|
| FPG (mmol/L)   | 5.18 ± 0.30            | 5.74 ± 0.50            | 8.29 ± 2.96         | 0.000**|
| 2h-PFG (mmol/L)| 5.92 ± 1.14            | 7.36 ± 1.75            | 14.77 ± 5.53        | 0.000**|
| HbA1c (%)      | 5.37 ± 0.23            | 5.82 ± 0.31            | 7.39 ± 1.83         | 0.000**|
| FT3 (pmol/L)   | 4.92 ± 0.77            | 4.99 ± 1.43            | 4.93 ± 1.15         | 0.005**|
| FT4 (pmol/L)   | 16.39 ± 2.39           | 16.63 ± 3.14           | 16.92 ± 2.95        | 0.000**|
| TSH (mIU/L)    | 2.80 ± 3.11            | 2.86 ± 3.59            | 2.83 ± 3.92         | 0.599|
| TG (mmol/L)    | 1.22 ± 1.01            | 1.39 ± 1.02            | 1.26 ± 1.19         | 0.000**|
| CHOL (mmol/L)  | 4.79 ± 1.02            | 5.10 ± 1.12            | 5.34 ± 1.25         | 0.000**|
| HDL (mmol/L)   | 1.46 ± 0.35            | 1.45 ± 0.36            | 1.38 ± 0.35         | 0.000**|
| LDL (mmol/L)   | 2.76 ± 0.80            | 3.02 ± 0.88            | 3.19 ± 0.96         | 0.000**|
| Crea (µmol/L)  | 64.01 ± 24.92          | 65.23 ± 18.68          | 68.40 ± 15.64       | 0.000**|
| Bili (µmol/L)  | 24.41 ± 3.83           | 25.13 ± 3.65           | 25.84 ± 3.75        | 0.000**|
| TR (µmol/L)    | 0.90 ± 0.12            | 0.91 ± 0.26            | 0.92 ± 0.17         | 0.000**|
| SBP (mmHg)     | 135.25 ± 21.59         | 140.43 ± 22.17         | 146.21 ± 23.21      | 0.000**|
| DBP (mmHg)     | 80.07 ± 12.29          | 82.22 ± 12.75          | 83.18 ± 12.63       | 0.000**|
| PR (c.p.m)     | 76.13 ± 11.70          | 78.58 ± 15.48          | 83.00 ± 14.15       | 0.000**|

Note: Data are presented as mean values ± SD and n (%).

BMI, body mass index; CCVD, cardio-cerebrovascular disease; CHOL, cholesterol; DBP, diastolic blood pressure; DM, diabetes mellitus; FBG, fasting blood glucose; HDL, high-density lipoprotein; 2h-PPG, 2-h postprandial glucose; LDL, low-density lipoprotein; FT3, free T3; FT4, free T4; HbA1c, glycated hemoglobin; PR, pulse rate; Pre-DM, prediabetes mellitus; SCH, subclinical hypothyroidism; TD, thyroid disorders; TG, triglyceride; TSH, thyroid-stimulating hormone; WHR, waist–hip ratio.

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**Prevalence and effects of thyroid disorders in study population**

The prevalence and effects of thyroid disorders in the study population were first investigated. Our results showed that the total prevalence of thyroid disorders in the study population was 13.52% (n = 1459). Moreover, compared with the group of subjects with normal glucose blood status (8.11%), thyroid disorders were more common in the diabetic patients (15.97%) and the prediabetic patients (13.48%) (both P < 0.01).

Among the diabetic patients, those with thyroid disorders were significantly older than those without thyroid disorders (58.55 ± 8.71 vs. 57.44 ± 8.51 years; P < 0.05). Moreover, 73.27% of the diabetic patients with thyroid disorders were females, whereas in those with only diabetic patients, females accounted for 54.37% (P < 0.01). Furthermore, patients with thyroid disorders obtained significantly higher HbA1c compared to those without thyroid disorders (7.71 ± 1.76% vs. 7.36 ± 1.77%; P < 0.001). In addition, diabetic patients without thyroid disorders had higher serum creatine levels compared to those with thyroid disorders (67.44 ± 12.00 vs. 65.40 ± 11.33; P < 0.001) (Table 2). There were no differences in BMI (25.13 ± 3.67 and 25.16 ± 3.56; P = 0.842) and WHR (0.91 ± 0.26; P = 0.116).

On the other hand, among prediabetic patients with or without thyroid disorders, similar differences were observed in age (55.68 ± 8.39 vs. 55.04 ± 8.71 years; P < 0.05), female proportion (76.99% vs. 57.05%; P < 0.01), HbA1c (5.87 ± 0.30% vs. 5.82 ± 0.31%; P < 0.001), and serum creatine level (63.61 ± 11.06 vs. 65.52 ± 19.73; P < 0.001) (Table 3). There were no difference in BMI (28.23 ± 104.2 and 26.27 ± 5.89) (P < 0.347) and WHR (0.92 ± 0.19 and 0.91 ± 0.06) (P < 0.236). Taken together, these results suggest that thyroid disorders...
could be associated with glucose disorders, and more females with diabetes have thyroid disorders.

Prevalence of CCVD

Next we investigated the prevalence of CCVD in these patients. Our results showed that there was significant difference in the prevalence of CCVD between diabetic patients with thyroid disorder and those with diabetes only (34.12 vs. 26.50%; \( P < 0.05 \)). But there was no difference in the prevalence of CCVD between the prediabetic patients with thyroid disorders and those without thyroid disorders (16.60 vs. 15.86%; \( P = 0.564 \)). Furthermore, the prevalence of CCVD was significantly higher in the diabetic patients with thyroid disorders than in the prediabetic patients with thyroid disorders (34.12 vs. 16.60%; \( P < 0.01 \)). These results suggest that the prevalence of CCVD is different in people with or without thyroid disorders, regardless of the state of glucose metabolism.
Risk factors of thyroid disorders among study groups

To analyze the risk factors of thyroid disorders among the study groups, we performed multiple logistic regression analysis. Our results showed that the risk of thyroid disorders in the female diabetic patients was 2.5-fold higher than that in males. Gender represented an important risk factor for the presence of thyroid disorders in the prediabetic patients (odd risk 2.39 with 95% CI (1.97–2.91, \( P = 0.002 \)) and normal subjects (odd risk 1.9 with 95% CI (1.12–3.27, \( P = 0.018 \)). Otherwise, elder diabetic patients were more likely to suffer from thyroid disorders (odd risk 1.02 with 95% CI (1.004–1.03, \( P = 0.009 \)). Moreover, diabetic patients with lower levels of cholesterol (HDL) were more inclined to suffer from thyroid disorders (odd risk 0.56 with 95% CI (0.39–0.82, \( P = 0.002 \)). Among the prediabetic patients, significant risk factors of thyroid disorders included the age (odd risk 1.01 with 95% CI (1.003–1.02, \( P = 0.008 \)), but not the gender. On the other hand, among the normal subjects, besides the gender, the FBG and HbA1c levels had odd risks of 2.635 with 95% CI (1.18–5.9, \( P = 0.019 \)) and 4.88 with 95% CI (1.39–17, \( P = 0.013 \), respectively, for thyroid disorders. It was remarkable that the impact of female gender related to the thyroid disorders was more profound in the diabetic patients than that among prediabetic patients, not to mention that in the normal subjects (Table 4). Taken together, these results suggest that female gender and old age in diabetic patients are risk factors for the thyroid disorders.

In the present study, our results showed that the prevalence of thyroid disorders among diabetic patients was 15.97%, obviously higher than that among the prediabetic patients (13.48%) and normal glycemia subjects (8.11%). Perros et al. [7] have shown that the prevalence of thyroid disorders in the diabetic population is 13.4%. Moreover, Akbar et al. [14] have shown that the prevalence of thyroid disorders in T2DM patients is up to 16%, in the Saudi population.

The prediabetic status is characterized by different degrees of insulin resistance (IR), \( \beta \) cell function (Beta), and hepatic glucose output, as well as different levels of glucagon and incretin hormones. Moreover, the thyroid hormones are related to IR, Beta, and hepatic glucose output [15]. It has been found that the prevalence of T2DM and prediabetes is higher among subjects with hypothyroidism than among normal control subjects [16], in line with our findings. Our results showed that the prevalence of thyroid disorders was significantly higher in the prediabetic patients (13.48%) than the normal glycemia population (8.11%). These findings suggest that, not only the diabetic patients, but also the prediabetic patients should pay attention to their thyroid function.

Men and women share different thyroid dysfunction propensities [17]. Various thyroid dysfunctions are more common in females, and the overall incidence would be increased along with aging for both genders, especially for the females [18]. Our results confirmed that the females had significantly higher incidence of thyroid disorders than males, both in the diabetic and prediabetic patients, which was in line with previous studies [19–21]. Moreover, the patients with co-existing thyroid disorders were much older than those without. Similar results have been obtained previously in the USA, indicating that the female and elderly patients have certain advantages considering the prevalence of thyroid diseases in the diabetic population [22]. Furthermore, our results showed that females suffered from more increased risks of developing thyroid disorders than males, and the effects in the diabetic patients were much more conspicuous than in the prediabetic patients, not to mention the normal glycemia subjects. This may be due to the estrogen’s protective effects on hyperglycemia, which are overwhelmed by the female tendency toward development of thyroid dysfunction [17]. However, the impacts of gender have rarely been compared among different glycemic groups in these previous researches.

Our results showed that, in both patients with diabetes or prediabetes, the HbA1c (presenting the control of blood glucose in the recent three months) was much higher in patients with thyroid disorders than in those without. The explanation might be that the thyroid hormones had pleiotropic effects on glucose metabolism and interfered with the diabetes management [23]. The thyroid gland, as a component of the endocrinial system in human beings, can be affected by the sustained hyperglycemia and the continuous endeavours, to cure the carbohydrate imbalance [24].

### Table 4. Risk factors for thyroid disorders.

| Risk factors | OR value | 95% CI  | \( P \) |
|-------------|----------|---------|--------|
| Gender      |          |         |        |
| DM group    |          |         |        |
| Age         | 1.016    | 1.004– 1.028 | 0.009** |
| HDL         | 0.562    | 0.388– 0.815 | 0.002** |
| Pre-DM group|          |         |        |
| Gender      | 2.394    | 1.968– 2.914 | 0.000** |
| Age         | 1.013    | 1.003– 1.024 | 0.008** |
| Normal group|          |         |        |
| Gender      | 1.911    | 1.117– 3.271 | 0.018*  |
| FBG         | 2.635    | 1.176– 5.904 | 0.019*  |
| 2 h-PPG     | 0.799    | 0.660– 0.967 | 0.021*  |
| HbA1c       | 4.881    | 1.394– 17.086 | 0.013*  |

\( P < 0.05, ^* P < 0.01 \) (analyzed by the multiple logistic regression test). DM, diabetes mellitus; FPG, fasting blood glucose; HDL, high-density lipoprotein; 2 h-PPG, 2-h postprandial glucose; Pre-DM, prediabetes mellitus.
In the present study, our results showed that the prevalence of CCVD was much higher among patients with thyroid disorders than in those without, which was more common in the diabetic patients than in the prediabetic subjects. These findings suggest that the abnormal thyroid hormone status can influence the function of cardio-cerebral vessels, especially in the hyperglycemia status. A previous cross-sectional study has shown that the thyroid hormone abnormalities are associated with the inflammatory activity and the CVE in the T2DM patients [20], which could be an explanation for our findings. It has also been shown that there is a positive correlation between the CHD risk and HbA1c and TSH in Ghana [25]. It is considerable to screen for thyroid disease in patients with T2DM while there are also gaps in guidance regarding screening patients with T2DM for thyroid dysfunction [26].

The prevalence of diabetes in the present study (27.57%) was more than 2 folds compared with the cross-sectional survey concerning a national representative sample of 98,658 Chinese adults in 2010 (11.6%) [27]. In recent years, the diabetes prevalence in China has been increasing with the rapid economic development and changing lifestyle, especially in the area where people have lower education levels and socio-economic development [28]. The total prevalence of thyroid diseases was 13.52% in our study, while the prevalence in males in the previous survey was 6.6% (only concerning the males) [18]. Another responsible factor for the high prevalence of thyroid disorders in our study population might be associated with lower education levels and socio-economic development [28]. The total prevalence of thyroid diseases was 13.52% in our study, while the prevalence in males in the previous survey was 6.6% (only concerning the males) [18]. Another responsible factor for the high prevalence of thyroid disorders in our study population might be associated with the improvement of testing technology on thyroid hormones, which would result in calculating higher disease prevalence, and excessive iodine intake [29].

There are some limitations about this study. First, this was a cross-sectional study, so the cause and effect relationship cannot be discerned. Further prospective studies should be carried out to address the causality issue. Second, the thyroid function was assessed only once, which may have included some transient thyroid disorders and subjects with non-thyroid illnesses.

Conclusions

In this study, our results showed that the routine screening for thyroid function should be performed not only among diabetic, but also among non-diabetic subjects with high levels of blood glucose, especially for the elderly females. Diabetic and prediabetic patients with thyroid disorders were prone to suffer from CCVD than those without thyroid disorders, especially for the diabetic patients. However, due to the limited data from the single centre, it cannot adequately represent the entire population. Therefore, larger epidemiological studies are still needed to investigate the prevalence of thyroid diseases.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

[1] Yang W, Lu J, Weng J, et al. Prevalence of diabetes among men and women in China. N Eng J Med. 2010;362:1090–1096. author reply 2426.
[2] Gu D, Reynolds K, Duan X, et al. Prevalence of diabetes and impaired fasting glucose in the Chinese adult population: International Collaborative Study of Cardiovascular Disease in Asia (Interasia). Diabetologia. 2003;46:1190–1198.
[3] King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: prevalence, numerical estimates, and projections. Diabetes Care. 1998;21:1414–1431.
[4] Hage M, Zantout MS, Azar ST. Thyroid disorders and diabetes mellitus. J Thyrr Res. 2011;2011:1.
[5] Wang C. The relationship between type 2 diabetes mellitus and related thyroid diseases. J Diabetes Res. 2013;2013:1:390534.
[6] Brenna G, Danzi S, Klein I. Potential therapeutic applications of thyroid hormone analogs. Nat Rev Endocrinol. 2007;3:632–640.
[7] Perros P, McCrimmon RJ, Shaw G, et al. Frequency of thyroid dysfunction in diabetic patients: value of annual screening. Diabetic Med. 1995;12:622–627.
[8] Celani MF, Bonati ME, Stucci N. Prevalence of abnormal thyrotropin concentrations measured by a sensitive assay in patients with type 2 diabetes mellitus. Diabetes Res (Edinburgh, Scotland). 1994;27:15–25.
[9] Sotak S, Felsoci M, Lazurowa I. Type 2 diabetes mellitus and thyroid disease: a two-sided analysis. Medicine. 2018;119:361–365.
[10] Kristensen SL, Preiss D, Jhund PS, et al. Risk related to pre-diabetes mellitus and diabetes mellitus in heart failure with reduced ejection fraction: insights from prospective comparison of ARNI with ACEI to determine impact on global mortality and morbidity in heart failure trial. Cir Heart Fail. 2016;9:pii: e002560.
[11] Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. JAMA. 2013;310:948–959.
[12] Ning G. Risk Evaluation of cancers in Chinese diabetic individuals: a longitudinal (REACTION) study. J Diabetes. 2012;4:172–3. 3:0407.2012.00182.x.
[13] Standards of medical care in diabetes–2010. Diabetes Care. 2010;33 Suppl 1:S11–S61.
[14] Akbar DH, Ahmed MM, Al-Mughales J. Thyroid dysfunction and thyroid autoimmunity in Saudi type 2 diabetics. Acta Diabetol. 2006;43:14–18.
[15] Basu R, Barosa C, Jones J, et al. Pathogenesis of pre-diabetes: role of the liver in isolated fasting hyperglycemia and combined fasting and postprandial hyperglycemia. J Clin Endocrinol Metab. 2013;98:E409–E17.
[16] Ashrafuzzaman SM, Taib AN, Rahman R, et al. Prevalence of diabetes among hypothyroid subjects. Mymensingh Med J. 2012;21:129–132.
[17] Meng Z, Liu M, Zhang Q, et al. Gender and age impacts on the association between thyroid function and metabolic syndrome in Chinese. Medicine (Baltimore). 2015;94:e2193.
[18] Cooper DS, Biondi B. Subclinical thyroid disease. Lancet. 2012;379:1142–1154.
[19] Moura Neto A, Parisi MC, Tambascia MA, et al. Relationship of thyroid hormone levels and cardiovascular events in patients with type 2 diabetes. Endocrine. 2014;45:84–91.
[20] Diez JJ, Iglesias P. Subclinical hyperthyroidism in patients with type 2 diabetes. Endocrine. 2012;42:157–163.
[21] Severinski S, Banac S, Severinski NS, et al. Epidemiology and clinical characteristics of thyroid dysfunction in children and adolescents with type 1 diabetes. Coll Antropol. 2009;33:273–279.
[22] Gray RS, Irvine WJ, Clarke BF. Screening for thyroid dysfunction in diabetics. Br Med J. 1979;2:1439.
[23] Kadiyala R, Peter R, Okosimne OE. Thyroid dysfunction in patients with diabetes: clinical implications and screening strategies. Int J Clin Pract. 2010;64:1130–1139.
[24] Al-Geffari M, Ahmad NA, Al-Sharqawi AH, et al. Risk factors for thyroid dysfunction among type 2 diabetic patients in a highly diabetes mellitus prevalent society. Int J Endocrinol. 2013;2013:1–6.
[25] Sarfo-Kantanka O, Sarfo FS, Ansah EO, et al. The effect of thyroid dysfunction on the cardiovascular risk of type 2 diabetes mellitus patients in Ghana. J Diabetes Res. 2018;2018:1.
[26] Ward RJ, Heald AH, Ogunmekan S, et al. Should we be screening for thyroid dysfunction in patients with type 2 diabetes mellitus? Br J Gen Pract. 2018;68:94–95.
[27] Wang T, Xu Y, Xu M, et al. Awareness, treatment and control of cardiometabolic disorders in Chinese adults with diabetes: a national representative population study. Cardiovasc Diabetol. 2015;14:28.
[28] Pan XR, Yang WY, Li GW, et al. Prevalence of diabetes and its risk factors in China, 1994. National Diabetes Prevention and Control Cooperative Group. Diabetes care. 1997;20:1664–1669.
[29] Khatiwada S, Kc R, Sah SK, et al. Thyroid dysfunction and associated risk factors among nepalese diabetes mellitus patients. Int J Endocrinol. 2015;2015:1.