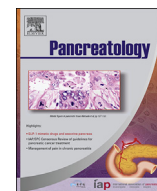




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Original article

The correlation between pancreatic steatosis and metabolic syndrome in a Chinese population

Jie Zhou ^a, Ming-Long Li ^{a,*}, Dan-Dan Zhang ^a, Hai-Yan Lin ^b, Xiao-Hua Dai ^c, Xiang-Lan Sun ^a, Jian-Ting Li ^d, Li-Yuan Song ^a, Hui Peng ^b, Meng-Meng Wen ^b^a Department of Endocrinology, Shandong Provincial Hospital Affiliated to Shandong University, Jinan, China^b Physical Examination Center, Shandong Provincial Hospital Affiliated to Shandong University, Jinan, China^c Department of Radiology, Shandong Provincial Hospital Affiliated to Shandong University, Jinan, China^d Department of Endocrinology, Jinan Central Hospital Affiliated to Shandong University, Jinan, China

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ABSTRACT

Background: Type 2 diabetes mellitus, obesity and hepatic steatosis showed a strong correlation with metabolic syndrome. However, data on the influence of pancreatic steatosis on metabolic syndrome are lacking.

Objective: Our aim is to perform the prevalence of pancreatic steatosis in adults and its association with metabolic syndrome in a Chinese population.

Methods: This was a cross-sectional study, randomly selected. A total of 1190 health examination subjects were recruited. Pancreatic steatosis or hepatic steatosis was diagnosed via trans-abdominal sonography. The clinical and metabolic parameters were compared between the two groups, and their associations with pancreatic steatosis were examined.

Results: The prevalence of pancreatic steatosis was 30.7%. The presence of pancreatic steatosis was significantly increased by age, gender, central obesity, hepatic steatosis, hypertriglyceridemia and hyperglycemia. In the logistic regression analysis, age ($P < 0.05$), central obesity ($P < 0.01$), diabetes ($P < 0.05$), hypertriglyceridemia ($P < 0.05$) and hepatic steatosis ($P < 0.01$) were independently associated with pancreatic steatosis. The number of the parameters of the metabolic syndrome in pancreatic steatosis group was more than that in non-pancreatic steatosis group [(2.5 ± 1.1) vs (1.4 ± 1.2)] ($P < 0.01$).

Conclusion: The pancreatic steatosis is strongly associated with the parameters of metabolic syndrome, such as central obesity, diabetes, and hepatic steatosis.

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Introduction

Obesity is associated with the metabolic syndrome, which consists of low plasma high density lipoprotein cholesterol levels, hypertriglyceridemia, hypertension, impaired glucose regulation and abdominal obesity [1]. And obesity also causes fat infiltration of organs such as the striated muscle, heart, liver, and pancreas [2]. Accumulation of lipids in tissues other than subcutaneous adipose tissue, such as in the visceral adipose tissue, skeletal muscle is linked to insulin resistance, which is central to the pathophysiology of type 2 diabetes [3–5].

Most of the previous work in the area of ectopic fat has focused on muscle and liver, but the studies about pancreatic fat deposition

is relatively rare. And the clinical consequences of pancreatic steatosis remain unclear. Pancreatic steatosis was easily detectable by using modern imaging techniques, such as ultrasonography, endoscopic ultrasonography, computed tomography and magnetic resonance imaging. Therefore, the aim of our study was to investigate the prevalence characteristic and the trend of pancreatic steatosis in adults and its association with metabolic syndrome in a Chinese population.

Methods

Patients

This is a cross-sectional research. All the examinees who received a health checkup at the Health Examination Center of Shandong Provincial Hospital affiliated to Shandong University between January 2013 and December 2013 were screened. Subjects

* Corresponding author. Tel.: +86 15168887159.

E-mail address: liminglong@medmail.com.cn (M.-L. Li).

with the following conditions or diseases were excluded: 1) an age of <18 or ≥80 years; 2) serum creatinine >1.5 mg/dL; 3) alcohol consumption ≥20 g/d in the past year; 4) patients with liver or pancreas disease; 5) history or current use of glucocorticosteroids, insulin; 6) any acute or chronic inflammatory diseases; 7) advanced malignant diseases. This study was approved by the local ethics committee. The written informed consent and assent were received from all examinees.

Clinical and biochemical parameters

Body weight and height were measured while the subjects were barefoot and wearing light indoor clothes, and the body mass index (BMI) was calculated. Waist circumference (WC) was measured to the nearest 0.1 cm at the narrowest point between the lower limit of the ribcage and the iliac crest. Obesity was defined as BMI ≥25 kg/m² according to the Asia-specific BMI cut-off values from the World Health Organization report [6,7]. Central obesity was defined as WC ≥ 90 cm in men and ≥80 cm in women.

The subjects were divided into different groups on the basis of the lifestyles. According to cigarette smoking, they were divided into non-smokers (never smoking), ever smokers (at least 12 packs per year, lasting for half a year). According to the eating habits, they were divided into three groups: often vegetarian, combination of vegetarian and meat, and often meat. Habitual physical exercise was categorized as regular physical exercise (vigorous exercise at least three times per week) and no regular physical exercise.

After an overnight 12-h fast, all subjects received a blood test, including complete blood count. Liver function, renal function, amylase concentration, fasting blood glucose (FBG), concentration, total cholesterol (TC), triglyceride (TG) concentration, high density lipoprotein cholesterol (HDL-C), and low density lipoprotein cholesterol (LDL-C) were measured by Automatic Biochemical Analyzer AU5800 Beckman. Insulin concentration was measured using a chemiluminescent immunoassay (Roche 8000, Cobas 602).

Abdomen sonography and diagnostic criteria of pancreatic steatosis

Liver and pancreas sonography was performed simultaneously by a single experienced ultrasound expert with high resolution ultrasonography (TOSHIBA Aplio Artida TA700) using a 3.5 MHz linear transducer. Both pancreatic steatosis and hepatic steatosis were diagnosed by hepatologists who were blind to all the subjects' medical information. According to the guidelines which the Chinese Society of Hepatology published for the diagnosis and treatment of fatty liver, the diagnosis criteria of fatty liver are as follows: bright liver, characteristic echo patterns of hepatorenal echo contrast, vascular blurring, and deep (posterior beam) attenuation [8]. On sonography, pancreatic steatosis usually appears as a hyperechoic, homogeneous, edge blurring, plump in shape [9]. Pancreatic steatosis was diagnosed when there was an increase in echogenicity of the pancreatic body over that of the kidney. As the pancreas could not be compared directly with the kidney in the same window, the examiner compared the difference between hepatic and renal echogenicity, and then obtained an objective pancreato-renal echo contrast [10]. Using this method, all subjects were classified into either pancreatic steatosis or non-pancreatic steatosis groups.

Definition of metabolic syndrome

Metabolic syndrome was confirmed according to the Chinese Diabetes Society (CDS) criteria when a subject had three or more of the following five components [11]: 1) obesity: BMI ≥ 25 kg/m²; 2) fasting blood glucose ≥6.1 mmol/L or receiving antidiabetic

medication; 3) triglycerides ≥1.7 mmol/L; 4) HDL cholesterol <1.04 mmol/L; and 5) BP ≥130/85 mmHg or receiving antihypertensive medication. We also analyzed central obesity, defined as waist circumference >90 cm in men or >80 cm in women according to the American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement (AHA/NHLBI) [12]. Diabetes was defined according to the American Diabetes Association's recommendation. Prediabetes was defined as fasting plasma glucose ≥5.5 mmol/L but <7 mmol/L [13].

Evaluation of insulin resistance

The measure of insulin resistance was obtained using the HOMA-IR (homeostasis model assessment insulin resistance). The value for insulin resistance can be assessed by the formula: HOMA-IR = (fasting serum glucose (mmol/L) × fasting serum insulin (mIU/L)/22.5) and the β-cell function (HOMA-β) was calculated $20 \times \text{fasting serum insulin (mIU/L)} / (\text{fasting serum glucose (mmol/L)} - 3.5)$ [14].

Statistical analysis

All analyses were performed using SPSS software, version 21.0 (SPSS, Inc., Chicago, IL, USA). All normally distributed continuous variables were expressed as means ± SD. If the distribution was not normal, the continuous variables among the groups were compared using ANOVA. Differences between the pancreatic steatosis and non-pancreatic steatosis group were determined using the Student's *t* test. Multinomial logistic regression was used to evaluate independent risk factors of pancreatic steatosis. Chi square test was used to calculate the relationship between pancreatic steatosis and metabolic syndrome. A value of *p* < 0.05 was considered statistically significant.

Results

Baseline characteristics of the patients

A total of 1190 participants (600 female and 590 male) were studied in our project. And the mean age of them was 49.0 ± 14.1 years. Table 1 shows the situation of drugs used in all subjects.

The characteristics of subjects were shown in Table 2. Comparison with the control group, the pancreatic steatosis was significantly associated with the higher levels of metabolism index (*P* < 0.05). The prevalence of pancreatic steatosis was increased significantly by age, male, WC, BMI, blood pressure, hepatic steatosis, total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol and fasting plasma glucose, fasting serum insulin, HOMA-IR, HOMA-B, alanine transaminase (ALT), and aspartate transaminase (AST). There were also significant differences in the life style, such as smoking, eating habits, while no obvious difference was found in terms of physical exercise between the two groups.

The multivariate logistic regression analysis of factors for pancreatic steatosis

To investigate the effects of clinical variables on the risk of pancreatic steatosis, we performed logistic regression analysis (Table 3). Pancreatic steatosis as the variable, the logistic regression analysis was conducted on the factors of gender, age, abdominal obesity, prediabetes or diabetes, hepatic steatosis, hypertriglyceridemia and hypercholesterolemia. Finally, we found that age (*P* < 0.05), abdominal obesity (*P* < 0.01), prediabetes or diabetes (*P* < 0.05), hepatic steatosis (*P* < 0.01), and hypertriglyceridemia (*P* < 0.05) were statistically associated with pancreatic steatosis,

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