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Prevalence and related risk factors of hypertension and normal-high blood pressure in patients with type 2 diabetes mellitus admitted to hospital: a cross sectional study

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Abstract: **With the increase of China's population and economic development, diabetes (DM) has become a serious public health problem, the complications of DM are also serious. Among them, patients with DM complicated with hypertension have to face the double risk of infection and cardiovascular disease. Not only the cost of medical care has increased, but also the quality of life has declined. The purpose of this study was to compare the differences in lifestyle and body characteristics between patients with DM complicated with hypertension, DM with normal-high blood pressure and patients with DM without normal-high blood pressure, and to provide clues for the inference of risk factors related to DM complicated with hypertension. A cross-sectional study was conducted T2DM patients hospitalized in a hospital from January 2017 to December 2017. One-way ANOVA and chi-square test were used to judge the difference between the two groups. A total of 79 patients with simple DM, 92 patients with normal-high blood pressure and 138 patients with DM complicated with hypertension were enrolled in our study. We found differences in age, neutrophil count, lymphocyte ratio, uric acid (UA), creatinine (CRE), total protein (TP), glycosylated hemoglobin (HbA1c), body mass index (BMI), course of disease and self-control between the two groups. We found that the age, body mass index (BMI) and inflammatory response in diabetic patients with hypertension were significantly higher than those in patients with simple DM and DM with normal-high blood pressure. However, the self-control of patients with hypertension is better than that other groups. Therefore, with the prolongation of illness time, patients need to control the occurrence of complications through self-control and weight loss.**

Keywords: Type II diabetes mellitus; Hypertension; Body mass index; Inflammation; Normal-high blood pressure

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1. Introduction

The term "diabetes" was first coined by Apollo News of Memphis more than 2200 years ago, although the description of the characteristics of the disease has been around as early as 1500 BC[1]. DM is a growing global problem, as the Global Diabetes report says, DM, a disease no longer associated with affluence, is on the rise around the world. In 2017, the number of people with DM worldwide is as high as 424.9 million, and about 4 million people died of DM (20-79 years old). Only in the course of the year, global spending on adult diabetes care amounted to $723.4 billion. It is expected that by 2045, the number of people with diabetes worldwide will reach 626.8 million, or about 9.9 per cent of the total population[2].

Type 1 DM, as an autoimmune disease, is caused by the body attacking its own pancreatic β cells, resulting in inadequate insulin secretion, and type 2 DM is mainly related to insulin resistance. Type 2 DM is the most common type of diabetes, accounting for about 90% of all cases of diabetes[3-5]. Type 2 DM is slow to develop and usually does not show acute metabolic disorders, so it may take a long time to detect, and as many as 1/3 to 1/2 of cases of type 2 DM in the population may not have been diagnosed[2].

With the aging of China's population, the risk of hypertension and other cardiovascular diseases is also significantly increasing[6]. Studies have shown that people with DM are more likely to develop hypertension and that people with hypertension have an increased risk of type 2 DM[7]. The incidence of cardiovascular complications, coronary heart disease, peripheral arterial disease and stroke in DM with hypertension was 2 to 4 times higher than that in patients with simple hypertension[8, 9]. Clinical evidence shows that DM and hypertension are independent risk factors of cardiovascular disease respectively, and when the two are combined, they can promote the occurrence of vascular complications, resulting in a significant increase in the incidence and mortality of cardiovascular and cerebrovascular diseases[10]. Normal high blood pressure is the transition stage between normal blood pressure and hypertension. At present, some studies have found that the incidence and mortality of cardiovascular disease will increase significantly in patients with n normal-high blood pressure complicated with diabetes[11]. Some scholars believe that the risk of cardiovascular disease in patients with normal-high blood pressure complicated with diabetes is equivalent to the risk of primary hypertension in non-diabetic patients[12]. According to the data of the China Hypertension

Prevention and treatment guidelines revision Committee, the cardiovascular risk of people with systolic blood pressure (120-139 mm Hg) or diastolic blood pressure (80-89 mm Hg) was more than double that of people with blood pressure level of 110/75 mmHg after 10 years. In the middle-aged population with blood pressure 120 / 129 / 80-84 mm Hg and 130 / 85-89 mm Hg, 45 percent and 64 per cent of patients developed hypertension 10 years later, respectively[13]. Because of this, the prevention and control of type 2 DM complicated with hypertension is extremely prominent. In order to find out the related risk factors of DM complicated with hypertension, a cross-sectional survey was carried out by collecting the relevant information of inpatients with type 2 DM in a city hospital.

2. Methods

2.1. Study Population

A total of 309 patients between the ages of 18 and 80 who were hospitalized and clinically treated in the Municipal people's Hospital from January 2017 to December 2017 were included in the study.

2.2. Detection of indices

T2DM was diagnosed by World Health Organization criteria based on the fasting plasma glucose (FPG) level. Participants fasted for 8-10 hours before the blood test. Patients with hypertension were determined according to the Chinese guidelines for the Prevention and treatment of Hypertension: in the absence of antihypertensive drugs, blood pressure was measured three times on different days, systolic blood pressure (SBP) ≥ 140 mm Hg and / or diastolic blood pressure (DBP) ≥ 90 mm Hg. And the patient had a history of hypertension, antihypertensive drugs are currently being used, and although blood pressure is below 140 / 90 mm Hg, it should still be diagnosed as hypertension. The blood pressure level of SBP is 120 – 139 mm Hg or DBP is 80 – 89 mm Hg was set as normal high blood pressure[13].

Basic information and anthropometric measures of all patients were collected, such as gender, age, educational level, household registration type, height, weight, waist circumference and hip circumference. The formula for calculating BMI (kg / m2) is: BMI = weight (kg) / height (m)2. We used the revised BMI criteria for the Chinese population to evaluate: BMI < 18.5 as underweight, 18.5 - 23.9 as normal weight, 24.0 - 27.9 as overweight, ≥ 28.0 as obese[14].

Determination of blood biochemical indexes including uric acid (UA), creatinine (CRE), urea (Ur), triglyceride (TG), total cholesterol (TCHO) by automatic biochemical analyzer.

2.3. Statistical analysis

We use SPSS 17.0 for statistical analysis. The characteristics of T2DM complicated with hypertension (DM + H), T2DM complicated with normal-high blood pressure (DM + N), simple T2DM (DM) groups were compared and analyzed. The mean and standard deviation for continuous variables such as age, DM duration, BMI and UA value, and proportions for categorical variables such as the prevalence of hypertension, the percentage of sex, age group, educational level and household registration type, are reported. A chi-square test was used to test categorical variables and one-way ANOVA was used to compare continuous variables. P value less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of basic information

A total of 309 T2DM patients were included in our study (18-80 years of age), among whom 79 is simple T2DM, 92 patients were T2DM patients with normal-high blood pressure and 138 had coexisting hypertension. A comparison of the basic information between the three groups is shown in Table 1. The mean age was 56.59 years for all simple DM patients, and the higher mean age in the DM + H group ($p < 0.05$). In the simple DM group, 51.90% were male, the DM + N group were 56.52% and the DM + H group were 51.52% ($p > 0.05$). We grouped the educational level according to high school or higher, primary or middle school and illiteracy, there was no statistical difference between the three groups ($p > 0.05$). According to China's national conditions, we have been grouped according to urban household registration and rural household registration ($p > 0.05$). In addition, we also analyzed the marital status, and there was no statistical difference among the three groups ($p > 0.05$).

3.2. Comparison of Blood routine examination, biochemical Indexes and HbA1c

A comparison of the indicators between the three groups is shown in Table 2. Of a total of 309 people, 275 had blood routine results, including 63 (22.91%) in the simple DM group, 83 (30.18%) in the DM + N group and 129 (46.91%) in the DM + H group. And 282 people had the results of blood biochemical indexes, including 63 (22.34%) patients in simple DM group, 81 (28.72%) patients in DM + N group and 138 (48.94%) patients in DM + H group. The neutrophil count was 3.91 for DM +N patients and the value of DM + H group was 4.68 ($p < 0.05$). In addition, there were also significant differences in lymphocyte ratio between the three groups, which were 32.24 in simple DM group, 31.86 in DM + N

group and 28.95 in DM + H group, respectively ($p < 0.05$). In the blood biochemical indexes, total protein (TP), uric acid (UA) and creatinine (CRE) in the simple DM group were significantly lower than those in the DM + H group (64.49 vs 67.08, 258.55 vs 319.47 and 49.86 vs 66.86, $p < 0.05$). The UA in DM + N group was also significantly lower than that in DM+ H group (275.21 vs 319.47, $p < 0.05$). As an index of glycosylated hemoglobin (HbA1c) used to evaluate blood glucose control, we found that HbA1c in simple DM and DM + N patients was significantly lower than that in DM + H patients ($p < 0.05$).

Table 1. Baseline characteristics of DM, DM + N and DM + H participants

	DM	DM +N	DM + H	P-value
Age	53.53±12.55	55.48±11.97	59.09±9.55	0.001[b,c]
Age group				0.001
18-44	16 (20.25%)	18 (19.57%)	7 (5.07%)	
45-59	37 (46.84%)	36 (39.13%)	59 (42.75%)	
60-	26 (32.91%)	38 (41.30%)	72 (52.17%)	
Gender				0.730
Male	41 (51.90%)	52 (56.52%)	71 (51.45%)	
Household registration				0.092
Urban	17 (21.52%)	22 (23.91%)	47 (34.06%)	
Rural	54 (68.35%)	64 (69.57%)	81 (58.70%)	
Marital status				0.513
Unmarried	1 (1.27%)	0 (0%)	0 (0%)	
Unmarried	72 (91.14%)	87 (94.57%)	129 (93.48%)	
Others[a]	6 (7.59%)	5 (5.43%)	9 (6.52%)	
Degree of education				0.835
Illiterate	6 (7.59%)	5 (5.43%)	12 (8.70%)	
Primary or junior high school	48 (60.76%)	61 (66.30%)	82 (59.42%)	
High school degree or above	17 (21.52%)	20 (21.74%)	34 (24.64%)	
Occupation				0.073
Farmers	34 (43.04%)	54 (58.70%)	60 (43.48%)	
Workers	12 (15.19%)	4 (4.35%)	17 (12.32%)	
Others[d]	33 (41.77%)	34 (36.96%)	61 (44.20%)	
BMI	24.01±3.42	25.04±3.42	25.82±3.77	0.002[b]
BMI group				0.022
⩽18.4	3 (3.80%)	2 (2.17%)	2 (1.45%)	
18.5-23.9	39 (46.84%)	26 (28.26%)	43 (31.16%)	
24.0-27.9	29 (36.71%)	47 (51.09%)	60 (43.48%)	
⩾28.0	8 (10.13%)	17 (18.48%)	33 (23.91%)	
WHR	0.91±0.14	0.92±0.07	0.93±0.09	0.554

[a] Others including single or widowed or divorced people.
[d] Others including administrative cadres, scientific and technological workers, medical staff, teachers, businessmen, students, retirees and unemployed.
[b] There is a statistical difference between DM group and DM + H group.
[c] That there is a statistical difference between DM + N group and DM + H group.
The quantitative data were expressed by m±SD. Qualitative data are expressed as n (%).
The sum of the percentages of some groups did not reach 100% because of a small number of missing values.

3.3. Comparison of questionnaire Survey and anthropometric Indexes

BMI means in the DM +H group was higher than simple DM and DM + N groups ($p < 0.05$). And the number of overweight and obese patients in the DM + H group was also significantly higher than that in the other two groups. The duration of DM was significantly longer in patients with hypertension than in other two groups of patients without hypertension ($p < 0.05$).

The number of patients with hypertension in complete diet control and regular self-monitoring of blood glucose was significantly higher than that in DM and DM + N groups ($p < 0.05$). But there was no significant difference in physical exercise between the three groups.

Table 2. Comparison of risk factors between DM and DM + H group

Variables	DM	DM + N	DM + H	P-value
HbA1c	10.32±2.06	9.98±1.87	9.30±2.12	0.002[b,c]
Neutrophil count	4.26±2.08	3.91±1.59	4.68±2.50	0.044[c]
Neutrophil ratio	60.02±9.91	59.49±9.26	62.32±10.99	0.115
Lymphocyte count	2.14±0.73	2.02±0.66	1.99±0.69	0.354
Lymphocyte ratio	32.24±9.85	31.85±8.88	28.95±9.99	0.031[b,c]
Monocyte count	0.42±0.17	0.40±0.15	0.43±0.17	0.597
Monocyte ratio	6.23±2.27	6.38±1.98	6.09±2.10	0.613
RBC	4.35±0.54	4.49±0.59	5.37±10.45	0.551
HGB	131.14±17.95	135.30±20.17	131.59±18.96	0.306
TP	64.49±6.46	66.32±6.67	67.08±7.28	0.048[b]
UA	258.55±70.92	275.21±81.51	319.47±94.46	<0.001[b,c]
CRE	49.86±12.07	58.41±42.87	66.86±29.18	0.002[b]
CHO	4.65±1.14	4.51±1.01	4.89±1.49	0.116
TG	1.53±1.03	1.80±1.59	2.01±1.44	0.115
high-density lipoprotein	1.17±0.40	1.10±0.28	1.15±0.33	0.448
Low-density lipoprotein	2.89±0.91	2.70±0.89	2.93±1.22	0.329
Diabetes duration, y	6.15±6.40	7.27±6.78	9.63±6.95	0.001[b,c]
Diet control				0.005
Complete control	12 (15.19%)	7 (7.61%)	21 (15.22%)	
A little control.	35 (44.30%)	45 (48.91%)	83 (60.14%)	
No control	24 (30.38%)	35 (38.04%)	24 (17.39%)	
Physical exercise				0.937
No	30 (37.97%)	32 (34.78%)	48 (34.78%)	
Yes	40 (50.63%)	48 (52.17%)	67 (48.55%)	
Blood glucose monitoring				0.031
Regular	12 (15.19%)	21 (22.83%)	35 (25.36%)	
Irregular	35 (44.30%)	35 (38.04%)	62 (44.93%)	
Never	23 (29.11%)	24 (26.09%)	18 (13.04%)	

[b] indicates that there is a statistical difference between DM group and DM + H group.
[c] indicates that there is a statistical difference between DM + N group and DM + H group.
The quantitative data were expressed by m±SD. Qualitative data are expressed as n (%).
The sum of the percentages of some groups did not reach 100% because of a small number of missing values.

4. Discussion

In this cross-sectional study of Chinese adults (18 - 80 years of age), we showed that there were significant differences in age, BMI, neutrophil count, lymphocyte ratio, TP, UA, CRE and some living habits between patients with simple DM, DM with normal-high blood pressure and patients with DM complicated with hypertension.

We found that there were significant differences in age between the three groups. The average age of patients with hypertension was significantly older than that of the other two groups. And there were still significant differences in young, middle-aged and elderly people of different ages. The number of elderly people with hypertension was also significantly higher than that of the other two groups. The possible reason for this is that as you get older, the prevalence of hypertension increases, a phenomenon that has been found in many studies[15-17]. And it is worth mentioning that in a Russian study, it was found that, on average, the biological age of hypertensive men was 17.6 years older than the passport age, and that of women was 13.4 years older than the passport age[18].

In terms of duration of illness, we found that the duration of illness in the combined group was significantly longer than that in the simple DM and DM + N group. And we used autonomous blood glucose monitoring and diet control to evaluate the health attitude of the patients. The proportion of patients with DM complicated with hypertension who had regular autonomous blood glucose monitoring and good diet control was significantly

higher than that in simple DM and DM + N groups ($P < 0.05$, $P < 0.05$). And in the number of physical examinations less than once a year, never carried out blood glucose monitoring and no control of diet at all, the number of people in the simple DM and DM + N groups was significantly higher than that in the combined group. Group without hypertension does not pay as much attention to its own health status as the combined group, which may be due to the longer and longer course of disease in the combined group, which leads to more and more serious complications or increase the probability of recurrence of certain diseases[19-25]. Because of this, more serious patients will be more concerned about their own health. This conclusion also explains why the HbA1c of DM with hypertension group is slightly lower than that of DM and DM + N groups, and it is statistically significant. This may be due to the importance attached to the disease in the DM + H group and its better self-control than that without hypertension group. However, this cannot be ruled out as a result of stronger clinical treatment in the DM + H group.

BMI is an indicator derived from weight divided by the square of height, which is widely used in the field of public health to assess the health status of the human body. At present, BMI has been used as a related factor in the early prediction of hypertension. In a historical cohort study from Japan, 636 subjects were divided into six groups, ranging from low to high, and followed up for 27 years (17059 person-years) to compare the incidence of hypertension during that period. The results showed that there was not only a significant difference in the prevalence of hypertension among the six groups ($p < 0.001$), but also a step-by-step increase in the risk ratio ($p < 0.001$). And after adjusting the living habits such as smoking and exercise, there are still similar conclusions[26]. In another study of children, it was found that the average blood pressure of people who were overweight in childhood and whose BMI was normal during adolescence was similar to that of those who had normal BMI during both periods. In contrast, people who were overweight in both periods or had a normal BMI in childhood but were overweight in adolescence had higher blood pressure during adolescence than those with normal BMI in both periods[27]. In the same four-year cohort study of children over the age of 6 and 8, overweight and obese school-age children also showed an alarming incidence of hypertension compared with normal-weight groups[28].

In our study, the BMI of DM patients with hypertension was significantly higher than that of patients with simple DM patients. A similar conclusion appears in a study of Bangladeshis. The study found that the prevalence of hypertension (1.55-1.77) and type 2 diabetes (1.54-1.93) in people with higher BMI (23.0-24.9) was higher than that in patients with normal BMI (18.5-22.9)[29]. In addition, in a multistage stratified sampling study of 3072 Uygur and 3195 Han adults in China, anthropometry and biochemical tests, it was found that both Uygur and Han people, high BMI value will lead to an increase in the prevalence of hypertension[30]. Which confirms our findings. Therefore, BMI can be regarded as an important factor affecting the development of hypertension in patients with diabetes.

However, this index still has some limitations, it cannot accurately distinguish between lean body mass and body fat, so it is not perfect to evaluate the body structure and muscle ratio between people who are already different, such as previous studies have found that Asians have higher levels of body fat and visceral tissue than African-Americans and Caucasians with similar body mass indexes[31-33]. Another obesity criterion, waist-hip ratio, was also introduced in this study. Some studies suggest that waist circumference and waist hip ratio (WHR) are better indicators of obesity than BMI. Some studies suggest that waist circumference and waist-hip ratio are better markers of obesity than BMI, while others suggest that BMI and WHR are also good factors for coronary heart disease[34]. But, in this study, there was no difference in WHR between the two groups.

According to the report, serum UA was positively correlated with cardiovascular risk factors such as hypertension, insulin resistance, dyslipidemia and central obesity[35, 36]. This was the same as the results in our study, which were significantly higher in the hypertension group than in the other two groups. This leads to an increase in the prevalence of cardiovascular and renal diseases[37, 38]. The effect of these risk factors on the kidney also explains why the serum CRE level in DM + H group is significantly higher than that in DM and DM + N groups.

A number of studies have shown that white neutrophil count is positively correlated with the incidence and mortality of cardiovascular diseases such as hypertension and coronary heart disease[39, 40]. At present, chronic low-grade inflammation is considered to be the mechanism of this phenomenon[41-43]. Inflammation accelerates the occurrence of hypertension by increasing the microvascular capillary resistance, platelet aggregation, and increasing the level of cathecolamine[43-47]. In our study, the significant increase in neutrophil count and lymphocyte ratio in DM patients with hypertension seemed to indicate a higher state of inflammation or infection in patients without hypertension. The positive correlation between BMI and chronic low-grade inflammation has been reported for a long time[48, 49]. Our conclusion also echoes the difference in BMI between the two groups.

The subjects of this study are inpatients with T2DM in hospital. the diagnosis of the disease is carried out by the attending doctor. the results of biochemical examination are issued by professional examiners, and the information is accurate and direct. In addition to the results of biochemical examination, we also conducted a questionnaire survey of patients in order to understand the living habits of patients and some basic information. It can compare the difference between DM patients and DM patients with hypertension in a more comprehensive way, so as to provide clues for inferring the risk factors of DM complicated with hypertension. The interpretation of the data in this study is limited by the following factors: First, this study is a single-center, cross-sectional survey, such a study cannot carry out causal inference, and there is a certain choice bias. Caution should therefore be exercised in interpreting the results. Second, the blood pressure of the subjects was measured during hospitalization, and it was not ruled out that some of the subjects might have white-coat hypertension. Third, the study included a questionnaire survey of patients, which can lead to memory bias. Finally, there is a lack of indicators such as sex hormone levels, genotypes and endothelial function in our study, and these potential confounding factors cannot be adjusted. All this needs to be supplemented by higher quality research in the future.

5. Conclusion

In summary, the cross-sectional study, which included a total of 309 people, showed that the age, BMI, HbA1c, diabetes duration and inflammation of patients with DM complicated with hypertension were significantly difference between simple DM patients and DM with normal-high blood pressure. However, the self-discipline of patients with hypertension in this study is worthy of recognition. This warns us that, with the increase in the duration of diabetes, patients need to control their weight and lifestyle to reduce the incidence of combined high blood pressure.

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