Study on Relationships Between Dietary Mineral Intakes and Blood Pressure and Blood Lipid in TB patients

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Abstract. The relationship between pulmonary tuberculosis (PTB) and diabetes mellitus (DM) has been previously attracted much attention. DM co-morbidity in PTB is associated with poor PTB treatment outcomes. The purpose of this study is to evaluate the food diversification levels, and the correlation between blood pressure, blood lipids and dietary intake of Ca, P, Mg, Fe, Zn, Cu and Mn. A total of 108 patients were eligible in the study and 36 of them were suffering from both TB and DM, 72 were TB only. Food types were detected by the investigation of dietary frequency, the intakes of minerals were assessed by using food intake survey for 3 days using a 24-h recall method. The result showed that energy and nutrients in TB patients with and without DM were significantly lower than the Recommended Nutrient Intake (RNI), formulated by the Chinese Nutrition Society. And correlation analysis showed that Zn dietary intake had a positive correlation with systolic BP and diastolic BP. And Ca, P, Mg, Fe, Zn, Cu and Mn were positively correlated with HDL cholesterol. Thus it is concluded that the dietary intake of minerals may play an important role in controlling blood pressure and lipids in TB patients.

Keywords: Diabetes, Tuberculosis, Dietary intake, Blood pressure, Blood lipids

Introduction

Tuberculosis (TB) is a global public health issue posing serious harm to the human health [1]. Developed countries reduce the morbidity and mortality of TB mainly by developing more effective anti-TB drugs and improving the social and economic conditions. In developing countries, TB is still an important threat to human health, especially those with HIV prevalence and type 2 diabetes rapidly rising area. Double burden of diseases such as TB and DM has attracted close attention [2]. Diabetes is a chronic noncommunicable depleting diseases cause serious damage to human health. The combination of TB and DM and double burden of TB and DM represent a big health threat, which make the treatment failure more frequent [4]. With the current global increase in DM largely driven by increasing prevalence in the developing world, the DM population is anticipated to reach 552million by 2030[5]. In China, where there are experiencing incredible increase in DM prevalence, an age standardized prevalence of diabetes of 9.7% (10.6% in men and 8.8% in women)and prevalence of pre-diabetes as 15.5% (16.1% in men and 14.9% in women)[3], also a high burden of TB exists.

At the same time, China accounts for nearly 17% of the world's TB burden, with an estimated 1.5 million new cases and approximately 270,000 deaths due to TB every year in China. It carried out a large Meta analysis and discovered that DM patients were 3.1 times

(95% CI 2.27–4.26) more likely to have TB than non-diabetic controls and it has been estimated that the TB risk attributable to DM was between 15% and 25% [6].

Nutrient consumption is an important character of TB people, the nutritional status of patients significantly influenced the development and prognosis of disease outcome. It also delayed healing and even made TB disease progression and deterioration. Therefore, the reasonable nutrition guidance plays an important role in the treatment and rehabilitation of TB patients. The control of blood glucose in DM patients is closely related to the daily diet, and DM patients need to implement the lifelong nutrition therapy to restrain the energy intake. Diabetes is also a consumptive disease, when TB patients have diabetes, that may aggravate metabolic disturbance. Now medical workers are facing a great difficulty that how to make the two kinds of mutual conflicts of the collocation to rationalize, so as to promote the recovery of the disease.

Dietary minerals play an important role in regulating and maintaining various physiological functions in the human body despite it is small requirement. According to the needs of the body, these minerals were divided into macrominerals and trace minerals. Researches showed that various types of mineral deficiency or excess are closely linked with prevention and management of the blood pressure and blood lipids [8].

It has been reported that the intake levels of some macrominerals such as K, Ca, and Mg have a negative correlation with blood pressure [9, 10]. In particular, Ca, which is reported to combine with fat and bile acids in the diet, and inhibit the body of absorption, so increasing Ca intake can reduce blood cholesterol, triglycerides and phospholipids [12]. P is related to the physiological function of Ca and Mg. The epidemiological studies showed that trace elements Fe, Zn and Cu were related to the incidence of coronary artery disease, and the mechanism is related to vascular cell dysfunction and inflammatory reaction [13, 14, 15]. It was reported that the deficiency of Mg causes the inhibition of glucose tolerance, carbohydrate and lipid metabolism, and degradation of serum high density lipoprotein [16, 17].

This study aims to evaluate patients dietary patterns and nutrient intake levels of TB and TB-DM. At the same time to explore the relationship between mineral intake and blood pressure and blood lipid.

Methods

Study population and design. We conducted a cross-sectional study among TB patients who received anti-TB treatments from January 2014 until March 2015 at this hospital. These were purposively selected among those who were diagnosed with TB. The diagnosis of TB was made within the TB prevention and control system in China, where clinical symptoms, sputum smear and chest x-ray were the principal component; and diagnosis of DM was based on WHO criteria for the classification of glucose tolerance based on fasting plasma glucose (FPG) [7]. All adults (⩾18 years) newly-diagnosed TB patients who registered for Directly Observed Treatment; who can able to read and write Chinese characters and have the ability to complete the questionnaire by themselves and voluntarily participating the investigation. If they were accompanied with serious physical or mental disorders or HIV, or they were unconsciousness and cannot take care of themselves in daily life, or they reluctanted to participate in this study, then we excluded them.

Data collection. Data were obtained from both the patients' medical records and questionnaires. The patients' medical records were reviewed to obtain information, such as symptom, chest x-ray, biochemical index, blood, diabetic status, and sputum-smear status. On the other hand, the questionnaire was used to obtain information regarding their marital status, occupation, ethnicity, education level, exposure to other TB cases, adherence to treatment, smoking history, alcohol intake history. Collecting the type, composition and weight of all

intake food (excluding condiments) of the survey by 24-hour dietary recall table, including three meals and snacks.

Statistical analysis. Data were analyzed using SPSS software version 18.0.and characteristics were analyzed. Independent sample t test was used to test continuous variables. The nonparametric tests were used whenever the variables were not normally distributed. The significance of the correlations among the factors was verified by Person's partial correlation coefficient. A p value of <0.05 was considered statistically significant.

Results

We selected 108 clinical patients during the period (Table 1). And in the study 36 of them were suffering from both TB and DM (TB-DM patients group), 72 of them were TB only (TB patients group). The human body measurement index and biochemical index are shown in table 1.

The comparison between the energy and nutrients intake of TB patients group and RNI (Table 2) showed that except protein daily intake reached RNI, the rest of all kinds of vitamins and minerals dietary daily intake were lower than the RNI (P<0.05). The results of Energy and Nutrients analyzed from 24h dietary recall data showed that TB-DM patients' daily protein 70.52±28.70 g, vitamin C 91.45±50.20 mg, Mg 294.04±155.12 mg were found to be no statistically significant than RNI (P>0.05). But we observed that other vitamins and minerals intake in this comparison were found to be statistically significant (P<0.05).

Table 4 shows the correlation between mineral intake, blood pressure and serum lipids. The results showed that there was a positive correlation between Zn and systolic blood pressure and diastolic blood pressure, and the seven trace elements were positively correlated with high density lipoprotein, but Ca and Cu were negatively correlated with triglyceride.

Table 1 Characteristics of the study subjects (N=108)

	TB	TB-DM	P value
N(Male/Female)	72(56/16)	36(28/8)	-
Age	48.03±10.50	50.39±9.22	0.254
BMI(kg/m^2)	15.37±10.18	16.17±11.28	0.710
CHO(mmol/L)	4.18±0.99	4.57±1.48	0.167
TG(mmol/L)	1.11±0.56	1.57±1.37	0.065
LDL(mmol/L)	2.47±1.23	2.50±1.07	0.930
HDL(mmol/L)	1.28±0.41	1.32±0.44	0.696
TP(g/L)	65.78±8.51	65.38±6.10	0.803
ALB(g/L)	39.92±5.54	39.65±8.29	0.843
UA(mmol/L)	312.79±135.76	269.80±122.31	0.117
CREA(mmol/L)	58.96±18.31	54.71±15.15	0.237
HGB(g/L)	127.06±17.22	126.89±18.95	0.963

Table 2 Energy and Nutrients Intake Level of TB and TB-DM patients

	TB	TB-DM	RNI
Energy (kcal)	1819.66±793.01[b]	1765.52±703.05[c]	2400
Protein (g)	69.91±25.94	70.52±28.70	75
Fat (g)	51.82±28.95	61.63±32.72	-
Dietary fiber[a] (g)	12.76±5.83[b]	12.05±7.43[c]	30
Carbohydrate[a] (g)	268.39±134.36	232.18±103.55	-
Retinol[a] (μg)	483.75±349.52[b]	581.86±393.97[c]	800
Thiamine (mg)	0.96±0.42[b]	1.03±0.49[c]	1.4
Riboflavin (mg)	0.90±0.31[b]	0.99±0.37[c]	1.4
Niacin[a] (mg)	14.56±7.00[b]	14.89±6.52[c]	1.4
Vitamin C[a] (mg)	99.78±45.26[b]	91.45±50.20	100
Vitamin E[a] (mg)	11.70±5.37[b]	11.05±7.06[c]	10
Potassium (mg)	1732.35±581.61[b]	1739.20±729.49	2000
Sodium[a] (mg)	1388.60±993.13[b]	946.13±519.68[c]	2200
Calcium (mg)	398.18±153.83[b]	366.32±179.74[c]	800
Magnesium[a] (mg)	322.18±139.63[b]	294.04±155.12	350
Iron[a] (mg)	23.29±12.17[b]	21.39±14.14[c]	15
Zinc (mg)	10.38±4.60[b]	10.60±5.26[c]	15.5
Copper[a] (mg)	1.64±0.72[b]	1.69±1.09[c]	2
Phosphorus (mg)	1085.89±403.71[b]	1063.46±405.86[c]	700
Selenium[a] (μg)	65.20±33.96[b]	60.50±30.94[c]	50
Manganese (mg)	5.70±2.27[b]	4.81±2.13[c]	3.5

[a] Data analysis was carried out logarithmic transformation

[b] TB compared with RNI

[c] TB-DM compared with RNI

Table 3 Correlation between mineral intake and blood pressure and blood lipid

Variables	Systolic BP	Diastolic BP	Total cholesterol	HDL cholesterol	LDL cholesterol	Triglyceride
Ca	0.111	0.088	-0.051	0.288[d]	-0.074	-0.350[e]
P	0.076	0.132	-0.034	0.311[e]	-0.089	-0.171
Mg	0.058	0.125	-0.013	0.305[e]	-0.083	-0.216
Fe	-0.055	-0.086	-0.037	0.260[d]	-0.109	-0.216
Zn	0.272[d]	0.324[e]	-0.047	0.324[e]	-0.096	-0.195
Cu	-0.770	0.038	-0.025	0.385[d]	-0.077	-0.299[e]
Mn	-0.138	-0.039	-0.022	0.292[d]	-0.091	-0.175
Cu/Zn	-0.231[d]	-0.151	0.016	0.171	-0.029	-0.256[d]

HDL cholesterol and Triglyceride analysised by Spearman's partial correlation test. Other variables analysised by Pearman's partial correlation test.

[d] $P<0.05$

[e] $P<0.01$

Discussion

Our study showed that inadequate mineral intake was associated with blood pressure and abnormal lipid metabolism and metabolism. The intake of minerals in the diet of patients is insufficient, significantly less than RNI. Zn deficiency reduces NOS activity because NOS contains Zn, and reduced NOS activity in artery walls could cause endothelial dysfunction and reduce endothelium-mediated vasodilation, and thus, contribute to the development of hypertension [23, 24]. Furthermore, many enzymes that were involved in the regulation of arterial blood pressure, such as angiotensin-converting enzyme and neutral endopeptidases, contain Zn [25, 26]. Therefore, adequate Zn intake seems to be necessary.

Cu is known to be an essential nutrient. But because the Zn and Cu have similar physical and chemical properties, the two elements have antagonistic biological effects. In this study, Cu intake had significant correlation with HDL and TG, but Mg had not. Cu is known to be an important nutrient for the normal cardiovascular functions in both humans and experimental animals. Cu deficiency, especially, was reported to incur heart disease and increase blood lipids [27]. In this study, Cu intake had significant correlation with serum lipids. Few studies on the relation between Cu and blood pressure have been conducted, it reported that Cu deficiency incurred an increase of blood pressure in rats. But this study is limited in discussing the direct correlation between Cu intake and blood pressure revealed. Thus, continued studies on this were required.

Found in the dietary survey of TB patients, mineral intake (Ca, P, Mg, Fe, Zn, Cu, Mn) was positively correlated with HDL cholesterol, including Ca, Cu were negatively correlated with TG. Changes in Ca^{2+} may be not only the result of lipid metabolism disorders, but also lead to the disorder of lipid metabolism. Mg^{2+} can compete with Ca^{2+} for binding to the Ca^{2+} channel, inhibiting the flow of Ca^{2+}[11] . The formation of atherosclerosis was the process of absorption and deposition of calcium [22]. At the same time, the relationship between Mg and lipid was becoming more important, increasing Mg intake can help reduce blood lipid levels [23].

Mn, which was a trace mineral needed for normal metabolism of amino acids, proteins, lipids, and carbohydrates. That was known to be associated with blood lipids. It has been reported that Mn supplementation reduced blood lipids in ovariectomized rats, which in turn improved lipid metabolism after menopause [28]. From the correlation analysis, the daily dietary intake of Mn was positively correlated with high density lipoprotein. This result may suggest that dietary Mn intake may have an important role in blood lipids.

Daily intake of energy and most nutrients of TB and TB-DM patients in our study were significantly lower than the RNI, Which means patients' daily dietary intakes of nutrients were clearly insufficient in this study. TB was a wasting disease, and nutritional consumption was a major feature of patients with TB [18]. The study found that the energy and nutrients intake were generally low, and the intake of energy, vitamins and minerals were closely related to the occurrence and development of the disease. Retinol involved in maintaining the integrity of the alveolar epithelium structure, and can help maintain normal immune system function and strengthen the body resistance to respiratory tract infection. Vitamin C was known for its antioxidant effect, and it has long been used for the liver protection in the process of TB treatment. A study showed vitamin C level in serum was of great significance for disease and drug efficacy test [19]. The result of this study indicated that the vitamin C level in the diet was lower than RNI, so it should be noted in the patient's treatment process. Other trace elements also played an important role in the body. Such as potassium plays a main role in carbohydrate and protein metabolism. To keep the normal intracellular osmotic pressure; maintain the normal function of the nerve muscle and myocardial function and maintain cells inside and outside the acid-base balance, etc [15]. Ca was not only the main component of bones and teeth, also participate in a variety of physiological activities in the body. Ca deficiency can lead to low immunity, and the body prone to infection. Suffering from tuberculosis itself was prone to reduce blood calcium level [20]. Moreover, tuberculosis foci calcification needed a lot of Ca. Ca deficiency will affect the calcification process, resulting in illness delayed healing. Besides, isoniazid, rifampicin and enzyme inhibitors can reduce25-OH-D and 1, 25-$(OH)_2$D levels, which results in the decrease of blood calcium [21]. With the extension of the duration disease, it leaded to loss of appetite, so vitamins and minerals needed by body was very limited which provided by the diet every day. Insufficient nutrients intake of TB patients could cause damage to a number of physiological functions of the body, and made the patient's condition become worse, which was not conducive to clinical treatment.

Due to the number of this survey was less, therefore, could not accurately and comprehensively reflect the dietary patterns of TB. On the other hand, due to the characteristics of TB and the differences between individuals, as well as the food to eat it will be affected by various factors. Therefore, in the future study, we should be more comprehensive collection of patient's diet, and accurate assessment of various nutrients and mineral intake.

Funding: This study was funded by Natural Science Foundation of China (NSFC, No. 81472983).

Conflict of Interest: All authors declare that they have no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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