

# Correlation Analysis Between Uric Acid and Metabolic Syndrome in the Elderly Population

**Guqiao Nie**

Huazhong University of Science and Technology

**Jing Jing Wan**

Union Hospital, Huazhong University of Science and Technology

**Lei Jiang**

Union Hospital, Huazhong University of Science and Technology

**Shu Kai Hou**

Community health service center, Gutian street, Qiaokou District, WuHan

**Wen Peng** (✉ [pengwen666@sina.com](mailto:pengwen666@sina.com))

Union Hospital, Huazhong University of Science and Technology

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## Research Article

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# Abstract

## Background

The prevalence of metabolic syndrome in the elderly is gradually increasing, which accounts for the largest burden of non-communicable diseases worldwide and has direct effects on health. Research on the relationship between uric acid and metabolic syndrome in the elderly is relatively lacking. The purpose of this study is to explore the diagnostic value of uric acid levels for metabolic syndrome, compared to other components of metabolic syndrome.

## Materials and methods

We collected the physical examination data of 1,267 elderly people in the community in Wuhan, and used SPSS IBM 22.0 for data analysis. Perform correlation analysis, logistic regression analysis and draw ROC curve.

## Results

The prevalence of hyperuricemia was 28.1%, and metabolic syndrome was 18.6%; the uric acid level of the non-metabolic syndrome group was lower than that of the metabolic syndrome group (337.31 vs 381.91  $\mu\text{mol/L}$ ;  $P < 0.05$ ); Pearson analysis revealed uric acid levels are correlated with blood pressure, BMI, triglyceride, high-density lipoprotein cholesterol. Logistic regression analysis results suggest that uric acid is a risk factor for metabolic syndrome. Metabolic syndrome components TG and HDL levels are also related to uric acid levels. The result is described as OR value and 95% CI (OR 1.003 [1.001, 1.005]). By drawing the ROC curve, we found that the area under the curve for uric acid to diagnose metabolic syndrome is 0.64 (sensitivity: 79.3%, specificity: 45.1%), which is similar to other components of metabolic syndrome.

## Conclusion

We confirmed the correlation between uric acid levels and metabolic syndrome in the elderly Chinese population.

# Introduction

Metabolic syndrome is a multifactorial pathological condition defined by the association of several metabolic disorders. [1] Studies from various countries show a worldwide distribution of metabolic syndrome with a prevalence related to age. [2, 3]. The management of metabolic syndrome and the definition of metabolic syndrome in the elderly are particularly important. Metabolic syndrome is an independent risk factor for cardiovascular diseases, diabetes, etc., which is often accompanied with increasing uric acid level. [4] Whether uric acid has an effect on metabolic syndrome is controversial. [5]

Uric acid is an oxidation product of purine metabolism in the circulatory system. Hyperuricemia can cause abnormal fat accumulation in body tissues, and adipokines can induce the production of reactive oxygen species and cause the formation of free radicals, which is a pro-oxidant factor. [6–10] In contrast, uric acid is also considered to be an antioxidant, which can fight against superoxide anions, hydroxyl radicals and peroxynitrite. [5, 11] Its anti-oxidant protection can be reflected in cell apoptosis, cancer and aging. [12] Oxidative stress is inseparable from the formation of metabolic syndrome. [13] The two-way regulation of oxidative stress by uric acid may be closely related to the level of uric acid in people with metabolic syndrome. Therefore, we designed such a cross-sectional study clinically to explore the correlation between the two.

Our research will focus on the level of uric acid and metabolic syndrome in the elderly, and explore the relationship between them. The optimal cut-off value of uric acid at risk of metabolic syndrome was initially obtained.

# Materials And Methods

## Study population

We collected the medical examination data of  $\geq 65$ -year-old group at a community medical examination center between January 1, 2016 and December 31, 2016. A total of 1267 elderly people were included in the study, including 556 males and 711 females. The overall average age was  $71.64 \pm 5.605$  years.

### **General data and biochemical indicators**

Data for this study were obtained from the physical examination records of the elderly people in the community. For example, basic information such as height, weight, age, gender, etc. are inquired from the database of the medical examination center. The doctor used a mercury sphygmomanometer on the upper arm to measure blood pressure—systolic blood pressure and diastolic blood pressure. The average value of two blood pressure measurements taken at least five minutes apart was used. Biochemical indices including FBG, blood lipids, and uric acid (UA) were all measured using venous blood obtained from the participants on an empty stomach. Levels of serum UA, TGs, HDL-C and low-density lipoprotein cholesterol (LDL-C), and fasting blood glucose (FBG) were measured using Roche E602 and Roche C701 (both of which are automatic biochemical analyzers).

## **Result**

### **Characteristics of the research population**

In Table 1, we divided the population into two groups according to whether the metabolic syndrome was diagnosed or not. The diagnosis of metabolic syndrome is based on Chinese Diabetes Society. The continuous variables were expressed by average addition and subtraction  $\pm$  standard deviation, two independent samples t-test were performed, the classified variables were expressed as percentage, and the variance test was performed. The difference is statistically significant when the P value is  $< 0.5$ . In addition, the average serum uric acid level was higher compared to subjects with non-MetS and this difference was significant ( $381.91$  vs  $337.31$   $\mu\text{mol/L}$ ;  $P < 0.05$ ) as the Table 1 shows.

Table 1  
Clinical characteristics of the different groups

| Characteristic or parameter   | MetS (N = 234) | Non-MetS (N = 1033) | p-value |
|---|----------------|---------------------|---------|
|   | Mean ± SD      | Mean ± SD           |         |
| Age, years  | 71.64 ± 5.605  | 71.39 ± 5.409       | < 0.001 |
| Waist, cm   | 93.87± 8.407   | 86.51±8.91          | < 0.001 |
| BMI, kg/m <sup>2</sup>  | 27.14 ± 3.19   | 23.98 ± 3.25        | < 0.001 |
| DBP, mm Hg  | 82.97 ± 10.97  | 76.54 ± 11.29       | < 0.001 |
| SBP, mm Hg  | 148.08 ± 13.82 | 131.26 ± 18.17      | < 0.001 |
| TG, mmol/L  | 2.02 ± 0.96    | 1.31± 0.75          | < 0.001 |
| TC, mmol/L  | 4.78 ± 1.10    | 4.60 ± 0.89         | 0.024   |
| HDL, mmol/L   | 1.02 ± 0.22    | 2.75 ± 0.77         | < 0.001 |
| LDL, mmol/L   | 2.92 ± 0.91    | 2.76 ± 0.76         | 0.005   |
| UA, μmol/L  | 381.91 ± 95.01 | 337.31 ± 89.48      | < 0.001 |
| FBG, mmol/L   | 6.76 ± 2.03    | 5.33 ± 1.18         | < 0.001 |
|   | N (%)          | N (%)               |         |
| Gender (% male)   | 107 (45.72)    | 449 (43.46)         | 0.56    |
| BMI= body mass index, BP=blood pressure, CVD=cardiovascular disease, FBG= Fasting blood glucose, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, MetS= metabolic syndrome, TC = total cholesterol, TG = triglyceride, UA=uric acid |                |                     |         |

#### Correlation analysis between UA level and various parameters of Mets

Table2 shows that gender, age, blood pressure, abdominal circumference, BMI, TG, HDL-C were correlated with uric acid level and had statistical significance. In the correlation analysis, we can observe that there is a correlation between the level of uric acid and the various components of metabolic syndrome. For example, uric acid is negatively correlated with HDL-C ( $r = -0.268$ ,  $p < 0.001$ ).

Table 2  
Bivariate correlation analysis between uric acid and components of MetS

| Factors                | r        | p value |
|------------------------|----------|---------|
| Gender                 | 0.350**  | <0.001  |
| Age, years             | 0.114**  | <0.001  |
| SBP, mm Hg             | 0.177**  | <0.001  |
| DBP, mm Hg             | 0.135**  | <0.001  |
| BMI, kg/m <sup>2</sup> | 0.234**  | <0.001  |
| Waist,cm               | 0.283**  | <0.001  |
| FBG, mmol/L            | 0.047    | 0.094   |
| TG, mmol/L             | 0.217**  | <0.05   |
| TC, mmol/L             | -0.051   | 0.071   |
| HDL, mmol/L            | -0.268** | <0.001  |
| LDL, mmol/L            | 0.007    | 0.803   |
| TG/HDL                 | 0.218**  | <0.001  |

## Logistic Regression Between Ua Level And Mets

After regression analysis(as Table 3 shows), we found that uric acid level may be an independent risk factor for metabolic syndrome, with an OR of 1.003, which is interpreted as a doubling of the risk of diagnosis of MetS for each increase in uric acid level, we have constructed three models, an unadjusted rough model, model 3, which includes all the variables that may have an impact, and model 2, which only adjusts except for biochemical indicators, and after regression analysis, we find that uric acid level may be an independent risk factor for metabolic syndrome, with an OR of 1.003. The difference was statistically significant.

Table 3  
Logistic regression results of the association of patient characteristics with MetS

| Exposure     | Model1 |         |                     | Model2 |         |                     | Model3 |         |                     |
|--------------|--------|---------|---------------------|--------|---------|---------------------|--------|---------|---------------------|
|              | B      | p-value | OR (95% CI)         | B      | p-value | OR (95% CI)         | B      | p-value | OR(95% CI)          |
| UA,mmol/l    | 0.005  | <0.001  | 1.005(1.003, 1.006) | 0.003  | <0.001  | 1.003(1.001, 1.005) | 0.003  | 0.014   | 1.003(1.001, 1.005) |
| Gender(male) | -      | -       | -                   | -0.126 | 0.492   | 1.135(0.791, 1.627) | -0.247 | 0.291   | 1.281(0.809, 2.027) |
| age, years   | -      | -       | -                   | -0.032 | 0.045   | 0.968(0.939, 0.999) | -0.033 | 0.083   | 0.968(0.933, 1.004) |
| SBP, mm Hg   | -      | -       | -                   | 0.053  | <0.001  | 1.054(1.043, 1.065) | 0.068  | <0.001  | 1.07(1.056, 1.084)  |
| BMI, kg/m2   | -      | -       | -                   | 0.257  | <0.001  | 1.294(1.224, 1.367) | 0.257  | <0.001  | 1.293(1.212, 1.38)  |
| GLU, mmol/L  | -      | -       | -                   | -      | -       | -                   | 0.594  | <0.001  | 1.81(1.594, 2.056)  |
| TG, mmol/L   | -      | -       | -                   | -      | -       | -                   | 0.693  | <0.001  | 1.999(1.568, 2.549) |
| HDL, mmol/L  | -      | -       | -                   | -      | -       | -                   | -3.112 | <0.001  | 0.045(0.016, 0.126) |

## Roc Curves Between Ua Level And Mets

After analysis above, we draw different ROC curves. As figure1 shows, the AUC of UA, TG, TC, GLU, HDL, LDL and BMI are 0.641, 0.786, 0.542, 0.771, 0.276, 0.544, 0.773 respectively. The AUC of uric acid is similar to the titer of TG, GLU, HDL and BMI in the diagnosis of metabolic syndrome, and its sensitivity and specificity are 79.3% and 45.1%, respectively.

## Discussion

The prevalence of metabolic syndrome in the elderly is high, according to the data of the World Health Organization, the prevalence of metabolic syndrome in the elderly ranged from 11–43% (median 21%), and NCEP is 23–55% (median 31%). [14–17] Our study revealed the relationship between uric acid and metabolic syndrome in elderly Chinese population. In addition, we analyzed the correlation between uric acid levels and blood lipids, sugar levels, and blood pressure and found the relationship among these.

Hyperuricemia is a risk factor for cardiovascular events. [18, 19] Similarly, metabolic syndrome is also an independent risk factor for cardiovascular events. [2] In fact, there are different opinions about the correlation between uric acid and metabolic syndrome. Studies have shown that uric acid has nothing to do with metabolic syndrome and metabolic syndrome components [20] L. CIBIČKOVÁ et al. conducted an investigation and found that uric acid is related to metabolic syndrome, and the correlation is most obvious in the case of dyslipidemia. [21] Manfredi Rizzo et al. believe that the metabolic syndrome centered on insulin resistance can lead to hyperinsulinemia. Hyperinsulinemia in the body will increase the reabsorption of uric acid in the renal tubules, thereby forming hyperuricemia. [22]

Some studies even showed that uric acid is an independent risk factor for metabolic syndrome. [23–25]. Endy Adnan et al. investigated 102 outpatients and found that among subjects with MetS, serum uric acid levels were significantly higher than those of non-MetS subjects. [26] Our research found that various lipid components of metabolic syndrome are correlated

with uric acid levels in elderly Chinese population. A study suggested that higher intracellular uric acid levels could induce mitochondrial translocation of the nicotinamide adenine dinucleotide phosphate oxidase subunit, the nicotinamide adenine dinucleotide phosphate oxidase 4, further leading to increased mitochondrial oxidative stress, mitochondrial dysfunction and citrate to release to the cytosol, ultimately promoting to the synthesis of lipid and TG. [27, 28] In addition, the enzyme activity that catalyzes the decomposition of TG is affected by high levels of uric acid, which inhibits the decomposition of serum TG, leading to the incidence of hypertriglyceridemia.[29]. Hyperuricemia reduction in the Pound mouse or fructose-fed rats, as well as hyperuricemia induction by uricase inhibition in rodents and studies using cell culture have suggested that uric acid plays an important role in the development of metabolic syndrome. These studies have shown that high uric acid levels regulate the oxidative stress, inflammation and enzymes associated with glucose and lipid metabolism, suggesting a mechanism for the impairment of metabolic homeostasis. [30]

Metabolic syndrome is defined as insulin resistance syndrome (IR), which may lead to the occurrence of MetS.[31, 32] Studies have suggested that hyperuricemia and insulin resistance have a two-way relationship. [19, 33] Increasing serum uric acid can lead to insulin resistance, through the low-pressure bioavailability of nitric oxide (NO), and ultimately produce oxidative stress in the mitochondria. [26] IR can also cause hyperuricemia by increasing the sodium reabsorption mechanism and increase the absorption of uric acid. The increase in serum uric acid is negatively correlated with insulin sensitivity. [34] These data may indicate that hyperuricemia is probably an important factor of MetS.

At the end, several limitations should be mentioned. First, cross-sectional research cannot draw a causal relationship between the MetS and uric acid affected by the type of research. Second, we could not obtain some useful data, such as drug use. Therefore, we hope to conduct multi-center and prospective research in the future. In summary, we hope to bring new content to the management of metabolic syndrome for the elderly in China through our research. The common pathogenesis of hyperuricemia and metabolic syndrome is also worthy of further exploration.

## Conclusion

This study is one of the few studies to analyze the correlation uric acid and metabolic syndrome in the elderly population in Chinese community. The diagnostic value of blood lipids, blood sugar, BMI and blood pressure for metabolic syndrome is close to that of uric acid. The level of uric acid in the elderly population may indicate a high risk of metabolic syndrome.

## Declarations

### Acknowledgements:

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### Contributions:

Guqiao Nie and Jingjing Wan wrote the main manuscript. Peng Wen was responsible for research ideas and writing guidance; Lei Jiang and Shukai Hou collected research data; Guqiao Nie and Lei Jiang analyzed the data; All authors reviewed the manuscript (S237).

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### Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Ethics approval

This study was conducted in accordance with the contents of the Declaration of Helsinki. All patient information is anonymous and will not cause any harm to the patient. Participants were not required to provide informed consent. The study was approved by the Institutional Review Board of Tongji Medical College, Huazhong University of Science and Technology.

## Consent for publication

Not Applicable.

## Conflict of Interest:

All authors declare that they have no conflicts of interest

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## Figures

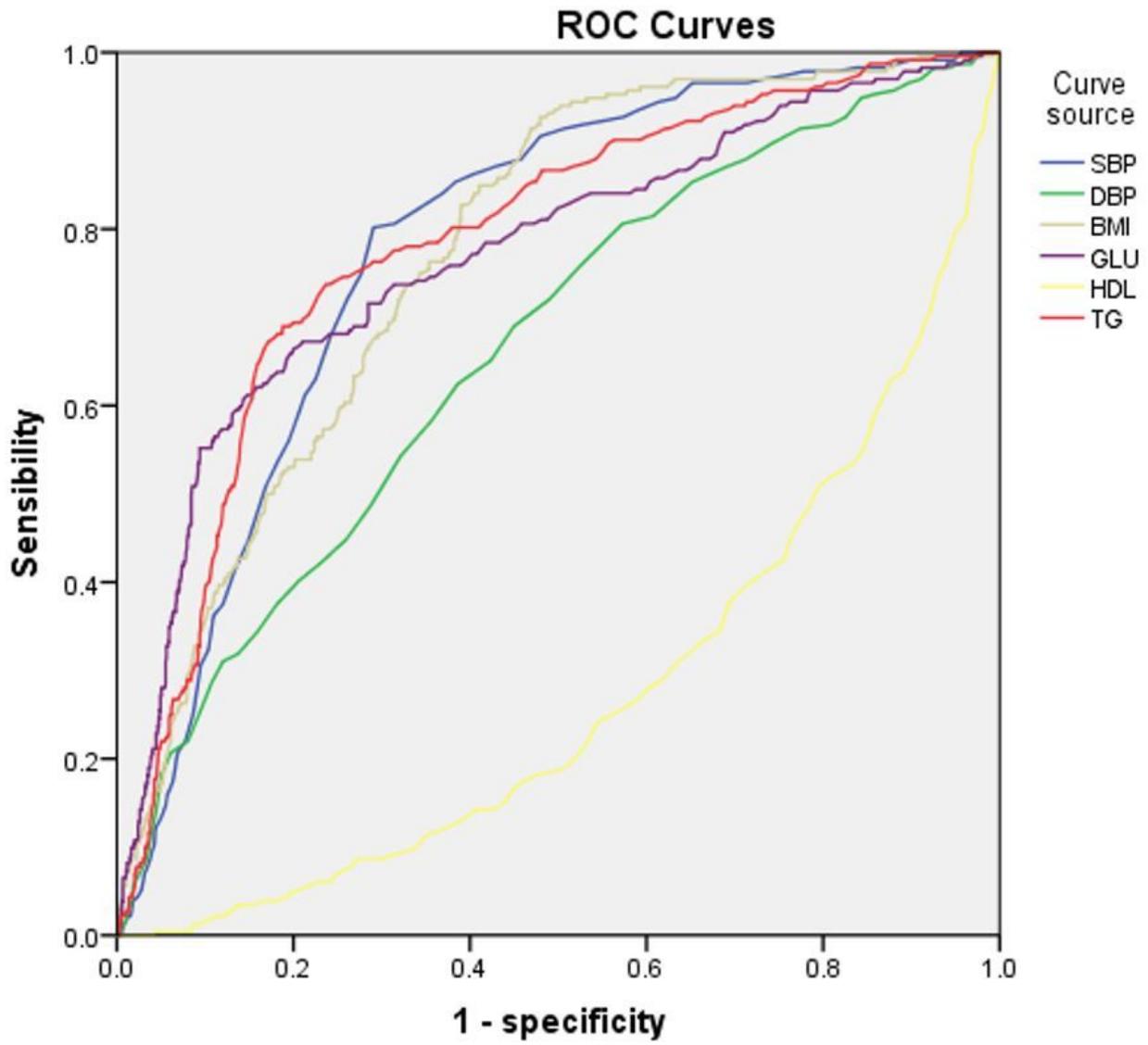


Figure 1

ROC curve between UA and MetS