Diabetes, Metabolic Syndrome and Obesity

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

# Hyperuricemia Remission After Sleeve Gastrectomy in Chinese Patients and Establishment of a Preoperative Predictive Model: A Retrospective Cohort Study with a Mean Follow-Up of 20 Months

Xiyuan Chen, Zhehong Li, Zheng Wang, Yilan Sun, Mingyue Shang, Chenxu Tian, Zhaohui Liao, Dongbo Lian, Buhe Amin, Dexiao Du, Guangzhong Xu, Nengwei Zhang, Liang Wang

Surgery Centre of Diabetes Mellitus, Capital Medical University Affiliated Beijing Shijitan Hospital, Beijing, People's Republic of China

Correspondence: Liang Wang; Nengwei Zhang, Surgery Centre of Diabetes Mellitus, Capital Medical University Affiliated Beijing Shijitan Hospital, 10th Tieyi Road, Haidian District, Beijing, 100038, People's Republic of China, Tel +8619800320171; +86 13801068802, Email 1911110644@pku.edu.cn; zhangnw1@sohu.com



**Background:** A significant proportion of patients with obesity have comorbid hyperuricemia (HUA). However, the curative effect of sleeve gastrectomy (SG) on HUA remains debated.

**Objective:** To clarify the remission effect of SG on HUA, analyze potential influencing factors, and establish a predictive model using preoperative data.

**Methods:** Pre- and post-operative data from 130 patients with obesity and HUA who underwent SG in our hospital were collected and evaluated for the therapeutic effect on HUA. Binary logistic regression analysis was employed to screen the influencing factors and the ones with predictive value. Predictive model was constructed, then evaluated using the area under the receiver operating characteristic (ROC) curve (AUC) and internal and external validations. Complete remission of HUA was defined as a follow-up SUA level that no longer met the reference value for diagnosing HUA, i.e., an SUA concentration of <428 μmol/L (in males) or <357 μmol/L (in females), according to the reference value in our hospital's laboratory.

**Results:** The mean follow-up duration is 20.4 months. After ≥ one year post SG, the complete remission rate of HUA was 58%. Preoperative hip circumference (HC) and preoperative serum uric acid (SUA) level were found to be predictive variables, the AUC values of which, along with their combination in predicting this outcome, were 0.696, 0.731, 0.738, respectively, $p > 0.05$. The joint predictive model was found to have a sensitivity and specificity of 0.776 and 0.738, respectively, and its reliability was confirmed by internal and external validations.

**Conclusion:** Some patients can achieve HUA complete remission following SG after 1 year. Preoperative SUA concentration and HC can be utilized to predict this outcome in Chinese patients with obesity. The joint predictive model offers potentially better clinical value.

**Keywords:** laparoscopic sleeve gastrectomy, obesity, hyperuricemia, uric acid, hip circumference, prognostic prediction

## Introduction

A significant proportion of patients with obesity have comorbid hyperuricemia (HUA). HUA occurs due to excessive endogenous (urea synthesis and cell renewal) or exogenous (dietary intake) uric acid or the insufficient excretion of uric acid.[1] HUA is the basis of gout, and not only causes severe osteoarthritis but also damages multiple vital organs and systems, such as the kidneys and the cardiovascular system. Severe cases of HUA may even develop into a life-threatening condition.[2] Globally, HUA exhibits a varied prevalence across different populations, ranging from 2.6% to

Received: 30 November 2024
Accepted: 6 May 2025
Published: 12 August 2025

36%,[3] which is related to economic development level, dietary habits, race, and other factors.[3–5] According to the latest reports, in mainland China, HUA has an estimated incidence of 17.7%,[6] while this figure has been found to be as high as 69% within the Chinese population with obesity.[7] Obesity is one of the most critical pathogenic factors that can cause HUA through vital pathways such as adipocytokine signaling pathways, insulin resistance, and cholesterol metabolism.[8]

Metabolic and bariatric surgery (MBS) has been widely used to treat obesity following its introduction in mainland China in the early 21st century. Presently, MBS is performed in over 37000 cases annually, with sleeve gastrectomy (SG) accounting for up to 81.5% of the surgeries.[9] Numerous studies have proved that SG is efficacious in treating obesity and its comorbidities such as type 2 diabetes (T2D), hypertension,[10] and hyperlipidemia.[11] However, the curative effect of SG on HUA are limited[12] and remains debated. The mainstream view holds that SG is effective for HUA.[13,14] However, contradictory research findings have suggested that MBS is ineffective for HUA and may even increase uric acid levels.[15] Moreover, the factors affecting the outcome of HUA in patients who undergo MBS are yet to be determined. Nevertheless, researchers have largely noted a generally stable internal environment and limited changes in various biochemical indicators, including serum uric acid (SUA) levels, after ≥1 year following MBS.[16–18]

This study aimed to clarify the therapeutic efficacy of SG on HUA, identify the preoperative factors affecting the therapeutic effects on HUA, and establish a predictive model to predict the remission outcome of HUA after SG in Chinese patients with obesity.

# Materials and Methods

## Patients

The study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of our institution (approval no.: sjtkyll-lx-2022(076)). Informed consent was provided from patients. We selected patients who underwent MBS in our center from August 30, 2011 to July 31, 2023. Inclusion criteria were as follows: patients who ① met the diagnostic criteria for HUA and obesity; ② had complete preoperative data (including body measurements and biochemistry indicators); ③ meet the eligibility criteria for MBS set by the Chinese Guidelines for Surgical Treatment of Obesity and Type 2 Diabetes in 2014[19] and underwent SG; ④ had follow-up data at least 1 year after the operation; and ⑤ were Chinese residents. The exclusion criteria were as follows: ① dietitians failed to provide postoperative dietary guidance to; ② experienced severe complications such as bleeding and underwent secondary surgery; ③ had major medical events after surgery, including pregnancy and tumor occurrence; ④ used uric acid - lowering drugs within 1 week before the blood test.

## Definitions

SUA levels were measured using a Mindray BS-2800M automatic biochemical analyzer. According to the reference value in our hospital's laboratory, HUA was defined as an SUA concentration of ≥428 μmol/L (in males) or ≥357 μmol/L (in females). Complete remission of HUA was defined as a follow-up SUA level that no longer met the reference value for diagnosing HUA, i.e., an SUA concentration of <428 μmol/L (in males) or <357 μmol/L (in females).

Obesity was defined as body mass index (BMI) ≥28 kg/m$^2$ basing on Chinese criteria.[20] Hypertension was defined as systolic ≥140 mmHg and/or diastolic ≥90 mmHg.[21] T2D was indicated by typical symptoms random plasma glucose≥11.1 mmol/L or fasting plasma glucose≥7.0 mmol/L or 2-hour glucose level during oral glucose tolerance test ≥11.1 mmol/L, or glycosylated hemoglobin (A1C) ≥6.5%.[22] Hyperlipidemia was diagnosed as an abnormal level of blood lipids, i.e., total cholesterol (TC) ≥5.18 mmol/L, or triglyceride (TG) ≥1.70 mmol/L, or high-density lipoprotein cholesterol (HDL-C) <1.04 mmol/L, or low-density lipoprotein cholesterol (LDL-C) ≥3.37 mmol/L.[23]

## Surgical Approach

The surgical procedure was consistent with previous reports,[24] and all procedures were performed by the same surgeon following the same standards.

## Postoperative Follow-Up

Follow-up was conducted via online (such as WeChat or telephone) and offline (including hospitalization or outpatient reexamination) methods. The follow-up data encompassed recent general conditions (including diet and sleep health), current body measurements (such as weight, waist circumference, and hip circumference [HC]), and laboratory test results from the most recent postoperative follow-up examination, such as the levels of SUA, A1C, HDL-C, LDL-C, TC, and TG.

## Statistical Analysis

Categorical variables were compared using the chi-square or Fisher's exact tests, as applicable. The Kolmogorov–Smirnov test was performed to assess the normality of the measurement data. Accordingly, normally distributed data were expressed as mean ± standard deviation, while non-normally distributed data were presented as median (interquartile range). The independent-samples *t*-test and nonparametric test were conducted to compare normally and non-normally distributed data, respectively. Binary logistic regression analysis was employed to screen the predictive variables. Receiver operating characteristic (ROC) curves were plotted to determine the optimal cut-off values, and areas under the ROC curve (AUC) were compared. A two-sided p-value of <0.05 was considered statistically significant. Data processing and analysis were performed using R version 4.4.0 (R Foundation for Statistical Computing, Vienna, Austria) and Zstats 1.0 (www.zstats.net). The ROC curves were drawn using MedCalc for Windows version 23.0.1 (MedCalc Software, Ostend, Belgium). All other statistical analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA).

# Results

## Patient Characteristics

A total of 130 patients were included in this study. Among them, 100 patients who underwent surgery from August 30, 2011 to August 1, 2022 were allocated to the modeling group, while the remaining 30 who received surgery from August 2, 2022 to July 31, 2023 were enrolled in the external validation group. The patient screening process is depicted in Figure 1.

The follow-up duration of the modeling group is presented in Table 1. The average follow-up time of the total 100 patients was 20.41 months, with 10 years as the longest period. The follow-up results demonstrated that 58 patients achieved complete remission of HUA after SG, whereas 42 did not.

The average age of the patients in the modeling group was 31.95 ± 9.69 years. The median preoperative BMI was 39.56 kg/m$^2$, and the average preoperative SUA level was 478.75 ± 74.70 μmol/L. Table 2 compares the preoperative baseline data between the patients in the modeling group who attained complete remission and those who did not. Significant differences in age, weight, BMI, waist circumference, HC, and SUA concentration were observed between the two groups. However, no significant differences were found in terms of sex; height; waist-hip ratio; the levels of TG, HDL-C, LDL-C, TC, and A1C; and the prevalence of hypertension, hyperlipidemia, T2D, fatty liver disease, or obstructive sleep apnea-hypopnea syndrome.

Table 3 compares the baseline data between the training and validation groups.

## Binary Logistic Regression Analysis

We conducted a binary logistic regression using whether HUA reached complete remission as the dependent variable and the variables with significant differences between the complete remission and no remission groups, i.e., age, weight, BMI, waist circumference, HC, and SUA concentration, as independent variables. The results revealed that only preoperative SUA level and preoperative HC had predictive value for the remission effect of SG on HUA after 1 year (Table 4).

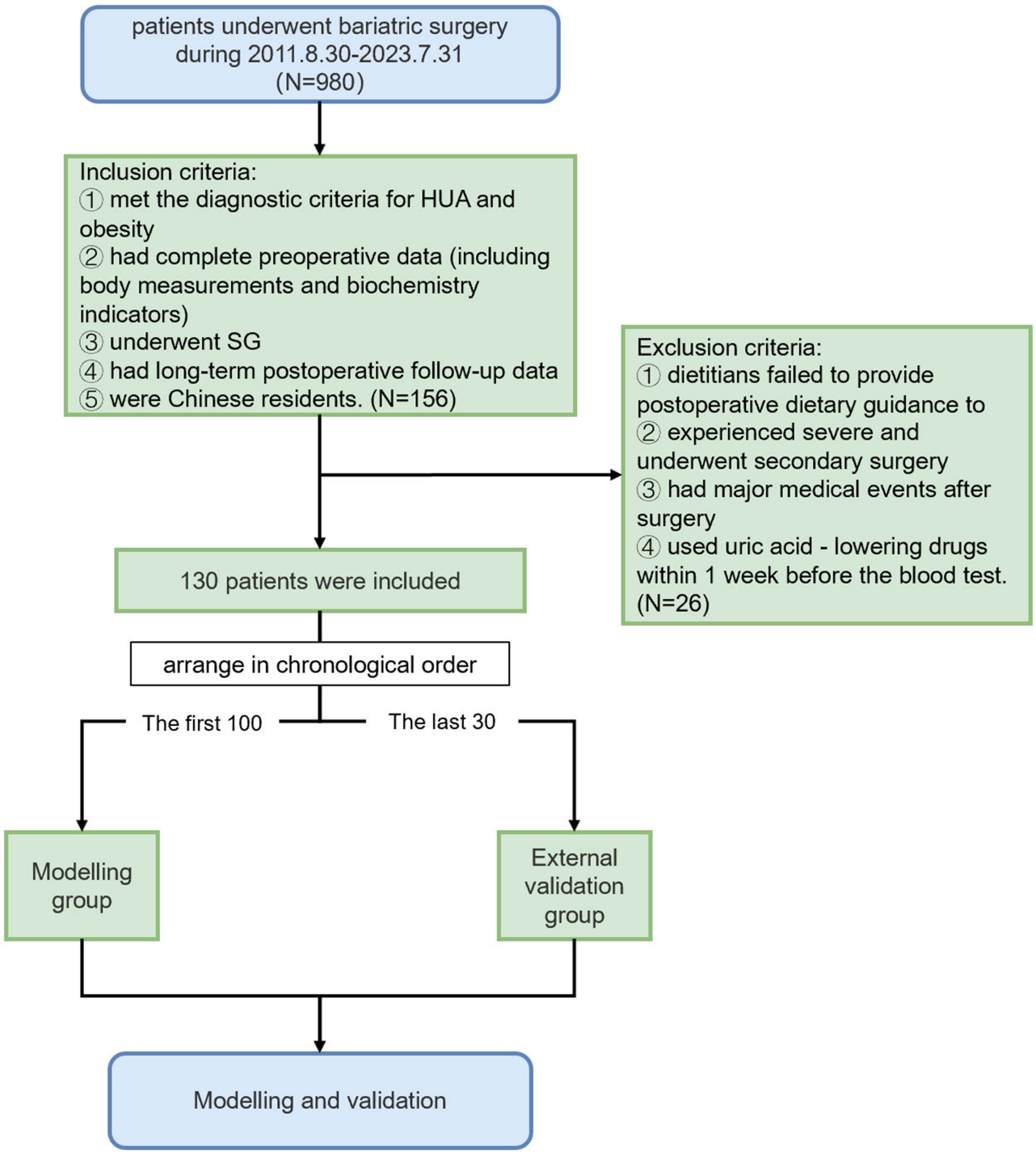


**Figure 1** Patient screening process.

## ROC Curves

The ROC curve drawn with whether complete remission of HUA was achieved as the categorical variable and preoperative HC as the independent variable demonstrated that the optimal cut-off value for predicting the remission of postoperative HUA was 135 cm (AUC = 0.696; 95% confidence interval [CI]: 0.596–0.784; sensitivity, 0.793; specificity, 0.500; $p < 0.001$). Similarly, the ROC curve constructed with preoperative SUA concentration as the

**Table 1** Follow-Up Duration of Modeling Group

| | Total (n=100) | Unrelieved (n=42) | Remission (n=58) | Statistic | *P* |
|---|---|---|---|---|---|
| Follow-up duration | | | | - | 0.699 |
| 12-18 months | 72 (72.00) | 32 (76.19) | 40 (68.97) | | |
| 18-36 months | 17 (17.00) | 5 (11.90) | 12 (20.69) | | |
| 36-60 months | 6 (6.00) | 3 (7.14) | 3 (5.17) | | |
| Over 5 years | 5 (5.00) | 2 (4.76) | 3 (5.17) | | |

**Note**: Fisher exact.

**Table 2** Comparison of Baseline Data Between Those Who Reached Complete Remission and Those Who Did Not in the Modeling Group

| | Total (n=100) | Unrelieved (n=42) | Remission (n=58) | Statistic (t/ Z/$\chi^2$) | *P* |
|---|---|---|---|---|---|
| Age (years) | 31.95±9.69 | 29.14±8.52 | 33.98±10.05 | −2.53 | 0.013※ |
| Gender | | | | 2.68 | 0.101 |
| Male (%) | 25 (25.00) | 14 (33.33) | 11 (18.97) | | |
| Female (%) | 75 (75.00) | 28 (66.67) | 47 (81.03) | | |
| Preoperative height (m) | 1.69±0.08 | 1.70±0.09 | 1.68±0.06 | 1.21 | 0.229 |
| Preoperative weight (kg) | 115.25 (99.95, 130.00) | 122.00 (102.38, 142.50) | 108.00 (98.55, 123.25) | −2.43 | 0.015※ |
| Preoperative BMI (kg/m$^2$) | 39.56 (35.79, 45.77) | 42.49 (37.71, 50.43) | 39.00 (35.02, 43.50) | −2.20 | 0.028※ |
| WC (cm) | 124.45±19.26 | 131.45±20.55 | 119.39±16.68 | 3.24 | 0.002※ |
| HC (cm) | 131.04 ±17.42 | 138.40±18.96 | 125.71±14.13 | 3.67 | 0.001※ |
| WHR | 0.95 ± 0.07 | 0.95 ± 0.06 | 0.95 ± 0.07 | −0.01 | 0.993 |
| Hypertension (%) | 31 (31.00) | 14 (33.33) | 17 (29.31) | 0.18 | 0.668 |
| Hyperlipidemia (%) | 60 (60.00) | 28 (66.67) | 32 (55.17) | 1.34 | 0.247 |
| T2D (%) | 25 (25.00) | 10 (23.81) | 15 (25.86) | 0.05 | 0.815 |
| Fatty liver (%) | 94 (94.00) | 40 (95.24) | 54 (93.10) | 0.00 | 0.986 |
| OSAHS (%) | 31 (31.00) | 12 (28.57) | 19 (32.76) | 0.20 | 0.655 |
| Preoperative SUA (μmol/L) | 478.75±74.70 | 513.52±73.19 | 453.57±65.60 | 4.30 | 0.001※ |
| TG (mmol/L) | 1.64(1.22, 2.21) | 1.76(1.16, 2.25) | 1.60(1.22, 2.19) | −0.12 | 0.903 |
| HDL-c (mmol/L) | 1.09±0.19 | 1.06±0.22 | 1.11±0.17 | −1.22 | 0.226 |
| LDL-c (mmol/L) | 3.07(2.76, 3.67) | 3.09(2.69, 3.85) | 3.07(2.78, 3.58) | −0.16 | 0.875 |
| TC (mmol/L) | 4.86±0.78 | 4.81±0.87 | 4.90±0.71 | −0.60 | 0.553 |
| A1C (%) | 5.90(5.60, 6.60) | 5.90(5.62, 6.30) | 5.95(5.60, 6.60) | −0.04 | 0.967 |

**Note**: ※p-value<0.05.

**Abbreviations**: t, *t*-test; Z, Mann–Whitney test; $\chi^2$, Chi-square test; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; T2D, type 2 diabetes; OSAHS, obstructive sleep apnea-hypopnea syndrome; SUA, serum uric acid; TG, triglyceride; HDL-c, high-density lipoprotein cholesterol; LDL-c, low-density lipoprotein cholesterol; TC, total cholesterol; A1C, glycosylated hemoglobin.

**Table 3** Comparison of Baseline Data of Modelling Group and Validation Group

| | Total (n=130) | Modelling Group (n=100) | Validation Group (n=30) | Statistic (t/ $\chi^2$) | *P* |
|---|---|---|---|---|---|
| Age (years) | 31.84±9.58 | 31.95±9.69 | 31.47±9.32 | 0.24 | 0.809 |
| Gender | | | | 0.32 | 0.573 |
| Male (%) | 31 (23.85) | 25 (25.00) | 6 (20.00) | | |
| Female (%) | 99 (76.15) | 75 (75.00) | 24 (80.00) | | |
| Preoperative Height (m) | 1.69±0.08 | 1.69±0.08 | 1.69±0.07 | −0.27 | 0.790 |
| Preoperative weight (kg) | 119.06±29.86 | 120.40±30.92 | 114.61±26.01 | 0.93 | 0.354 |
| Preoperative BMI (kg/m$^2$) | 41.33±8.59 | 41.83±8.90 | 39.68±7.37 | 1.20 | 0.232 |
| WC (cm) | 123.33±19.40 | 124.45±19.26 | 119.57±19.71 | 1.21 | 0.227 |

(*Continued*)


https://doi.org/10.2147/DMSO.S508015

**Table 3** (Continued).

| | Total (n=130) | Modelling Group (n=100) | Validation Group (n=30) | Statistic (t/ $\chi^2$) | *P* |
|---|---|---|---|---|---|
| HC (cm) | 129.98 ±16.82 | 131.04±17.42 | 126.47±14.37 | 1.31 | 0.193 |
| WHR | 0.95 ± 0.07 | 0.95 ± 0.07 | 0.94 ± 0.08 | 0.44 | 0.659 |
| Hypertension (%) | 38 (29.23) | 31 (31.00) | 7 (23.33) | 0.66 | 0.418 |
| Hyperlipidemia (%) | 83 (63.85) | 60 (60.00) | 23 (76.67) | 2.78 | 0.096 |
| T2D (%) | 30 (23.08) | 25 (25.00) | 5 (16.67) | 0.90 | 0.342 |
| Fatty liver (%) | 123 (94.62) | 94 (94.00) | 29 (96.67) | 0.01 | 0.915 |
| OSAHS (%) | 51 (39.23) | 31 (31.00) | 20 (66.67) | 12.31 | 0.001※ |
| Preoperative SUA (μmol/L) | 474.15±81.84 | 478.75±74.70 | 458.83±102.11 | 1.17 | 0.224 |
| TG (mmol/L) | 1.91±1.14 | 1.92±1.14 | 1.90±1.14 | 0.06 | 0.953 |
| HDL-c (mmol/L) | 1.09±0.18 | 1.09±0.19 | 1.08±0.15 | 0.22 | 0.825 |
| LDL-c (mmol/L) | 3.31±0.82 | 3.20±0.75 | 3.67±0.93 | −2.81 | 0.006※ |
| TC (mmol/L) | 4.92±0.84 | 4.86±0.78 | 5.11±1.01 | −1.43 | 0.155 |
| A1C (%) | 6.24±1.27 | 6.30±1.35 | 6.04±0.97 | 0.99 | 0.325 |

**Note**: ※p-value<0.05.
**Abbreviations**: t, *t*-test; $\chi^2$, Chi-square test; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; T2D, type 2 diabetes; OSAHS, obstructive sleep apnea-hypopnea syndrome; SUA, serum uric acid; TG, triglyceride; HDL-c, high-density lipoprotein cholesterol; LDL-c, low-density lipoprotein cholesterol; TC, total cholesterol; A1C, glycosylated hemoglobin.

**Table 4** Binary Logistic Regression Analysis of Predictive Factors for Complete Remission of HUA

| | OR (95% CI) | *P* |
|---|---|---|
| HC (cm) | 0.963 (0.936~0.991) | 0.010※ |
| Preoperative SUA (μmol/L) | 0.990 (0.983~0.996) | 0.002※ |

**Note**: ※p-value<0.05.
**Abbreviations**: SUA, serum uric acid; HC, hip circumference.

independent variable found that the optimal cut-off value for predicting the remission of postoperative HUA was 457 μmol/L (AUC = 0.731; 95% CI: 0.633–0.814; sensitivity, 0.621; specificity, 0.762; $p < 0.001$).

Next, we combined preoperative HC and preoperative SUA concentration and generated the ROC curve with this joint predictor as the independent variable. The optimal cut-off value of this joint predictive model was 0.414 (AUC = 0.773; 95% CI: 0.679–0.851; sensitivity, 0.776; specificity, 0.738; $p < 0.001$). All constructed ROC curves are illustrated in Figure 2. No significant differences were observed in the pairwise comparisons of the ROCs of the two predictors and the joint predictor (Table 5).

## Internal and External Validation

Since HC and SUA are simple and easy to obtain and do not involve additional trauma or expenses during clinical application, the joint predictive model established based on the joint predictor with good sensitivity and specificity potentially offers greater value in clinical practice, even without significant differences from the other two models. Therefore, the combined predictive model was chosen to be further validated.

The combined prediction model was assessed by conducting an internal validation test (Figure 3) and calibration curve analysis (Figure 4), with the results showing that the predicted probability was consistent with the observed probability (AUC = 0.772). Among the 30 patients in the external validation set, 22 attained complete remission of HUA

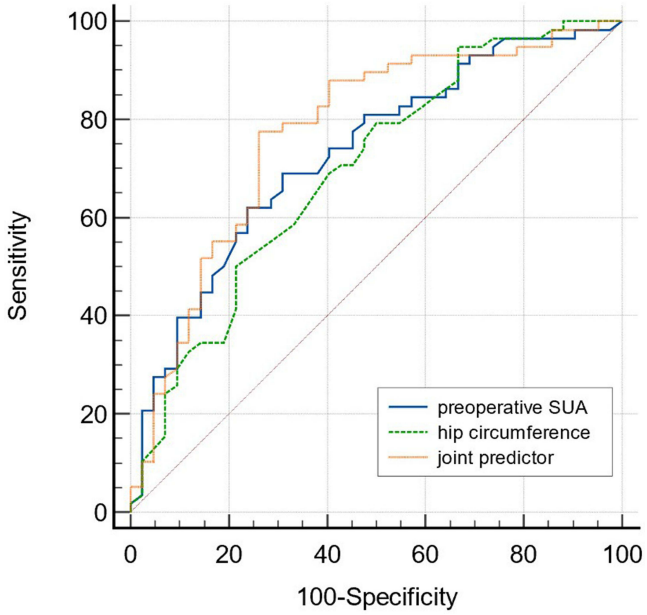


**Figure 2** Comparison of ROC curves of predictive models of preoperative SUA, HC and joint predictor.

at 1 year after surgery, whereas eight did not. Moreover, the consistency between the predicted and observed probabilities in the external validation group was even higher than that in the internal validation group (AUC = 0.875).

## Discussion

In this study, we explored the influencing factors of the HUA remission effect 1 year or more after LSG, and established a clinically user - friendly predictive model based on preoperative data.

Current studies have reported varying findings on the changes in SUA levels after MBS. A study in Sweden showed that SUA concentrations remain decreased for up to 10 years following MBS.[13] A prospective longitudinal study[14] demonstrated that most patients with preoperative gout experience a drop in SUA levels below the treatment target concentration at 12 months following SG, with this change even observed in some of those without uric acid-lowering medication. A meta-analysis conducted by Yeo et al[25] indicated that SUA concentrations begin to decline after the third month following surgery, with a continued reduction until the third-year post-surgery. Birben et al[26] revealed that SUA levels at 1 month after SG were significantly higher than the preoperative levels. However, this pattern was only observed in patients without preoperative HUA. In the case of patients with preoperative HUA, no significant increase in SUA was detected at 1 month following surgery. However, Katsogridaki et al[15] found that HUA remained in 53.9% of patients with preoperative HUA, while 11.5% developed gout. A Chinese population investigation by Li et al[27] showed that the SUA levels of patients with obesity rose to the highest value at 1 week after surgery rather than 1 month, with these values dropping to baseline levels at 3 months following surgery. However, the researchers failed to provide additional data with longer follow-up. Another study by Wang et al[28] involving 25 patients who did not meet the obesity criteria but had undergone SG due to T2D reported that all nine patients with preoperative HUA achieved remission at the 1-year follow-

**Table 5** Comparison of Areas Under the Three Receiver Operating Characteristic Curves

| | Preoperative SUA vs HC | Preoperative SUA vs Joint Predictor | HC vs Joint Predictor |
|---|---|---|---|
| Difference value | 0.0347 | 0.0427 | 0.0774 |
| Standard error (95% CI) | 0.0645 (−0.0917~0.161) | 0.0316 (−0.0192~0.105) | 0.0398 (−0.000564~0.155) |
| Z value | 0.538 | 1.353 | 1.946 |
| *P* | 0.5906 | 0.1761 | 0.0517 |

**Abbreviations**: SUA, serum uric acid, HC, hip circumference.


https://doi.org/10.2147/DMSO.S508015

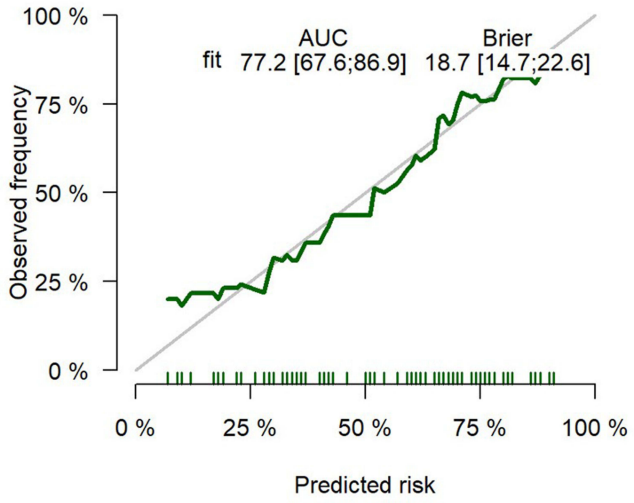


**Figure 3** Internal validation.

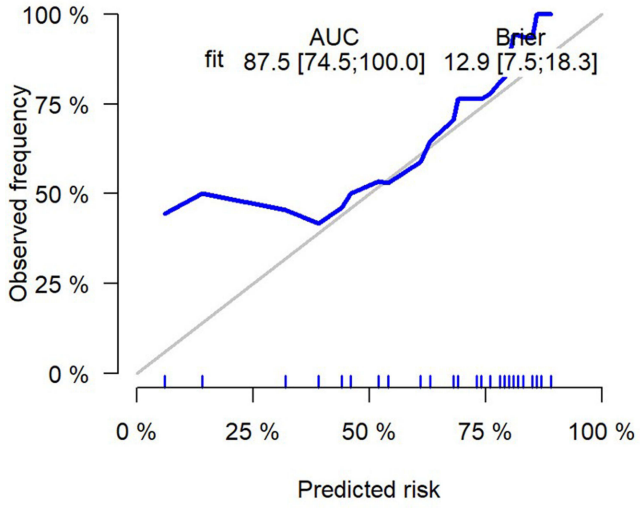


**Figure 4** External validation.

up after surgery, but two with normal preoperative SUA met the criteria of HUA at 3 months after surgery. Although SG has a clear and lasting curative effect on many metabolic components comorbid with obesity, its curative effect on HUA is still debated. Our study sample population and related data indicated that Chinese people with obesity and preoperative HUA, after 1 year, the remission rate of SG for HUA is 58%.

One of the mechanisms of HUA remission after MBS may be related to the inevitable reduction of exogenous purines caused by decreased food intake. Furthermore, uric acid excretion is closely related to renal function.[29] The long-term improvement of renal function following MBS[30] may also help lower SUA levels. Many researchers propose that HUA improvement post-surgery depends on weight loss,[26,31] but no consensus has been reached on this relationship. Dalbeth et al[14] found that during the process of patients losing weight >5 kg before receiving SG, the SUA level did not change much. In line with this result, De La Harpe et al[32] indicated that the remission rate of HUA after Roux-en-Y gastric bypass (RYGB) is not linked to alterations in weight. Thus, other factors may have been involved in the patients who failed to achieve complete HUA remission after surgery.

A crucial part of metabolic and bariatric surgical treatment is the postoperative diet advocated by the American Society for Metabolic and Bariatric Surgery (ASMBS) and the International Federation for the Surgery of Obesity and

Metabolic Disorders (IFSO), which features the intake of high-protein, low-carbohydrate, and low-fat foods, induces the release of endogenous purines.[33–35] The gut microbiome and its secreted transport proteins (such as ABCG2 and glucose transporter 9 [GLUT9], also known as SLC2A9) are also critically involved in the absorption and secretion of uric acid. HUA caused by the mutation or knockdown of intestinal SLC2A9[36] may be challenging to alleviate via MBS. The polymorphisms of genes such as estrogen receptor-α (ESR1)[37] and PPARγ[38] have also shown potential predictive value for predicting HUA remission after MBS. Thus, MBS such as SG for HUA in patients with obesity exhibit large individual differences in therapeutic effects. Therefore, a simple, economical, and effective predictive model is urgently required to assist in the clinical assessment of this patient population.

MBS is currently recognized as the most effective treatment that provides long-lasting improvements for obesity and its comorbidities. The efficacy of MBS in HUA has also been gradually attracting attention,[39] and has been included in the guidelines of the European League Against Rheumatism (EULAR).[40] Among the 100 patients in the modeling group of our study, the remission rate of HUA at least 1 year after LSG was 58%, with 42% of the patients still experiencing HUA. Given the considerably high number of patients with HUA even after surgery, an easy-to-use and effective preoperative predictive model is critically needed to guide clinical decisions and assist in perioperative management. This study selected Chinese patients with obesity and preoperative HUA as the research patients and retrospectively analyzed the factors related to HUA remission following SG. Along with the remission rate of 58% for HUA after SG, we found that preoperative HC and preoperative SUA level could be independently employed to predict the complete remission effect of SG on HUA. Our analysis showed that the AUC values of the predictive models of preoperative HC and preoperative SUA concentration for HUA remission were 0.696 (0.596, 0.784) and 0.731 (0.633, 0.814), respectively. Additionally, the combined predictive model using preoperative HC and preoperative SUA level achieved an AUC of 0.773 (0.679, 0.851), with sensitivity and specificity as high as 0.776 and 0.738, respectively, and its reliability was further confirmed by internal and external validations. The joint predictive model developed in this study offers an important reference value for patients with preoperative HUA who meet the indications for MBS.

HC is usually measured by gently placing a soft ruler on the skin over the highest point of the hips and wrapping it around the body. HC is one of the body measurements that have great significance in MBS. Lu et al[41] collected data on 30 independent variables from three aspects from 540 patients and used canonical correlation analysis to identify the most accurate indicator of the weight loss effect. The results revealed that the basic characteristics of patients were the key factors affecting the weight loss effect, with HC displaying the greatest contribution to this aspect, which showed an r value as high as 0.934 and much higher than BMI, weight, and waist circumference. A study by Cheang et al[42] indicated that the SUA levels of Chinese patients with severe obesity were closely related to their HC, but the study did not involve surgery. Lu et al also found that the prevalence of hyperuricemia was higher in people with a larger hip circumference. This may be related to the fact that people with a greater HC have higher gluteal muscle mass, and more endogenous uric acid are generated via metabolization.[43] To our knowledge, there are currently few studies on the correlation between HC and HUA, and no current research has utilized HC to predict HUA remission after MBS or changes in SUA concentration.[44–46] The predictive model established in this study demonstrated that higher preoperative SUA levels were indicative of a lower likelihood of HUA remission after surgery, which is in line with common sense.

This study has several strengths that are noteworthy. One strength is that we collected comprehensive biochemical data, especially SUA levels, before and after surgery, including several data from ≥5 years following surgery. The availability of these data addresses, to a certain extent, the current lack of long-term data on SUA in Chinese patients with obesity after MBS. The second strength is that this study developed a reliable predictive model relying only on preoperative data, which help patients who are eager to get rid of HUA through MBS obtain rational expects. Furthermore, this predictive model may contribute to better case management and clinical decision-making.

This study has certain limitations that should be considered. First, our study had a relatively small sample size, with only 100 patients in the modeling group. However, different from surgeries such as those for tumors, MBS has a generally poor follow-up compliance rate.[47,48] Thus, obtaining postoperative follow-up data, including SUA levels, from all 100 patients was notably difficult. Nevertheless, we used these data to successfully establish a predictive model

with excellent sensitivity and specificity. Second, the present study only included patients who underwent SG. Hence, the predictive effect of the investigated variables on HUA remission after other surgical procedures, such as RYGB, requires further validation. Third, given the nature of retrospective study, recall bias may have affected our findings. However, the SUA data utilized as the evaluation criteria for end events were exported from the hospital database and were true and reliable. Therefore, the reliability of the model developed in our study can still be guaranteed. Finally, the remission criterion for HUA applied in this study may have been extremely stringent. We defined complete remission as completely normal SUA levels from the latest tests after surgery. This criterion led to the inevitable classification of unrelieved HUA among some patients whose SUA levels had not dropped to the normal range but had significantly decreased after surgery. This shortcoming may have resulted in the estimated remission rate of HUA being lower than the actual situation. In summary, the increasing prevalence of obesity and HUA across large proportions of the population in the current society necessitates large-sample, multi-center, large-scale studies with long-term follow-up and validation of HUA remission following MBS and to assist in making clinical decisions that are beneficial to doctors and affected patients.

## Conclusion

Some patients who undergo SG can achieve complete remission of HUA. Additionally, preoperative SUA level and preoperative HC can be used to predict the remission effect of SG on HUA in Chinese patients with obesity. The combined predictive model based on the above two variables may provide greater clinical value.

## Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of our institution (Capital Medical University Affiliated Beijing Shijitan Hospital, approval no.: sjtkyll-lx-2022(076)).

## Consent

Informed consent was provided from patients.

## Funding

This work was supported by ①Talent Training Program at Beijing Shijitan Hospital, Capital Medical University during the 14th Five-Year Plan Period, No. 2024LJRCZNW, ②the Capital Medical University Affiliated Beijing Shijitan Hospital Youth Fund Project No. 2023-
q09, ③China Railway Group Co., Ltd. Science and Technology Research and Development Plan, No. J2023Z612.

## Disclosure

The authors declare that they have no conflicts of interests.

## References

1. American College of Physicians, American Physiological Society; Choi HK, Mount DB, Reginato AM. Pathogenesis of gout. *Ann Intern Med*. 2005;143(7):499–516. doi:10.7326/0003-4819-143-7-200510040-00009
2. Choi HK, Zhang Y. Bariatric surgery as urate-lowering therapy in severe obesity. *Ann Rheum Dis*. 2014;73(5):791–793. doi:10.1136/annrheumdis-2013-204861
3. Liu R, Han C, Wu D, et al. Prevalence of hyperuricemia and gout in Mainland China from 2000 to 2014: a systematic review and meta-analysis. *BioMed Res Int*. 2015;2015:762820. doi:10.1155/2015/762820
4. Multidisciplinary Expert Task Force on Hyperuricemia and Related Diseases. Chinese multidisciplinary expert consensus on the diagnosis and treatment of hyperuricemia and related diseases. *Chin Med J*. 2017;130(20):2473–2488. doi:10.4103/0366-6999.216416
5. Uaratanawong S, Suraamornkul S, Angkeaw S, Uaratanawong R. Prevalence of hyperuricemia in Bangkok population. *Clin Rheumatol*. 2011;30(7):887–893. doi:10.1007/s10067-011-1699-0
6. Song J, Jin C, Shan Z, Teng W, Li J. Prevalence and risk factors of hyperuricemia and gout: a cross-sectional survey from 31 provinces in Mainland China. *J Transl Intern Med*. 2022;10(2):134–145. doi:10.2478/jtim-2022-0031
7. Qu X, Zheng L, Zu B, Jia B, Lin W. Prevalence and clinical predictors of hyperuricemia in Chinese bariatric surgery patients. *Obes Surg*. 2022;32(5):1508–1515. doi:10.1007/s11695-021-05852-6
8. Panlu K, Zhou Z, Huang L, Ge L, Wen C, Lv H. Associations between obesity and hyperuricemia combing Mendelian randomization with network pharmacology. *Heliyon*. 2024;10(6):e27074. doi:10.1016/j.heliyon.2024.e27074

9. Chinese Society for Metabolic and Bariatric Surgery (CSMBS), Chinese Society for Integrated Health of Metabolic and Bariatric Surgery (CSMBS IH), Chinese Obesity and Metabolic Surgery Collaborative (COMES Collaborative). Chinese obesity and metabolic surgery database: annual report 2023 (in Chinese). *Chin J Obes Metab Dis*. 2024;10(2):73–83. doi:10.3877/cma.j.issn.2095-9605.2024.02.001
10. Abhishek F, Ogunkoya GD, Gugnani JS, et al. Comparative analysis of bariatric surgery and non-surgical therapies: impact on obesity-related comorbidities. *Cureus*. 2024;16(9):e69653. doi:10.7759/cureus.69653
11. Holt BL, Rice WV. A prospective single-center study evaluating the efficacy of the stomach, intestinal, and pylorus-sparing procedure. *Surg Obes Relat Dis off J Am Soc Bariatr Surg*. 2023;19(6):612–618. doi:10.1016/j.soard.2022.12.020
12. Lampropoulos C, Kehagias D, Bellou A, et al. Critical time points for assessing long-term clinical response after sleeve gastrectomy-A retrospective study of patients with 13-year follow-up. *Obes Surg*. 2025;35(2):571–581. doi:10.1007/s11695-024-07659-7
13. Maglio C, Peltonen M, Neovius M, et al. Effects of bariatric surgery on gout incidence in the Swedish obese subjects study: a non-randomised, prospective, controlled intervention trial. *Annals of the rheumatic diseases*. 2017;76(4):688–693. doi:10.1136/annrheumdis-2016-209958
14. Dalbeth N, Chen P, White M, et al. Impact of bariatric surgery on serum urate targets in people with morbid obesity and diabetes: a prospective longitudinal study. *Ann Rheum Dis*. 2014;73(5):797–802. doi:10.1136/annrheumdis-2013-203970
15. Katsogridaki G, Tzovaras G, Sioka E, et al. Hyperuricemia and acute gout after laparoscopic sleeve gastrectomy. *Clin Obes*. 2019;9(2):e12296. doi:10.1111/cob.12296
16. Zetu C, Popa S, Golli AL, Condurache A, Munteanu R. Long-term improvement of dyslipidaemia, hyperuricemia and metabolic syndrome in patients undergoing laparoscopic sleeve gastrectomy. *Arch Endocrinol Metab*. 2020;64(6):704. doi:10.20945/2359-3997000000273
17. Inge TH, Courcoulas AP, Jenkins TM, et al. Weight loss and health status 3 years after bariatric surgery in adolescents. *N Engl J Med*. 2016;374 (2):113–123. doi:10.1056/NEJMoa1506699
18. Maciejewski ML, Arterburn DE, Scoyoc LV, et al. Bariatric surgery and long-term durability of weight loss. *JAMA Surg*. 2016;151(11):1046. doi:10.1001/jamasurg.2016.2317
19. Liu JG, Zheng CZ, Wang Y. Chinese guidelines for surgical treatment of obesity and type 2 diabetes (2014). *Chin J Pract Surg*. 2014;34 (11):1005–1010. doi:10.7504/CJPS.ISSN1005-2208.2014.11.01
20. Chinese Medical Association, Chinese Medical Journals Publishing House, Chinese Society of General Practice. Guideline for primary care of obesity (2019) (in Chinese). *Chin J Gen Pract*. 2020;19(02):95–101. doi:10.3760/cma.j.issn.1671-7368.2020.02.002
21. Writing Group of 2010 Chinese Guidelines for the Management of Hypertension. 2010 Chinese guidelines for the management of hypertension (in Chinese). *Chin J Cardiol*. 2011;39(7):579–616. doi:10.3760/cma.j.issn.0253-3758.2011.07.002
22. Chinese Diabetes Society. Guideline for the prevention and treatment of type 2 diabetes mellitus in China (2020 edition) (in Chinese). *Chin J Diabetes Mellitus*. 2021;13(4):315–409. doi:10.3760/cma.j.cn115791-20210221-00095
23. Joint Committee for Developing Chinese guidelines on Prevention and Treatment of Dyslipidemia in Adults. Chinese guidelines on prevention and treatment of dyslipidemia in adults (2007) (in Chinese). *Chin J Cardiol*. 2007;35(05):390–419. doi:10.3760/j.issn:0253-3758.2007.05.003
24. Wang L, Xu G, Tian C, et al. Combination of single-nucleotide polymorphisms and preoperative body mass index to predict weight loss after laproscopic sleeve gastrectomy in Chinese patients with body mass index ≥ 32.5 kg/m$^2$. *Obes Surg*. 2022;32(12):3951–3960. doi:10.1007/s11695-022-06330-3
25. Yeo C, Kaushal S, Lim B, et al. Impact of bariatric surgery on serum uric acid levels and the incidence of gout—A meta-analysis. *Obes Rev*. 2019;20(12):1759–1770. doi:10.1111/obr.12940
26. Birben B, Akkurt G, Tez M, Yildiz BD. Long-term impact of sleeve gastrectomy on serum uric acid levels. *Turk J Med Sci*. 2023;53(1):206–210. doi:10.55730/1300-0144.5574
27. Li M, Liu Y, Zeng N, et al. Alterations in the serum urate concentrations after bariatric surgery: a short-term prospective observational study. *Obes Surg*. 2021;31(4):1688–1695. doi:10.1007/s11695-020-05181-0
28. Wang L, Wang J, Jiang T. Effect of laparoscopic sleeve gastrectomy on type 2 diabetes mellitus in patients with body mass index less than 30 kg/m2. *Obes Surg*. 2019;29(3):835–842. doi:10.1007/s11695-018-3602-4
29. Chi J, Chen Y, Li C, et al. NUMB dysfunction defines a novel mechanism underlying hyperuricemia and gout. *Cell Discov*. 2024;10(1):106. doi:10.1038/s41421-024-00708-6
30. Huang H, Lu J, Dai X, et al. Improvement of renal function after bariatric surgery: a systematic review and meta-analysis. *Obes Surg*. 2021;31 (10):4470–4484. doi:10.1007/s11695-021-05630-4
31. Serpa Neto A, Rossi FMB, Valle LGM, Teixeira GK, Rossi M. Relation of uric acid with components of metabolic syndrome before and after Roux-en-Y gastric bypass in morbidly obese subjects. *Arq Bras Endocrinol Metabol*. 2011;55(1):38–45. doi:10.1590/S0004-27302011000100005
32. de La Harpe R, Rüeger S, Kutalik Z, et al. Weight loss directly influences intermediate-term remission of diabetes mellitus after bariatric surgery: a retrospective case-control study. *Obes Surg*. 2020;30(4):1332–1338. doi:10.1007/s11695-019-04283-8
33. Eisenberg D, Shikora SA, Aarts E, et al. 2022 American society for metabolic and bariatric surgery (ASMBS) and international federation for the surgery of obesity and metabolic disorders (IFSO): indications for metabolic and bariatric surgery. *Surg Obes Relat Dis off J Am Soc Bariatr Surg*. 2022;18(12):1345–1356. doi:10.1016/j.soard.2022.08.013
34. Tana C, Busetto L, Di Vincenzo A, et al. Management of hyperuricemia and gout in obese patients undergoing bariatric surgery. *Postgrad Med*. 2018;130(6):523–535. doi:10.1080/00325481.2018.1485444
35. Song K, Kong X, Yu Z, Xiao H, Ren Y. Research progress on bariatric surgery for hyperuricemia. *BMC Surg*. 2024;24(1):235. doi:10.1186/s12893-024-02525-w
36. Ezenabor EH, Adeyemi AA, Adeyemi OS. Gut microbiota and metabolic syndrome: relationships and opportunities for new therapeutic strategies. *Scientifica*. 2024;2024(1):4222083. doi:10.1155/2024/4222083
37. Wang W, Liou TH, Lee WJ, Hsu CT, Lee MF, Chen HH. ESR1 gene and insulin resistance remission are associated with serum uric acid decline for severely obese patients undergoing bariatric surgery. *Surg Obes Relat Dis*. 2014;10(1):14–22. doi:10.1016/j.soard.2012.10.011
38. Lee MF, Liou TH, Wang W, et al. Gender, body mass index, and PPARγ polymorphism are good indicators in hyperuricemia prediction for han Chinese. *Genet Test Mol Biomark*. 2013;17(1):40–46. doi:10.1089/gtmb.2012.0231
39. Kehagias I, Bellou A, Kehagias D, et al. Long-term (11 + years) efficacy of sleeve gastrectomy as a stand-alone bariatric procedure: a single-center retrospective observational study [published correction appears in Langenbecks Arch Surg. 2023 Feb 16;408(1):92. doi: 10.1007/s00423-023-02824-5]. *Langenbecks Arch Surg*. 2022;408(1):4. doi:10.1007/s00423-022-02734-y

40. Richette P, Doherty M, Pascual E, et al. 2016 updated EULAR evidence-based recommendations for the management of gout. *Ann Rheum Dis*. 2017;76(1):29–42. doi:10.1136/annrheumdis-2016-209707
41. Lu G, Dong Z, Huang B, et al. Determination of weight loss effectiveness evaluation indexes and establishment of a nomogram for forecasting the probability of effectiveness of weight loss in bariatric surgery: a retrospective cohort. *Int J Surg*. 2023;109(4):850. doi:10.1097/JS9.0000000000000330
42. Cheang C, Law S, Ren J, Chan W, Wang C, Dong Z. Prevalence of hyperuricemia in patients with severe obesity and the relationship between serum uric acid and severe obesity: a decade retrospective cross-section study in Chinese adults. *Front Public Health*. 2022;10:986954. doi:10.3389/fpubh.2022.986954
43. Lu W, Zhao X, Sheng J, et al. Hip circumference has independent association with the risk of hyperuricemia in middle-aged but not in older male patients with type 2 diabetes mellitus. *Nutr J*. 2023;22(1):45. doi:10.1186/s12937-023-00874-5
44. Pizza F, D'Antonio D, Lucido FS, et al. The role of ursodeoxycholic acid (UDCA) in cholelithiasis management after one anastomosis gastric bypass (OAGB) for morbid obesity: results of a monocentric randomized controlled trial. *Obes Surg*. 2020;30(11):4315–4324. doi:10.1007/s11695-020-04801-z
45. Pizza F, D'Antonio D, Lucido FS, et al. Postoperative clinical-endoscopic follow-up for GERD and gastritis after one anastomosis gastric bypass for morbid obesity: how, when, and why. *Obes Surg*. 2020;30(11):4391–4400. doi:10.1007/s11695-020-04805-9
46. Pizza F, D'Antonio D, Lucido FS, et al. Does antrum size matter in sleeve gastrectomy? A prospective randomized study. *Surg Endosc*. 2021;35(7):3524–3532. doi:10.1007/s00464-020-07811-1
47. de la Cruz-Muñoz N, Xie L, Quiroz HJ, et al. Long-term outcomes after adolescent bariatric surgery. *J Am Coll Surg*. 2022;235(4):592. doi:10.1097/XCS.0000000000000325
48. Kochis M, Bizimana C, Stetson A, et al. Metabolic and bariatric surgery outcomes in adolescents: a single center's seven-year update. *Surg Endosc*. 2024;38(11):6908–6917. doi:10.1007/s00464-024-11273-0