original article

Relation of uric acid with components of metabolic syndrome before and after Roux-en-Y gastric bypass in morbidly obese subjects

Relação do ácido úrico com os componentes da síndrome metabólica antes e após o bypass gástrico com reconstrução em Y-de-Roux em pacientes obesos mórbidos

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ABSTRACT

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Objective: The purpose of the study was to investigate the prevalence of hyperuricemia in morbidly obese subjects before and after Roux-en-Y gastric bypass (RYGBP) and its relationship with metabolic syndrome abnormalities. **Subjects and method:** We evaluated 420 morbidly obese patients. Pre and postoperative (8 months after RYGBP) blood samples were drawn. Obese patients underwent laparoscopic RYGBP and after eight months all the tests were repeated. **Results:** The overall prevalence of hyperuricemia was 34.28%. Hyperuricemia was more common in men than in women (51.72 *vs.* 29.72%; p = 0.0002). Men with hyperuricemia were more likely to have diabetes (p = 0.034) and more elevated fasting plasma glucose levels (p = 0.027). Women with hyperuricemia were more likely to have hypertension (p = 0.003), metabolic syndrome (p = 0.001), elevated triglycerides (p = 0.001) and GGT (p = 0.009), and decreased HDL (p = 0.011). After surgery, uric acid levels decreased from 5.60 ± 1.28 to 4.23 ± 1.20 (p < 0.0001). The prevalence of hyperuricemia decreased from 33.6% to 6.4% (p < 0.0001), in men from 48.3% to 17.2% (p < 0.0001) and in women from 29.7% to 3.6% (p < 0.0001). **Conclusion:** Concentrations of uric acid were associated with the prevalence of metabolic abnormalities in this sample of morbidly obese patients. Also, weight loss after RYGBP can reduce uric acid levels and the prevalence of hyperuricemia. Arq Bras Endocrinol Metab. 2011;55(1):38-45

RESUMO

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Objetivo: O objetivo do estudo foi investigar a prevalência de hiperuricemia em pacientes obesos mórbidos antes e após o bypass gástrico com reconstrução em Y-de-Roux (RYGBP) e sua relação com anormalidades da síndrome metabólica. **Sujeitos e métodos:** Foram avaliados 420 pacientes com obesidade mórbida. Amostras de sangue pré e pós-operatório (8 meses após RYGBP) foram obtidas. Os pacientes obesos foram submetidos a RYGBP laparoscópica e após oito meses todos os testes foram repetidos. **Resultados:** A prevalência de hiperuricemia foi 34,28%. A hiperuricemia foi mais comum em homens do que em mulheres (51,72 *vs.* 29,72%, p = 0,0002). Homens com hiperuricemia foram mais propensos a ter diabetes (p = 0,034) e tinham níveis mais elevados de glicemia de jejum (p = 0,027). Mulheres com hiperuricemia foram mais propensas a ter hipertensão arterial (p = 0,003), síndrome metabólica (p = 0,001), triglicérides elevado (p = 0,001) e GGT (p = 0,009) e diminuição de HDL (p = 0,011). Após a cirurgia, os níveis de ácido úrico diminuíram de 5,60 ± 1,20 para 4,23 ± 1,20 (p < 0,0001). A prevalência de hiperuricemia diminuiu 33,6% para 6,4% (p < 0,0001), em homens de 48,3% para 17,2% (p < 0,0001) e nas mulheres de 29,7% para 3,6% (p < 0,0001). **Conclusão:** As concentrações de ácido úrico foram associadas com a prevalência de anormalidades metabólicas nesta amostra de pacientes com obesidade mórbida. Além disso, a perda de peso após RYGBP pode reduzir os níveis de ácido úrico e a prevalência de hiperuricemia. Arq Bras Endocrinol Metab. 2011;55(1):38-45

INTRODUCTION

Metabolic syndrome comprises several abnormalities that occur together more often than would be expected by chance. Typically, general or central adiposity, elevated blood pressure, dyslipidemia, and hyperglycemia are thought to be part of this syndrome. In addition, several other abnormalities including those of fibrinolysis, thrombosis, inflammation, and endothelial function are strongly related to the syndrome.

There continues to be a need to better understand the pattern of risk factor clustering that constitutes metabolic syndrome and the relationship of the syndrome to emerging risk factors for cardiovascular disease. The positive association between serum uric acid and cardiovascular diseases such as stroke or ischemic heart disease has been recognized since the 1950s and has been confirmed by numerous epidemiological studies (1-3). However, whether uric acid is an independent risk factor for cardiovascular mortality is still disputed as several studies have suggested that hyperuricemia is merely associated with cardiovascular diseases because of confounding factors such as obesity, dyslipidemia, hypertension, use of diuretics and insulin resistance (4,5).

Elevated serum uric acid levels (UA) are commonly seen in association with glucose intolerance, hypertension, and dyslipidemia, a cluster of metabolic and hemodynamic disorders which characterize the so-called metabolic syndrome (6,7). Studies performed in healthy volunteers as well as in subjects with asymptomatic hyperuricemia have suggested that the link between metabolic syndrome and serum uric acid is related to the ability of insulin to decrease uric acid clearance in the renal proximal tubule resulting in an increase in serum uric acid levels (8).

The purpose of the present study was to investigate the prevalence of hyperuricemia in morbidly obese subjects before and after Roux-en-Y gastric bypass (RYGBP) and its relationship with metabolic syndrome abnormalities.

SUBJECTS AND METHOD

Study population

Four hundred and twenty morbidly obese patients were considered eligible to participate in this study according to the following inclusion criteria: body mass index (BMI) ≥ 40 kg/m², age between 18 and 60 years, and no history of liver disease. Most patients (68.5%) were women and the mean body mass index was 47.1 ± 5.4 kg/m².

Study protocol and follow-up

Pre and postoperative (at 8 months after bariatric surgery) blood samples were drawn after a minimum fasting period of 8h. Laboratorial analyses were performed using standard methodologies. BMI is defined as the individual's body weight divided by the square of his/her height. To define metabolic syndrome (MS) we used the International Diabetes Federation (IDF) criteria: waist circumference ≥ 94 cm in men, ≥ 80 cm in women or BMI ≥ 30 kg/m²; triglyceride levels ≥ 150 mg/dL (1.7 mmol/L) and/or specific treatment; HDL-C levels < 40 mg/dL (1 mmol/L) in men, < 50 mg/dL (1.3 mmol/L) in women and/or specific treatment; fasting glucose ≥ 100 mg/dL (5.6 mmol/L) and/or DM2 patient; systolic blood pressure ≥ 130 mmHg, diastolic blood pressure ≥ 85 mmHg and/or specific treatment. An individual must present at least three of the five risk factors to be diagnosed with MS. Hyperuricemia was defined as uric acid > 6 mg/dL (women) and 6.8 mg/dL (men).

The obese patients underwent laparoscopic RYGBP and after eight months all the tests were repeated. RYGBP is a mixed technique that uses more of a restrictive and less of a disabsortive participation. Its main characteristics are the formation of a gastric "pouch" (15 ± 5 mL), an alimentary loop of 100 cm, a biliopancreatic loop of 60 cm, and a common loop.

This retrospective study was approved by the Ethics Committee of Faculdade de Medicina do ABC.

Statistical methods

Data were first tested for normal distribution with the Kolmogorov-Smirnov test. For cross-sectional comparisons, concentration of uric acid between those with and without metabolic syndrome and its components at baseline were compared using ANCOVA adjusted for age and ethnicity. The patients were divided into four equal quarters on the basis of uric acid distributions and linear regression analysis was used to test for trends across the four groups fitting quantitative variables for the four groups.

For prospective analyses baseline means (with SDs) were calculated for subjects in follow-up with t tests, Wilcoxon tests or χ^2 tests. The association of uric acid with anthropometric and metabolic variables was evaluated using Pearson correlation analysis controlled for age and ethnicity. Multivariate logistic regression models were used to assess associations of uric acid with

risk of prevalent metabolic syndrome and with the improvement of it after weight loss, taking in account potential confounders. We evaluated the degree to which uric acid predicted improvement of metabolic syndrome after Roux-en-Y gastric bypass using logistic regression.

All statistical analyses were made with the statistical software package SPSS (v16.0; SPSS, Chicago, IL) and MedCalc software. Statistical significance was considered at $p < 0.05$.

RESULTS

The overall prevalence of hyperuricemia was 34.28%. Hyperuricemia was more common in men than in women (51.72 vs. 29.72%; p = 0.0002). Some characteristics of the study population according to hyperuricemia status are shown in table 1. Men with hyperuricemia, as compared with those without the condition, were more likely to have diabetes (p = 0.034) and more elevated fasting plasma glucose levels (p = 0.027). Women with hyperuricemia as compared with their counterparts without the condition were more likely to have hypertension (p = 0.003), metabolic syndrome (p = 0.001), elevated triglycerides (p = 0.001) and GGT (p = 0.009), and decreased HDL (p = 0.011).

In men, GGT and fasting plasma glucose showed a graded increase according to uric acid quartiles. In women we observed an increase in triglyceride levels and hypertension prevalence (Table 2). In men, mean GGT in the fourth quartile was higher than that in the first quartile (p = 0.006), and in women mean triglycerides in the fourth quartile was higher than that in the first quartile (p = 0.033). The prevalence of metabolic syndrome in men was higher in the second quartile than that in the first quartile (p = 0.023), and the prevalence of hypertension and fasting plasma glucose ≥ 100 mg/dL in the second and fourth quartile was higher than that in the first quartile (p = 0.002 for the second quartile and p = 0.009 for the fourth quartile of hypertension and p = 0.038 for the second quartile and p = 0.009 for the fourth quartile of fasting plasma glucose ≥ 100 mg/dL). In women the prevalence of hypertension was higher in the third and fourth quartile than that in the first quartile (p = 0.030 for the third quartile and p = 0.000 for the fourth quartile), and the prevalence of triglycerides ≥ 150 mg/dL was higher in the fourth quartile than that in the first quartile (p = 0.000).

Pearson's correlation coefficients for the relationship between uric acid and each variable in women were significant for triglycerides (r = 0.20; p = 0.029) and GGT (r = 0.23; p = 0.018). In men the correlation was significant also for GGT (r = 0.45; p = 0.013) and for fasting plasma glucose (r = 0.38; p = 0.039). As shown in table 3, elevated triglycerides and hypertension were statistically significantly associated with higher uric acid concentration in women. There was no statistical significance between metabolic abnormalities and uric acid concentrations in men.

Table 1. Characteristic of the study population according to hyperuricemia status*

Variables	Men (n = 87)			Women (n = 333)		
	Non-hyperuricemia (n = 42)	Hyperuricemia (n = 45)	p value	Non-hyperuricemia (n = 234)	Hyperuricemia (n = 99)	p value
Age (years)	29.66 ± 8.3	36.85 ± 8.8	0.032	38.76 ± 10.1	37.69 ± 9.7	0.609
BMI (kg/m²)	46.49 ± 4.8	45.06 ± 5.5	0.469	43.73 ± 4.0	43.79 ± 4.4	0.945
Hypertension	15 (35.7%)	24 (53.3%)	0.151	99 (42.3%)	60 (60.6%)	0.003
Diabetes	3 (7.14%)	12 (26.6%)	0.034	42 (17.9%)	15 (15.1%)	0.644
MS	22 (52.3%)	32 (71.1%)	0.113	100 (42.2%)	63 (63.3%)	0.000
TG (mg/dL)	217.07 ± 137.3	181.71 ± 66.0	0.390	130.35 ± 59.7	179.97 ± 98.4	0.001
HDL (mg/dL)	45.33 ± 9.6	44.86 ± 10.6	0.900	49.71 ± 11.2	43.82 ± 9.9	0.011
FPG (mg/dL)	92.67 ± 11.5	111.29 ± 28.4	0.027	96.95 ± 22.7	101.48 ± 27.6	0.370
TB (mg/dL)	0.56 ± 0.1	0.68 ± 0.4	0.373	0.62 ± 0.6	0.57 ± 0.2	0.684
Cr (mg/dL)	0.93 ± 0.1	1.05 ± 0.2	0.164	0.79 ± 0.1	0.79 ± 0.1	0.951
GGT (IU/L)	40.00 ± 18.9	53.21 ± 29.1	0.156	34.85 ± 16.3	51.45 ± 49.7	0.009

Data expressed as mean ± SD or n (percentage).
* Hyperuricemia defined as uric acid > 6 mg/dL (women) and 6.8 mg/dL (men).
MS: metabolic syndrome; TG: triglyceride; FPG: fasting plasma glucose; TB: total bilirubin; Cr: creatinine; GGT: Gamaglutamil tranferase.

Table 2. Baseline characteristics by uric acid quartiles

Variables	Quartiles of serum uric acid				p value
	1	2	3	4	
Men (87)					
Uric acid range (mg/dL)	≤ 6.14	6.15 – 6.69	6.70 – 7.74	≥ 7.75	
No. Subjects	21	18	27	21	
Age (years)	27.57 ± 5.6	32.50 ± 11.7	35.66 ± 9.0	36.00 ± 8.8	0.072
BMI (kg/m²)	46.26 ± 4.46	47.89 ± 6.1	45.80 ± 6.1	43.53 ± 3.8	0.260
Uric acid (mg/dL)	5.22 ± 0.6	6.45 ± 0.1	7.07 ± 0.3	8.11 ± 0.4	0.000
Total bilirubin (mg/dL)	0.47 ± 0.1	0.66 ± 0.1	0.55 ± 0.2	0.81 ± 0.6	0.154
Creatinine (mg/dL)	0.88 ± 0.2	0.91 ± 0.0	1.08 ± 0.1	1.04 ± 0.3	0.108
GGT (IU/L)	34.14 ± 19.5	44.66 ± 19.0	35.77 ± 19.0	73.71 ± 22.4	0.003
Triglycerides (mg/dL)	171.29 ± 79.1	243.00 ± 182.6	199.11 ± 104.6	193.00 ± 58.2	0.887
HDL (mg/dL)	47.14 ± 10.1	45.00 ± 10.5	44.11 ± 7.8	44.43 ± 13.3	0.603
Fasting glucose (mg/dL)	87.00 ± 5.5	96.83 ± 14.3	108.11 ± 28.0	112.14 ± 27.7	0.027
Metabolic syndrome	9 (42.8%)	15 (83.3%)	12 (44.4%)	15 (71.4%)	0.588
Hypertension	3 (14.2%)	12 (66.6%)	12 (44.4%)	12 (57.1%)	0.204
FPG ≥ 100 mg/dL	3 (14.2%)	9 (50%)	12 (44.4%)	12 (57.1%)	0.159
HDL ≤ 40 mg/dL	6 (28.5%)	6 (33.3%)	9 (33.3%)	9 (42.8%)	0.622
TG ≥ 150 mg/dL	12 (57.1%)	9 (50%)	24 (88.8%)	18 (85.7%)	0.107
Women (333)					
Uric acid range (mg/dL)	≤ 4.69	4.70 – 5.29	5.30 – 6.09	≥ 6.10	
No. subjects	78	81	81	93	
Age (years)	39.11 ± 9.1	35.81 ± 8.8	41.74 ± 11.7	37.32 ± 9.6	0.948
BMI (kg/m²)	44.82 ± 5.0	43.32 ± 3.5	43.11 ± 3.26	43.78 ± 4.5	0.346
Uric acid (mg/dL)	3.77 ± 0.5	5.02 ± 0.1	5.62 ± 0.2	6.56 ± 0.7	0.000
Total bilirubin (mg/dL)	0.58 ± 0.2	0.53 ± 0.2	0.75 ± 1.0	0.56 ± 0.2	0.740
Creatinine (mg/dL)	0.81 ± 0.1	0.78 ± 0.1	0.77 ± 0.1	0.80 ± 0.1	0.837
GGT (IU/L)	36.57 ± 21.7	34.62 ± 14.0	45.88 ± 53.0	41.67 ± 21.5	0.315
Triglycerides (mg/dL)	127.23 ± 62.9	133.19 ± 63.8	132.30 ± 52.4	181.61 ± 101.2	0.008
HDL (mg/dL)	46.85 ± 10.8	50.67 ± 10.6	50.15 ± 12.9	44.61 ± 9.7	0.366
Fasting glucose (mg/dL)	94.50 ± 15.0	103.33 ± 29.6	96.63 ± 28.5	98.55 ± 21.3	0.791
Metabolic syndrome	42 (53.8%)	48 (52.9%)	45 (55.5%)	42 (45.1%)	0.607
Hypertension	27 (34.6%)	27 (33.3%)	48 (52.9%)	57 (61.2%)	0.003
FPG ≥ 100 mg/dL	21 (26.9%)	30 (37.0%)	33 (40.7%)	30 (32.2%)	0.757
HDL ≤ 50 mg/dL	51 (65.3%)	42 (51.8%)	48 (52.9%)	69 (74.1%)	0.281
TG ≥ 150 mg/dL	24 (30.7%)	33 (40.7%)	36 (44.4%)	54 (58.0%)	0.051

FPG: fasting plasma glucose; TG: triglycerides.

In men, hyperuricemia showed sensitivity and specificity of 41.1 and 50.0% for the diagnosis of metabolic syndrome and in women sensitivity was 76.2% and specificity 32.6% (Figure 1).

After surgery, uric acid levels decreased from 5.60 ± 1.28 to 4.23 ± 1.20 (p < 0.0001). In men this decrease was from 6.75 ± 1.12 to 5.36 ± 1.42 (p < 0.0001) and in women from 5.31 ± 1.14 to 3.93 ± 0.93 (p < 0.0001) (Figure 2). Prevalence of hyperuricemia decreased from 33.6% to 6.4% (p < 0.0001), in men from 48.3% to 17.2% (p < 0.0001) and in women from 29.7% to 3.6% (p < 0.0001). In women GGT and metabolic syndrome and hypertension prevalence showed a graded increase according to uric acid quartiles (Table 4). In women, mean GGT in the fourth quartile was higher than that in the first and second quartile (p = 0.019 and p = 0.004, respectively) and mean triglycerides in the fourth quartile were higher than that in the second quartile (p = 0.005).

Table 3. Means of uric acid (mg/dL) according to selected features of metabolic abnormalities

Variables	Men (n = 87)			Women (n = 333)		
	n	Uric acid (mg/dL)	p value	n	Uric acid (mg/dL)	p value
Metabolic syndrome						
Yes	51	6.82 ± 1.14		177	5.27 ± 1.14	
No	36	6.64 ± 1.14	0.667	156	5.35 ± 1.16	0.738
BMI						
< 45 kg/m²	51	6.91 ± 1.14		228	5.23 ± 1.07	
≥ 45 kg/m²	36	6.52 ± 1.10	0.372	105	5.46 ± 1.29	0.337
Hypertension						
Yes	39	6.96 ± 1.04		159	5.61 ± 1.17	
No	48	6.58 ± 1.19	0.369	174	5.03 ± 1.05	0.007
Fasting plasma glucose						
< 100 mg/dL	51	6.54 ± 1.05		219	5.27 ± 1.20	
≥ 100 mg/dL	36	7.04 ± 1.20	0.251	114	5.38 ± 1.04	0.600
Triglyceride						
< 150 mg/dL	24	6.22 ± 1.06		186	5.12 ± 1.05	
≥ 150 mg/dL	63	6.95 ± 1.10	0.122	147	5.54 ± 1.22	0.044
HDL						
> 40 mg/dL / > 50 mg/dL	57	6.60 ± 1.12		123	5.16 ± 0.90	
≤ 40 mg/dL / ≤ 50 mg/dL	30	7.03 ± 1.13	0.090	210	5.39 ± 1.26	0.277

BMI: body mass index.
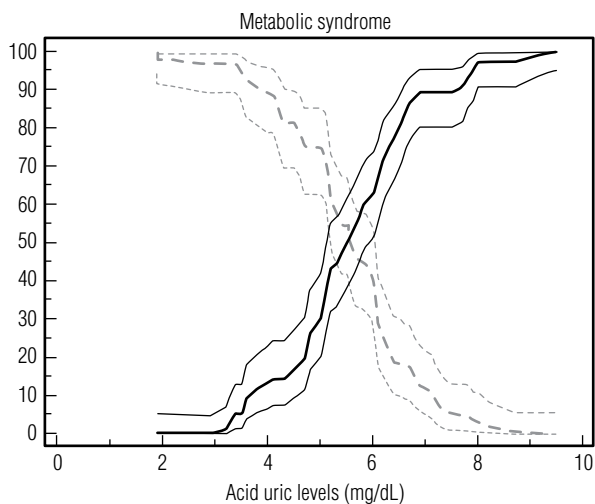
Figure 1. Levels of uric acid for the diagnosis of metabolic syndrome (men and women). Sensitivity (*black line*) and specificity (*gray line*).
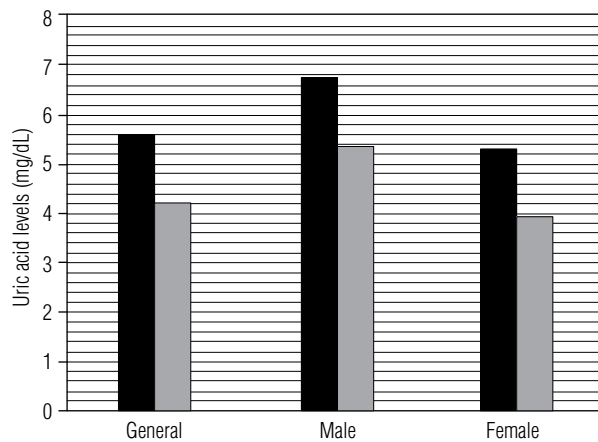
Figure 2. Uric acid levels before (*dark bars*) and after (*gray bars*) Roux-en-Y gastric bypass in general, men and women. All p values are less than 0.0001.

Patients with improvement of metabolic syndrome after RYGBP showed a greater decrease of uric acid levels than those without improvement of MS (- 1.52 ± 1.10 *vs.* 1.23 ± 1.23, respectively; p = 0.031). In the group of patients with hyperuricemia before RYGBP, those who became normouricemic after surgery showed 2.70 more chance of improvement of metabolic syndrome than those without normalization of uric acid levels.

DISCUSSION

We showed in the present study that hyperuricemic men have a higher prevalence of diabetes and higher fasting glucose. Women showed a higher prevalence of hypertension, metabolic syndrome, hypertriglyceridemia, and low HDL. In general, elevated levels of uric acid seem to be related to many metabolic abnormalities. Weight loss after RYGBP is accompanied by

Table 4. Characteristics by uric acid quartiles eight months after Roux-en-Y gastric bypass

Variables	Quartiles of serum uric acid				p value
	1	2	3	4	
Men (87)					
Uric acid range (mg/dL)	≤ 4.24	4.25 – 5.49	5.50 – 6.24	≥ 6.25	
No. subjects	21	21	24	21	
Age (years)	27.57 ± 5.9	32.50 ± 12.7	36.15 ± 9.1	36.20 ± 8.9	0.081
BMI (kg/m²)	32.96 ± 5.0	32.89 ± 3.5	30.78 ± 3.2	31.66 ± 4.3	0.367
Uric acid (mg/dL)	3.62 ± 0.7	4.70 ± 0.3	5.91 ± 0.2	7.15 ± 0.7	< 0.000
Total bilirubin (mg/dL)	0.84 ± 0.3	0.91 ± 1.0	0.97 ± 0.7	0.92 ± 0.4	0.782
Creatinine (mg/dL)	0.75 ± 0.1	0.74 ± 0.1	0.65 ± 0.0	0.71 ± 0.1	0.334
GGT (IU/L)	31.57 ± 34.1	42.14 ± 27.0	30.25 ± 18.1	19.00 ± 8.2	0.227
Triglycerides (mg/dL)	96.86 ± 51.3	92.14 ± 31.4	86.75 ± 31.9	99.14 ± 37.4	0.994
HDL (mg/dL)	33.86 ± 14.8	44.00 ± 12.1	40.38 ± 9.0	42.00 ± 6.6	0.277
Fasting glucose (mg/dL)	80.71 ± 9.3	86.14 ± 4.1	86.25 ± 5.7	79.71 ± 6.2	0.839
Metabolic syndrome	6 (28.5%)	3 (14.2%)	3 (12.5%)	3 (14.2%)	0.497
Hypertension	3 (14.2%)	3 (14.2%)	3 (12.5%)	3 (14.2%)	0.974
FPG ≥ 100 mg/dL	0 (0.0%)	3 (14.2%)	0 (0.0%)	0 (0.0%)	0.647
HDL ≤ 40 mg/dL	15 (71.4%)	6 (28.5%)	15 (62.5%)	9 (42.8%)	0.570
TG ≥ 150 mg/dL	3 (14.2%)	0 (0.0%)	0 (0.0%)	3 (14.2%)	0.983
Women (333)					
Uric acid range (mg/dL)	≤ 3.29	3.30 – 3.89	3.90 – 4.49	≥ 4.50	
No. subjects	87	78	72	96	
Age (years)	39.13 ± 9.2	34.81 ± 7.1	41.71 ± 11.7	38.32 ± 9.6	0.912
BMI (kg/m²)	30.67 ± 2.8	30.97 ± 3.2	31.55 ± 4.8	32.05 ± 3.5	0.113
Uric acid (mg/dL)	2.86 ± 0.4	3.56 ± 0.1	4.15 ± 0.1	5.03 ± 0.6	< 0.000
Total bilirubin (mg/dL)	0.56 ± 0.2	0.59 ± 0.3	0.50 ± 0.2	0.50 ± 0.1	0.244
Creatinine (mg/dL)	0.66 ± 0.1	0.73 ± 0.1	0.66 ± 0.1	0.68 ± 0.1	0.837
GGT (IU/L)	17.55 ± 7.4	15.11 ± 7.0	21.58 ± 12.7	28.88 ± 23.4	0.001
Triglycerides (mg/dL)	90.66 ± 28.4	74.00 ± 23.7	87.75 ± 28.3	101.56 ± 37.9	0.067
HDL (mg/dL)	44.86 ± 11.1	44.54 ± 9.2	49.08 ± 15.8	46.84 ± 11.1	0.323
Fasting glucose (mg/dL)	82.90 ± 7.5	81.50 ± 6.9	81.96 ± 6.1	85.03 ± 8.8	0.243
Metabolic syndrome	3 (3.4%)	6 (7.6%)	6 (8.3%)	18 (18.7%)	0.043
Hypertension	0 (0.0%)	9 (11.5%)	21 (29.1%)	21 (21.8%)	0.006
FPG ≥ 100 mg/dL	3 (3.4%)	3 (3.8%)	0 (0.0%)	6 (6.2%)	0.705
HDL ≤ 50 mg/dL	63 (72.4%)	57 (73.0%)	39 (54.1%)	72 (75%)	0.871
TG ≥ 150 mg/dL	3 (3.4%)	0 (0.0%)	3 (4.1%)	9 (9.3%)	0.191

FPG: fasting plasma glucose; TG: triglycerides.

reduction in uric acid levels and by reduction in the prevalence of hyperuricemia.

Previous studies have showed a close relation between hyperuricemia and metabolic syndrome in adults and children (9,10). Several potential mechanisms could account for the elevated concentrations of uric acid among those with metabolic abnormalities. Renal clearance of urate is inversely related to the degree of insulin resistance (7). Furthermore, higher concentrations of insulin are known to reduce the renal excretion of urate (11). For example, exogenous insulin can reduce renal excretion of urate in both healthy and hypertensive subjects. Thus, the reduced renal excretion of urate among patients with metabolic syndrome may explain the increased frequency of hyperuricemia (12). Insulin may enhance renal urate reabsorption via stimulation of the urate-anion exchanger URAT1 and/or the Na⁺-dependent anion cotransporter in brush border membra-

nes of the renal proximal tubule (13,14). In addition, because serum concentrations of leptin and urate tend to rise together, some investigators have suggested that leptin may affect renal reabsorption (14,15). Increased consumption of fructose, which is associated with obesity, has been shown to elevate concentrations of uric acid (16,17). Finally, in the metabolic syndrome, impaired oxidative phosphorylation may increase systemic adenosine concentrations by increasing the intracellular concentrations of coenzyme A esters of long-chain fatty acids. Increased adenosine, in turn, can result in renal retention of sodium, urate, and water (18,19). Some have speculated that chronically increased extracellular adenosine concentrations may also contribute to hyperuricemia by increasing urate production.

Although hyperuricemia is well recognized as a risk factor for atherosclerotic diseases such as myocardial infarction and stroke, the independence of this association from other confounding factors has remained controversial. This is mostly because serum uric acid is associated with other cardiovascular risk factors, such as hypertension and dyslipidemia (20). Several previous studies have analyzed possible associations between hyperuricemia and coronary heart disease and their independence. Although some studies have reported a positive association between hyperuricemia and coronary heart disease (21,22), others have not (23,24). Most studies showing negative results advocated, as expected, that the association between uric acid and coronary heart disease is not truly independent, but it is dependent on other risk factors for coronary heart disease. On the other hand, it is possible that uric acid is an independent risk factor for coronary heart disease in some selected populations, such as alcohol abstainers (25).

In accordance with previous studies, we found that serum uric acid levels are higher in men than in women, although uric acid levels in women tend to increase above the age of 50 (26). Considering both genders, these differences in serum uric acid levels and the increase after menopause in females have been reported previously and attributed to the influence of sexual hormones (27). We also found that male subjects have a higher prevalence of hyperuricemia than women. The most striking association found in our study is certainly the close relationship between serum triglycerides and serum uric acid levels and hyperuricemia. This observation was made principally in women. The correlation of triglycerides with uric acid has been previously found in several groups of patients (8,28). The mechanism for

the strong association of triglyceride values and serum uric acid levels has still not been elucidated. Although, genetic factors have been associated with the concurrence of gout and hypertriglyceridemia, most investigators tend to conclude that hyperuricemia and hypertriglyceridemia reflect more the lifestyle of the patient, as part of the metabolic syndrome, than genetic factors (29).

Sustained weight reduction was accompanied by significant decrease in uricemia as showed by other studies (30,31). Such effect may be explained by a correction of uric acid renal clearance resulting from the near-normalization of hyperinsulinemia and insulin resistance. Besides the already known benefits of bariatric surgery on blood pressure, plasmatic lipids and metabolic syndrome (32-37), improvement of hyperuricemia may contribute to the improvement of cardiometabolic risk in morbidly obese patients.

In conclusion, concentrations of uric acid were associated with the prevalence of metabolic abnormalities in this sample of morbidly obese. Furthermore, weight loss after RYGBP can reduce uric acid levels and the prevalence of hyperuricemia as shown in other articles (30,38).

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