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Original Article

Effects of Body Mass Index on Urinary Lithogenic Factors in Urinary System Stone Patients

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Abstract

Aim: Obesity and metabolic syndrome are becoming more prevalent these days. In addition, we know that urinary stone disease is also on the rise. In this study, we wanted to examine if body mass index (BMI) had a negative effect on the stone disease by evaluating 24-hour urinalysis in stone patients and recurrence rates in our region.

Materials and methods: From January 2017 to December 2019, a total of 193 patients were assessed retrospectively in terms of their 24-hour urine analysis results and blood parathyroid hormone (PTH) values. These patients were divided into 3 groups by their BMI <25, 25-30, and ≥30 (group 1, 2, and 3, respectively). Demographic and 24-hour urine analysis data were compared between the groups. Patients with and without recurrent stones were divided into 2 groups and lithogenic factors were analyzed. Possible lithogenic risk factors for recurrent stone formation were examined in a multivariate logistic regression analysis. Pearson and Spearmen correlation analysis was used for correlation.

Results: Groups 1, 2, and 3 had 107, 55, and 31 patients, respectively. There was a statistically significant difference between the groups in their BMI, diabetes mellitus (DM), hypertension (HT), gout, spontaneous stone passage, and extracorporeal shock wave lithotripsy (ESWL) factors. While the mean of BMI was similar for groups 2 and 3, the mean of group 1 was statistically significantly lower. Group 3 exhibited statistically significant higher rates of DM, HT, and gout diseases in comparison to the other groups. ESWL and spontaneous stone removal factors were statistically significantly higher in groups 2 and 3 than in group 1. According to the results of the 24-hour urine analysis, the urinary pH, uric acid, calcium, oxalate, and phosphate values were statistically different in group 1 from other groups. Urinary pH was more acidic and uric acid, calcium, oxalate, and phosphate values were higher in groups 2 and 3. Only BMI was statistically different from the lithogenic factors in the patient groups with and without recurrent stones. Also, in the multifactorial logistic regression analysis, BMI factor was found to be significant in duplicate stone formation. There was a weak but statistically significant correlation between the amount of uric acid and stone volume (r=0.307, p=0.04).

Conclusion: Increased BMI negatively affects the lithogenic factors in urine and facilitates the formation of recurrent stones.

Keywords

BMI, calcium, citrate, cystine, lithogenic factors, magnesium, obesity, oxalate, phosphate, PTH, uric acid

INTRODUCTION

Stone disease affects 7%-15% of the population and is a disease observed more often in men than in women (1.8/1). Genetic and environmental factors are the main causes of this disease. Factors like diabetes mellitus (DM), obesity, bariatric surgeries, small intestine surgeries, vitamin C supplements, nutritional habits, and excessively warm climate

and working in warm environments for long durations are blamed for the etiology of this disease. Some of these factors affect urine pH, while some affect urinary metabolites.[1]

Obesity has become a continuously increasing epidemic problem in the present day, especially in developed countries.[2] Studies in recent times have reported that more than 30% of Americans are obese. Obesity is simultaneously a metabolic syndrome causing many morbid, mortal, and chronic diseases led by type 2 DM, heart diseases, hypertension, pregnancy complications, and sleep apnea. Based on epidemiological studies, urinary system stone disease may be added to the morbidities due to obesity. While recent epidemiological studies reported increasing prevalence of obesity[3], the prevalence of kidney stone disease was also reported to increase[4]. This association leads to the conclusion that these diseases share a common pathophysiology. However, to date, very little is known about the pathophysiological relationship between obesity and stone disease. Some studies reported that obesity and being overweight lowered urine pH and increased uric acid, calcium, oxalate, and phosphate in urine.[5]

AIM

In this study, we aimed to see whether there was a negative effect of weight on stone disease by assessing 24-hour urine analysis in stone patients in our region.

MATERIALS AND METHODS

Study design

This study has analytical and descriptive qualities. After receiving Ethics Committee permission (Health Sciences University XX Training and Research Hospital Ethics Committee, date 11.3.2022 and decision number 95), the 24-hour urine analysis of patients performed between January 2017 and December 2019 were retrospectively assessed. Patients with a stone disease history during the previous 8 weeks receiving diet and medical treatment for stone disease, pregnant or lactating women, patients with cystinuria, inflammatory bowel disease, chronic renal failure, hepatic disease, thyroid or parathyroid disease, immunological disease, ileal or colonic resection, bariatric surgery, struvite stones, or primary hyperoxaluria and receiving potassium citrate, hydrochlorothiazide, vitamin B6, vitamin C, allopurinol, glucocorticoids, triamterene, indinavir and sulfadiazine and calcium preparations that may affect 24-hour urine parameters were excluded from the study. Patients aged ≥16 years with all anthropometric (height and weight) data were included in the study. Files for a total of 230 patients meeting the study criteria were investigated and we assessed 195 patients with full data using 24-hour urine results. To determine whether 24-hour urine had been correctly collected or not, urine creatinine was measured. Patients with values for urine creatinine of ≥800 mg/day for men and ≥600 mg/day for women were accepted as having 24-hour urine collected accurately. All participants provided informed consent.

All patients were divided into 3 groups according to their body mass index values as <25, between 25 and 30, and ≥30, respectively. Group 1 comprised patients with BMI <25 and group 2 comprised patients with BMI between 25 and 30, and group 3 – with BMI ≥30. Group 1, 2 and 3 included 107, 55, and 31 patients, respectively. Their age, DM, hypertension (HT), gout, spontaneous stone passage, extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL) and family history of stone, stone volume were investigated as demographic data. Parameters in 24-hour urine analysis included pH, creatinine, calcium, oxalate, uric acid, cystine, citrate, phosphate and magnesium values, and blood parathormone (PTH). We considered patients with recurrent stones who had undergone at least 2 spontaneous stone removal and/or ESWL and/or stone operations. Then, lithogenic factors were analyzed by dividing patients with and without recurrent stones into 2 groups.

Urine collection

Patients began collecting urine in a collection container after first morning urination. From that point, all 24-hour urine (including from the following morning) was accumulated in the collection container. The sample was then brought directly to the hospital in the morning and given to the laboratory.

Methods of analysis

Uric acid, calcium, oxalate, phosphate, magnesium, and citrate were investigated with the photometric method and results are given as mg/24 hours. Cystine was measured with the GC-MS method and results are reported as mg/day. Urine pH was measured with the dipstick method in fresh urine samples from first morning urination. Blood PTH was investigated with the ECLIA method and results are given as pg/mL. Abnormal values were urine volume less than 2000 cc/day, calcium more than 200 mg/day, magnesium more than 73 mg/day, oxalate more than 40 mg/day, citrate more than 250 mg/day, uric acid more than 600 mg/day, phosphate more than 1300 mg/day, and urine pH below 5.5.

Statistical analysis

Statistical analyses were performed using the SPSS 22.0 (IBM, New York, USA). Continuous variables are given as mean ± standard deviation, while categoric data are given as frequency distribution and percentages (%). Data were assessed with the Kolmogorov-Smirnov and Shapiro-Wilk tests for fit to normal distribution. Normally distributed continuous variable data were compared with one-way ANOVA, and categorical data were compared with Krus-

kal-Wallis analysis. Bonferroni tests were used for post-hoc analyses. T test and chi-square test were used for analysis between groups with and without recurrent stones. Multivariate logistic regression analysis was performed to analyze the factors affecting recurrent stone formation. $P<0.05$ was accepted as statistically significant. The data were analyzed at a 95% confidence level and the threshold for statistical significance was accepted as $p<0.05$ for all analyses. The correlation between urinary lithogenic factors and stone volume was tested with Pearson's analysis, and the correlation between urinary lithogenic factors and surgical treatment requirements was tested with the Spearmen analysis ($r>0.7$, strong correlation, and statistical significance was set at $p<0.05$).

Results

Groups 1, 2, and 3 comprised 107, 55, and 31 patients, respectively. There was no statistical difference between the groups in age, sex, PCNL, family history and stone volume factors. There was a statistically significant difference between the groups in BMI, DM, HT, gout, spontaneous stone passage, and ESWL factors. While the mean of BMI was similar for groups 2 and 3, the mean of group 1 was statistically significantly lower. DM, HT and gout diseases were statistically significantly higher in group 3 than in the other groups. ESWL and spontaneous stone passage factors were statistically significantly higher in groups 2 and 3 than in group 1 **(Table 1)**.

According to the results of 24-hour urine analysis, the urinary pH, uric acid, calcium, oxalate and phosphate values were statistically different between the groups. Urinary pH according to Bonferroni test: group 2 and 3 were statistically significantly more acidic than group 1. In groups 2 and 3, 16% and 20% of the patients, respectively, had a urine pH of 5.5 and below compared to 6% in group 1. Group 3 was the group with the highest uric acid values. Eighteen percent of the patients in this group were above the laboratory upper limit. While groups 2 and 3 were statistically similar in terms of uric acid values, uric acid values in group 1 were statistically significantly lower than the other two groups.

In terms of urinary calcium values, group 2 average was the highest, groups 2 and 3 were statistically similar. However, group 1 had statistically significant lower urinary calcium values than the other two groups. Moreover, while the rate of hypercalciuric patients was 21% in group 2, it was 8% in group 3, and 14% in group 1.

Group 3 was the group with the highest urinary oxalate values. While groups 2 and 3 were similar in terms of oxalate values, group 1 was the group with the lowest statistically significant urinary oxalate values. While hyperoxaluria was observed in 23% of the patients in group 3, this rate was 14% in group 2 and 7% in group 1.

In terms of urinary phosphate values, group 3 was the group with the highest mean value. Groups 2 and 3 showed statistical similarity in terms of phosphate values. However, phosphate values in group 1 were statistically significantly lower than in the other two groups. Hyperphosphaturia was detected in 12%, 9%, and 6% of patients in groups 3, 2, and 1, respectively **(Table 2)**.

Table 1. Demographic characteristics

	Group 1 (BMI <25)	Group 2 (BMI 25-30)	Group 3 (BMI ≥30)	*p*	Post hoc test *P* value		
					Group 1-2	Group 1-3	Group 2- 3
Age, year, (mean±SD) *	33.8±10.8	32.0±10.3	34.1±9.0	0.784			
Sex, no (%)				0.530			
Female	42 (39.3%)	24 (41%)	20 (65%)				
Male	65 (60.7%)	31 (56%)	11 (35%)				
Total	107	55	31				
BMI, (kg/m^2) (mean±SD) *	22.7±3.8	28.4±2.6	34.2±1.4	0.001	<0.001	<0.001	0.145
DM, n (%)	15 (14%)	14 (25%)	11 (35%)	0.013	0.260	0.028	0.768
HT, n (%)	14 (13%)	11 (20%)	10 (32%)	0.034	0.838	0.014	0.223
Gout, n (%)	1 (0.9%)	2 (4%)	6 (20%)	<0.001	1.000	<0.001	0.002
Spontaneous stone expulsion, n (%)	21 (19.2%)	33 (60%)	15 (48%)	<0.001	<0.001	0.06	0.744
ESWL, n (%)	18 (16.8%)	23 (41%)	14 (45%)	0.001	0.003	0.008	1.000
PCNL, n (%)	8 (7.5%)	10 (18%)	6 (20%)	0.089			
Family history positivity, n (%)	63 (%58.8)	31 (56%)	17 (55%)	0.760			
Stone volume, mm^3, (mean±SD) *	365±90	403±124	380±142	0.420			

BMI: body mass index; HT: hypertension; DM: diabetes mellitus; ESWL: extracorporeal wave lithotripsy; PCNL: percutaneous nephrolithotomy; SD: standard deviation

Table 2. Result of 24-hour urine analyses

	ANOVA				Post hoc test		
					P value		
	Group 1 (BMI <25)	Group 2 (BMI 25-30)	Group 3 (BMI ≥30)	*P* value	Group 1-2	Group 1-3	Group 2-3
pH	6.15±0.35	5.89±0.26	5.71±0.62	<0.001	<0.001	<0.001	0.496
Uric acid, mg/day	537±278	678±450	730±230	<0.001	<0.001	<0.001	0.440
Calcium, mg/day	240±102	312±102	282±94	0.040	<0.001	<0.001	0.287
Oxalate, mg/day	25±10	39±23	44±20	<0.001	<0.001	<0.001	0.354
Citrate, mg/day	252±169	325±224	286±280	0.232			
Cystine, mg/day	22±16	25±22	24±14	0.338			
Phosphate, mg/day	763±257	880±170	915±124	<0.001	<0.001	<0.001	0.732
Magnesium, mg/day	68±43	60±45	67±34	0.670			
Creatinine, mg/dL	1763±426	1640±314	1732±410	0.321			
Urine volume, mL	1790±599	1750±455	1830±650	0.935			
PTH, pg/mL	46±18	54±46	49±41	0.397			

PTH: parathormone; All data are given as mean ± standard deviation

The 24-hour creatinine values for each male and female patient in the study group were used to determine whether urine was collected accurately or not. The 24-hour urine creatinine values were 1763±426 mg/day in group 1, 1640±314 mg/day in group 2, and 1732±410 mg/day in group 3 and there was no statistical difference between the groups (p=0.321). The mean total amount of urine for 24 hours in groups 1, 2, and 3 was 1790±599 mL, 1750±455 mL, and 1830±650 mL, respectively, (p=0.935) bringing the mean daily urine volume of the three groups of stone patients with different BMI values below 2 liters. We found that in groups 1, 2, and 3, the daily urine volumes of 17, 14, and 9 patients, respectively, were around 1000 cc **(Table 2)**.

Only the BMI factor was statistically different between patients with and without recurrent stones. BMI was higher in patients with recurrent stones. Multivariate logistic regression analysis showed that patients with a BMI ≥25 had a 2-fold risk of recurrent stone formation **(Table 3)**.

The correlation between lithogenic factors in 24-hour urine, stone volume, and surgical treatment requirements was found using correlation analysis (Pearson's and Spearman's correlation tests). There was no significant correlation between surgical treatment requirements and lithogenic factors. There was a weak but statistically significant correlation between uric acid and stone volume (r=0.307, p=0.04) (**Fig. 1**, **Table 4**).

Table 3. Lithogenic factors in patients with and without recurrent stones and multivariate logistic regression analysis of effective lithogenic factors in patients with recurrent stones

	With recurrent stones	Without recurrent stones	*P*	Multivariate analysis		
				Odds ratio	95% CI	*p*
No	50	143				
pH	5.95±0.34	5.93±0.35	0.644			
Uric acid, mg/day	557±197	559±461	0.977			
Calcium, mg/day	261±73	246±68	0.180			
Oxalate, mg/day	29±10	30±10	0.556			
Citrate, mg/day	294±105	280±81	0.339			
Cystine, mg/day	24±9	24±8	0.900			
Magnesium, mg/day	62±21	60±19	0.340			
Phosphate, mg/day	840±97	790±145	0.176			
BMI, kg/m^2	27±5	24±5	0.019	2.004	1.143-3.512	0.015

CI: confidence interval

Table 4. Correlation between 24-hour urinary lithogenic factors with stone volume and surgical treatment requirements

24-hour urinary parameters	Stone volume (p value)	Surgical treatment requirements
pH	0.07 (0.949)	−0.18 (0.430)
Oxalate	−0.35 (0.752)	−0.34 (0.140)
Uric acid	0.307 (0.04)	−0.212 (0.090)
Calcium	0.000 (0.999)	−0.090 (0.176)
Citrate	0.055 (0.615)	−0.210 (0.250)
Cystine	−0.148 (0.176)	−0.470 (0.165)
Phosphate	−0.097 (0.376)	−0.085 (0.540)
Magnesium	−0.112 (0.309)	−0.135 (0.320)

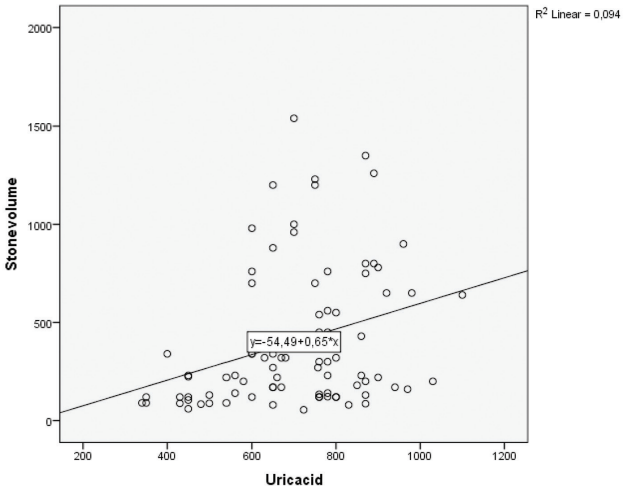

Figure 1. Pearson's correlation graph of uric acid and stone volume.

DISCUSSION

Aune et al.[6] found that stone formation increased 1.4 times in overweight patients, while it increased by 2-3 times in obese and severely obese patients. A study by Akarken et al.[7] found that metabolic syndrome components like obesity, hyperlipidemia, and hypertension, along with the ratio of visceral fat tissue to subcutaneous fat tissue, were important factors for kidney stone formation. Deng et al.[8] found that the risks for hypertension and DM were higher in overweight and obese patients compared to people with a standard weight, and this situation increased the tendency to ward off urinary system stone disease. Taylor et al.[9] reported a connection between BMI and waist circumference measurements with increased kidney stone formation. Sorensen et al.[10] found that the risk of stone formation increased as BMI increased. Lama et al.[11] reported that in kidneys containing calcium oxalate stones, perirenal fat volume was higher than in patients without stones and the increase in abdominal visceral fat tissue was associated with uric acid and calcium oxalate stone formation, while the ratio of visceral fat tissue to subcutaneous fat tissue was positively correlated with renal stone formation. In fact, obesity in the pediatric age group was reported to increase stone formation risk without observing any change in lithogenic amounts in urine.

In this study, we found that increasing BMI showed a positive correlation with the increase of lithogenic factors such as urinary pH, uric acid, calcium, oxalate and phosphate, but inhibitory factors such as citrate and magnesium did not change. In fact, in multivariate analysis, BMI was the only factor predicting recurrent stone formation. Siener et al.[4] reported that weight and obesity increased lithogenic factors without changing stone inhibitors in urine for formation of calcium oxalate stones and that people who were overweight had a higher risk of calcium oxalate saturation compared to patients with normal weight.

Abdominal obesity is reported to make urinary pH more acidic as a result of increasing the net acid load in urine by reducing reabsorption of H+ ions and ammonium secretion from proximal renal tubules causing insulin resistance.[12] Zanette et al.[13] reported that patients with hypercalciuria and hyperuricosuria had high endogenous organic acid levels, which caused urine pH to fall. Additionally, high protein intake in overweight stone patients is known to increase urine acidity. Because of the decrease in urine pH, tubular uric acid crystal saturation is easier, increasing uric acid stone formation, a long-known fact. Additionally, as BMI increases, urinary uric acid amounts elevate in both sexes.[14] A national database study assessing 5942 patients with a variety of urinary stones reported that excessively overweight men and women had higher serum and urinary uric acid levels compared to overweight men and women.[3] For this reason, the elevated urinary uric acid level in patients with high BMI in our study is considered to be due to both consumption/nutrition and body mass weight. In this study, we also found a weak positive correlation between uric acid and stone volume. In other words, as the amount of uric acid in the urine increased, the stone size also increased. There are studies in the literature reporting that factors such as age, UTI, recurrence, serum calcium, serum phosphate, and urine albumin correlate directly with stone size.[15,16] However, we could not find an article that studies the connection between urinary lithogenic factors and stone volume. Since the causes of stone formation are multifactorial, we think that this positive correlation should be

considered in studies with larger series in order to make a decision and make recommendations.

We observed in our study that the increase in BMI showed a positive correlation with the increase in the number of patients with DM. It has also been found that as BMI increases, urine becomes more acidic and uric acid levels become higher. Spiwakov et al.[17] stated that acidic urine is the most frequently observed abnormality in patients with DM and is responsible for the formation of uric acid stones. Assimos discovered that insulin resistance in type 2 diabetes causes a deficit in the kidneys' ammonium production, lowering urinary pH.[18] creating as a result suitable environment for uric acid stones. Nerli et al.[19] highlighted that there is a strong correlation between type 2 diabetes and uric acid stone formation and that there is a strong association between DM, BMI, and low urinary pH.

Urinary calcium excretion was reported to be higher in overweight and obese males compared to normal weight males.[4] High urinary uric acid levels may simultaneously lower the solubility of calcium oxalate in urine and cause calcium oxalate stone formation. Additionally, glycosaminoglycans, inhibitors of calcium oxalate crystallization in urine, were reported to be associated with calcium oxalate stone formation in obese people with reduced inhibitory activity. The 6th National Stone Congress in Japan emphasized that kidney stones increased with the reported increase in urinary calcium and uric acid excretion associated with metabolic syndrome. Kohjimoto et al. identified a positive correlation between BMI and urinary calcium excretion.[12] Insulin reduces calcium absorption in renal tubules in overweight patients and was found to increase urinary excretion of calcium. Additionally, with Dukan-like diets dominated by animal protein, urinary calcium increases, citrate reduces and lithogenic risk is reported to increase.[20] In men, urinary calcium and BMI were associated; as BMI increased, urinary calcium increased, while urinary calcium levels returned to normal when dietary sodium and phosphorus were fixed.

Danilovic et al.[21] reported a positive relationship between weight and urinary oxalate excretion. When compared with healthy people, those patients who had oxalate stones were shown to have higher oxalate absorption rates.[22] Seiner et al.[4] predicted that excessive intake of foods rich in chocolate and oxalate, especially in overweight and obese women, may cause high oxalate excretion in urine. In studies conducted in overweight rats, it was found that intestinal and renal tubular oxalate excretion decreased due to the inhibition of the transport pathway by proinflammatory cytokines increasing in the intestinal wall.[22,23] It has been suggested that the decrease in *Oxalobacter formigenes* colonization in obese patients reduces the oxalate excretion mechanism.[22] A study of idiopathic renal calcium stone patients found a clear degree of association between urine oxalate excretion with BMI.[24] In another study reporting a positive correlation between oxalate excretion with BMI only in women, obese women with BMI >30 kg/m2 had 39% oxalate excretion compared to women with normal weight. Lemann et al.[25] identified a positive correlation between oxalate excretion in urine and fat-free body mass. Ekeuro et al.[26] reported higher urine oxalate values in obese stone patients compared to non-obese patients.

Taylor et al.[9] and Curhan et al.[27] identified positive correlations between BMI, uric acid and phosphate excretion with multivariate regression analysis. Deng et al.[8] reported that urine phosphate values were higher in overweight cases compared to normal weight people in multiple regression analysis of 24-hour urine results in individuals without stone disease (p=0.047). Khand et al.[28] reported a positive correlation between hypocitraturia and phosphaturia in first-time stone patients and considered that high urinary phosphate amount was the main risk factor for calcium urolithiasis. Gyawali et al.[29] found that people with stone formation had higher urine phosphate level to a clear degree compared to people without stones and this situation was a risk for stone formation in urine. Siener et al.[4] reported that urinary phosphate excretion was higher in overweight and obese patients with calcium stones.

It has been reported that primary parathyroid hyperplasia causes stone formation in approximately 5% of kidney stone patients. Normally, when blood levels of calcium reach the optimum level, PTH secretion from the parathyroid stops. However, in case of primary hyperplasia, the parathyroid does not listen to the stop command and PTH continues to be released. As serum PTH levels increase, hypercalcemia and hypercalciuria occur. It causes calcium oxalate supersaturation, which causes stone formation in the urine.[30] However, we did not detect any difference in PTH levels in this study.

The main limitation of our study is that it is retrospective. We could not include serum electrolytes and stone composition data in our study. We also could not investigate diet and nutritional habits in our study. Apart from BMI, we could not investigate the effects of other obesity parameters like visceral obesity, waist circumference measurement, subcutaneous fat rates, and visceral fat/subcutaneous fat ratio on lithogenic factors and stone formation. In the future, it is recommended that prospective multicenter studies encompassing these parameters be performed.

CONCLUSION

As the BMI index increases, the amount of urinary lithogenic factors increases. On the other hand, there is no change in the amount of inhibitory urinary lithogenic factors. As BMI increases, the risk of recurrent stone formation increases.

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Competing Interests

The authors have declared that no competing interests exist.

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Влияние индекса массы тела на литогенные факторы мочи у пациентов с камнями мочевой системы

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Резюме

Цель: Ожирение и метаболический синдром в наши дни становятся всё более распространёнными. Кроме того, мы знаем, что растёт число случаев мочекаменной болезни. В этом исследовании мы хотели выяснить, оказывает ли индекс массы тела (ИМТ) негативное влияние на мочекаменную болезнь, оценивая 24-часовой анализ мочи у пациентов с камнями и частоту рецидивов в нашем регионе.

Материалы и методы: С января 2017 г. по декабрь 2019 г. ретроспективно оценены 193 пациента по результатам суточного анализа мочи и показателям паратгормона (ППГ) в крови. Эти пациенты были разделены на 3 группы по ИМТ <25, 25-30, и ≥30 (1-я, 2-я и 3-я группы соответственно). Демографические данные и данные суточного анализа мочи сравнивались между группами. Пациенты с рецидивирующими камнями и без них были разделены на 2 группы и проанализированы литогенные факторы. Возможные литогенные факторы риска рецидивирующего камнеобразования были изучены с помощью многомерного логистического регрессионного анализа. Для корреляции использовался корреляционный анализ Pearson и Spearman.

Результаты: В группах 1, 2 и 3 было 107, 55 и 31 пациент соответственно. Между группами наблюдалась статистически значимая разница по показателям ИМТ, сахарного диабета (СД), гипертонии (ГТ), подагры, спонтанного выхода камней и факторов экстракорпоральной ударно-волновой литотрипсии (ESWL). Хотя среднее значение ИМТ было одинаковым для групп 2 и 3, среднее значение группы 1 было статистически значимо ниже. В группе 3 наблюдался статистически значимо более высокий уровень заболеваемости СД, ГБ и подагрой по сравнению с другими группами. Факторы ESWL и спонтанного удаления камней были статистически значимо выше во 2-й и 3-й группах по сравнению с 1-й группой. По результатам суточного анализа мочи показатели pH мочи, значения мочевой кислоты, кальция, оксалатов и фосфатов статистически различались в группе 1 от других групп. pH мочи был более кислым, а значения мочевой кислоты, кальция, оксалатов и фосфатов были выше во 2-й и 3-й группах. Только ИМТ статистически отличался от литогенных факторов в группах пациентов с рецидивирующими камнями и без них. Кроме того, в ходе многофакторного логистического регрессионного анализа было обнаружено, что фактор ИМТ является значимым при образовании двойных камней. Установлена слабая, но статистически значимая корреляция между количеством мочевой кислоты и объемом камня (r=0.307, p=0.04).

Заключение: Увеличение ИМТ отрицательно влияет на литогенные факторы мочи и способствует образованию рецидивирующих камней.

Ключевые слова

ИМТ, кальций, цитрат, цистин, литогенные факторы, магний, ожирение, оксалат, фосфат, ПТГ, мочевая кислота