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Relationship between urine pH value and stone types in patients with urolithiasis in Dr. Soetomo Hospital Surabaya

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Abstract— Urolithiasis is a situation where stones are found in urinary tracts. This disease is the third most common disease in the urinary system. The leading factors behind stone formation are including age, hormones, muscle mass, diet, body index, climate factors, fluid balance and urine PH. This study aims to discover the relationshipbetween urine pH value and stone types in patients with urolithiasis. This study is an observational analytic study with a cross-sectional method using secondary data in the form of medical records from Urology department of Dr. SoetomoRegional Hospital 2019 - 2020. This study obtained 56 research samples, with the age group characteristics ranging from six- 76 years old. The average age was 49, 92 ± 12.91, on 43 men and 13 women. PH range that was most frequently found layes on pH 4.5 - 8.0. The average pH valueswere as follow: carbonate stones composition was6.16, oxalate was 6.33, calcium was 7, phosphate was 6.38, ammonium was 6.33, while uric acid was 6.25.

Keywords— Urolithiasis , urine pH, calcium, carbonate, uric acid

1. Introduction

Urolithiasis or urinary tract stones is the situation where there are stones formed in the urinary tract. Those stones occurs due to various factors. One of the factors isthe increase of stone-formingexcretion, i.e.xanthine, phosphate, calcium, oxalate, and urate[1]. Urolithiasis is the third most commonly found disease in the urinary system after urinary tract infections and prostate disease[2]. The prevalence and incidence of urolithiasis in recent decades has increased in some Asian countries.One study conducted in Japan stated that the prevalence of kidney stones is increasing in the elderly population[3].

The most common type of *urolithiasis* in Asia is calcium oxalate, approximately 75to 90%, followed by uric acid,with approximately 5to 20%. There are different stones types in developed and developing countries. The most common stone types in developed countries are struvite, while the most common stone types in developing countries are calcium oxalate and uric acid[4]. Epidemiological data shows that the stone incidence in children and adolescents have increased as in adults. Besides, the number of recurrent stone patients was also quite high[5]. There are two kinds of risk factors of stone formation, i.e. intrinsic and extrinsic factors. Intrinsic factors are factors that already exist and could not be changed such as age, sex, family background, and ethnicity. While extrinsic factors are lifestyle, habits, environment, and education level[6].

In this study, researchers conducted observations on examining pH levels in the urinalysis of patients with urolithiasis. One study suggested that the pH pattern of urine would affect the type of stone formed. The types of calcium and phosphate stones form at alkaline urine pH, while cystine and uric acid types would be formed in acidic pH conditions[7]. This study aims to discover the relationshipbetween urine pH value and stone types in patients with urolithiasis. The research hypothesis is the relation between the urine pH with the type of calcium, oxalate, carbonate, phosphate, ammonium, and uric acid stones.

2. Patients and Methods

This study utilized an observational study with a cross-sectional approach using secondary data in the form of medical records from the Urology Department of SoetomoRegional Hospital from June 2018 up to May 2019. The population of the study were all urolithiasis patients as shown in the medical record data. The sample size in this study were all medical records of urolithiasis patients that met the inclusion requirements, including undergone a urinalysis examination, have completed medical record data and have received stones removal surgery. The samplingwas carried out by utilizing a total sampling technique.

The data regarding the PH of the patients were categorized into values <7 (acid), = 7 (neutral) and> 7 (base). The types of stones are categorized based on their composition, i.e: calcium, oxalate, phosphate, carbonate, ammonium and uric acid. This research data was presented in tables and graphs, with the chi-square testanalysis.The computer program utilized by the researchers to process the data was SPSS V23. The type of data used to identify the pH value in *urolithiasis* patients was ordinal.

3. Results

3.1 Characteristics of Urolithiasis Patients

Table 1. The Characteristics of Urolithiasis Patients

Characteristics		N (%)	Average: (min-max)
Sex	Male	43 (76.78%)	
	Female	13 (23.22%)	
Age	Under 51	21 (37.5%)	
	51 – 60	24 (42.86 %)	
	Above 60	11 (19.64%)	
			49.92 ± 12.91 (6-76)

This research was conducted at the Urology Department of Soetomo Hospital in the period 1 June 2018 - 31 May 2019. The medical record data collection was carried out in two places, namely in the Clinical Pathology Laboratory and in the Technology Science Room of Soetomo Hospital. There were 56 data included in the inclusion data, 51 data exclusion. The distribution of patient age groups, the oldest urolithiasis incidence rate was 76 years and the youngest was 6 years old with an average age of 49.93 years, there were 43 men (76.8%) and 13 women (23.2 %).

3.2 Description of pH Value on Stone Composition

Table 2. The Description of PH Value on Stone Composition

Stone Composition	Average pH Value	Total Patients	Percentage (%)
Carbonate	6.16	40	71.4
Oxalate	6.33	43	76.8
Calcium	7	2	3.6
Phosphate	6.38	8	14.3
Ammonium	6.33	9	16.1
Uric acid	6.25	55	98.2

The number of urolithiasis patients containing carbonate had an average pH of 6.16, an oxalate stone component, an average pH of 6.33, a calcium stone component, an average pH of 7 (neutral), a phosphate stone compound with an average pH of 6, 38, the component of ammonium stones with an average pH of 6.33 and the component of uric acid stones with an average pH of 6.25.

3.3 Stone Analysis Results

Table 3. The Results of Stone Analysis

Stone Composition	PH < 7	PH 7	PH > 7	Total
Carbonate	31	4	5	40
Oxalate	30	7	6	43
Calcium	1	0	1	2
Phosphate	5	2	1	8
Ammonium	7	1	1	9
Uric acid	41	7	7	55

The composition of carbonate, oxalate, phosphate, ammonium and uric acid rocks is mostly at acidic pH.

3.4 Distribution of Stone Composition in Urolithiasis Patients

Table 4. The Distribution of Stone Composition in Urolithiasis Patients

	One Component	Two Components	Three Components	Four Components
Total	1	15	34	6
Percentage (%)	1.8	26.8	60.7	10.7

The average patient has 2-3 types of stone composition.

3.5 Relationship between pH range and stone composition of urolithiasis patients

Table 5. The Relationship between pH ranges based on acid-based with stone compositionSource

Stone Composition	pH <7	pH = 7	PH >7	Total	Fisher's Exact (*p-value*)
Carbonate	31 (55.4%)	4 (7.1%)	5 (8.9%)	40	0.703
Oxalate	30 (53.6%)	7 (12.5%)	6 (10.7%)	43	0.254
Calcium	1 (1.8%)	0	1 (1.8%)	2	0.441
Phosphate	5 (8.9%)	2 (3.6%)	1 (1.8%)	8	0.553
Ammonium	7 (12.5%)	1 (1.8%)	1 (1.8%)	9	1.000
Uric acid	41 (73.2%)	7 (12.5%)	7 (12.5%)	55	1.000

Data analysis was performed with the Chi-Square Test to determine the relationship between the pH range and rock type, using Fisher's Exact Test. The test results showed that there was no statistically significant relationship between pH range and stone composition ($p > 0.05$).

4. Discussion

The characteristics of Urolithiasis Patients

The results of this study indicated that the highest urolithiasis prevalence was at the age category of 51-60 years, which is in line with the study statedthat the highest prevalence of urolithiasis is at the age of 50 - 59 years on male patients and 60 - 69 years on female patients. Ageing will increase the risk of uric acid with the type of urolithiasis, and will decrease the risk of urinary tract infections in both males and females [8]. The incidence of urolithiasis rise above the age of 30. It is caused by activities with an extremely high frequency which increase dehydrationrisk. Unhealthy lifestyles such as stress, staying up late and aging (aging will cause endocrine hormoneschanges)[6]. Based on table 1, the prevalence of men with any type of stones is higher than women. This result is in line with the research stated that the prevalence of kidney stones in men occurs more commonly than in women. Numorous factors lead to this including hormones. Androgen hormones increase oxalate excretion and cause calcium oxalate deposition. Meanwhile, the hormone estrogen reduces the oxalate excretion in urine. The other factor is that men have more muscle mass, which also rises the final result of metabolism and increases the risk of stone formation. Male'surinary tract is more complicated and complex than in female's[9]. Their urinary tract anatomyis more complicated, therefore the risk of obstruction and *benign prostate hyperplasia* (BPH) will increase. Besides, food also contribute towards this i.e., a high amount of processed meat consumed, as well as alcohol and coffee [6].

PH Value on Stone Composition

Urolithiasis is a disease coming from numorous factors, such as food, water balance, and urine pH[10]. Normal urine pH value is rather acidic[11]. The pH value is the main stone formation factor[12]. The pH value of urine affects the formation of stones, because it will affect the kidneys in reabsorption or secretion of metabolic substances and affect the solubility of a substance[13]. Based on urine pH data, most patients have acidic pH <7. It is in line with the highest frequency stone composition which resulted in the form of uric acid. Consuming foods containing lots of animal protein will increase the occurrence of uric acid stones due to acidic pH as well as uric acid excretion which increase in the urine. Otherwise, consuming vegetables and foods with high phytate content will increase the pH value of urine[14]. Other factors affecting the urine PH value are timed collection, food, collection techniques and temperature. Urine in the early morning is more acidic.Its pH value depends on the food consumed before[15]. The pH value of urine is influenced by intrinsic factors such as renal tubular acidosis,and extrinsic factors such as hyperventilation syndrome.Foodand drugs consumed also influence and affect a stone formation[16]. The results of this study indicatedthatstone formations were most frequently found at pH 4.5 - 8.0 or at pH <7. Uric acid and oxalic

acid were the most stone composed, yet phosphate and calcium were the stones composed with low frequency. This is because urine PH value decreases by aging. uric acid stones will increase at low pH whereas phosphate stone type will instead decrease[17].

Stone Analysis

Stones with the types of calcium carbonate, calcium phosphate, and struvite are more soluble at pH 6.8, while uric acid and cystine are more soluble at alkaline pH (>7).On the other hand, PH value does not play any roles on stones with the type of calcium oxalate[16]. Calcium carbonate and apatite stone types will experience precipitation at pH 6.8. Meanwhile, struvite experiences precipitation at a more alkaline pH, i.e. >7.2[18]. The solubility of calcium phosphate decrease at pH >6.0, as a result, the risk of calcium phosphate stone formation increase[19]. Infectious or struvite stones formed in patients with a pH >6.0. Uric acid stones will crystallize at a low pH. At pH 5.3 crystallization begins with daily excretion amounted as 800 mg[20].

The distribution of Stone Composition in Urolithiasis

Based on table 3, the type of stone with a mixed composition shows a multifactorial cause. the possible risk factors in calcium stonesare hypocitraturia, hypercalciuria, hyperthyroidism and acidosis in the renal tubules[9].

The relationship between pH range and stone composition in urolithiasis patients

The impacts of urine pH towards calcium oxalate stones formation is still controversial as they are mostly formed at all pH types. urine pH does not influence stones with the type of calcium oxalate. The formation of calcium oxalate stones, monohydrate,or dihydrateare not associated with urine pH[12]. In this study, pH is found not associated with the stone type formed.It is because there are other factors contributing in stone formation besides ph, e.g. urine volume, substances compositions in urine that can increase stone formation such as uric acid and calcium,as well as the substances composition that inhibit stone formation such as magnesium and citrate.

Several reasons that might lead to this differences results offered are the differences in population size, population characteristics, risk factors, the classification of stone composition and urine pH, limited urinalysis data, and differences in stone analysis methods. This study uses retrospective data with a small number of patients, therefore further supported research is needed over a certain period of time (cohort study) in order to identify the relationship between urine pH and stone type as well as to clarify the results of this study.

5. Conclusion

The results of this study indicatedthat there was no relationship between urine pH value and the type of calcium, carbonate, phosphate, ammonium, uric acid and oxalate stones compotsition in urolithiasis patients.

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7. Disclosure statement

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