Differences In Risk Of Urinary Tract Stones Based On Demographics, Kidney Function, and Urianalysis In Pematangsiantar, Indonesia : A Single-Center Study

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Abstract. Urolithiasis, or urinary tract stones, is a solid mass that forms in the upper (kidneys, ureters) or lower urinary system (bladder, urethra). This study evaluates urinary tract stone risks based on demographics, kidney function, and urinalysis results using a quantitative, cross-sectional survey design with retrospective secondary data. From 873 samples, 438 had stones (62.6% male), with the bladder as the most common location (38.7%). The average age was 52 years (2–91 years), and the highest incidence occurred in 2021 (20.8%). Siantar Sitalasari showed the highest prevalence (11.2%). The stone group had average kidney function values of urea 26 mg/dl, creatinine 1.1 mg/dl, and GFR 79 ml/min/1.73m². Urinalysis showed elevated leukocytes (26.6%), erythrocytes (24.5%), and calcium oxalate (0.8%). No significant demographic or kidney function risk differences were found, though urine sediment analysis indicated crystal presence, suggesting potential stone formation.

Keywords: Urinary tract stones, Demographics, Kidney function, Urinalysis

1 Introduction

Urolithiasis, also known as urinary tract stones, is a solid mass found in the human urinary tract that looks like stones. These hard masses can arise in the upper part of the urinary system (ureters and kidneys) and the lower part of the urinary system (urethra and bladder) [1][2]. According to data from the global burden of disease (GDB) in the study of Qian et al (2022), the global incidence of urinary tract stones increased by 48.57% in 2019 compared to 1990 with an age group of 40 to 60 years, and is more dominant in men. In Indonesia, the exact incidence rate of urinary tract stones is unknown. However, based on the 2013 Basic Health Research, approximately 170,000 incidents are estimated

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to occur annually, with the island of Sumatra having a greater contribution of 0.6%. Specifically, urinary tract stone incidence is not prevalent by location of residence. An increase in the incidence of urinary tract stones in the presence of elevated blood levels of urea and creatinine indicates a decline in renal function, which causes urine levels of urea and creatinine to decrease, which is directly proportional to the decrease in glomerular filtration rate [3]. In the incidence of urinary tract stones, it is shown that 60%-70% of men and women experience various symptoms that can affect the increase of erythrocytes (hematuria), the number of leukocytes, and urine components such as urine sediment [4]. Based on the above explanation, the authors are interested in researching differences in the risk of urinary tract stones based on the results of examining kidney function, age, and urinalysis. The author wants to evaluate the differences in risk factors for urinary tract stones based on demographic data, renal function, and urinalysis at Vita Insani Hospital Pematangsiantar.

2 Literature Review

Urinary tract stones rank among the three most common urological conditions, following urinary tract infections and benign prostatic hyperplasia. This condition predominantly affects individuals aged 60-69, with men experiencing urinary tract stones at a rate three to four times higher than women. The kidneys are the primary site for stone formation, and non-invasive treatments are often preferred. A descriptive study conducted by Simanullang (2019) analyzed patients with urinary tract stones at Martha Friska Pulo Braya Hospital from 2015 to 2017 using random sampling. The findings indicated that stones occurred primarily in males aged 30-50, particularly self-employed individuals, with stones often located in the ureter and treated with ureteroscopy (URS) [5].

Ureteral stones can impact renal function due to postrenal obstruction or urinary tract infections. Rapid stone removal is recommended to prevent severe complications such as anuria and urosepsis, with improvements in renal function expected following stone extraction. However, further research is needed to determine whether URS has adverse effects. Selmi et al. (2021) prospectively studied 126 patients undergoing retrograde intrarenal surgery (RIRS) for kidney stones from 2018 to 2020. The estimated glomerular filtration rate (eGFR) was measured before surgery and tracked postoperatively over three-time points: immediately after surgery, at 30 days, and 90 days post-operation. The study observed an improvement in eGFR from a preoperative average of 82.28 ± 25.20 mL/min/1.73 m^2 to 90.92 ± 22.97 mL/min/1.73 m^2 on the first postoperative day and 94.54 ± 21.95 mL/min/1.73 m^2 at three months. Although the eGFR improved over the short term, significant long-term improvement was noted, especially in female patients. Predictive factors for eGFR improvement included the presence of ureteral obstruction and high preoperative serum creatinine levels [6].

A comprehensive prediction model for urolithiasis, using accessible clinical data collected in emergency settings, may aid in patient-centered diagnostic imaging decisions. A retrospective study by Kim and Oh (2023) analyzed clinical factors, blood chemistry, and urine parameters in patients undergoing non-contrast computed tomography (CT) for suspected urolithiasis. The study developed a logistic regression scoring system and evaluated its effectiveness through the area under the curve (AUC) analysis. In the derivative group (n=673), 566 patients were diagnosed with urolithiasis. The study identified predictive factors such as age over 35, a history of urolithiasis, pain duration under 8 hours, nausea and vomiting, costovertebral angle tenderness, serum creatinine levels $\geq$ 0.92 mg/dL, erythrocyte count $\geq$ 10, absence of leukocytes, and crystalluria [7].

3 Method

This research protocol has been ethically approved by the Universitas Prima Indonesia Health Research Ethics Commission with Number 003/KEPK/UNPRI/I1/2024 and has obtained a research permit from Vita Insani Hospital Pematangsiantar. This study used a quantitative approach using analytic observation, by collecting data from patients diagnosed with urinary tract stones between 2021 and 2023 at Vita Insani Hospital. The sampling method used is non-probability sampling, specifically consecutive sampling, focusing on patients with complete medical records, renal function tests, and urinalysis. Exclusion criteria include patients without complete medical records, those with chronic kidney disease (ureum $>$ 200 mg/dl, creatinine elevated by 100% of normal, GFR $<$ 60 mL/min/1.73 m^3), chronic heart failure, a history of long-term diuretic or antibiotic use, and patients on carbonic anhydrase inhibitors such as acetazolamide and topiramate. For statistical analysis, data will be processed using coding techniques and univariate analysis to determine mean, median, standard deviation, and range for numerical data. Categorical data will be summarized using frequencies and percentages presented in tables. Bivariate analysis will be conducted using Epi Info to evaluate the odds ratio (OR) and risk difference (RD) of demographics, renal function, and urinalysis in relation to urinary tract stone incidence. Statistical tests will include independent t-tests for normally distributed data, and Chi-Square tests for categorical data, with the Fisher Exact test employed when necessary. The study operationalizes demographics, renal function, and urinalysis as independent variables, with the incidence of urinary tract stones as the dependent variable.

4 Results

In this study, data were collected from 1045 patients from the Urology Clinic of Vita Insani Hospital Pematangsiantar in 2021-2023, but only 873 patients became research subjects. In this study, 438 patients were diagnosed with urinary tract stones and 435 patients were diagnosed without urinary tract stones. Of the 438 patients diagnosed with urinary tract stones, 274 (62.6%) were male.

Table 1. Demographic data

Data	Urolithiasis n (%)	Non-Urolithiasis n (%)	P
Age [Median (Min-Max)]	52 (2-91)	67 (42-96)	P<0,001b
Year of Treatment			
2021	182 (20.8)	157 (18)	0,026a
2022	136 (15.6)	122 (14)	
2023	120 (13.7)	156 (17.9)	
District			
West Siantar	21 (4.8)	17 (3.9)	P<0,001a
Siantar Marihat	13 (3)	2 (0.5)	
Siantar Marimbun	11 (2.5)	10 (2.3)	
Siantar Martoba	23 (5.3)	25 (5.7)	
South Siantar	13 (3)	10 (2.3)	
Siantar Sitalasari	49 (11.2)	44 (10.1)	
East Siantar	26 (5.9)	21 (4.8)	
North Siantar	31 (7.1)	16 (3.7)	
District of Simalungun, Toba, Samosir	197 (45)	261 (60)	
Etc	54 (12.3)	29 (6.7)	
Total	438 (50.2)	435 (49.8)	

Description: [a]Uji Chi-Square; [b]Uji Mann-Whitney

Table 2. Location of urolithiasis

Location	n (%)
Kidney	38 (8.7)
Kidney and Ureter	31 (7.1)
Ureter	15 (3.4)
Bladder	338 (77.2)
Urethra	14 (3.2)
Total	438 (100)

Based on Table 1, the normality test shows that the age data is not normally distributed ($p < 0.05$), so the age distribution is presented in the form of the median (min-max). The Mann-Whitney test non-parametric statistical analysis is carried out; it is known that there is a significant age difference ($p < 0.001$) between groups with the age distribution of the urolithiasis patient group 52

(2-91) years and the non-urolithiasis patient group 67 (42-96) years. It is known that there is a significant relationship (p=0.026) between years of treatment and the incidence of urolithiasis with the distribution of years of treatment in the urolithiasis patient group in 2021, namely 182 (20.8%). Then it is also known that the distribution of sub-districts has a significant relationship (p< 0.001) with the urolithiasis group located where most of them live in Simalungun, Toba, Samosir 197 (45%) except for sub-districts in Pematangsiantar, etc. (sub-districts outside the Simalungun, Toba, and Samosir regions) 54 (12.3%), and Siantar Sitalasari 49 (11.2%). Likewise, in Table 2, it is known that the distribution of the location of stones in the incidence of urolithiasis is found to be primarily located in the bladder 338 (77.2%). A normality test was conducted on renal function data. It was found that all renal function data were not normally distributed. Therefore, data presentation was carried out in the form of median (min-max), and different test analyses were carried out using non-parametric analysis of the Mann-Whitney test.

Table 3. Renal function data analysis

Data	Urolithiasis [Median (Min-Max)]	Non-Urolithiasis [Median (Min-Max)]	Pb
Ureum	26 (2.5-273)	30 (10-228)	P<0,001
Creatinine	1.1 (0.4-21)	9 (0.7-64)	P<0,001
GFR	79 (0.9-167)	68 (6-114)	P<0,001

Description: ^{b} Uji Mann-Whitney

Based on Table 4, it is known that there is a significant relationship (p< 0.001) between leukocytes and the incidence of BSK with the distribution of the urolithiasis group with high leukocytes as many as 232 (26.6%) patients and normal 206 (23.6%) patients, then the non-urolithiasis group with high leukocytes as many as 292 (33.4%) patients and normal 143 (16.4%) patients. It is known that there is a significant relationship (p< 0.001) between erythrocytes and the incidence of urolithiasis with the distribution of the urolithiasis group with high erythrocytes as many as 214 (24.5%) patients and normal 224 (25.7%) patients, then the non-urolithiasis group with high erythrocytes as many as 283 (32.4%) patients and normal 152 (17.4%) patients. It was found that there was no significant relationship (p=0.157) between urine sediment and the incidence of urolithiasis with the distribution of the urolithiasis group with ca oxalate as many as 7 (0.8%) patients, negative 431 (49.4%) patients, and no patients with triple phosphatase, then the group without urolithiasis with ca oxalate as many as 8 (0.9%) patients, triple phosphatase 4 (0.5%) patients, and negative 423 (16.4%) patients.

Table 4. Urinalysis Data Analysis

Data	Urolithiasis n (%)	Non-Urolithiasis n (%)	P
Leukocytes			
High	232 (26.6)	292 (33.4)	P<0.001[a]
Normal	206 (23.6)	143 (16.4)	
Erythrocytes			P<0.001[a]
High	214 (24.5)	283 (32.4)	
Normal	224 (25.7)	152 (17.4)	
Urine Sediment			
Ca Oxalate	7 (0.8)	8 (0.9)	
Negative	431 (49.4)	423 (16.4)	0.157[c]
Triple Phosphatase	0 (0)	4 (0.5)	

Description: [a] Uji Chi-Square; [c] Uji Fisher-Freeman-Halton Exact

The results of research conducted at Vita Insani Hospital Pematangsiantar from data from 2021-2023 show that there are 274 (62.6%) male patients with a group of patients at the age of 52 years, found to be primarily located in the bladder 338 (77.2%). The results of this study show no difference in risk factors, whereas urolithiasis in males is more prevalent than in females. This study agrees with a study conducted by Qian et al. (2020), which shows that the incidence of urolithiasis is found in the age group 40 to 60 years, with the male gender being more dominant. The incidence of urolithiasis is more frequent in the age group of 40 to 60 years, with a predominance among males. This is due to several factors related to physiological changes, lifestyle, and increased medical risks within this age range. After age 40, the body's metabolism tends to slow down, which can lead to the accumulation of certain substances, such as calcium or oxalate, in the urinary tract, triggering stone formation. Additionally, the natural decline in kidney function with age also contributes to a higher risk of stone formation. Specifically, men have a higher risk of developing UTS compared to women due to physiological factors and lifestyle habits. One contributing factor is the higher testosterone levels in men, which are associated with increased oxalate excretion in urine, a key component of stone formation. Furthermore, men's common lifestyle and dietary habits, such as high animal protein intake and low fluid consumption, also increase the risk of stone formation. These factors help explain why UTS occurrence is more prevalent among men aged 40 to 60 [8], [9]. Events in the bladder can be caused by the physiological function of the bladder, which is to store urine produced by the kidneys so that it reaches a threshold capacity of approximately 300-450 ml. Storing urine for too long (the habit of holding urine for too long) can cause stone-forming masses to collect in the bladder and accumulate causing stones in the bladder [10].

In this study, there was a significant relationship ($p = 0.026$) between years of treatment and the incidence of urolithiasis, with the distribution of years of treatment in the urolithiasis patient group highest in 2021, namely 182 (20.8). Several factors may contribute to this trend. First, climate and environmental conditions may play an important role, especially in tropical regions like Indonesia, where hot weather can lead to quicker dehydration, increasing the risk of kidney stone formation due to higher urine concentration. Second, lifestyle habits, such as high salt and animal protein intake or insufficient water consumption, can also contribute to the high incidence of UTS. Additionally, increased disease awareness and easier access to healthcare services have enabled more patients to seek medical check-ups and receive diagnoses. The COVID-19 pandemic may have also influenced this trend, as many patients avoided hospitals at the onset of the pandemic, opting to seek medical care in 2021 when conditions began to improve [11].

It was also found that there was a significant relationship ($p < 0.001$) between the location of residence and the incidence of urolithiasis, with the location of residence of the most urolithiasis patients in Simalungun, Toba, Samosir 197 (45%) except for sub-districts in Pematangsiantar, etc (sub-districts outside Simalungun, Toba, and Samosir) 54 (12.3%), and Siantar Sitalasari 49 (11.2%). Focusing on the Pematangsiantar area, although there is no previous research data linking the incidence of urolithiasis to the location of residence, this could be due to several possibilities, such as the condition of the patient's body (genetic and hereditary), drinking water quality (high calcium and oxalate levels), dietary habits (excessive consumption of high protein), and lack of awareness about urolithiasis. In addition, the most potent risk factors for urinary tract stones are diabetes mellitus (DM), age, body mass index (BMI), gender, decreased physical activity, hypertension (increased blood pressure), and decreased frequency of fluid intake [12].

In this study, a statistically significant distribution was obtained based on the results of renal function examination ($p < 0.001$), which found that the distribution of uranium and creatinine increased in the non-urolithiasis group compared to urolithiasis. Meanwhile, the distribution of GFR decreased in the non-urolithiasis group compared to urolithiasis. This aligns with previous research, where increased urea and creatinine can rule out infection following urinary tract stones.10 In another study, it was found that the urolithiasis group experienced less GFR decline, namely the percentage of GFR $\geq$60 mL/min/1.73 m2 (5.4%). The results of the above studies indicate that the incidence of urolithiasis shows less risk of damage to kidney function. The significant relationship between the increase in serum and keratin with a decrease in glomerular filtration rate (GFR) is caused by obstruction or blockage of flow in the urinary tract that can increase renal pressure and damage kidney tissue so that the kidneys cannot function properly in filtering urea and creatinine. This causes urea and creatinine to accumulate in the blood, and a situation with high levels of creatinine in the blood will be inversely proportional to damage to kidney function characterized by a decrease in glomerular filtration rate (GFR) [13], [14].

Based on the results of the study, it was found that urolithiasis patients had a significant relationship ($p < 0.001$) with leukocytes and erythrocytes. The distribution of the non-urolithiasis group had high leukocyte values, namely 292 (33.4%) patients, compared to the urolithiasis group with high leukocyte values, namely 232 (26.6%) patients. Similarly, the distribution of high erythrocyte values in the non-urolithiasis group was 283 (32.4%) patients, compared to the urolithiasis group with a distribution of high erythrocyte values of 214 (24.5%). This aligns with previous research, where the findings of high erythrocytes and low leukocytes in acute UTI symptoms correlate with urinary tract stones. The increase in leukocytes (white blood cells) and erythrocytes (red blood cells) in cases of urinary tract stones indicates inflammation and irritation of the urinary tract. Urinary tract stones can cause physical trauma to the urinary tract wall, which then causes inflammation. When there is inflammation, the body responds by increasing the number of leukocytes to fight infection or tissue damage. Leukocytes function to fight microorganisms that may enter the injured or irritated urinary tract. The presence of foreign objects, such as stones in the urinary tract, can trigger the body's immune response. The body tries to protect itself from further damage by sending more leukocytes to the affected area to help heal and fight potential infection [13].

There was no significant association between the presence or absence of urinary sediment in the urinary tract and non-stone groups. Urine sediment analysis only indicates the presence of crystals or mineral components, suggesting the potential for stone formation. This test can detect types of crystals, such as calcium oxalate or uric acid crystals. However, it does not always accurately identify the specific type of stone, as crystals visible in urine sediment are not necessarily fully formed solid stones. More accurate stone identification typically requires further analysis, such as infrared spectroscopy or chemical analysis on stones removed from the body through surgery or spontaneous expulsion. Without such procedures, urinalysis often does not provide specific results to determine the exact type of stone, making the findings more general and only an initial indication [15].

In this study, 7 patients (0.8%) with urinary tract stones were found to have calcium oxalate. This aligns with previous research, where the highest crystal mass was produced when calcium and oxalate were present in a 1:1 ratio in the urine. Oxalatetemporary external factors do not influence oxalate secretion, as these factors are exclusively linked to kidney stones and oxalate excretion is mainly affected by systemic metabolic factors. No significant difference was observed between oxalate excretion in healthy kidneys and kidneys with stones. [15], [16], [17].

5 Conclusion

Based on the results of research conducted to determine differences in the risk of urinary tract stones, a significant association or no difference in risk was found regarding demographics, kidney function (urea, creatinine, GFR), and urinalysis (leukocytes and erythrocytes). However, an insignificant association or a difference in risk was observed in the urine sediment analysis, as it only indicated the presence of crystals or mineral components, which suggests the potential for stone formation.

References

1. Y. Liu et al., "Epidemiology of urolithiasis in Asia," *Asian J. Urol.*, vol. 5, no. 4, pp. 205–214, 2018, doi: 10.1016/j.ajur.2018.08.007.
2. I. P. E. Juliantara and I. K. Sukadana, "Analisis CT Scan Urografi dengan Klinis Batu Saluran Kemih di Instalasi Radiologi Rumah Sakit Bhayangkara Makassar Surtika Umar KUB (Kidney-Ureter-Bladder), Pielografi Intravena (IVP), Ultrasound (USG), Magnetic Resonance Imaging (MRI), Dual Energ," vol. 1, no. 4, 2023.
3. Heriansyah, A. Humaedi, and N. Widada, "Description of Ureum and Creatinin in Chronic Kidney," *J. Binawan*, vol. 1, no. 4, pp. 8–14, 2019.
4. Y. Chen, C. H. Liao, B. J. Chiang, H. C. Huang, and Y. W. Chou, "A lower urine white blood cell median can be a predictor of undiscovered urolithiasis in patients with acute urinary tract symptoms," *Urol. Sci.*, vol. 31, no. 3, pp. 115–121, 2020, doi: 10.4103/UROS.UROS_12_20.
5. P. Simanullang, "Karakteristik Pasien Batu Saluran Kemih di Rumah Sakit Martha Friska Pulo Brayan Medan Tahun 2015 s/d 2017," *J. Darma Agung*, vol. 27, no. 1, pp. 807–813, 2019.
6. V. Selmi, S. Sarı, M. Caniklioğlu, Ü. Öztekin, M. S. Taspinar, and L. Işıkay, "Effect of endoscopic ureteral stone treatment on kidney function," *Cureus*, vol. 13, no. 1, 2021.
7. H. J. Kim and S. H. Oh, "Comprehensive prediction of urolithiasis based on clinical factors, blood chemistry and urinalysis: UROLITHIASIS score," *Sci. Rep.*, vol. 13, no. 1, pp. 1–9, 2023, doi: 10.1038/s41598-023-42208-9.
8. N. Nurfitriani and A. A. G. Oka, "Usia dan obesitas berhubungan terhadap penyakit batu saluran kemih di RSUP Sanglah Denpasar periode Januari 2014 sampai Desember 2014," *Intisari Sains Medis*, vol. 10, no. 2, pp. 258–262, 2019, doi: 10.15562/ism.v10i2.186.
9. X. Qian et al., "Epidemiological Trends of Urolithiasis at the Global, Regional, and National Levels: A Population-Based Study," *Int. J. Clin. Pract.*, vol. 2022, p. 6807203, 2022, doi: 10.1155/2022/6807203.
10. J. McAninch and T. F. Lue, *Smith & Tanagho's General Urology*, 2022.
11. M. Ezzat, M. G. Elsheikh, and G. M. Elshorbagy, "Egyptian urinary stones in the COVID-19 outbreak: a multi-center study," *African J. Urol.*, 2024, doi: 10.1186/s12301-024-00420-7.
12. B. S. Noegroho et al., *Panduan Penatalaksanaan Klinis Batu Saluran Kemih Edisi Pertama*, Jakarta: Ikatan Ahli Urologi Indonesia, 2018.
13. I. Alini and A. Rizaldi, "Penilaian Laboratoris dan Radiologik pada kasus Nyeri Kolik Renal akibat Batu Ginjal dan Batu Ureter Di IGD RSU Putri Bidadari Stabat," *J. Ilm. Simantek*, vol. 6, no. 4, pp. 95–105, 2020.
14. N. Arunkajohnsak, T. Taweemonkongsap, S. Leewansangtong, S. Srinualnad, K. Jongjitaree, and E. Chotikawanich, "The correlation between demographic factors and upper urinary tract stone composition in the Thai population," *Heliyon*, vol. 6, no. 8, p. e04649, 2020, doi: 10.1016/j.heliyon.2020.e04649.
15. P. Wang et al., "Study of risk factor of urinary calculi according to the association between stone composition with urine component," *Sci. Rep.*, vol. 11, no. 1, pp. 1–7, 2021, doi: 10.1038/s41598-021-87733-7.

16. F. Mohammadalibeigi, M. Shirani, H. Seyed-Salehi, and L. Afzali, "Biochemical urinalysis of healthy kidney and stone-generating kidney in unilateral urolithiasis," *J. Ren. Inj. Prev.*, vol. 8, no. 2, pp. 151–156, 2019, doi: 10.15171/jrip.2019.28.
17. F. Qiu, Y. Xu, X. Ji, J. Pu, J. Zhou, and Y. Huang, "Incidence and correlation of metabolic syndrome and kidney stones in a healthy screening population," *Transl. Androl. Urol.*, vol. 10, no. 9, pp. 3646–3655, 2021, doi: 10.21037/tau-21-689.