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ORIGINAL ARTICLE

Factors associated with nephrolithiasis at Royal Prima General Hospital

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ABSTRACT

The high incidence of kidney stones, or nephrolithiasis, at Royal Prima General Hospital in Medan, affecting 234 patients, constitutes a significant problem requiring resolution. The varied nature of nephrolithiasis presentations observed is attributable to numerous influencing factors. Potential causes of kidney stones include inadequate fluid intake, excessive or insufficient physical activity, obesity, high salt consumption, and other unhealthy behaviours. Furthermore, underlying medical conditions such as diabetes, obesity, and hypertension can elevate the risk of kidney stone formation. This research aimed to analyse the factors associated with nephrolithiasis at Royal Prima General Hospital in Medan. This study employed an observational analytical design with a retrospective approach. The study population comprised the medical records of 234 patients diagnosed with nephrolithiasis who sought treatment at Royal Prima General Hospital in Medan between August 2023 and August 2024. Total sampling was utilised, resulting in a sample size of 234. Data analysis involved univariate, bivariate, and multivariate methods. The results revealed that the majority of patients were aged 46-60 years (n=99, 42.3%) and were male (n=147, 62.8%). Significant associations were found between blood pressure, body mass index (BMI), age, and nephrolithiasis at Royal Prima General Hospital in Medan. However, no significant association was observed between gender and nephrolithiasis. Age (X4) was identified as the variable most strongly associated with nephrolithiasis at Royal Prima General Hospital in Medan.

Keywords: nephrolithiasis, blood pressure, BMI, gender, age

INTRODUCTION

The kidneys are vital organs that maintain the body's internal environment. Normal cellular function and survival depend on the regulation of salt, acid, and other electrolyte concentrations within this internal fluid environment.[1] Kidneys prevent waste accumulation, control fluid balance, stabilise electrolyte levels (sodium, potassium, and phosphate), and produce hormones and enzymes that regulate blood pressure, red blood cell production, and bone strength.[2] Renal dysfunction, such as urolithiasis (urinary tract stones) and nephrolithiasis (kidney stones), increases the risk of chronic kidney disease. Untreated chronic disease can impair other organ functions and elevate mortality risk.[3]

Nephrolithiasis, or kidney stones, are urological disorders resulting from the deposition of crystalline components and organic matrices within urine. These stones form from excess waste products secreted by the body. Kidney stones are hard masses of minerals and salts that develop within the kidneys.[4] Kidney stones can occur in the kidneys, ureters, bladder, and urethra. They originate from crystallised waste products in the blood that accumulate within the kidneys. Calcium and oxalic acid are key chemicals involved in stone formation. Over time, these materials harden into stone-like formations.[5]

The incidence of nephrolithiasis is increasing annually.[6] In the United States, prevalence rose to 8.8% by the late 2000s and reached 10% during 2013-2014.[7] Approximately one million patients seek primary care, and 300,000 receive emergency treatment for nephrolithiasis. Globally, 10% of men and 5% of women are affected. In Indonesia, there were 37,636 new cases, 58,959 outpatient visits, and 19,018 hospitalisations, with a mortality rate of 1.98% (378 deaths), according to hospital data.[8] The prevalence of nephrolithiasis in Indonesia is estimated at 6 per 1,000 residents, or 1,499,400 individuals. It predominantly affects those aged

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30-60 years.[2] Indonesian hospital data indicates 37,636 new cases, 58,959 outpatient visits, 19,018 hospitalisations, and 378 deaths (1.98% mortality).[9]

Potential causes of kidney stones include inadequate fluid intake, excessive or insufficient exercise, obesity, high-salt diets, and other unhealthy behaviours. Underlying conditions like diabetes, obesity, and hypertension also increase risk.[10] Hypertension, or high blood pressure, is a global health issue known as the "silent killer." Body weight or body mass index (BMI) is a significant contributing factor.[11] Factors influencing blood pressure include obesity, diet, lifestyle, smoking, physical activity, and alcohol and salt consumption. Obesity and excess weight are strong predictors of hypertension.[12] In Indonesia, hypertension prevalence increased from 25.8% in 2013 to 34.1% in 2018.[13]

Hypertension can contribute to kidney stone formation by narrowing and damaging renal blood vessels, impairing kidney filtration and function.[10] Indonesian Renal Registry (IRR) data from 2017 indicates that hypertension causes 45% of kidney failure cases. Epidemiological studies confirm a positive association between hypertension and kidney stones.[7] Recent research suggests that a history of hypertension is the only clinical parameter correlated with papillary calcification in cadaveric kidneys. A possible hypothesis is that some hypertensive individuals with calculi may share genetic, metabolic, and nutritional predispositions that manifest as nephrolithiasis early in life and hypertension later.[14]

Obesity is another potential risk factor for nephrolithiasis. It involves increased body fat in adipose tissue, assessed via anthropometric measurements like BMI.[15] Obesity, defined as abnormal or excessive fat accumulation, poses health risks, including to the urinary system. In 2016, over 650 million adults worldwide were obese.[16] Obesity is particularly associated with uric acid nephrolithiasis.[17] Obesity, characterised by excess body fat, can be measured using BMI and skinfold thickness. A BMI of ≥25 kg/m2 defines obesity. Studies on idiopathic calcium oxalate stone formers found a 59.2% obesity rate.[15] Obese individuals often exhibit lower urine pH and elevated uric acid, oxalate, and calcium levels.[18] This study aims to analyse the factors associated with nephrolithiasis at Royal Prima General Hospital, Medan.

METHOD

This study employed a retrospective observational analytical design to investigate the relationships between various independent variables and the incidence of nephrolithiasis without direct intervention on study subjects. Data were collected from pre-existing medical records of patients at Royal Prima General Hospital Medan, located at Jalan Ayahanda No. 68A, Medan, North Sumatra, over a five-month period from August to December 2024. The study population comprised all nephrolithiasis patients recorded in the hospital's medical records from August 2023 to August 2024, totaling 234 individuals. A total sampling technique was utilized, with inclusion criteria limited to patients aged over 30 years and excluding those with ureterolithiasis or vesicolithiasis.

The independent variables analyzed were blood pressure, body mass index (BMI), gender, and age, while the dependent variable was the incidence of nephrolithiasis. Blood pressure was categorized as normal or high (≥140/90 mmHg). BMI was classified as normal, underweight, or obese. Gender was categorized as male or female, and age was grouped into 30–45, 46–60, and >60 years. Nephrolithiasis was defined as the presence of kidney stones, diagnosed via CT scan, and categorized by stone location: left kidney, right kidney, multiple stones in the left kidney, multiple stones in the right kidney, stones in both kidneys, or multiple stones in both kidneys.

A quantitative approach was adopted, integrating primary and secondary data. Primary data, including patient symptoms and behaviors, were extracted directly from medical records, following Sudjana (2018). Secondary data, derived from books, journals, and articles (Abdullah et al., 2022; Sujarweni, 2020), and documentary studies, including photographs and academic works, were utilized to support and validate the primary data. The patient medical record served as the primary research instrument, with supporting instruments including documentation tools and a laptop for data processing, ensuring accuracy and precision.

The research procedure was structured into three phases: preparation, implementation, and results evaluation. The preparation phase involved setting up the medical records as the primary instrument. The implementation phase encompassed medical record collection, observation, data grouping, processing, analysis, and documentation. The results evaluation phase focused on data processing and conclusion derivation. Data processing began with a thorough review of medical record completeness. Incomplete or erroneous data were modified or excluded. Data were then coded numerically, recorded on coding sheets (e.g., gender: 1=female, 2=male), and entered into SPSS Version 25 for analysis. Univariate analysis

described variable characteristics using frequency distributions and percentages, calculated as p=(f/n)×100%, where p is the percentage, f the frequency, and n the total sample.

Bivariate analysis examined relationships between independent and dependent variables using cross-tabulations and the Chi-square test or Fisher's Exact Test when necessary. Statistical significance was set at p≤0.05, and correlation coefficients were interpreted as follows: 0.00–0.199 (very weak), 0.20–0.399 (weak), 0.40–0.599 (moderate), 0.60–0.799 (strong), and 0.80–1.000 (very strong). Multivariate analysis utilized logistic regression to assess the influence of multiple independent variables on nephrolithiasis. Variables with p<0.25 were included, and those with p>0.05 were sequentially excluded. This analysis estimated individual risk probabilities based on blood pressure, BMI, gender, and age. The dependent variable, nephrolithiasis, was categorized by kidney stone location.

RESULTS

The study population, comprising 234 patients, exhibited a male predominance (62.8%, n=147) compared to females (37.2%, n=87). Age distribution displayed a bimodal pattern, with the largest group aged 46-60 years (42.3%, n=99), followed closely by those over 60 years (40.2%, n=94). The youngest cohort, aged 30-45 years, constituted 17.5% of the population (n=41). Elevated blood pressure was prevalent, observed in 70.1% of patients (n=164), while 29.9% (n=70) presented with normal blood pressure. Obesity was highly represented, with 61.1% of patients (n=143) classified as obese, compared to 23.5% (n=55) with normal BMI and 15.4% (n=36) classified as underweight.

Table 1. Respondent characteristic

Variable	Total (n= 234)	
	n	%
Gender		
Male	147	62,8
Female	87	37,2
Age		
30-45 years	41	17,5
46-60 years	99	42,3
> 60 years	94	40,2
Blood pressure		
Normal	70	29,9
Elevated	164	70,1
BMI		
Normal	55	23,5
Underweight	36	15,4
Obese	143	61,1
Nefrolithiasis		
Left kidney stone	35	15
Right kidney stone	36	15,4
Left kidney stones (Multiple)	37	15,8
Right kidney stones (Multiple)	39	16,7
Bilateral kidney stones	29	12,4
Bilateral kidney stones (Multiple)	58	24,8

Nephrolithiasis was common, with a detailed analysis of stone location and multiplicity. Unilateral stones were found in 15% of patients in the left kidney (n=35) and 15.4% in the right kidney (n=36), with multiple stones in 15.8% of left kidneys (n=37) and 16.7% of right kidneys (n=39). Bilateral stones were present in 12.4% of patients with single stones in both kidneys (n=29) and 24.8% with multiple stones in both kidneys (n=58), indicating a substantial presence of nephrolithiasis, particularly multiple and bilateral stones, within this patient cohort.

Age demonstrated a significant association with kidney stone presence (p<0.001). Specifically, the 46-60 year age group exhibited the highest incidence of kidney stones, particularly multiple stones. Furthermore, individuals over 60 years old presented with a notably elevated prevalence of bilateral kidney stones, especially multiple bilateral stones. In contrast, the 30-45 year age group was characterized by unilateral kidney stone presentation exclusively. These findings suggest a positive correlation between advancing age and the likelihood of developing nephrolithiasis, especially multiple and bilateral stones. While the odds ratio for age (0.803) indicated a slight decrease in the odds of kidney stone presence, the highly significant p-value warrants further detailed investigation to elucidate this discrepancy.

Similarly, a significant association was observed between elevated blood pressure and kidney stone presence (p<0.001). Individuals with elevated blood pressure exhibited a substantially higher prevalence of kidney stones across all categories, notably multiple and bilateral stones, compared to those with normal blood pressure. Again, the odds ratio (0.733) suggested a slight decrease in odds, necessitating further scrutiny in light of the significant p-value. These results underscore elevated blood pressure as a significant independent risk factor for nephrolithiasis.

Body mass index (BMI) also showed a significant association with kidney stone presence (p<0.001). Obese individuals presented with a markedly increased prevalence of kidney stones, especially multiple and bilateral stones, compared to those with normal or underweight BMI. Interestingly, the underweight group exhibited a higher prevalence of unilateral kidney stones than the normal weight group. The odds ratio for BMI (0.777), similar to age and blood pressure, indicated a slight decrease in odds, which requires further investigation given the significant p-value. This highlights obesity as a significant independent risk factor for kidney stone formation.

Table 2. Risk factors associated with nefrolithiasis

Risk factors	Nefrolithiasis (n (%))						Total	*p*	OR
	Left kidney stone	Right kidney stone	Left kidney stones (Multiple)	Right kidney stones (Multiple)	Bilateral kidney stones	Bilateral kidney stones (Multiple)			
Gender									
Male	23 (9,8)	17 (7,3)	23 (9,8)	27 (11,5)	19 (8,1)	38 (16,2)	147 (62,8)	0,436	0,349
Female	12 (5,1)	19 (8,1)	14 (6)	12 (5,1)	10 (4,3)	20 (8,5)	87 (37,2)		
Age									
30-45 years	21 (9)	20 (8,5)	0	0	0	0	41 (17,5)	0,000	0,803
46-60 years	14 (6)	16 (6,8)	28 (12)	33 (14,1)	3 (1,3)	5 (2,1)	99 (42,3)		
> 60 years	0	0	9 (3,8)	6 (2,6)	26 (11,1)	53 (22,6)	94 (40,2)		
Blood pressure									
Normal	33 (14,1)	31 (13,2)	1 (0,4)	3 (1,3)	2 (0,9)	0	70 (29,9)	0,000	0,733
Elevated	2 (0,9)	5 (2,1)	36 (15,4)	36 (15,4)	27 (11,5)	58 (24,8)	164 (70,1)		
BMI									
Normal	30 (12,8)	25 (10,7)	0	0	0	0	55 (23,5)	0,000	0,777
Underweight	5 (2,1)	11 (4,7)	6 (2,6)	6 (2,6)	7 (3)	1 (0,4)	36 (15,4)		
Obese	0	0	31 (13,2)	33 (14,1)	22 (9,4)	22 (9,4)	143 (61,1)		

In summary, age, elevated blood pressure, and obesity were significantly associated with an increased risk of kidney stone development. Notably, advancing age correlated with an increased risk of multiple and bilateral kidney stones. Elevated blood pressure and obesity emerged as strong independent risk factors for all forms of kidney stone presentation. While the odds ratios for age, blood pressure, and BMI suggested a slight decrease in odds, the highly significant p-values necessitate a more detailed examination to reconcile these findings. Gender, however, did not demonstrate a statistically significant association with kidney stone formation in this study.

The most influential risk factor identified is age, with an extremely high odds ratio of 10,380. This suggests that increasing age is associated with a dramatically increased risk of developing kidney stones. To put this into perspective, older individuals have over ten thousand times the odds of developing kidney stones compared to younger individuals, when all other variables are held constant. This extremely high number indicates that age is a very strong predictor.

Table 3. Most influential risk factors for nephrolithiasis

Variable	Odds Ratio
Age	10,380
Blood pressure	4,441
BMI	4,569

Blood pressure is also a significant risk factor, with an odds ratio of 4,441. Individuals with higher blood pressure are over four thousand times more likely to develop kidney stones. This highlights the substantial impact of hypertension on kidney stone formation. Similarly, body mass index (BMI), a measure of body fat based on height and weight, demonstrates a strong association with kidney stones, with an odds ratio of 4,569. Those with a higher BMI are also over four thousand times more likely to develop kidney stones. This reinforces the link between obesity and the increased risk of nephrolithiasis.

In summary, this data strongly suggests that age, elevated blood pressure, and a high BMI are all major contributing factors to the development of kidney stones. The extremely high odds ratios indicate a very strong correlation between these variables and the likelyhood of developing nephrolithiasis.

DISCUSSION

This study found a strong correlation between age and nephrolithiasis. The incidence of nephrolithiasis increased with age, with the highest prevalence observed in the >60 age group (40.2%). The increased risk of nephrolithiasis with age may be attributed to age-related physiological changes. Renal function can decline with age, and metabolic alterations can affect urine composition. Furthermore, comorbidities such as diabetes and hypertension, which are more prevalent in older individuals, can elevate the risk of nephrolithiasis. These findings are consistent with previous research by Maulana et al.[19] which demonstrated an association between age and nephrolithiasis incidence in the surgical inpatient ward of Dr. H. Abdoel Moeloek Regional General Hospital, Lampung Province. Advancing age appears to increase the percentage of stone formation, reaching a peak in adulthood, possibly due to the incomplete development of

nephron anatomy in children, characterized by shorter lengths and reduced volumes of the proximal tubules and loop of Henle, thus limiting crystal formation.[8]

This study also revealed a significant association between blood pressure and nephrolithiasis. The majority of patients experienced hypertension, and chi-square test results confirmed a strong relationship between high blood pressure and nephrolithiasis incidence. Hypertension is defined as blood pressure of 140/90 mmHg or higher. It can have severe consequences if left untreated. Hypertensive patients often exhibit no symptoms. Blood pressure measurements are conducted to assess blood pressure status.[7] Hypertension is one of the most common conditions in the general population, affecting all age groups from adolescents to the elderly. According to the WHO, hypertension is a condition where blood vessels persistently exhibit elevated blood pressure. Blood pressure, often referred to as the 'silent killer', is a chronic disease with the highest global prevalence, influenced by environmental, lifestyle, and genetic factors, and has significant effects on conditions like heart failure, myocardial infarction, cardiovascular disease, and stroke. It can also be influenced by medications, stress, physical inactivity, high salt intake, and potassium deficiency.[20] While hypertension does not directly cause kidney stones, it can lead to renal abnormalities, which subsequently increase the risk of kidney stone formation. Thus, renal dysfunction and hypertension are interrelated.[7]

Additionally, this study identified a significant association between BMI and nephrolithiasis. A substantial proportion of patients had a BMI in the obese category, and chi-square test results indicated a strong correlation between obesity and nephrolithiasis incidence. These findings align with research by Eko et al.[15] which also demonstrated a significant association between obesity and nephrolithiasis. Obese individuals tend to have an increased risk of uric acid urinary tract stones. This is attributed to the decreased urinary pH in overweight and obese patients, resulting from reduced ammonia excretion and increased endogenous acid production. Nephrolithiasis is a multifactorial disease, with obesity being one of the contributing factors. Research indicates that obesity is associated with a spectrum of metabolic abnormalities, including dyslipidemia, hypertension, impaired carbohydrate tolerance, insulin resistance, and hyperinsulinemia. These conditions constitute metabolic syndrome. Researchers have hypothesized that the increased prevalence of metabolic syndrome enhances the predisposition to uric acid and calcium oxalate stone formation. Obesity can increase the risk of kidney stone formation through several mechanisms. Obese patients often have a lower urinary pH, which increases the risk of uric acid stone formation. Furthermore, obesity is frequently associated with metabolic syndrome, which includes dyslipidemia, insulin resistance, and hyperinsulinemia. These conditions can alter urine composition and elevate the risk of calcium oxalate stone formation.

In contrast to the aforementioned factors, this study did not find a significant association between gender and nephrolithiasis. Nevertheless, descriptive data indicated a higher occurrence of nephrolithiasis in males. Nephrolithiasis is more common in males due to the longer anatomical structure of the male urinary tract, which increases the likelihood of stone-forming substance deposits. Androgen hormones influence the increased formation of calcium oxalate stones, while estrogen hormones have the opposite effect, reducing oxalate excretion, plasma oxalate concentration, and plasma calcium crystal deposits. Calcium levels, the primary component of stone formation, are higher in male urine compared to female urine, and citrate levels, which inhibit stone formation, are higher in female urine than in male urine, thus predisposing males to a higher risk of stone formation.[17]

CONCLUSION

This study demonstrates that age, elevated blood pressure, and obesity are significant independent risk factors for nephrolithiasis. Advancing age, particularly exceeding 60 years, exhibits a strong correlation with increased risk, especially for multiple and bilateral kidney stones. Elevated blood pressure and obesity are also significantly associated with all forms of kidney stone presentation. While a descriptive difference indicated a higher prevalence of nephrolithiasis in male patients, gender did not achieve statistical significance as an independent risk factor. Although the observed odds ratios for age, blood pressure, and body mass index (BMI) were slightly lower than initially hypothesized, they still reveal a substantial impact on kidney stone development. Notably, the exceptionally high odds ratio for age (10,380) underscores its potent role as a risk factor. These findings reinforce the importance of considering age-related physiological changes, hypertension-induced renal abnormalities, and obesity-related metabolic disturbances in the pathogenesis of nephrolithiasis. Further research is warranted to elucidate the discrepancy between the magnitude of the odds ratios and the statistically significant p-values observed for age, blood pressure, and

BMI. This investigation should focus on exploring potential confounding factors and underlying mechanisms. Ultimately, this study corroborates existing literature and expands the current understanding of risk factors associated with nephrolithiasis.

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