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Epidemiology and types of urolithiasis

Epidemiologia i rodzaje kamicy układu moczowego

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Abstract

Urolithiasis is a lifestyle disease. Sex, age, race, place of residence (geographical region), chronic diseases, lifestyle (including diet) and various genetic factors contribute to the risk of calculus formation within the urinary tract. The prevalence of urolithiasis in adults ranges from 1 to 20%, and children account for 2–10% of patients. The annual incidence of paediatric urolithiasis is estimated at several cases per 100,000 children worldwide; it is the reason for approximately 1 per 1,000 hospitalisations among paediatric patients. The prevalence of urolithiasis has been increasing in both adults and children. In young children, the disease is usually a result of a genetically determined metabolic defect (such as hypercalciuria, distal tubular acidosis, familial hypomagnesaemia with hypercalciuria and nephrocalcinosis, or Lesch–Nyhan syndrome). Another significant risk factor in children is a urinary tract defect with urinary retention. Urinary tract infections, in turn, may be either a cause or a complication of urolithiasis. In older children and adults, malnutrition, obesity and metabolic syndrome play a significant role. Other factors conductive to urolithiasis are: certain drugs, low level of physical activity, long immobilisation, low fluid intake, warm climate, inadequate diet and improper vitamin D_3 supplementation. The disease recurs within 5 years in 50% of patients. Urolithiasis and its complications may lead to end-stage renal failure. The disease can be divided into different types based on the chemical composition of a calculus, aetiology of the disease and site of calculus formation (upper or lower urinary tract). The composition of calculi is quite often mixed, and they form due to various causes.

Keywords: urolithiasis, hypercalciuria, children, epidemiology

Streszczenie

Kamica układu moczowego jest chorobą cywilizacyjną. Na ryzyko powstawania złogów w drogach moczowych mają wpływ: płeć, wiek, rasa, miejsce zamieszkania (region geograficzny), choroby przewlekłe, styl życia – w tym dieta – oraz liczne czynniki genetyczne. Częstość występowania kamicy u dorosłych waha się od 1 do 20%. Dzieci stanowią 2–10% wszystkich osób z kamicą układu moczowego. Zapadalność na tę chorobę wśród dzieci na świecie szacuje się na kilka przypadków na 100 000 dzieci na rok; odpowiada ona za około 1 na 1000 hospitalizacji pacjentów pediatrycznych. Zarówno u dorosłych, jak i u dzieci obserwuje się wzrastającą częstość kamicy układu moczowego. U małych dzieci jest ona najczęściej spowodowana genetycznie uwarunkowanymi defektami metabolicznymi (m.in. hiperkalciuria, kwasica kanalikowa dystalna, rodzinna hipomagnezemia z hiperkalciurią i nefrokalcynozą, zespół Lescha–Nyhana). Innym ważnym czynnikiem ryzyka powstawania złogów u dzieci są wady układu moczowego związane z zastojem moczu. Zakażenia układu moczowego mogą być przyczyną lub powikłaniem kamicy. U starszych dzieci i osób dorosłych istotną rolę odgrywają niedożywienie, otyłość i zespół metaboliczny. Do innych czynników ryzyka kamicy należą przyjmowanie niektórych leków, niska aktywność fizyczna, długotrwałe unieruchomienie, mała podaż płynów, ciepły klimat, nieprawidłowa dieta i niewłaściwa suplementacja witaminy D_3. Do nawrotu choroby w ciągu 5 lat od jej rozpoznania dochodzi u 50% pacjentów. Kamica i jej powikłania mogą prowadzić do rozwoju schyłkowej niewydolności nerek. Kamicę moczową można podzielić na różne rodzaje ze względu na skład chemiczny złogu, etiologię oraz miejsce powstawania złogu (górne lub dolne drogi moczowe). Nierzadko złogi mają mieszany skład, a przyczyna ich powstawania jest uwarunkowana wieloma czynnikami.

Słowa kluczowe: kamica układu moczowego, hiperkalciuria, dzieci, epidemiologia

EPIDEMIOLOGY OF UROLITHIASIS

Urolithiasis is the effect of calculus formation from chemical substances present in urine. Until recently, the disease was mainly diagnosed in adulthood. At present, however, it more and more frequently affects also children, irrespective of their age. The prevalence of urolithiasis depends on age, sex, race, place of residence (geographical region) and socioeconomic factors.

According to the epidemiological data, the prevalence of urolithiasis in adults ranges from 1 to 20%[1,2], with the greatest incidence noted between the age of 20 and 40 years[1]. These data are probably underestimated due to a possible asymptomatic course. Moreover, the prevalence varies across the regions of the world. In Asia, urolithiasis is diagnosed in 1–5% of the population, except for Saudi Arabia where the prevalence is the highest in the world and reaches 20.1%. The average prevalence in Europe is 5–9%, while in Canada and United States, it amounts to 13–15%[3,4]. There may be differences in prevalence rates within a single country as the disease depends on a geographical region. In the south of the United States, the disease is noted in approximately 15% of people, while in only 7% in the north. A gradual increase in the prevalence of urolithiasis has been observed in all regions of the world. In Germany, it increased from 4% to 4.7% in 1979–2001[5]. In Turkey, almost a 5-fold increase has been noted within a decade[6]. This is linked with a change in lifestyle and better imaging.

Calculi in the urinary tract develop more often in males than in females. In the United States, the male-to-female ratio is 1.7–1.3:1, in Germany 2.4:1, in Iraq 2.5:1 and in Saudi Arabia 5:1[7–10]. In the recent years, the prevalence of urolithiasis in women has been increasing, mainly due to lifestyle changes[11]. The disease is more common in the white race. In the United States, it is diagnosed in 5.9% of Caucasian individuals and in 1.7% of individuals of African American ancestry[12]. Irrespective of the race, however, lifestyle changes do affect the prevalence of urolithiasis. Dietary and environmental factors may contribute to hyperoxaluria, hypocitraturia, hypercalciuria or hyperuricosuria. Increased prevalence rates of urolithiasis in the United Arab Emirates and Saudi Arabia probably result from warm climate, greater risk of dehydration and low amount of produced urine. Restricted water intake and dietary habits lead to hypercrystalluria and calculus formation.

Furthermore, the global epidemic of obesity is associated with greater prevalence of urolithiasis. The risk of developing the disease also depends on the type of obesity, with the greatest risk observed in individuals with central obesity. The greater the waist circumference and body mass index, the greater the risk of urolithiasis. Obese individuals excrete greater amounts of oxalates, uric acid, sodium and phosphate compared to those with normal body mass. In addition, epidemiological studies indicate that type 2 diabetes, hypertension, obesity, hypercholesterolaemia and nicotinism increase the risk of nephrolithiasis[13].

Children account for 2–10% of urolithiasis patients[14,15]. The prevalence of paediatric urolithiasis is estimated at 1–5% in developed countries and at even 15% in developing countries[4,16]. However, the real prevalence is difficult to estimate as the disease may be asymptomatic in the developmental period, with urinary stones detected in a routine abdominal ultrasonography or incidentally during a diagnosis of other diseases[15]. In the United States, the disease occurs in 1 per 1,000–7,600 children admitted to hospital[3,17]. In Croatia, 1 per 400 hospital admissions is related with urolithiasis, and the estimated incidence among children of this country reaches 6.5/100,000/year[18]. In Iceland, urolithiasis is a reason for 1 per 1,000 hospitalisations, and the annual incidence is estimated at 5.6/100,000/year[19]. As in the adult form, the incidence of paediatric urolithiasis has been increasing as well, mainly in children of the Caucasian race[17,20–22]. An American study demonstrated that the incidence of nephrolithiasis increased from 7.9/100,000/year in 1996 to 18.5/100,000/year in 2007[20].

In Poland, 23–43% of children with urolithiasis are younger than 1 year of age[23,24]. In these cases, the disease is mainly caused by congenital or acquired metabolic defects associated with hypercrystalluria (hypercalciuria, hyperuricosuria, hyperphosphaturia, hyperoxaluria, cystinuria) and/or hypocitraturia. In total, metabolic disturbances are identified in approximately 75% of these children[23]. Young children more often present with nephrocalcinosis and calculi located in the kidneys, while the cystic or ureteral location of calculi is observed in older children[15]. In the first decade of life, urolithiasis is more common in boys (1.2:1 at the age of 0–5 years, 1.3:1 at the age of 6–10 years), while the predominance in girls is observed in the second decade of life (0.96:1 at the age of 11–15 years and 0.3:1 at the age of 16–20 years)[25]. Data from the south-eastern parts of the United States indicate a growing percentage of females among urolithiasis patients: in 1996, the incidence in boys was 8 cases/100,000/year, and in girls 7.7/100,000/year, whereas in 2007 the respective values increased to 21.9/100,000/year and 15.3/100,000/year[20].

Urinary stone formation depends on genetic and environmental factors[26]. Children of parents with urolithiasis are at a 2–16-fold greater risk of developing the disease compared with the general population. In siblings of a urolithiasis patient, the risk of calculus formation is increased by 35–65%[4,15]. Approximately 16.4–35.9% of young children with this disease have renal and urinary tract malformations (defects associated with chronic urinary retention in the urinary tract or vesicoureteral reflux). The presence of a urinary tract defect predisposes to recurrent urolithiasis. Moreover, children with this disease more often develop urinary tract infections. It is believed that urolithiasis may be both a cause and a complication of recurrent urinary tract infections[4,15].

In older children, lifestyle factors predominate in the aetiology of urolithiasis. As in adults, the increase in the incidence in developed countries is associated with diet

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(excessive intake of protein and salt) and low physical activity. The dietary content of animal protein in the diet of European and American children is 3–5 times greater than daily requirement. Urolithiasis is more often identified in obese children with metabolic syndrome. An analysis of patients from the American Kids' Inpatient Database (KID) has shown that, as in adults, hypertension, diabetes mellitus and obesity are risk factors of paediatric urolithiasis[22]. It must be remembered, however, that malnutrition is also conductive to this disease due to the coexisting catabolic processes[27].

It is worth emphasising that epidemiological studies demonstrate a decline in the prevalence of struvite urolithiasis. In a French study, it decreased from 11.1% in 1980s to 6.1% in the first decade of the 21st century[28]. The prevalence of this type of urolithiasis in the Polish population is 1.4–24% depending on the institution[23,29].

Urolithiasis is a recurring disease. A recurrence is identified within 5 years in 50% of patients and within 10 years in 80–90% of patients[30]. The younger the child is at the diagnosis, the greater the risk of recurrence, the more frequent the complications and the more difficult the treatment.

Urolithiasis is an independent risk factor of chronic kidney disease. The risk of end-stage renal failure (ESRD) is doubled in urolithiasis patients. The progression to ESRD is also preconditioned by concomitant urinary tract infections and defects (urinary retention, solitary kidney and neurogenic bladder). More rapid progression of chronic kidney disease is observed in patients with staghorn stones (infected urolithiasis) and uric acid calculi[15,17,31].

TYPES OF PAEDIATRIC UROLITHIASIS

There are several ways to classify paediatric urolithiasis. It can be analysed based on[4,15]:

- the type of calculus;
- aetiology;
- location.

The classification based on the chemical composition of a calculus is of the greatest significance. However, it must be underlined that mixed forms are quite frequent. Data on calculus composition vary across geographical regions. Types of urolithiasis and the occurrence of particular types of calculi (including their predominant constituent) are presented in Tab. 1. Calcified stones prevail in most regions of the world. Usually, the main component of stones is calcium oxalate mono- or dihydrate (whewellite: $Ca(COO)_2{*}H_2O$; weddellite: $Ca(COO)_2{*}2H_2O$]. Calculi made of calcium phosphate, uric acid and ammonium magnesium phosphate are characterised by a slightly lower global frequency of occurrence.

Depending on the aetiology, the following are distinguished:

- metabolic urolithiasis that is secondary to a congenital metabolic defect, which is the most common cause of urolithiasis in developed countries; the defect may concern only the kidney (e.g. renal hypercalciuria) or have a systemic nature with kidney manifestation (e.g. primary hyperoxaluria, xanthinuria, Lesch–Nyhan syndrome);
- infected urolithiasis, i.e. associated with the presence of urease-producing bacteria in the urinary tract;
- urolithiasis occurring due to: environmental factors (e.g. induced by medications, for instance overdose

Country	Tunisia (33)	China (34)	Poland (29)	United Kingdom (35)	The Netherlands (36)	United States* (37)	India** (38)
Number of examined children	120	177	135	121	71	5,245	325 (of which 146 calculi were tested)
Age	From 5 to 15 years Mean: 8 years	From 6 months to 16 years Mean for boys: 6.94 ± 4.89 years Mean for girls: 6.15 ± 3.79 years	From 2 to 18 years Median: 14.6 years	Boys: from 3 months to 15 years Median: 3 years Girls: from 4 months to 11.4 years Median: 4 years	From 6 months to 18.3 years Mean: 8.8 ± 5.6 years	From 1 to 18 years Mean: 13.3 ± 4.1 years	From 3 to 17 years Mean: 8 years
Sex (m/f)	2.08/1	2.90/1	1.11/1	2.10/1	2.09/1	0.77/1	3.01/1
Whewellite	65%	50%	Total 73%	Total 50%	Calcium oxalate: 20% Calcium phosphate: 16% Calcium oxalate and phosphate: 23%	83%	68.5%
Weddellite	5%	15%					17%
Calcium phosphate	1%	0%	9%			61%	5%
Struvite	10%	2%	13%	29%	25%	4.4%	3%
Uric acid	7%	10%	0%	No data	8%	1%	1.5%
Carbonic apatite	5%	9%	0%	No data	–	0.4%	0%
Cystine	3%	9%	1%	3%	8%	2.3%	0%
Ammonium urate	3%	4.5%	0%	No data	–	3%	2%
Xanthine	1%	0%	0%	No data	–	–	0%
Sodium urate	–	0.5%	0%	No data	–	–	0%

m – male; **f** – female.
* No dominant component was identified due to a large percentage of mixed calculi; a total number of components exceeds 100%.
** Mixed calculi – 3%.

Tab. 1. Types of calculi in the urinary tract and the occurrence of a given type of calculus (or its predominant component)[29,33–38, own modification]

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of vitamin D_3 that induces hypercalciuria, carbonic anhydrase inhibitors that elicit hypocitraturia or by drugs that crystallise in the urinary tract, such as indinavir), melamine exposure, extreme dietary errors or monothematic diet (e.g. oxalate-abundant diet or ketogenic diet).

In practice, mixed aetiology is seen in most cases (e.g. calcium- and sodium-rich diet in a patient with idiopathic hypercalciuria). Urinary tract defects that carry a risk of urinary retention and urinary tract infections (e.g. obstructive uropathies, neurogenic bladder) should be listed as additional predisposing factors (and somewhat even as aetiological factors).

As for the location of calculi, the disease can be classified as follows:

- upper urinary tract urolithiasis;
- lower urinary tract urolithiasis.

Up to the 19th century, cystolithiasis prevailed in children. At present, the disease mostly affects the upper urinary tract. It is believed that the preponderance of cystolithiasis (especially in boys) was a result of feeding young children products with a high carbohydrate content (flour, rice) and a low phosphate content, which predisposes to the formation of insoluble calculi in the urinary bladder[32].

Conflict of interest

The authors do not report any financial or personal affiliations to persons or organisations that could adversely affect the content of or claim to have rights to this publication.

References

1. Trinchieri A: Epidemiology of urolithiasis: an update. Clin Cases Miner Bone Metab 2008; 5: 101–106.
2. Sharma AP, Filler G: Epidemiology of pediatric urolithiasis. Indian J Urol 2010; 26: 516–522.
3. Ramello A, Vitale C, Marangella M: Epidemiology of nephrolithiasis. J Nephrol 2000; 13 (Suppl 3): 45–50.
4. López M, Hoppe B: History, epidemiology and regional diversities of urolithiasis. Pediatr Nephrol 2010; 25: 49–59.
5. Hesse A, Brändle E, Wilbert D et al.: Study on the prevalence and incidence of urolithiasis in Germany comparing the years 1979 vs. 2000. Eur Urol 2003; 44: 709–713.
6. Alpay H, Ozen A, Gokce I et al.: Clinical and metabolic features of urolithiasis and microlithiasis in children. Pediatr Nephrol 2009; 24: 2203–2209.
7. Scales CD Jr, Curtis LH, Norris RD et al.: Changing gender prevalence of stone disease. J Urol 2007; 177: 979–982.
8. Qaader DS, Yousif SY, Mahdi LK: Prevalence and etiology of urinary stones in hospitalized patients in Baghdad. East Mediterr Health J 2006; 12: 853–861.
9. Khan AS, Rai ME, Gandapur et al.: Epidemiological risk factors and composition of urinary stones in Riyadh Saudi Arabia. J Ayub Med Coll Abbottabad 2004; 16: 56–58.
10. Knoll T, Schubert AB, Fahlenkamp D et al.: Urolithiasis through the ages: data on more than 200,000 urinary stone analyses. J Urol 2011; 185: 1304–1311.
11. Scales CD Jr, Curtis LH, Norris RD et al.: Changing gender prevalence of stone disease. J Urol 2007; 177: 979–982.
12. Stamatelou KK, Francis ME, Jones CA et al.: Time trends in reported prevalence of kidney stones in the United States: 1976–1994. Kidney Int 2003; 63: 1817–1823.
13. Taylor EN, Stampfer MJ, Curhan GC: Obesity, weight gain, and the risk of kidney stones. JAMA 2005; 293: 455–462.
14. Schwarz RD, Dwyer NT: Pediatric kidney stones: long-term outcomes. Urology 2006; 67: 812–816.
15. Habbig S, Beck BB, Hoppe B: Nephrocalcinosis and urolithiasis in children. Kidney Int 2011; 80: 1278–1291.
16. Rizvi SA, Naqvi SA, Hussain Z et al.: Pediatric urolithiasis: developing nation perspectives. J Urol 2002; 168: 1522–1525.
17. VanDervoort K, Wiesen J, Frank R et al.: Urolithiasis in pediatric patients: a single center study of incidence, clinical presentation and outcome. J Urol 2007; 177: 2300–2305.
18. Milošević D, Batinić D, Turudić D et al.: Demographic characteristics and metabolic risk factors in Croatian children with urolithiasis. Eur J Pediatr 2014; 173: 353–359.
19. Edvardsson V, Elidottir H, Indridason OS et al.: High incidence of kidney stones in Icelandic children. Pediatr Nephrol 2005; 20: 940–944.
20. Sas DJ, Hulsey TC, Shatat IF et al.: Increasing incidence of kidney stones in children evaluated in the emergency department. J Pediatr 2010; 157: 132–137.
21. Bush NC, Xu L, Brown BJ et al.: Hospitalizations for pediatric stone disease in United States, 2002–2007. J Urol 2010; 183: 1151–1156.
22. Matlaga BR, Schaeffer AJ, Novak TE et al.: Epidemiologic insights into pediatric kidney stone disease. Urol Res 2010; 38: 453–457.
23. Wachnicka-Bąk A, Jobs K, Jung A et al.: Kamica układu moczowego u dzieci w wieku 0–3 lata w badaniach własnych z uwzględnieniem współwystępowania wad i zakażeń układu moczowego. Pediatr Med Rodz 2016; 12: 164–170.
24. Kiliś-Pstrusińska K, Zwolińska D, Medyńska A: Kamica układu moczowego u dzieci do 4 roku życia. Pol Merkur Lek 2000; 8: 184–186.
25. Novak TE, Lakshmanan Y, Trock BJ et al.: Sex prevalence of pediatric kidney stone disease in the United States: an epidemiologic investigation. Urology 2009; 74: 104–107.
26. Goldfarb DS, Fischer ME, Keich Y et al.: A twin study of genetic and dietary influences on nephrolithiasis: a report from the Vietnam Era Twin (VET) Registry. Kidney Int 2005; 67: 1053–1061.
27. Selimoğlu MA, Menekşe E, Tabel Y: Is urolithiasis in children associated with obesity or malnutrition? J Ren Nutr 2013; 23: 119–122.
28. Daudon M, Bouzidi H, Bazin D: Composition and morphology of phosphate stones and their relation with etiology. Urol Res 2010; 38: 459–467.
29. Kirejczyk JK, Porowski T, Filonowicz R et al.: An association between kidney stone composition and urinary metabolic disturbances in children. J Pediatr Urol 2014; 10: 130–135.
30. Uribarri J, Oh MS, Carroll HJ: The first kidney stone. Ann Intern Med 1989; 111: 1006–1009.
31. Keddis MT, Rule AD: Nephrolithiasis and loss of kidney function. Curr Opin Nephrol Hypertens 2013; 22: 390–396.
32. Halstead SB: Epidemiology of bladder stone of children: precipitating events. Urolithiasis 2016; 44: 101–108.
33. Alaya A, Nouri A, Najjar MF: Urolithiasis in Tunisian children: a study of 100 cases. Saudi J Kidney Dis Transpl 2009; 20: 1096–1100.
34. Sun X, Shen L, Cong X et al.: Infrared spectroscopic analysis of urinary stones (including stones induced by melamine-contaminated milk powder) in 189 Chinese children. J Pediatr Surg 2011; 46: 723–728.
35. Coward RJ, Peters Cj, Duffy PG et al.: Epidemiology of paediatric renal stone disease in the UK. Arch Dis Child 2003; 88: 962–965.
36. Rellum DM, Feitz WF, van Herwaarden AE et al.: Pediatric urolithiasis in a non-endemic country: a single center experience from The Netherlands. J Pediatr Urol 2014; 10: 155–161.
37. Gabrielsen JS, Laciak RJ, Frank EL et al.: Pediatric urinary stone composition in the United States. J Urol 2012; 187: 2182–2187.
38. Abhishek, Kumar J, Mandhani A et al.: Pediatric urolithiasis: Experience from a tertiary referral center. J Pediatr Urol 2013; 9: 825–830.