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REVIEW ARTICLE

Urolithiasis: History, epidemiology, aetiologic factors and management

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Abstract

Urolithiasis is defined as a disease diagnosed by the presence of one or more stones in the urinary tract. It is one of the oldest and most widespread diseases known to man, their discovery and characterisation chronology began with the civilisation's history. This pathology has a multifactorial aetiology, very frequent worldwide with geographic and racial variation, their prevalence is increasing in lockstep with socioeconomic development. In fact, this disorder affects between 2 and 20% of the population, with an approximate recurrence rate of 30% to 50% in 5 years. Furthermore, calcium-type stones, which are composed of calcium oxalate (CaOx) alone or a mixture of CaOx and calcium phosphate are the most common, accounting for more than 80% of cases. The medical management of urolithiasis is done by medical treatments and/or by surgical intervention for the stones extraction by the techniques such as extracorporeal shock wave lithotripsy (ESWL), ureteroscopy (URS), percutaneous nephrolithotomy (PCNL) and open surgery. However, various therapies, including thiazide diuretics and alkaline citrate, are used in an attempt to prevent stones recurrence induced by hypercalciuria and hyperoxaluria, but the scientific evidence for their effectiveness is less convincing. On the other hand, endoscopic and ESWL methods have revolutionised the treatment of urinary lithiasis, but these costly methods, can cause acute kidney injury and decreased renal function, in addition, do not prevent the probability of new stone formation. The deepening of our knowledge on all points relating to this disease is a priority for specialists in order to find adequate solutions for this disease. This review provides an overview of urolithiasis, its history, epidemiology, clinical manifestation, diagnosis and treatment methods.

Keywords: Aetiologic factors, diagnosis, epidemiology, history, management, urolithiasis.

BACKGROUND

Urolithiasis, also known as king's disease, is one of the most common diseases and a major public health problem concern around the world. The pathology is caused by an urinary biochemical imbalance between stone-forming inhibitors and promotors in a process called lithogenesis.[1] It is characterised by the presence of stones in the kidneys (parenchyma, calyx, etc.), or in the urinary tract (pelvis, ureter, bladder) (Fig. 1), therefore causing pain, bleeding and can lead to renal failure. The disease has been recognised since the dawn of history and methods of treatment have been reported in various medical writings from different civilisation. Treatment and prevention of urolithiasis recurrence requires a better understanding of the disease, the

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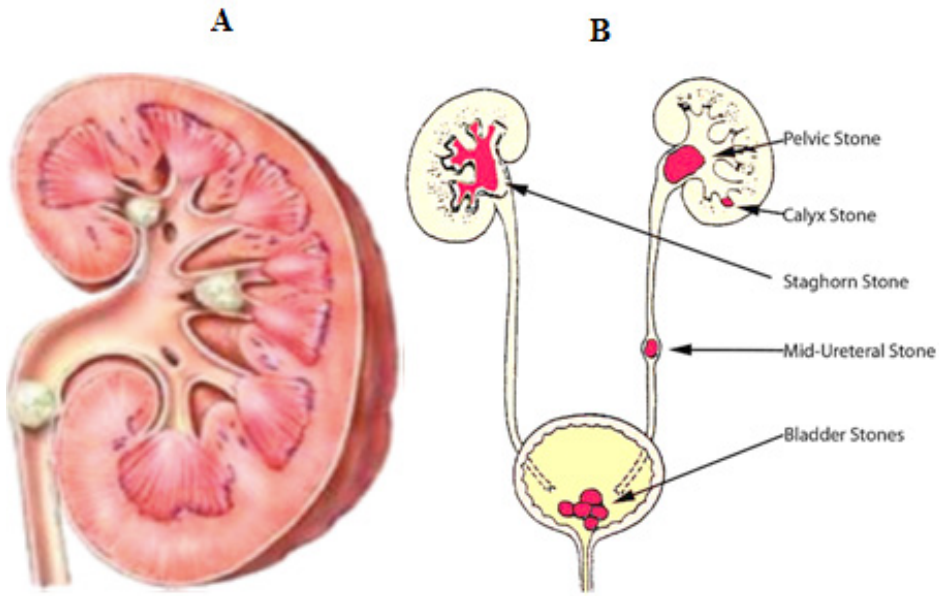

FIG. 1: Localisation of urinary stones in the kidney (A)[2] and in the urinary tract (B)[3].

mechanisms involved stones formation and the relationship that exists between other disorder.

Urinary Stones

The term "stones" is derived from the Latin calculus (pebbles)[4], and refers to a pathological biomineralisation product, defined as an agglomeration of crystals bound by an organic matrix. Except for rare types, which have a matrix content of approximately 65%, the latter accounts for 2 to 5% of the total mass of stones.[5] It is composed primarily of proteins, amino acid polymers, lipids and cellular compounds.[6–9]

The role and importance of this matrix has been explained in a paradoxical way by some researchers including Boyce (1968)[10], who proposed that it actively participates in the assembly of kidney stones, serves as a model and controls crystallisation within its limits.[11]

On the other hand, and in an opposite way, Vermeulen & Lyon (1968) considered that the matrix and its ubiquitous presence as a simple coincidence, because the stones crystallise in the urine with the presence a large macromolecules, and that proteins form a discontinuous layer around the small crystals whose sizes varies between 10 to 20 nm. However, they suggested that newly formed crystals with a macromolecular layer are less likely to dissolve during ionic and urinary pH changes, hence the matrix's importance in the formation of stones.[11,12] A third possibility has been proposed by Khan and Kok (2004), who suggest that the matrix compounds play different roles in two events, which do not necessarily take place at the same site. The first is manifested by the stone centre formation which involves the formation and retention of crystals and occurs in the short term. While the second involves their later constructions, it is a long-term event that occurs after the formation and maintenance of stones nest.[5]

History of the disease

The discovery and characterisation of stones chronology are not recent. It started and went in parallel with civilisation's history. Archaeological and paleontological documents clearly show that this pathology is one of the oldest human diseases. The earliest recorded urinary and bladder stones were identified by Shattock in 1905[13], found in Egyptian mummies and aged approximately 4400 BC. -JC for the first stone and from 4800 BC. -JC for the second.[13]

However, this disease has been cited in various scientific and literary writings throughout the human civilization's history (Fig. 2). The first literary references in relation to stone disease were revealed in of Asutu in Mesopotamia medical texts, between 3200 and 1200 BC. -JC. These writings describing symptoms and ordering treatments to dissolve stones such as the use of black saltpetre, ostrich eggshell, pine turpentine and the sex part of the donkey.[14–16] The old traditional Egyptian medicine has also reported therapeutic schemes for the treatment of urinary tract diseases, including stones which are

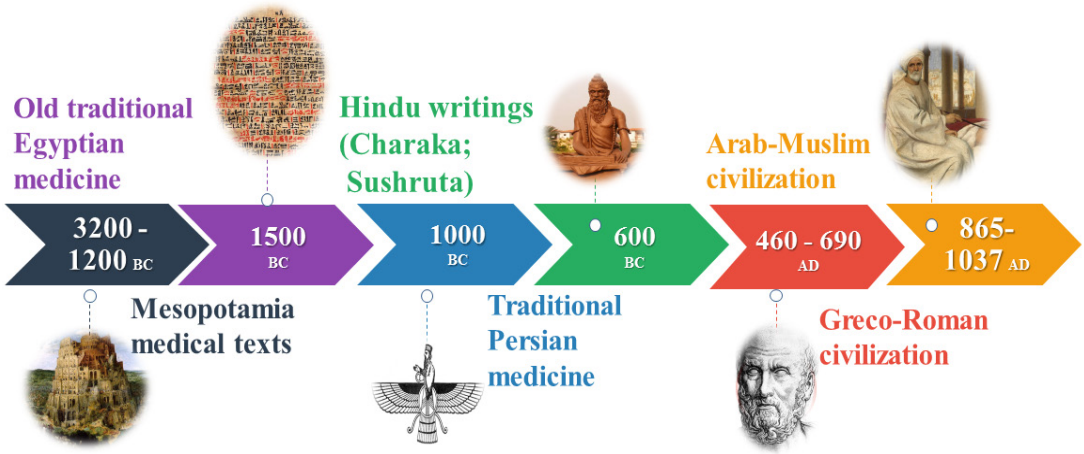

FIG. 2. Urolithiasis history.

found in the Ebers papyrus (1500 BC).[17,18] Also, the system of traditional Persian medicine dating back to 1000 BC describes the symptoms of stone disease and suggests methods of treatment based on the adoption of a bath and massage with scorpion oil, diet and the use mixture of some vegetables infusion.[14]

The Hindu writings of ancient India had mentioned this disease, mainly by two famous physicians Charaka and Sushruta (about 600 BC). The latter describes in their texts collection on the traditional medicine practice "*Sushruta Samhita*", the causes of stone formation. He recommended many medical treatments and provided a detailed description of the surgical procedure, including perineal lithotomy.[14,15,17,18] The contributions of the ancient Greeks and Romans are numerous and diverse. Hippocrates (460-377 BC) described kidney diseases and defined the symptoms of bladder stones. He also stated his warnings and concerns about the risks of performing lithotomy in their Oath "*I will not cut persons labouring under the stone but will leave this to be done by practitioners of this work*".[14,15,17,19,20] Ammonius of Alexandria (276 BC) was the first to suggest crushing stones in order to facilitate their removal. Cornelius Celsus (25 BC to 40 AD) described the abdominal pain of patients with urolithiasis, his description of perineal lithotomy marked a turning point in the history of urology. This technique was practiced with very little change and remained very useful until the end of the 18th century. Calus Plinus Secundus (AD 23–79), Galen (AD 131–200), and Paul d'Aegine (AD 625–690) were other notable physicians practising lithotomy.[14,15,17,21,22]

During the Arab-Muslim civilisation, stone extraction procedures were also known and frequently reported by Rhazes (865-925 AD), Ibn Sina (980-1037 AD) and especially by Abulcasis (Ibn Abbas Alzahrawi) (936-1013 AD), one of the fathers of modern surgery. The latter showed a considerable experience in surgery (the technique of perineal cystolithotomy), by modifying the lithotomy technique performed by Celsus and Paul d'Égina. His book "Al-Tasreef" clearly shows the improvement of this technique and the reduction of its risks. He appeared to be the first doctor to crush stones in the urethra.[14,15,17,23]

During the period from the Renaissance up to this point, there was a revolution and a rapid increase in intellectual creativity in many areas that are related to this disease:

- Sabuncuoğlu Serafettin (1385-1470) and Ahi Ahmed Celebi (1432-1522) had described a new technique of stones transurethral fragmentation and bladder irrigation, as well as rules to facilitate stones passage and dissolution.[15,24]
- Francisco de Romanis (1520) had made the first major scientific improvement since Celsus and Albucasis, to overcome the difficulty of locating the bladder neck.[14,15,25]
- Pierre Franco (1561), performed the first stone extraction by suprapubic lithotomy.[14,15,25]
- Jérôme Cardan (1501-1576), allowed the opening of the lumbar abscess.[14,15]
- Jacques de Beaulieu (1651-1714), introduction the "lateral lithotomy", this method was perfected and popularized.[14,15,17]
- William Cheselden (1722) and John Douglas (1719), extra-peritoneal approach.[14,15]
- Wollaston (1810), cystine, the first amino acid described, was isolated from urinary stones.[26]

- Jean Civiale (1824), introduction the modifications on the "primitive lithotrite" developed by Albucasis, to capture and fragment stones in the bladder.[14,15,17]
- Ingalls (1873), first nephrotomy.[14,15,25]
- Bigelow (1874), development of a stronger and harder lithotrite "litholopaxy", introduced into the bladder (with anaesthesia) to crush and remove stone fragments.[14,15]
- Max Nitze (1879), a lens system development for cystoscope.[26]
- Heinecke (1879), first pyelotomy.[14,15]
- Le Dentu (1881), first nephrolithotomy.[14,15]
- Max Brodel (1901), description of the kidney's avascular region.[14,15,25]
- Alexander von Lichtenberg (1906), radiological method for renal tract visualization.[26]
- Hugh Hampton Young (1904), cystoscopic lithotrite (1912) Rigid ureteroscopy.[14,26]
- Moses Swick (1929), intravenous urography.[26]
- Yutkin (1954), Electrohydraulic lithotripsy.[15,25]
- Goodwin (1955), the first percutaneous nephrostomy.[14,15,26]
- Marshall (1964), first experience of flexible ureteroscopy using a fiberscope.[15,26]
- Smith et Boyce (1967), introduction and popularisation of anatrophic nephrolithotomy for the treatment of staghorn stones.[15]
- (1970), percutaneous nephrolithotomy.[15]
- (1980), extracorporeal shock wave lithotripsy (ESWL).[14,15,25,26]

Epidemiology of urolithiasis

The epidemiological data of a given pathology can only be determined precisely if some factors such as geographical location, climate, race, sex, age, nutrition, and other environmental factors[27], endogenous and hereditary factors are taken into account.[28] However, according to Hesse *et al*. (2003), the ''occurrence'' parameter is determined by two factors: first, the incidence, which represents the number of the new disease cases per population, measured over a given time interval. The second is the prevalence, which is the proportion of sick people detected in a population at a given time.[27] Furthermore, the epidemiological characteristics and aetiological factors of urinary lithiasis are constantly evolving, reflecting to a large extent the health conditions, dietary habits and population's standard of living.[29]

The prevalence of the disease in industrialised countries has increased dramatically over the past 50 years. This transformation finds evidence in the economic progression which reflects changes in socioeconomic level, lifestyle modifications and changing eating habits. Globally, this disease affects approximately 2 to 20% of the population with variations between countries (Fig. 3).[27]

The United States being an outstanding example for studying changes in the epidemiological behaviour of the disease, due to the studies availability, high level of richness, large populations, as well as geographic and ethnic diversity. However, the study carried out by Boyce *et al*. (1956) between 1948 and 1952 (across all country states) estimated the average annual of hospitalists incidence at 9.47p 100,000, with a variation between States from 4.31 to 19.25 per 100,000.[30]

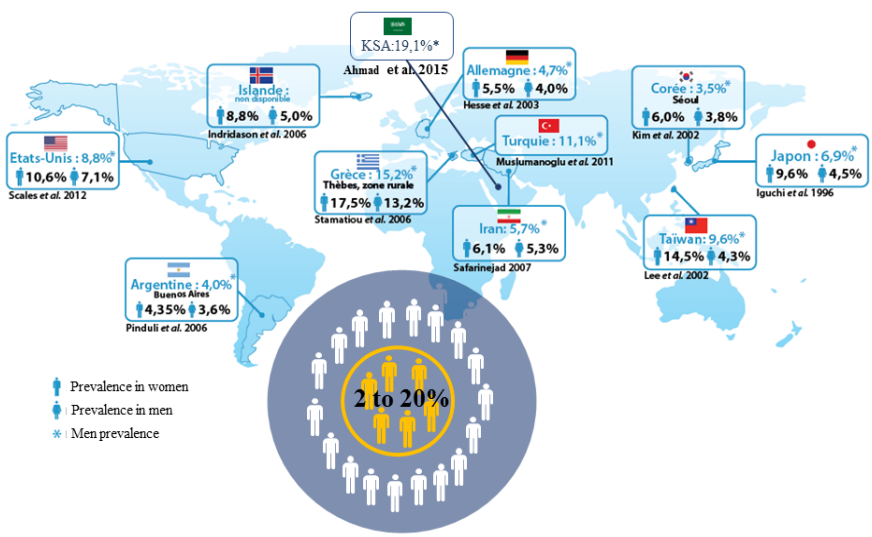

FIG. 3: Worldwide urolithiasis prevalence.

The work of Johnson *et al*. (1979) which lasted 25 years between 1950 and 1974 on the Rochester population, showed a significant increase of this disease in men, with an annual age-adjusted incidence around from 78.5 to 123.6 per 100,000 people. This parameter remained more or less stable in women with 36.0 per 100,000 people. The prevalence was also estimated in this population (Rochester) at 12% and 5% in men and women respectively[31], and another of 18.5% in Tennessee.[32] Later, Stamatelou *et al*. (2003) observed a nationwide increase in prevalence of 3.8 to 5.2% (from 1988 to 1994 and from 1976 to 1980) accompanied by variations in geography, ethnicity / race, age and gender.[33] Recent studies reveal the prevalence rate at 8.8%[34], and at 9.2%.[35] Forecasts for the 2030s estimated a prevalence at 9.5%.[36] Not far from USA, a similarity of epidemiological profile is marked in Canada compared to the last one, with a prevalence of 12%.[37,38]

In Europe, studies conducted after World War II showed a remarkable increase in the number of people affected by the disease (Table 1). The urolithiasis prevalence in the European Union was estimated between 5 to 10% in 2011, equivalent to 25 and 49 million people.[39,40]

In Germany, the disease trend was increased between 1979 and 2001, with an increase in the prevalence from 4.03 to 4.73% and the incidence from 0.54 to 1.47%.[27]

In Italy, the risk increased during these three decades and the prevalence tends towards 1.17% in 1983 against 1.72% in 1994[41], towards 4.14% in 2012 with an incidence of 2.32 / 1000P[42], regional variations were recorded with a major risk observed in Milano.[43] The picture is similar in Iceland with a prevalence of 4.7% in males and 3.2% in females.[44]

For Spain, UK and France, the disease frequencies are around 14.6% (2013-2014)[46], 7.14 to 11.62 % (between 2000 and 2010)[47] and 8.9% at age > 40 years (1994)[28,29] respectively.

The Eurasia zone is also marked by an increase in the incidence from 440.5 to 609.3 / 100,000P between 2002 and 2008 in Russia, from 53 to 6580 / 100,000P (1980 vs 2006) in Ukraine, 1030 and 2560/100,000P in Belarus (2004) and Tajikistan (2005) respectively[48].

In Asia, the work of Ogawa (2012) revealed an increase in prevalence in Japan from 4 to 10.8% between 1965 and 2005.[50] Zeng & He (2013) estimated the rate at 4% of China's urban population in 2008[54], and 9.6% in Taiwan between 1994 and 1996.[55] The Middle East had a higher rate of prevalence and major risk recorded in KSA with 19.1% between 2004 and 2008[57], Turkey with 11.1%[49] and Iran with 5.4%.[56]

However, the stones composition has changed considerably over these last decades, with a gradual increase in the frequency of calcium oxalate and calcium phosphate stones, even in the Eastern Hemisphere, where these stones were traditionally less common than uric acid and infection stones.[17]

Epidemiological studies carried out in different continents and countries indicate that calcium oxalate is very present with a levels varying between 51.3 and 78%, followed by calcium phosphate with a percentage varying between 11.9 and 13.8 %, then uric acid (from 6.9 to 11.9%), struvite (0.8 to 6%), cystine (0.6 to 2%), Brushite (1.1 to 1.5%) and finally the other components (0.1 to 1.1%).[28,29,39,50,60–62]

Urolithiasis recurrence is described as the disease reappearing in some patients after a period of time, which appears to be completely cured. It is a major issue for both patients and doctors. This parameter is a difficult subject to classify as a fundamental value, due to the heterogeneity of the factors involved, as well as the scarcity of studies that provide reliable data.[63] Generally, the recurrence rate is estimated at 30 to 50% within the first 5 years after the discovery of the first stone and from 50 to 60% within the next 10 years.[28,56,63,64]

In Morocco, a developing country, where access to healthcare is not the same across the country, which can lead to a loss of information about the disease. In addition, dietary habits differ from one region to another, and many patients rely on traditional medicine to initiate this disease, especially among the mountain population. In addition, there is a lack of studies regarding this disease, except for a few publications which have mainly focused on determining the stones composition collected in certain regions. From all the above, we could think that the epidemiological profile is far from reality and differs from one region to another.

However, the prevalence of urolithiasis in Morocco varies between 3.76 and 16.3% according to Joual *et al*. (1997).[65] The study conducted by Boumzaoued *et al*. (2015) in Moulay Ismail Military Hospital at Meknes reveals that the intra-hospital prevalence is 25.36%, with a male/ female ratio of 3.1, an average age of 47.1 years and the left side dominance compared to the right side (60.02 versus 35.84).[66] According to Laziri (2009),

TABLE 1: Epidemiology of urolithiasis worldwide

Region	Period	Patients	Incidence	Prevalence %	Note	Reference
Germany	1979vs. 2001	7500	0.54% vs. 1.47%	4.03 vs 4.73 M/F :3.96/4.08% (1979) M/F :5.5/4.0% (2001)	- Recurrence rate 42%	27
Italy (Milano)	1986vs. 1998	1575 vs. 512	0.4%	5.9 vs.9 M/F :6.8/4.9% (1986) M/F :10.1/5.8% (1998)	- The most affected age: 31-40 yesrs and 51-60 years	43
Italy (Parma)	1990	6000		6.1%	-CaOx 27.4% -AU 26.5% -Mix 8% -CaP 0.9% -Cys 0.6%	45
Italy	1983vs 1993-1994		0.168% (1993-1994)	1.17vs.1.72%	-↑ 47.0% -M/F : 1.84/ 1.6	41
Italy	2012	900994	2.23/1000 M/F 2.42/2.06	4.14% M/F 4.53/3.78%	- Geographic variation	42
Iceland	1967-1991	9039M 9619F	562/ 100,000 M 197/ 100,000F	4.7% M 3.2% F	-Prevalence in man ↑ from 4.8% (1967-1969) to 6.2% (1985-1991) (represented age: 50-59 years)	44
Spain	2013-2014	2444	2.9% M/F 3.3/2.6%	14.6% M/F 14.3/14.8%	-Highest observed prevalence: at age 46-50 et 61-65 among social class I	46
UK	2000 vs. 2010			7.14% vs. 11.62%.	- Annual prevalence ↑ from 0.102% to 0.166%.	47
France	1994	14 000		9,8 % (>40 years) M/F 13.6/7.6	- Recurrence rate: 53%; M/F54/52% - The average interval between two lithiasis episodes: 3.5 and 4 years	29 28

Russia	2002 vs. 2008		440.5 vs 609.3/100,000		Absolute number of urolithiasis cases: 629 453 vs 704 373 - Geographic variation - Urinary stone type (in St. Petersburg): Ox 66% P 20.8% AU/U 10.5% Cys 2.7%	48
Ex USSR						
Moscow	1980-2008		17 vs 468.4			
Ukraine	1980-2006		53 vs.6580			
Kyrgyzstan	1980		48			
Turkmenistan	1980		24			
Uzbekistan	1980		30			
Belarus	2004		1030			
Tajikistan	2005		2560			
Turkey		2468	1.7% (2008) M/F 1.4 vs 1.9	11.1% M/F 10.9 vs 11.2	- Ethnic variation - Recurrence rate: 16.7% after 1 year, 35.7% after 5 years.	49
Japan	1965 vs. 2005		0.437/1000P vs. 1.43/1000P	4 vs 10.8% M/F 4.7/2.1% (1965) M/F 15.1/6.8% (2005)	-CaOx (M/F) 35.1/17.9 → 74.9/63.1 -CaP (M/F) 4.2/9.1 →6.5/12.8 -Mix (M/F) 44.4/44.3 → 10.7/14.4 - Infection stone (M/F) 7.5/23.3→1.4/5.1 -Urate (M/F) 4.6/1.4 →5.5/2.2	50
Japan	1965 vs. 1995		68.9/100,000 vs 54.2/100,000 M/F 100.1/55.4 Vs M/F 81.3/29.5		- Risk of upper urinary tract stones occurring: M/F 4.3/1.8% (1965) Vs 9.0/3.8% (1995)	51
Korea	2009	8,298 inpatients 1,555 outpatients	457/100,000 M/F 589.09/ 326.64		-Incidence inpatients 133.0/100000 H/F 158.32/108.01 -Incidence outpatients 324.02/100000 M/F 430.78/218.64	52

China			1.5 and 2.0/100,000P	1 and 5 %	-Rate M/F 1/3 et 4/1 -67.7-89.6 % of patients aged between 21-50 years	53
China	2008	1169651 urban		4% M/F : 4.8/3.0%	- Prevalence in the north 4.1% vs 1.0% in the south	54
Taiwan	1994-1996	4588		9.6% M/F 14.5/4.3%	Geographic variation	55
Iran	2005	7649	1451/100,000	5.7% M/F 6.1/5.3	- Recurrence rate: 16% after 1 year, 32% after 5 years 53% after 10 years.	56
KSA	2004-2008	5371 H 4871 F500		19.1%	-Ethnic origin variation -Higher prevalence among Egyptian (29.5%) and Pakistani (24.9%)	57
Brazil	1996vs. 2010			-Number of hospitalisations 0.36 vs 0.61% -M/F 49.9 vs 50.1%	- Number of hospitalisations ↑ 69% -5% higher during the December to March - Ethnic variation : 63.2% white 35.8% black 0.7% Asian 0.2% Indian.	58
Argentina (Buenos Aires)	2006	1086		3.96% M/F 4.35/3.62%	subjects over 19 years, the prevalence rate =5.14% with M/F 5.98/ 4.49%	59

CaOx : Calcium oxalate; AU :Uric acid; Mix : Mixture stone; CaP : Calcium phosphate; Cys : Cystine; ↑: Increase; M/F : Male/Female ratio; Ox: Oxalate; P: Phosphate; AU/U: Uric acid/ Urate.

the average of annual hospital incidence rate is estimated at 30 per 100,000 in the Settat province.[67] In children, a prevalence of 0.83% was revealed between 2003 and 2013 in the Hassan II University Hospital Center in Fez.[68] The cumulative frequency was estimated at 0.25% during the period from 2000 to 2012 in the Meknes region, and an average hospital incidence rate was estimated at 21/100,000 in the paediatric surgery department of the Meknes regional hospital.[69] Regarding the stone composition, some researchers have found that calcium oxalate monohydrate is the major constituent, followed by uric acid, carbapatite and struvite.[67,70–72]

Clinical manifestation

Urolithiasis can remain asymptomatic for a long time, so it can be observed unexpectedly during an imaging examination or during a chronic kidney failure assessment.[73]

The initial presentation of urinary lithiasis is often accompanied by renal colic, which is pain caused by the displacement of a stone from the renal pelvis into the ureter, causes ureteral spasm and eventually obstruct.[62] The simple form of renal colic is frequent, characterised by sudden and intense pain, starting in the flank area radiating to the groin and progressing downwards and anteriorly into the genital area, as the stone descends into the ureter, with no peritoneal signs.[62,74,75] Generally, the pain is neither aggravated or reduced by a change of position, therefore may be accompanied by nausea and vomiting, adding also, that if the stone is lodged at the uretero-vesical junction, may cause a feeling of urinary frequency and urgency. However, all symptoms are relieved quite abruptly when the stone exits the ureter and passes into the bladder.[62] Other manifestations include persistent non-visible haematuria, intermittent visible haematuria, dysuria, penile oedema, enuresis, anorexia, and repetitive urinary tract infections.[63,76–78] The end-stage complications of infected stones can be life-threatening, including pyonephrosis, xanthogranulomatous pyelonephritis, perinephric abscesses and sepsis.[63]

Urolithiasis aetiologic factors

Determining and understanding the factors involved in promoting the formation of urinary stones are a very important part of treatment procedures. However, in order to implement a better treatment decision and have a satisfactory positive response, all the interactions and the complication of these factors must be taken into consideration.

1. Non-dietary risk factors

1.1 Family history

Urinary stones develop more frequently in people with a family history of the disease than in those without a family history. The risk ratio was estimated by Curhan *et al*. (1997) to be more than 2.57 times higher in individuals with a family history of the disease[79], and a recurrence threat of 1.2 was detected by Guerra *et al*. (2016).[80] The explanations about this factor remain limited on the likelihood of a genetic predisposition and environmental exposures combination shared by family members, mainly those related to eating habits.[63,64,81]

1.2 Relationship between urolithiasis and systemic disorders

Several diseases and systemic factors have been associated with an increased risk of urinary lithiasis occurrence. Primary hyperparathyroidism[82–84], renal tubular acidosis[85,86] and Crohn's disease[87–89] are affections that have been correlated with urolithiasis and increase the risk of stone formation.

A history of gout increases the risk of stone formation, both uric acid and calcium oxalate.[64] The Kramer & Curhan (2002) study, reported the chance to have a lithiasis history in people with gout at 49%.[90] These results were confirmed in men by a prospective study.[91] The relative risk (RR) of subsequent kidney stones in the age-adjusted (RR: 2.06) and multivariate (RR: 2.12) models was higher in patients with a confirmed gout diagnosis than in those without gout.[91]

Increased body size as assessed by weight and body mass index (BMI) is associated with an increased risk of stone formation, independent of other risk factors, including diet.[92] The magnitude of the increase in BMI risk is greater in women than in men.[92,93] The risk of stone formation in individuals with a BMI greater than or equal to 30 compared to those with a BMI of 21 to 23 was 30% higher in men, but almost twice as high in women.[64] Weight gain also increases the risk, weight gain of approximately 15.88 kg from early adulthood increases the risk of stone formation by 40% in men and by 80% in women.[64]

The study conducted by Taylor *et al*. (2005) revealed the positive association of diabetes with nephrolithiasis, independent of age, BMI, thiazide diuretic use and diet.[94] Daudon *et al*.

(2006) evaluated the types of stones in people with diabetes (type 2 diabetes), the proportion of uric acid stones was higher compared to calcium stones. The first type of stone was significantly 3 times higher in patients with stones with type 2 diabetes than in non-diabetic patients.[95] In the same lines, Cameron *et al.* (2006) demonstrate that a low pH level is the main risk factor for the uric acid stones formation.[96] In fact, diabetes may increase the risk of urinary stone formation by altering the urine composition. Insulin resistance is associated with high levels of free fatty acids in the plasma, which can enter the proximal tubular cells, interfering with the use of glutamine in ammonium production.[94] Likewise, this resistance contributes to the accumulation of ammonia and considerably reduces the pH, which favors the uric acid stones formation.[95] Low urine pH affects the ability of the urinary tract to excrete acid (citric acid), which increases the risk of stones containing calcium.[94]

The link between our pathology and hypertension has been adopted mainly in two opposing ways; The first considers that the incidence of urinary stones was significantly higher in hypertensive patients, i.e. people with high blood pressure are at an increased risk of developing a kidney stone.[97,98] On the contrary, the second shows that the risk of hypertension was higher in people with a history of nephrolithiasis and not vice versa. This association was independent of other risk factors recognised in these two pathologies.[99–101] In the same context, Gillen *et al*. (2005) established this hypothesis, but only in women.[102] In contrast, consumption of a DASH (Dietary Approaches to Stop Hypertension) type diet is associated with a marked decrease in the risk of urinary stone incidence.[103] Thus, it can reduce the risk of their formation by increasing the levels and volume of urinary citrate.[104]

The risk of cardiovascular disease has been associated with a history of urinary stone, although no causal relationship has been definitively established.[105] However, Ferraro *et al*. (2013) showed a modest increase in the risk of coronary heart disease in women with a history of stones, but not in men in prospective studies.[106] The survey by Alexander *et al*. (2014)and their prevalence is increasing. Kidney stone formers often have risk factors associated with atherosclerosis, but it is uncertain whether having a kidney stone is associated with higher risk of cardiovascular events. This study sought to assess the association between one or more kidney stones and the subsequent risk of cardiovascular events. Design, setting, participants, & measurements Cohort study of 3,195,452 people aged 18 years registered in the universal health care system in Alberta, Canada, between 1997 and 2009 (median follow-up of 11 years found a significantly higher risk of acute myocardial infarction of 40% in people with one or more episodes of stones. Concurrently, coronary angioplasty / coronary bypass surgery was 63% and stroke was 26%, with a greater effect in women than in men.[107] On the other hand, Domingos & Serra (2011) show that this relationship remained significant only for myocardial infarction in women with a risk of more than 57%[108], while the latter was 31% in the work of Rule *et al.* (2010).[109] In contrast, Fan *et al*. (2017) found that lithiasis disease was associated with a high prevalence of traditional and non-traditional risk factors for cardiovascular disease such as hypertension, albuminuria, chronic kidney disease, increased arterial stiffness and ankle brachial index, indicative of peripheral arterial disease.[110]

1.3 Environmental factors

Regions with higher average annual temperature and humidity appear to be contributing factors. People living under those conditions are prone to chronic dehydration, which results in low urine volumes and hypocitraturia, leading to an increased incidence of urinary stones especially of uric acid.[111,112] Seasonal variations have been mentioned with peak increases have been observed during the summer months.[113,114] Global warming trends are likely to shift and expand areas at increased risk for stone formation. A study modeling the impact of climate change on stone disease found that the fraction of the U.S. population living in areas at high risk for nephrolithiasis would increase from 40% in 2000 to 56% by 2050 and to 70% by 2095.[115]

1.4 Urinary risk factors

The crystallisation of stone forming salts is due to an abnormal urinary composition, of metabolic or environmental origin. These urinary risk factors are the basis for the diagnostic categorisation of stone-related diseases. Several factors can coexist in the same patient.[116] 24-hour urinalysis provides important prognostic information and direct treatment recommendations for the prevention of stone formation.

Hypercalciuria: Is defined as a calcium excretion in the urine, greater than or equal to 300 mg/day in men and 250 mg/day in women with a diet containing 1000 mg of calcium /day.[63,64,117] It affects approximately 20 to 60% of patients with stones[62,63,76,81,118] and contributes to calcium stone formation, by increasing the urinary calcium salt saturation and by deactivating negative charged urinary inhibitors.[116] The most common cause of hypercalciuria is increased absorption of calcium from the intestine. This disorder is also associated with low bone mineral density in the vertebrae, the causes of this latter are unknown.[116]

Hyperoxaluria: Where the oxalate urinary excretion is greater than 45 mg/day. This excretion can be present in 20 to 40% of patients affected by the disease, and the major risk is observed more in males than in females.[64,76,81] However, it should be noted that the risk of stone disease begins well below this oxalate excretion value. This may be due to the primary hyperoxaluria that causes the increased hepatic oxalate production or increased absorption in the short bowel syndrome called enteric hyperoxaluria (acquired), in which the intestine is overexposed to bile salts, resulting in increased permeability to oxalate. A diet low in oxalate and / or normal calcium to be raised, reduces oxalate urinary excretion.[63] In contrast, primary hyperoxaluria is rare and the result of autosomal recessive genetic disorders associated with oxalate synthesis. In fact, primary hyperoxaluria type I is caused by a mutation in the alanine: glyoxalate aminotransferase gene, while type II is caused by a mutation in the glyoxalate reductase / D-glycerate dehydrogenase gene.[62,116,118]

Hypocitraturia: Less than 320 mg/day urinary citrate excretion, found in 5-11% of new cases who developed stones. Citrate forms a soluble complex when it binds to calcium, thus preventing the binding of calcium to oxalate.[63,64] Hypocitraturia can be the result of distal renal tubular acidosis, chronic diarrheal syndrome, intestinal dysfunction, genetic factors, hypokalaemia, urinary tract infection, rich diet protein and low in alkali, but it is mainly of unknown aetiology.[116,117,119]

Hyperuricosuria: An elevated level of uric acid with excretion greater than 750 and 800 mg/day in women and men respectively, which results in spontaneous precipitation in solution. This precipitation can act as a scaffolding for crystalline aggregation of calcium oxalate and subsequent stone formation. Hyperuricosuria may be secondary to: uricosuric drugs, myeloproliferative disorders, primary gout or congenital disorders. Excessive intake of animal protein (especially purines) can increase uric acid excretion and decrease urine pH. The latter is a very important factor in controlling uric acid supersaturation.[63,117] However, allopurinol has been shown to be an effective agent in preventing the formation of calcium oxalate stones in patients with hyperuricosuria[120], also adding a decrease in protein intake is also useful.[62]

Cystinuria: Is a rare autosomal recessive disorder characterised by a reduced renal tubular reabsorption of the dibasic amino acids cystine, ornithine, lysine and arginine.[121] Over-excretion of cystine leads to stone formation due to their low solubility in urine at normal urine pH.[117] In fact, the solubility of cystine is pH-dependent (modest increase if the pH tends towards 7.5, greater increase if the pH exceeds 7.5) and varies according to the solubilises electrolytes and macromolecules. However, two genes responsible for cystinuria with multiples of mutations have been identified: the gene (SLC3A1) is responsible for type I cystinuria and completely recessive, while the gene (SLC7A9) is linked with non-type I (type II and III) and incompletely recessive. These two genes code respectively for two protein subunits rBAT and $b^{0,+}$ AT of a membrane transporter located in the renal proximal tube and epithelial cells of the gastrointestinal tract. Clinically, heterozygotes with type I mutations are silent, while heterozygotes non-I types (types II and III) have a wide range of urinary cystine levels and some even have symptomatic urolithiasis.[121–123]

Low urine volume: Is a common and modifiable risk factor, defined as a 24-hour urine volume less than 1L/ day, and present in 12 to 25% of lithiasic people. Low liquid consumption, with a low volume of urine production, produce high concentrations of solutes responsible for the stone formation in the urine. In addition, the risk decreases with high liquids intake, which stimulates the increase of total urine volume.[64,112]

Urine pH: A high urine pH leads to increased saturation of calcium phosphate, predisposing to develop lithiasis. A high urine pH can also lead to the formation of struvite stones, due to the low solubility of phosphate when excessive

ammonia is produced by the urea fragmentation. However, low urine pH predisposes to uric acid nephrolithiasis.[81]

Infection: Infection stones are formed when the upper urinary tract is infected by urease-producing bacteria, for example (*Proteus sp, Haemophilus sp, Ureaplasma urealyticum* and *Klebsiella sp*). These microorganisms hydrolyse urea to produce ammonia and hydroxide, increasing the urinary pH, consequently increasing phosphate dissociation to form trivalent phosphate. These latter bind to magnesium to form a "triple crystal" of struvite stone (magnesium phosphate ammonia) and / or calcium carbonate apatite. These stones mostly develop in a branched form (staghorn) which occupies a large part of the collection system.[116,117]

2. Dietary risk factors

Diet plays a very important role in influencing urine composition and therefore directly influences the risk of urolithiasis. The nutrients involved in this diet include calcium, animal protein, oxalate, sodium, sucrose, fructose, magnesium and potassium.[64,124,125]

Calcium: Excessive dietary calcium intake was considered to be a protective factor against urinary lithiasis formation, independent of other risk factors.[63] However, high dietary calcium intake binds with oxalate in the gut and subsequently reduces oxalate absorption.[125] Indeed, the study conducted by[126] reveals that the recurrence rate decreased by 50% in patients who followed a diet with a normal calcium intake (1200 mg/day) associated with a low intake of animal protein, compared to those who consumed a low calcium diet (400 mg/day). Unlike dietary calcium, calcium supplementation does not appear to reduce risk and may increase risk in older women.[125,127]

Oxalate: The proportion of dietary oxalate absorbed varies from 10% to 50% and is affected by concomitant dietary factors (such as calcium), intestinal flora and related diseases. In addition to this absorption, urinary oxalate is also derived from the endogenous metabolism of glycine, hydroxyproline, vitamin C and glycolate. However, the dietary contribution of urinary oxalate may be higher in stone formation. Up to one-third of patients with calcium oxalate nephrolithiasis may have increased dietary oxalate absorption, and in some cases, a deficiency in oxalate degradation by the bacteria O*xalobacter formigenes* in the gut may be the cause.[63,64,81,128]

Potassium: An increase in dietary potassium intake has been considered to reduce risk in men and older women.[63] Potassium consumption potentially reduces calcium excretion in the urine and stimulates urinary citrate excretion.[17]

Sodium / sucrose: A high intake is directly proportional to urinary calcium and independent of calcium intake.[63] Salt consumption invariably increases calcium excretion, conversely, their reduction decreases calciuria especially in hypercalcious.[129]

Vitamin C (ascorbic acid): Can be metabolised to oxalate, higher intake may increase the risk of calcium oxalate stone formation.[63,64] According to Traxer *et al*. (2003), the consumption of 2 g of vitamin C per day increases urinary oxalate excretion by 20% in normal subjects and by 33% in lithiasis subjects.[130] The risk of stone formation was greater than 40% in men who consumed more than 1g of vitamin C, compared to men who ingested less than the recommended daily allowance.[131]

Vitamin B6: Is a cofactor in oxalate metabolism and its deficiency increases the production and excretion of oxalate in the urine. High doses of the supplemental vitamin B6 may be beneficial in some patients with primary hyperoxaluria type 1.[64] A high intake of vitamin B6 may reduce the risk of stone formation.[132,133]

Animal Protein: High levels of animal protein in the diet lead to high urinary oxalate, low pH, and low urinary citrate.[63] Red meat, canned fish, meat extracts and muscle are rich in purine, which increases the uric acid concentration and therefore promotes stone formation. By recommendation, protein intake should be limited to 1g/kg/day.[112]

Liquid intake: Low fluid intake (<1200 ml / day) predisposes to the stone formation. Increased water consumption results in urine dilution of constituents that may precipitate, as well as a reduction in the residence time of free crystalline particles in the urine.[127]

Urolithiasis diagnosis and management

1. Diagnostic

This is a very important step that gives a general idea of the nature and causes of the disease in order to choose suitable treatment methods. Different diagnostic tools are used to confirm lithiasis.

1.1 Initial investigation

Urinary tract stones diagnosis begins with a history focusing on key elements, include a family or previous history of urinary stone, duration and progression of symptoms, and signs or symptoms of sepsis. Physical examination is often more helpful in ruling out non-urologic disease.[134]

Metabolic investigations are important to predict the likely stone type (if the stone is not available for analysis), identify the secondary causes and metabolic risk factors, evaluate the prognosis, and guide the treatment. Typically, a metabolic workup including fasting blood and punctual urine samples, as well as 24-hour urine is requested.[135] Practically, we use the methods described below.

Urine test strip: allows to look for haematuria, nitrituria, leukocyturia, glycosuria, proteinuria, but also estimates density and pH.[136]

Cytobacteriological exam of urine (CBEU): performed to complete a positive urine dipstick, before initiating antibiotic therapy. It allows to recognise the non-glomerular character of a hematuria and to identify the germs especially the bacteria with ureasic activity.[73,136]

Blood culture: carried out systematically in case of fever over 38.5 °C. In the case of obstructive pyelonephritis, this examination looks for possible sepsis.[73]

Biological examinations: include creatinine, complete blood count (CBC), and blood ionogram.[73]

Crisatlluria: performed on fasting morning urine to determine the pH, density and pre-existing crystals in the urine.

1.2 Diagnostic imaging

In order to search the existence of an upper excretory tract dilatation or a stone, several methods are used, among which we cite:

Ultrasound: non-invasive, inexpensive, rapid, preferred for pregnant women and in patients with a renal failure stage.[74] It allows visualisation of the stone and more delicate for the visualisation of lumbar or iliac lithiasis. Its sensitivity is excellent for pyelocalicular stones and for those of the lower ureter (full bladder).[136]

Abdominal x-ray: easy to perform in emergencies, but it has a poor sensitivity for detecting the lithiasis with a poor specificity (Hamm *et al*., 2001).[74] Therefore, this examination should not be done independently. However, the sensitivity is better when it is coupled with scanner.[74]

Intravenous Urogram (IVU): can show the entire upper urinary tract to the urethral opening, allows a fairly fine analysis, especially of the urothelium with a single iodine injection.[137] It has now replaced by the scanner without injection with almost unanimity. When the urologist wishes to visualise the urinary tree for an invasive procedure, this scanner is injected.[74]

Computed tomography (CT): an imaging method used to obtain cross-sections, reconstructed from measurements of the attenuation coefficients of the X-ray beam in the volume considered.[137] Injected or uninjected CT is the imaging test with the best sensitivity and specificity, giving dynamic 3D reconstructions. It helps to identify stones not visible on abdominal x-ray in particular uric stones, small stones, ureteral stones and to measure the density of these stones. It also allows to specify the differential diagnoses in nearly 50% of lumbar pain.[138]

1.3 Treatments

1.3.1 Dietary measures

Fluid intake is an essential component of treatment and should be adjusted to ensure that urine output is greater than 2.5 L/day. Balanced diet standardised in calcium (800 mg to 1 g/day), sodium (2 to 3 g/day), protein (0.8 to 1.4 g/kg/day), and limiting excessive intake of oxalate-rich foods to a threshold of 40 to 50 mg/day.[125]

1.3.2 Medical treatment

Renal colic treatment is based on the use of non-steroidal anti-inflammatory drugs (NSAIDs) which act by blocking the cyclo-oxygenases involved in the inflammatory cascade, reducing local edema and glomerular filtration rate.[74,139]

In recent years, the introduction of expulsion therapy based on drugs capable to facilitate the passage of distal ureteral stones. These are calcium channel blockers (such as Nifedipine) which act by relaxation of smooth muscle fibers and alpha blockers (such as Tamsulosin) that participate in peristalsis.[63,74,140] Yet despite their wide use, the evidence for the benefit of these agents in ureteral stones treatment remains weak.[63,141]

1.3.3 Surgical treatment

Surgical treatment aims to remove any stones in the urinary tract. Takes into account the stone location, its size, its composition, the urinary tract anatomy and the patient's morphology.

1.3.3.1 Extracorporeal Shock Wave Lithotripsy (ESWL)

Non-invasive method, applying waves created by an extracorporeal generator and focused on the stone in order to pulverise it. The stone localisation is done by ultrasound. The average success rate for the kidney is 60 to 80% and 80% for the ureter, depending on the stone's nature, their sizes and locations.[138,142]

1.3.3.2 Ureteroscopy (URS)

Invasive method that aims to remove stones stuck in the ureters or bladder, also can examine stones in the upper urinary tract. This procedure is painful and is performed by a ureteroscope in the form of a small wire that connects to a camera at the end. The latter is inserted into the urethra and passes into the bladder to remove stones.[143]

1.3.3.3 Percutaneous Nephrolithotomy (PCNL)

The procedure is invasive and consists in introducing a nephroscope through a percutaneous opening to fragment and extract stones larger than 2cm in diameter, or irregularly shaped (coralliform in particular).[73]

1.3.3.4 Open surgery

The use of open surgery for stone removal is declining due to the development of new non-invasive or semi-invasive methods such as ESWL, URS and PCNL. This method remains recommended for the treatment of large, coralliform stones where the predictable number of percutaneous accesses seems unreasonable.[144]

1.3.3.5 Alternative treatment based on medicinal and aromatic plants

Medical management of urolithiasis involves medical treatments and / or invasive surgical interventions to extract the stones, which may generate side effects and complications such as haemorrhage, hypertension, tubular necrosis, subsequent kidney fibrosis, renal failure, steinstrasse (several small stones blocking the ureter), pancreatitis, infection and persistent residue (potential nidus for new stone formation).[145–149] Research into treatment and prevention methods for this disease remains an avenue to be explored to avoid a possible recurrence in patients. In fact, the use of alternative methods, based on medicinal and aromatic plants (MAP) is very popular in the world, especially in developing countries. However, the exploitation of these traditional resources in research projects in order to verify experimentally the effectiveness of these resources and their applications is an issue and a challenge that must be addressed. Besides, ethnobotanical studies carried out in Morocco by various researchers have revealed the importance of some plants in the lithiasis treatment and in prevention of stones recurrence, as well as to relieve renal colic.[150–154]

On the other hand, in vitro studies show the effectiveness of plants extracts in inhibiting stone formation in different crystallisation stages (nucleation, growth, aggregation). Among these plants we can cite, *Rotula aquatica*[149], *Holarrhena antidysenterica*[147], *Origanum vulgare*[146], *Ammi visnaga*[155] *Phyllanthus niruri*[156], *Herniaria hirsuta*[157], *Trianthema monogyna*, *Macrotyloma uniflorum*[158], *Tamarix gallica* L.[159], *Punica granatum* L.[160], *Arbutus unedo* L.[161,162], act on calcium oxalate crystals. *Commiphora wightii*[163] *Citrus medica*, *Boerhaavia diffusa L*, *Rotula aquatica*[164] inhibit struvite crystal growth. *Chenopodium album*[165], *Tribulus terrestris*, *Bergenia ligulata*[166] against brushite crystal growth. *Mentha pulegium* and *Eucalyptus camaldulensis* essential oils show a very important effect against the Bacteria with ureasic activity responsible on infection lithiasis formation.[167] In addition, in vitro studies on cell culture models as well as work on animal models have been carried out by deferent researchers and show the preventive effect of plants against cell damage and stone formation.[146,149,168–173]

CONCLUSION

This review work allowed us to take stock of urolithiasis disease, which has a multifactorial aetiology and is one of the major public health problems. The risk and frequency of this disease have increased steadily over the last decades, which at the same time has increased the care costs and created a burden on the health system. Despite the scientific and technological development which we are currently aware, the treatment methods used to relieve patients with urinary stones do not show the desired effectiveness, hence the need to find alternatives. Studies on the plants' active components are progressing, with interesting results that need to be confirmed at the clinical level. In addition, the prevention accompanied by a diet remains effective.

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List of abbreviations: *AU/U: Uric acid/ Urate rate; AU: Uric acid; BMI: Body Mass Index; CaOx: Calcium Oxalate; CaP: Calcium phosphate; CBC: complete blood count; CBEU: Cytobacteriological exam of urine; CT: Computed tomography; Cys: Cystine; DASH: Dietary Approaches to Stop Hypertension; ESWL: Extracorporeal Shock Wave Lithotripsy; IVU: Intravenous Urogram; M/F: Male/Female ratio; Mix: Mixture stone; Ox: Oxalate; P: Phosphate; PCNL: Percutaneous Nephrolithotomy; RR: Relative Risk; URS: Ureteroscopy; ↑: Increase*

REFERENCES

1. Daudon M, Traxer O, Lechevallier E, Saussine C. La lithogenèse. Progrès en Urol. 2008 Dec;18(12):815–27.
2. Alelign T, Petros B. Kidney Stone Disease: An Update on Current Concepts. Adv Urol. 2018;2018:1–12.
3. Evan AP. Physiopathology and etiology of stone formation in the kidney and the urinary tract. Pediatr Nephrol. 2010;25:831–41.
4. Rieu P. Lithiases d'infection. Ann Urol (Paris). 2005 Feb;39(1):16–29.
5. Khan SR, Kok DJ. Modulators of urinary stone formation. Front Biosci. 2004;9(1–3):1450.
6. Khan SR, Shevock PN, Hackett RL. Presence of Lipids in Urinary Stones : Results of Preliminary Studies. Calcif Tissue Int. 1988;42(2):91–6.
7. Li SK, Xie AJ, Shen YH, Yu XR, Hu G. Biogenic synthesis of calcium oxalate crystal by reaction of calcium ions with spinach lixivium. Colloids Surfaces B Biointerfaces [Internet]. 2010;78(2):229–36.
8. Ouyang JM, Duan L, Tieke B. Effects of Carboxylic Acids on the Crystal Growth of Calcium Oxalate Nanoparticles in Lecithin-Water Liposome Systems. Langmuir. 2003;19(21):8980–5.
9. Shen Y, Li S, Xie A, *et al*. Controlled growth of calcium oxalate crystal in bicontinuous microemulsions containing amino acids. Colloids Surfaces B Biointerfaces. 2007;58(2):298–304.
10. Boyce H. Matrix of Human. 1968;45(November).
11. Aggarwal KP, Narula S, Kakkar M, Tandon C. Nephrolithiasis: Molecular Mechanism of Renal Stone Formation and the Critical Role Played by Modulators. Biomed Res Int. 2013;2013:1–21.
12. Vermeulen CW, Lyon ES. Mechanisms of genesis and growth of calculi. Am J Med. 1968;45(5):684–92.
13. Modlin M. A History of Urinary Stone. SA Med J. 1980;(October):652–5.
14. Shah J, Whitfield HN. Urolithiasis through the ages. BJU Int. 2002;89(8):801–10.
15. Tefekli A, Cezayirli F. The History of Urinary Stones: In Parallel with Civilization. Sci World J. 2013;2013:1–5.
16. Purpurowicz Z. Treatment procedures for urolithiasis. Polish Ann Med. 2010;17(1):123–8.
17. López M, Hoppe B. History, epidemiology and regional diversities of urolithiasis. Pediatr Nephrol. 2010;25(1):49–59.
18. Manfredini R, De Giorgi A, Storari A, Fabbian F. Pears and renal stones: Possible weapon for prevention? A comprehensive narrative review. Eur Rev Med Pharmacol Sci. 2016;20(3):414–25.
19. Dardioti V, Angelopoulos N, Hadjiconstantinou V. Renal diseases in the hippocratic era. Am J Nephrol. 1997;17(3–4):214–6.
20. Dimopoulos C, Gialas A, Likourinas M, Androutsos G, Kostakopoulos A. Hippocrates: Founder and Pioneer of Urology. Br J Urol. 1980;52(2):73–4.
21. Urquhart-Hay D. The knife and the stone. Aust N Z J Surg. 1999;69(4):267–75.
22. Riches E. The history of lithotomy and lithotrity. Ann R Coll Surg Engl. 1968;43(4):185–99.
23. Abdel-Halim RE, Altwaijiri AS, Elfaqih SR, Mitwalli AH. Extraction of urinary bladder stone as described by Abul-Qasim Khalaf Ibn Abbas Alzahrawi (Albucasis) (325-404 H, 930-1013 AD). Saudi Med J. 2003;24(12):1283–91.
24. Verit A, Aksoy S, Kafali H, Verit FF. Urologic techniques of Serefeddin Sabuncuoglu in the 15th century Ottoman period. Urology. 2003;62(4):776–8.
25. Ahmed S, Hasan MM, Mahmood ZA. Urolithiasis management and treatment: Exploring historical vistas of Greco-arabic contribution. J Pharmacogn Phytochem. 2016;5(5):167–78.

26. Stoller ML, Meng M V. Urinary Stone Disease: The Practical Guide to Medical and Surgical Management. Humana Press. 2007. 694 p.
27. Hesse A, Brändle E, Wilbert D, Köhrmann KU, Alken P. Study on the Prevalence and Incidence of Urolithiasis in Germany Comparing the Years 1979 vs. 2000. Eur Urol. 2003;44(6):709–13.
28. Daudon M. Épidémiologie actuelle de la lithiase rénale en France. EMC - Urol. 2008 Jan;1(1):1–17.
29. Daudon M, Traxer O, Lechevallier E, Saussine C. Épidémiologie des lithiases urinaires. Progrès en Urol. 2008 Dec;18(12):802–14.
30. Boyce WH, Garvey FK, Strawcutter HE. Incidence of urinary calculi among patients in general hospitals, 1948 to 1952. J Am Med Assoc. 1956;161(15):1437–42.
31. Johnson CM, Wilson DM, O'Fallon WM, Malek RS, Kurland LT. Renal stone epidemiology: A 25 year study in Rochester, Minnesota. Kidney Int. 1979;16(5):624–31.
32. Thun MJ, Schober S. Urolithiasis in Tennessee: An occupational window into a regional problem. Am J Public Health. 1991;81(5):587–91.
33. Stamatelou KK, Francis ME, Jones CA, Nyberg LM, Curhan GC. Time trends in reported prevalence of kidney stones in the United States: 1976–19941. Kidney Int. 2003;63:1817–23.
34. Scales CD, Smith AC, Hanley JM, Saigal CS. scales prevalence kidney stones US 2012. Ueropean Urol. 2012;62:160–5.
35. Lee JA, Abramowitz MK, Kipperman N, Drzewiecki BA, Melamed ML, Stern JM. Exploring the Association of Asthma with Urinary Stone Disease: Results from the National Health and Nutrition Examination Survey 2007–2014. Eur Urol Focus. 2018;1–7.
36. Antonelli JA, Maalouf NM, Pearle MS, Lotan Y. Use of the national health and nutrition examination survey to calculate the impact of obesity and diabetes on cost and prevalence of urolithiasis in 2030. Eur Urol. 2014;66(4):724–9.
37. Ramello A, Vitale C, Marangella M. Epidemiology of Nephrolithiasis. J Nephrol. 2000;13(3):S45–50.
38. Robertson W.G. HH. Epidemiology of Urinary Stone Disease in Saudi Arabia. Urol Res. 1994;18(1):453–5.
39. Osther PJS. Epidemiology of Kidney Stones in the European Union. In: Urolithiasis. London: Springer London; 2012. p. 3–12.
40. Raheem OA, Khandwala YS, Sur RL, Ghani KR, Denstedt JD. Burden of Urolithiasis: Trends in Prevalence, Treatments, and Costs. Eur Urol Focus. 2017;3(1):18–26.
41. Serio A, Fraioli A. Epidemiology of nephrolithiasis. - PubMed - NCBI. Vol. 81, Nephron 1999;81(suppl. 1999. p. 26–30.
42. Prezioso D, Illiano E, Piccinocchi G, Cricelli C, Piccinocchi R, Saita A, et al. Urolithiasis in Italy: An epidemiological study. Arch Ital di Urol e Androl. 2014;86(2):99–102.
43. Trinchieri A, Coppi F, Montanari E, Del Nero A, Zanetti G, Pisani E. Increase in the prevalence of symptomatic upper urinary tract stones during the last ten years. Eur Urol. 2000;37(1):23–5.
44. Indridason OS, Birgisson S, Edvardsson VO, Sigvaldason H, Sigfusson N, Palsson R. Epidemiology of kidney stones in Iceland: A population-based study. Scand J Urol Nephrol. 2006;40(3):215–20.
45. Borghi L, Ferretti PP, Elia GF, *et al*. Epidemiological Study of Urinary Tract Stones in a Northern Italian City. Br J Urol. 1990 Mar;65(3):231–5.
46. Arias Vega MR, Pérula de Torres LA, Carrasco Valiente J, Requena Tapia MJ, Jiménez García C, Silva Ayçaguer LC. Prevalence of urolithiasis in the 40 to 65 year old Spanish population: The PreLiRenE study. Med Clínica (English Ed). 2016 Jun;146(12):525–31.
47. Turney BW, Reynard JM, Noble JG, Keoghane SR. Trends in urological stone disease. BJU Int. 2012;109(7):1082–7.
48. Novikov A, Nazarov T, Startsev VY. Urolithiasis. In: Talati JJ, Tiselius HG, Albala DM, YE Z, editors. Epidemiology of Stone Disease in the Russian Federation and Post-Soviet Era. London: Springer London; 2012. p. 1–982.
49. Muslumanoglu AY, Binbay M, Yuruk E, *et al*. Updated epidemiologic study of urolithiasis in Turkey. I: Changing characteristics of urolithiasis. Urol Res. 2011;39(4):309–14.
50. Ogawa Y. Epidemiology of Stone Disease Over a 40-Year Period in Japan. In: Talati JJ, Tiselius HG, Albala DM, YE Z, editors. Urolithiasis. London: Springer London; 2012. p. 89–96.
51. Yoshida O, Terai A, Ohkawa T, Okada Y. National trend of the incidence of urolithiasis in Japan from 1965 to 1995. Kidney Int. 1999;56(5):1893–8.
52. Bae SR, Seong JM, Kim LY, *et al*. The epidemiology of reno-ureteral stone disease in Koreans: A nationwide population-based study. Urolithiasis. 2014;42(2):109–14.
53. Luo D, Li H, Wang K. Epidemiology of Stone Disease in China. In: Urolithiasis [Internet]. London: Springer London; 2012. p. 53–9.
54. Zeng Q, He Y. Age-specific prevalence of kidney stones in Chinese urban inhabitants. Urol Res. 2013;41(1):91–3.
55. Lee YH, Huang WC, Tsai JY, *et al*. Epidemiological Studies on the Prevalence of Upper Urinary Calculi in Taiwan. Urol Int. 2002;68:172–7.
56. Safarinejad MR. Adult urolithiasis in a population-based study in Iran: Prevalence, incidence, and associated risk factors. Urol Res. 2007;35(2):73–82.
57. Ahmad F, Nada MO, Farid A Bin, Haleem MA, Razack SMA. Epidemiology of urolithiasis with emphasis on ultrasound detection: a retrospective analysis of 5371 cases in Saudi Arabia. Saudi J kidney Dis Transplant. 2015;26(2):386–91.
58. Korkes F, Silva II JL da, Heilberg IP. Costs for in hospital treatment of urinary lithiasis in the Brazilian public health system. Einstein (São Paulo). 2011;9(4):518–22.
59. Pinduli I, Spivacow R, Del Valle E, *et al*. Prevalence of urolithiasis in the autonomous city of Buenos Aires, Argentina. Urol Res. 2006;34(1):8–11.
60. Amato M, Lusini ML, Nelli F. Epidemiology of Nephrolithiasis Today. Urol Int. 2004 Jul 19;72(1):1–5.

61. Menard O, Murez T, Bertrand J, *et al*. Épidémiologie des calculs urinaires dans le Sud de la France : étude rétrospective monocentrique. Progrès en Urol. 2016 May;26(6):339–45.
62. Worcester EM, Coe FL. Nephrolithiasis. Prim Care Clin Off Pract. 2008 Jun;35(2):369–91.
63. Arumuham V, Bycroft J. The management of urolithiasis. Surg. 2016 Jul;34(7):352–60.
64. Curhan GC. Epidemiology of stone disease. Clin Manag Urolithiasis. 2007;34:287–93.
65. Joual A, Rais H, Rabii R, el Mrini M, Benjelloun S. Epidémiologie de la lithiase urinaire. [Epidemiology of urinary lithiasis]. AnnUrol. 1997;31(2):80–3.
66. Boumzaoued H, Laziri F, Lekhlifi Z El, Qarro A, Assyry A El. Prevalence of urinary lithiasis in the Moulay Ismail Military Hospital Prévalence hospitalière de la lithiase urinaire à l ' hôpital militaire Moulay Ismail (Meknès-Maroc). J Mater Environ Sci. 2015;6(6):1578–83.
67. Laziri F. Etude rétrospective de la lithiase urinaire dans l'Hôpital Hassan II de la province de Settat (Maroc). African J Urol. 2009;15(2):117–23.
68. El Lekhlifi Z, Laziri F, Samih M, Hida M, Bouabdillah Y, Souilmi FZ. Epidemiological characteristics of childhood urolithiasis in Morocco. African J Urol. 2016;22(2):92–5.
69. El Lekhlifi Z, Laziri F, Boumzaoued H, Maouloua M, Louktibi M. Étude épidémiologique rétrospective sur la lithiase urinaire chez l'enfant dans la région de Meknès au Maroc (2000-2012). J Pediatr Pueric. 2014;27(1):23–8.
70. Bouatia M, Benramdane L, Oulad Bouyahya Idrissi M, Draoui M. An epidemiological study on the composition of urinary stones in Morocco in relation to age and sex. African J Urol. 2015;21(3):194–7.
71. El Habbani R, Chaqroune A, Sqalli Houssaini T, Arrayhani M, El Ammari J, Dami F, et al. Étude épidémiologique sur les calculs urinaires dans la région de Fès et sur le risque de récidive. Prog en Urol. 2016;26(5):287–94.
72. Oussama A, Kzaiber F, Mernari B, Hilmi A, Semmoud A, Daudon M. Analyse des calculs urinaires de l'adulte dans le Moyen Atlas marocain par spectrophotométrie infrarouge à transformée de Fourier. Prog en Urol. 2000;10(3):404–10.
73. Dalibon P. La lithiase urinaire, une affection sous surveillance. Actual Pharm. 2015;54(542):23–9.
74. El Khebir M, Fougeras O, Le Gall C, *et al*. Actualisation 2008 de la 8e Conférence de consensus de la Société francophone d'urgences médicales de 1999. Prise en charge des coliques néphrétiques de l'adulte dans les services d'accueil et d'urgences. Progrès en Urol. 2009 Jul;19(7):462–73.
75. Teichman JMH. Acute Renal Colic from Ureteral Calculus. N Engl J Med. 2004;350(7):684–93.
76. Alpay H, Ozen A, Gokce I, Biyikli N. Clinical and metabolic features of urolithiasis and microlithiasis in children. Pediatr Nephrol. 2009;24(11):2203–9.
77. Juan YS, Wu WJ, Chuang SM, *et al*. Management of symptomatic urolithiasis during pregnancy. Kaohsiung J Med Sci. 2007;23(5):241–6.
78. Thomas B, Hall J. Urolithiasis. Surgery. 2005;23(4):129–33.
79. Curhan G, Willett W, Rimm E, Stampfer M. Family History and Risk of Kidney stones. J Am Soc Nephrol. 1997;8:1568–73.
80. Guerra A, Folesani G, Nouvenne A, Ticinesi A, Allegri F, Pinelli S, et al. Family history influences clinical course of idiopathic calcium nephrolithiasis: case–control study of a large cohort of Italian patients. J Nephrol. 2016;29(5):645–51.
81. Baruah M, Devi Kr, Ranabir S. Nephrolithiasis: Endocrine evaluation. Indian J Endocrinol Metab. 2012;16(2):228.
82. Abusahmin H, Geen J, Das G. Subclinical urolithiasis in patients with asymptomatic primary hyperparathyroidism. Ther Adv Endocrinol Metab. 2018;9(11):325–7.
83. Lemos ALP, Andrade SRL, Pontes LLH, Teixeira PMC, Bandeira E, Bandeira LC, et al. High Rate of Occult Urolithiasis in Normocalcemic Primary Hyperparathyroidism. 2019;160.
84. Tay YKD, Liu M, Bandeira L, *et al*. Occult urolithiasis in asymptomatic primary hyperparathyroidism. Endocr Res. 2018;43(2):106–15.
85. Guimerà J, Martínez A, Tubau V, *et al*. Prevalence of distal renal tubular acidosis in patients with calcium phosphate stones. World J Urol. 2020;38(3):789-94.
86. Fuster DG, Moe OW. Incomplete Distal Renal Tubular Acidosis and Kidney Stones. Adv Chronic Kidney Dis. 2018;25(4):366–74.
87. Gaspar SRDS, Mendonca T, Oliveira P, Oliveira T, Dias J, Lopes T. Urolithiasis and Crohn's disease. Urol Ann. 2016;8(3):297–304.
88. Hueppelshaeuser R, Von Unruh GE, Habbig S, *et al*. Enteric hyperoxaluria, recurrent urolithiasis, and systemic oxalosis in patients with Crohn's disease. Pediatr Nephrol. 2012;27(7):1103–9.
89. Kim MJ, Woo SY, Kim ER, *et al*. Incidence and Risk Factors for Urolithiasis in Patients with Crohn's Disease. Urol Int. 2015;95(3):314–9.
90. Kramer HM, Curhan G. The association between gout and nephrolithiasis: The National Health and Nutrition Examination Survey III, 1988-1994. Am J Kidney Dis. 2002;40(1):37–42.
91. Kramer HJ, Choi HK, Atkinson K, Stampfer M, Curhan GC. The association between gout and nephrolithiasis in men: The Health Professionals' Follow-Up Study. Kidney Int. 2003;64(3):1022–6.
92. Taylor EN, Stampfer MJ, Curhan GC. the Risk of Kidney Stones. Jama. 2010;293(4):455–62.
93. Curhan GC, Willett WC, Rimm EB, Speizer FE, Stampfer MJ. Body size and risk of kidney stones. J Am Soc Nephrol. 1998;9(9):1645–52.
94. Taylor EN, Stampfer MJ, Curhan GC. Diabetes mellitus and the risk of nephrolithiasis. Kidney Int. 2005;68(3):1230–5.
95. Daudon M, Traxer O, Conort P, Lacour B, Jungers P. Type 2 diabetes increases the risk for uric acid stones. J Am Soc Nephrol. 2006;17(7):2026–33.
96. Cameron MA, Maalouf NM, Adams-Huet B, Moe OW, Sakhaee K. Urine Composition in Type 2 Diabetes: Predisposition to Uric Acid Nephrolithiasis. J Am Soc Nephrol [Internet]. 2006 May;17(5):1422–8.

97. Borghi L, Meschi T, Guerra A, *et al*. Essential arterial hypertension and stone disease. Kidney Int. 1999;55(6):2397–406.
98. Cappuccio FP, Siani A, Barba G, *et al*. A prospective study of hypertension and the incidence of kidney stones in men. J Hypertens. 1999;17(7):1017–22.
99. Kittanamongkolchai W, Mara KC, Mehta RA, *et al*. Risk of hypertension among first-time symptomatic kidney stone formers. Clin J Am Soc Nephrol. 2017;12(3):476–82.
100. Madore F, Stampfer MJ, Rimm EB, Curhan GC. Nephrolithiasis and risk of hypertension. Am J Hypertens. 1998;11(1):46–53.
101. Shang W, Li Y, Ren Y, Yang Y, Li H, Dong J. Nephrolithiasis and risk of hypertension: A meta-analysis of observational studies. BMC Nephrol. 2017;18(1):1–6.
102. Gillen DL, Coe FL, Worcester EM. Nephrolithiasis and increased blood pressure among females with high body mass index. Am J Kidney Dis. 2005;46(2):263–9.
103. Taylor EN, Fung TT, Curhan GC. DASH-style diet associates with reduced risk for kidney stones. J Am Soc Nephrol. 2009;20(10):2253–9.
104. Taylor EN, Stampfer MJ, Mount DB, Curhan GC. DASH-style diet and 24-hour urine composition. Clin J Am Soc Nephrol. 2010;5(12):2315–22.
105. Khan SR, Pearle MS, Robertson WG, *et al*. Kidney Stones. Nat Rev Dis Prim. 2016;2:1–22.
106. Ferraro PM, Taylor EN, Eisner BH, *et al*. History of kidney stones and the risk of coronary heart disease. JAMA - J Am Med Assoc. 2013;310(4):408–15.
107. Alexander RT, Hemmelgarn BR, Wiebe N, *et al*. Kidney stones and cardiovascular events: A cohort study. Clin J Am Soc Nephrol. 2014;9(3):506–12.
108. Domingos F, Serra A. Nephrolithiasis is associated with an increased prevalence of cardiovascular disease. Nephrol Dial Transplant. 2011;26(3):864–8.
109. Rule AD, Roger VL, Melton J, *et al*. Kidney stones associate with increased risk for myocardial infarction. J Am Soc Nephrol. 2010;21:1641–4.
110. Fan X, Kalim S, Ye W, *et al*. Urinary Stone Disease and Cardiovascular Disease Risk in a Rural Chinese Population. Kidney Int Reports. 2017;2(6):1042–9.
111. Atan L, Andreoni C, Ortiz V, *et al*. High kidney stone risk in men working in steel industry at hot temperatures. Urology. 2005;65(5):858–61.
112. Sofia NH, Walter TM, Sanatorium T. Prevalence and risk factors of kidney stone. Glob J Res Anal. 2016;5(March):183–7.
113. Chen Y kuang, Lin H ching, Chen C shyan, Yeh S der. Seasonal Variations in Urinary Calculi Attacks and Their Association With Climate : a Population Based Study. J Urol. 2008;179(February):564–9.
114. Lee SY, Kim MS, Kim JH, *et al*. Daily mean temperature Affects urolithiasis presentation in Seoul: A time-series analysis. J Korean Med Sci. 2016;31(5):750–6.
115. Brikowski TH, Lotan Y, Pearle MS. Climate-related increase in the prevalence of urolithiasis in the United States. Proc Natl Acad Sci USA. 2008;105(28):9841–6.
116. Pak CYC. Kidney stones. Lancet. 1998;351:1797–801.
117. Heilberg IP, Schor N. Renal stone disease: Causes, evaluation and medical treatment. Arq Bras Endocrinol Metabol. 2006;50(4):823–31.
118. Nicoletta JA, Lande MB. Medical Evaluation and Treatment of Urolithiasis. Pediatr Clin North Am. 2006;53(3):479–91.
119. Zuckerman JM, Assimos DG. Hypocitraturia: Pathophysiology and Medical Management. Rev Urol. 2009;11(3):134–44.
120. Ettinger B, Tang A, Citron J, Livermore B, Williams T. Randomized trial of allopurinol in the prevention of calcium oxalate calculi. N Engl J Med. 1986;315(22):1386–9.
121. Shekarriz B, Stoller ML. Cystinuria and other noncalcareous calculi. Endocrinol Metab Clin North Am. 2002;31(4):951–77.
122. Bouzidi H, Daudon M. abc Cystinurie : du diagnostic. Ann Biol Clin. 2007;65(5):473–81.
123. Calonge MJ, Gasparini P, Chillarón J, *et al*. Cystinuria caused by mutations in rBAT, a gene involved in the transport of cystine. Nat Genet. 1994;6(4):420–5.
124. Curhan GC, Willett WC, Knight EL, Stampfer MJ. Dietary Factors and the Risk of Incident Kidney Stones in Younger Women. Arch Intern Med. 2004;164:885–91.
125. Han H, Segal AM, Seifter JL, Dwyer JT. Nutritional Management of Kidney Stones (Nephrolithiasis). Clin Nutr Res. 2015;4:137–52.
126. Borghi L, Schianchi T, Meschi T, *et al*. Comparison of two diets for the prevention of recurrent stones in idiopathic hypercalciuria. N Engl J Med. 2002;346(2):77–84.
127. Sellaturay S, Fry C. The metabolic basis for urolithiasis. Surgery. 2008;26(4):136–40.
128. Holmes RP, Assimos DG. The impact of dietary oxalate on kidney stone formation. Urol Res. 2004;32:311–6.
129. Borghi L, Meschi T, Maggiore U, Prati B. Dietary Therapy in Idiopathic Nephrolithiasis. Nutr Rev. 2006;64(7):301–12.
130. Traxer O, Huet B, Poindexter J, Pak CYC, Pearle MS. Effect Of Ascorbic Acid Consumption On Urinary Stone Risk Factors. J Urol. 2003;170(August):397–401.
131. Taylor EN, Stampfer MJ, Curhan GC. Dietary Factors and the Risk of Incident Kidney Stones in Men : New Insights after 14 Years of Follow-up. J Am Soc Nephrol. 2004;15:3225–32.
132. Curhan GC, Willett WC, Rimm EB, Stampfer MJ. A prospective study of dietary calcium and other nutrients and the risk of symptomatic kidney stones. N Engl J Med. 1993;328(12):833–8.
133. Curhan GC, Willett WC, Speizer FE, Stampfer MJ. Intake of vitamins B6 and C and the risk of kidney stones in women. J Am Soc Nephrol. 1999 Apr;10(4):840–5.
134. Portis AJ, Sundaram CP. Diagnosis and initial management of kidney stones. Am Fam Physician. 2001;63(7):1329–38.
135. Johri N, Cooper B, Robertson W, Choong S, Rickards D, Unwin R. An update and practical guide to renal stone management. Nephron - Clin Pract. 2010;116(3):159–71.

136. Cochat P, Bacchetta J, Sabot J, Demède D. Lithiase urinaire de l'enfant Nephrolithiasis in children. J Pediatr Pueric [Internet]. 2012;25(5):255–68.
137. Doré B. Les lithiases rénales. Springer Science & Business Media; 2004. 416 p.
138. Lechevallier E, Saussine C, Traxer O. Imagerie et calcul de la voie excrétrice urinaire supérieure. Vol. 18, Progres en Urologie. 2008. p. 863–7.
139. Carpentier X, Traxer O, Lechevallier E, Saussine C. Physiopathologie de la colique néphrétique. Prog en Urol. 2008;18(12):844–8.
140. Doizi S, Letendre J, Bensalah K, Traxer O. Pharmacologic treatment of urinary lithiasis [Internet]. Vol. 23, Progres en Urologie. Elsevier Masson SAS; 2013. p. 1312–7.
141. De Coninck V, Antonelli J, Chew B, Patterson JM, Skolarikos A, Bultitude M. Medical Expulsive Therapy for Urinary Stones: Future Trends and Knowledge Gaps. Eur Urol. 2019;76(5):658–66.
142. Doré B. Extra corporeal shock wave lithotripsy (ESWL) procedure in urology. Ann Urol (Paris). 2005;39(3–4):137–58.
143. Khan F, Haider MF, Singh MK, Sharma P, Kumar T, Neda EN. A comprehensive review on kidney stones, its diagnosis and treatment with allopathic and ayurvedic medicines. Urol Nephrol Open Access J. 2019;7(4):69–74.
144. Lunardi P, Timsit MO, Roumiguie M, Dariane C, N'Guyen K, Beauval JB, et al. Traitement en un temps de la lithiase rénale complexe : à propos d'une série moderne de néphrotomies bivalves. Progrès en Urol. 2015 Feb;25(2):90–5.
145. Aslan Z, Aksoy L. Anti-inflammatory effects of royal jelly on ethylene glycol induced renal inflammation in rats. Int Braz J Urol. 2015 Oct;41(5):1008–13.
146. Khan A, Bashir S, Khan SR, Gilani AH. Antiurolithic activity of Origanum vulgare is mediated through multiple pathways. BMC Complement Altern Med. 2011 Dec 17;11(1):96.
147. Khan A, Khan SR, Gilani AH. Studies on the in vitro and in vivo antiurolithic activity of Holarrhena antidysenterica. Urol Res. 2012 Dec 24;40(6):671–81.
148. Patel PK, Patel MA, Vyas BA, Shah DR, Gandhi TR. Antiurolithiatic activity of saponin rich fraction from the fruits of Solanum xanthocarpum Schrad. & Wendl. (Solanaceae) against ethylene glycol induced urolithiasis in rats. J Ethnopharmacol. 2012 Oct;144(1):160–70.
149. Sasikala V, Radha SR, Vijayakumari B. In vitro evaluation of Rotula aquatica Lour. for antiurolithiatic activity. J Pharm Res. 2013 Mar;6(3):378–82.
150. Bouayyadi L, El Hafian M, Zidane L. Étude floristique et ethnobotanique de la flore médicinale dans la région du Gharb, Maroc. J Appl Biosci. 2015 Dec 7;93(1):8770.
151. Ghourri M, Zidane L, Douira A. Catalogue des plantes médicinales utilisées dans le traitement de la lithiase rénale dans la province de Tan-Tan (Maroc saharien). Int J Biol Chem Sci. 2014 Feb 20;7(4):1688.
152. Khouchlaa A, Tijane M, Chebat A, Hseini S, Kahouadji A. Ethnopharmacology study of medicinal plants used in the treatment of urolithiasis (Morocco). Phytotherapie. 2017 Oct 24;15(5):274–87.
153. Mikou K, Rachiq S, Oulidi AJ, Beniaich G. Étude ethnobotanique des plantes médicinales et aromatiques utilisées dans la ville de Fès au MarocEthnobotanical survey of medicinal and aromatic plants used by the people of Fez in Morocco. Phytothérapie. 2015 Aug 26;
154. Tahri N, Basti A EL, Zidane L, Rochdi A, Douira A. Etude Ethnobotanique Des Plantes Medicinales Dans La Province De Settat (Maroc). Kastamonu Üniversitesi Orman Fakültesi Derg. 2012;12(2):192–208.
155. Kachkoul R, Sqalli Houssaini T, Miyah Y, Mohim M, El Habbani R, Lahrichi A. The study of the inhibitory effect of calcium oxalate monohydrate's crystallization by two medicinal and aromatic plants: Ammi visnaga and Punica granatum. Progrès en Urol. 2018 Mar;28(3):156–65.
156. Barros ME, Schor N, Boim MA. Effects of an aqueous extract from Phyllanthus niruri on calcium oxalate crystallization in vitro. Urol Res. 2003;30(6):374–9.
157. Atmani F, Khan SR. Effects of an extract from Herniaria hirsuta on calcium oxalate crystallization in vitro. BJU Int. 2001 Dec 24;85(6):621–5.
158. Das I, Gupta SK, Ansari SA, Pandey VN, Rastogi RP. In vitro inhibition and dissolution of calcium oxalate by edible plant Trianthema monogyna and pulse Macrotyloma uniflorum extracts. J Cryst Growth. 2005 Jan;273(3–4):546–54.
159. Bensatal A, Ouahrani MR. Inhibition of crystallization of calcium oxalate by the extraction of Tamarix gallica L. Urol Res. 2008 Dec 11;36(6):283–7.
160. Kachkoul R, Houssaini TS, Mohim M, El Habbani R, Lahrichi A. Chemical Compounds Identification and Antioxidant and Calcium Oxalate Anticrystallization Activities of Punica granatum L. Evidence-Based Complement Altern Med. 2020 Feb 24;2020:1–14.
161. Kachkoul R, Sqalli Houssaini T, El Habbani R, Miyah Y, Mohim M, Lahrichi A. Phytochemical screening and inhibitory activity of oxalocalcic crystallization of Arbutus unedo L. leaves. Heliyon. 2018 Dec;4(12):e01011.
162. Kachkoul R, Squalli Housseini T, Mohim M, El Habbani R, Miyah Y, Lahrichi A. Chemical compounds as well as antioxidant and litholytic activities of Arbutus unedo L. leaves against calcium oxalate stones. J Integr Med. 2019 Nov;17(6):430–7.
163. Chauhan CK, Joshi MJ, Vaidya ADB. Growth inhibition of Struvite crystals in the presence of herbal extract Commiphora wightii. J Mater Sci Mater Med. 2009 Dec 21;20(S1):85–92.
164. Chauhan CK, Joshi MJ. In vitro crystallization, characterization and growth-inhibition study of urinary type struvite crystals. J Cryst Growth. 2013 Jan;362(1):330–7.
165. Sharma D, Dey YN, Sikarwar I, Sijoria R, Wanjari MM, Jadhav AD. In vitro study of aqueous leaf extract of Chenopodium album for inhibition of calcium oxalate and brushite crystallization. Egypt J Basic Appl Sci. 2016 Jun 8;3(2):164–71.
166. Joshi VS, Parekh BB, Joshi MJ, Vaidya ADB. Inhibition of the growth of urinary calcium hydrogen phosphate dihydrate crystals with aqueous extracts

of Tribulus terrestris and Bergenia ligulata. Urol Res. 2005 May 25;33(2):80–6.
167. Kachkoul R, Benjelloun Touimi G, Bennani B, *et al*. The Synergistic Effect of Three Essential Oils against Bacteria Responsible for the Development of Lithiasis Infection: An Optimization by the Mixture Design. Harhar H, editor. Evidence-Based Complement Altern Med. 2021 Aug 28;2021:1–17.
168. Aggarwal A, Tandon S, Singla S, Tandon C. Reduction of oxalate-induced renal tubular epithelial (NRK-52E) cell injury and inhibition of calcium oxalate crystallisation in vitro by aqueous extract of Achyranthes aspera. Int J Green Pharm. 2010;4(3):159.
169. Bano H, Jahan N, Makbul SAA, Kumar BN, Husain S, Sayed A. Effect of Piper cubeba L. fruit on ethylene glycol and ammonium chloride induced urolithiasis in male Sprague Dawley rats. Integr Med Res. 2018 Dec;7(4):358–65.
170. Bashir S, Gilani AH. Antiurolithic effect of Bergenia ligulata rhizome: An explanation of the underlying mechanisms. J Ethnopharmacol. 2009 Feb;122(1):106–16.
171. Bouanani S, Henchiri C, Migianu-Griffoni E, Aouf N, Lecouvey M. Pharmacological and toxicological effects of Paronychia argentea in experimental calcium oxalate nephrolithiasis in rats. J Ethnopharmacol. 2010 May;129(1):38–45.
172. Campos AH, Schor N. *Phyllanthus niruri* Inhibits Calcium Oxalate Endocytosis by Renal Tubular Cells: Its Role in Urolithiasis. Nephron. 1999;81(4):393–7.
173. Zhong Y Sen, Yu CH, Ying HZ, Wang ZY, Cai HF. Prophylactic effects of Orthosiphon stamineus Benth. Extracts on experimental induction of calcium oxalate nephrolithiasis in rats. J Ethnopharmacol. 2012 Dec;144(3):761–7.