Review

National Profiles of Urinary Calculi
A Comparison Between Developing and Developed Worlds

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Introduction. The incidence of urolithiasis has increased in both the developed and the developing countries during the past decades. Economically, the increase of urolithiasis contributes to the rise of the healthcare burden everywhere. Moreover, this increase has been associated with a change in the epidemiology of urolithiasis in terms of age and sex distribution, and also the location and type of calculi.
Materials and Methods. We searched the MEDLINE for relevant literature dating back to 1980. This review compared the trends in epidemiological factors affecting urolithiasis in the developed and the developing countries during the past decades.
Results. People in the developing countries are more likely to contract kidney calculi at a younger age than in the developed countries. Although calculus disease is still more prevalent in men than in women, the latter are increasingly affected in both worlds. Uric acid calculi are more prevalent in the developing than in industrialized countries. There is a progressive increase in the frequency of calcium oxalate and calcium phosphate calculi in the developing countries where these used to be less frequent.
Conclusions. The incidence and prevalence of urinary calculi is increasing globally. Many factors including aging of the population, changes in diet, global warming, and employment of more accurate diagnostic tools seem to be involved in this increase. An increasing affluence and adaptation of Western diet habits in many developing countries seem likely to contribute to the changes.

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INTRODUCTION

Urinary calculus is regarded as a multifactorial disease with involvement of epidemiological, biochemical, and genetic factors. Changes in those factors, eg, socio-economic status and dietary habits, may result in changes in the epidemiology of urinary calculi in various parts of the world. It is in the nature of these factors that they happen at different times, to a different extend, in different parts of the world. Hence, there is a resulting discrepancy between urinary calculus disease profiles, namely between developed and developing countries. For example, historical evidence has shown a significant increase in the prevalence of kidney calculi during the past 100 years. In contrast, the incidence of bladder calculi decreased, but only in the developed world. Bladder calculi must still be considered a significant problem in the developing world.

In this review we try to list and compare the available evidence on various epidemiological factors affecting calculus disease in the developed as well as the developing world. Comparing these changing trends may give hints to the etiology of calculus disease in general.

MATERIALS AND METHODS

We searched the MEDLINE database through the PubMed for relevant literature dating from 1980 to 2014. Keywords used were "epidemiology" AND "urinary calculi." Extracted articles were then screened for evidence on the 4 topics of epidemiology of calculus disease, age and sex distribution in calculus disease, calculus composition, and pediatric urolithiasis. The search was limited to articles in English. Data were sorted according to the origin of the study population into developed and developing countries.

This review did not pertain to provide an accurate statistical comparison of data. Rather, it tried to show trends and different developments in both worlds for calculus disease. We used the terminology "developed" and "developing." The literature may refer to these regions differently as "western and eastern" or "industrialized and rural economy."

RESULTS

Historical Background of Urolithiasis

Urinary calculi have affected humans since the dawn of history. It would be fascinating to know that the first evidence of urinary calculi dates back to 4800 BC, when the English archeologist E Smith found a bladder calculus from a 5000-year-old mummy in El Amrah, Egypt, in 1901.[1,2] Interestingly, through his research, he could only find 4 cases of calculus in thousands of mummies he examined, a finding that strengthened the hypothesis that urolithiasis was not so common in ancient Egypt.

Perhaps the earliest literary citations to calculus disease, describing symptoms and prescribing treatments to dissolve the calculus, are from the medical texts of Asutu in Mesopotamia, between 3200 BC and 1200 BC.[1] Surgery, as a treatment option for calculi, has been found in documents remained from Hindu and Greek writings. An ancient Indian surgeon named Sushruta (around 600 BC), who was the main physician to the king of India, provided detailed description on urinary anatomy, urinary calculi, and also over 300 surgical procedures, including perineal lithotomy, in his compiled book as "Sushruta Samhita." For obvious reasons, he was better acquainted with bladder calculi than urinary calculi. He also reported in his book the complications of urolithiasis including infection, anuria, and uremia. Usual therapy regimen for patients with calculus included a vegetarian diet, a urethral syringe of medicated milk, clarified butter, and alkalis. For those who suffered from severe and ongoing colicky pain for a long time, Sushruta recommended the so-called *steinschnitt* (stone cut) for treatment of bladder calculi.[3]

Urinary calculus was also well known to the ancient Greeks, as there is a reference to it in the famous *Oath of Medical Ethics for Physicians* by Hippocrates (460 BC to 370 BC), when he quotes "I will not cut for calculus, even for the patients in whom the disease is manifest; I will leave this operation to be performed by practitioners." Obviously, by this statement, he granted that calculus surgery was a specialist skill.[4] First person to conjecture that crushing a bladder calculus may make its removal easier was Ammonius (276 BC). He fixed the calculus with a hook and then crashed the calculus using a thin blunt-ended instrument. As he was the first who used the term *lithotomus* to refer to cutting a calculus, the nickname Lithotomus was granted to him.[4]

Perhaps the knowledge of urolithiasis reached the central Europe via Persia and ancient Greece. Iranian Muslim scientists notably improved the knowledge of diagnosis and management of urolithiasis.[5-8] Rhazes, (born in Ray, Iran) wrote a book named *Al-Hawi fi al-Tibb*, known in Europe as *Liber Continens*, and in Part 7, book I, he precisely explained the anatomy, physiology, and physiopathology of urinary tract diseases.[5] Interestingly, his suggestions for prevention of kidney calculi were similar to current advices including avoidance of hypercalciuria and increased saturation of urine. Avicenna, another Iranian eminent philosopher and physician of the 10th and 11th centuries, compiled a masterpiece called *Al-Canon fi al Tibb* (*The Canon on Medicine*), in which a complete explanation about the bladder (urocyst), urine, and the diseases of the urinary bladder has been brought in Part 19 of book III.[6,7] Fascinatingly, he mentioned in his book that remaining calculus fragments in the bladder after lithotripsy, even if very small, could act as a nidus and grows and forms large calculi again.[8]

Later, Abucasis (Ibn Abbas Alzahrawi, 930 AD to 1013 AD) introduced a modified technique of lithotomy and also invented a new lithotomy scalpel called *nechil*, which was very similar to scalpel used later by the Italian surgeon Marianus Sanctus in the 16th century and the English surgeon Shelsden in the 18th century (Figure 1).[1,9] In 16th to 18th centuries, the urolithiasis was reported to be found throughout all ages and social groups.

Determination of calculus composition, as well as urinary constituents, was possible at the end of the 18th century, and as time passed, various determinants of calculus such as uric acid, calcium, oxalate, and even rare, substances like xanthine and cysteine, were clarified.[10] Moreover, more improved methods of calculus removal such as litholopaxy were introduced by Bigelow in 1874 and cystoscopic lithotrite was presented by Young and Mckay (1870 to 1945)[11]; however, a spectacular change in calculus management was made when extracorporeal shockwave lithotripsy machine was used in 1980 for calculus breakage.[12]

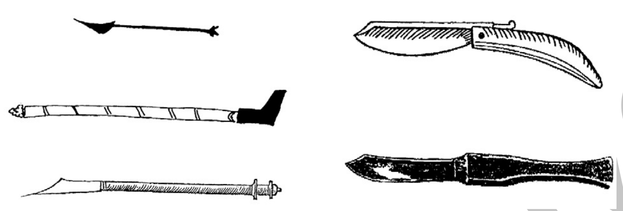

Figure 1. Left, The nechil scalpet of Alzahrawi. **Top Right,** Marianus Sanctus scalpet. **Bottom Right,** and Shelsden scalpet (adapted with permission from the publication by Abdel-Halim and colleagues[9]).

Epidemiology of Calculus Disease in the World

The prevalence of urinary calculus varies widely in different regions and depends greatly on geographic area, racial distribution, socio-economic status, and dietary habits. Worldwide, urolithiasis is the 3rd most frequent urological disease, affecting both males and females. Generally, the risk of adult urolithiasis seems to be higher in the western hemisphere (5% to 9% in Europe, 12% in Canada, 13% to 15% in the United States) than in the Eastern hemisphere (1% to 5%).[13] However, the highest lifetime risk of calculus formation is found in the United Arab Emirates and Saudi Arabia (Figure 2) with an approximate prevalence of 20%.[14]

Epidemiology of Calculus Disease in the Developed World

Based on the latest report from a cross-sectional analysis of responses to the National Health and Nutrition Examination Survey (NHANES; n = 12110; 2007 to 2010), which involved individuals aged greater than 20 years, the prevalence of urinary calculi for both sexes, and for men and women, in the United States was 8.8%, 10.6%, and 7.1%, respectively.[15] These data show a marked increase of 3.6% compared with the NHANES III cohort report which was performed in 1994 and showed an overall prevalence of 5.2%. These data indicate an increase in prevalence of urinary calculi from 1 in 20 to 1 in 11 persons from 1994 to 2010. It is of note that the previous figure of 5.2% had been almost stable since the early 1980s.[16]

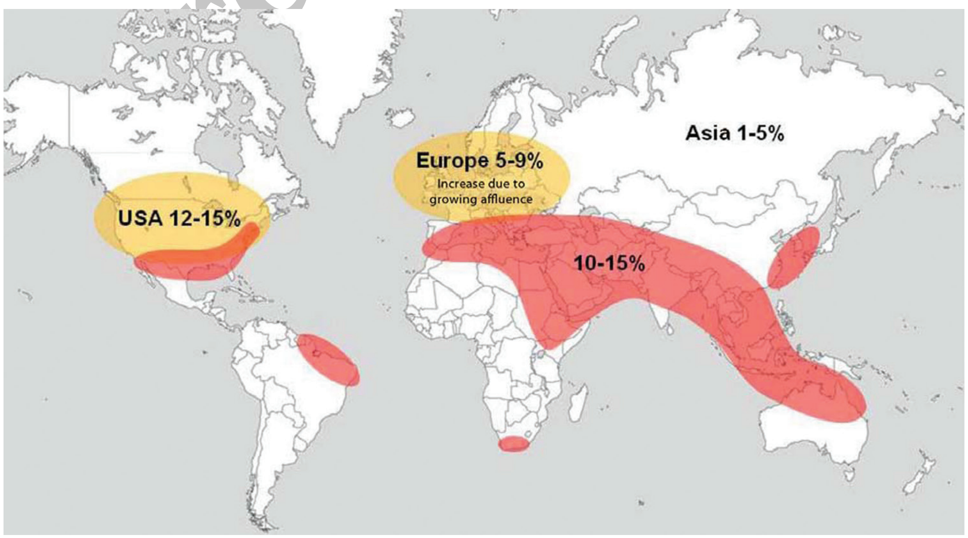

Figure 2. Stone belt (red) extends all the way around the world (adapted with permission from the publication by Fisang and colleagues[13]).

A similar increase in urinary calculus prevalence has been reported from the European countries. In Spain, the annual prevalence of upper urinary tract calculus disease increased from 4.2% in 1986 to 5.1% in 2007.[17] In Italy, the National Institute of Statistics database showed a prevalence of 1.7% and an incidence of 0.17 cases per 1000 patients in 1994, whilst these figures raised to 4.1% and 2.23 cases per 1000 patients in 2012, respectively.[18] In Germany, the prevalence and incidence of upper tract urolithiasis increased from 4% and 540 per 100 000 in 1979 to 4.7% and 1470 per 100 000 in 2001, respectively.[19] In the United Kingdom, the lifetime and annual prevalence of calculus disease have increased from 7.1% and 0.1% in 2000 to 11.6% and 0.2% in 2010, respectively.[20]

Japanese reports also showed a steady increase in the incidence of upper urinary tract calculi. The annual incidence (per 100 000 people) has steadily increased from 54.2 in 1965 to 56.4, 62.0, 68.9, and 114.3, respectively, in 1975, 1985, 1995, and 2005.[21] A recent published study in south Korea using the 2009 Health Insurance and Review and Assessment Service-National Patient Sample, containing 1 115 721 patients, estimated the annual incidence of upper tract urolithiasis to be 457 per 100 000 in the overall population.[22]

Epidemiology of Calculus Disease in the Developing World

There is an Afro-Asian calculus belt extending from North African countries in the West through Sudan, Egypt, Saudi Arabia, the United Arab Emirates, Iran, Pakistan, India, Myanmar, Thailand, Indonesia, to the Philippines in the East. Within this calculus belt, we find a high prevalence of urinary calculi.[23] It should be noted that nationwide comparative studies are rare in these countries. Many studies have had to rely on hospital admission rates for calculus disease as an indication of prevalence. Nevertheless, they seem to indicate an increased prevalence of kidney calculi in these countries, an observation which probably is caused by both improvements in diagnostic procedures and changes in nutritional and environmental factors.[14]

Based on a comprehensive report obtained from a national health examination survey that included 1 169 651 urban inhabitants throughout China, the age-adjusted prevalence of calculi was 4% in 2000.[24] which represents an increase compared to 1.5% prevalence in 1989.[25] In Malaysia, the incidence of urolithiasis showed a steady increase in the periods between 1962 to 1966, 1967 to 1971, and 1977 to 1981, with a reported incidence of 147.7 per 100 000, 175.8 per 100 000 and 298.0 per 100 000, respectively.[26] In Iran, the prevalence and incidence of urolithiasis in 2005 were 5.7% and 138.4 per 100 000, respectively, while in 2007, the incidence increased to 241 per 100 000.[27-29] A similar increase has been reported in other developing countries, such as Brazil (5%), India (4%), Taiwan (7.4%), and Turkey (14.8%).[14] Compared to other countries, Saudi Arabia, Kuwait, and United Arab Emirates have the highest life expectancy of calculus formation (> 20%).[30]

Comparison Between Developing and Developed Worlds

Table 1 shows a summary of changes in prevalence and incidence of upper tract calculi over time in both developed and developing countries. The average increases in prevalence and incidence in both worlds over 3 decades are depicted in Figures 3 and 4. It is widely discussed and commonly accepted that there is a shift in age and sex distribution of calculus disease. In the developed world, this is mainly attributed to a longer lifespan, bad lifestyle habits taken into later life, a more affluent lifestyle, and the adaptation of certain bad lifestyle habits–for a long time the domain of males–by females. In the developing world, the same is true to a lesser extent; these countries being in the process to adapt a Western lifestyle with the abovementioned "blessings."

Age and Sex Distribution in Urinary Calculus Disease in Developed Countries

In 2010 in the United States, the highest prevalence of kidney calculi was seen in a slightly younger age group (60 to 69 years) as compared to 1994 (70 to 74 years). The report also showed that although men still were more likely to be affected by kidney calculi than women (male-female ratio, 1.5), the increase in prevalence of calculi was more prominent in females (> 70%) than males (63%) over a 15-year period. Notably, the male-female ratio becomes more pronounced with increasing age with 3.4:3.4 in 20- to 29-year olds as compared to 19.1:9.4 in 60- to 69-year olds.[15]

Table 1. Reported Urinary Calculus Prevalence and incidence in developed and Developing Countries[15-30]

Country	Year	Prevalence, %	Incidence
Developed countries			
USA	1994	5.2	…
USA	2007-2010	8.8	…
Spain	1986	4.16	…
Spain	2007	5.06	…
Italy	1994	1.7	0.17per 1000
Italy	2012	4.14	2.23per 1000
Germany	1979	4.0	540per 100 000
Germany	2001	4.7	1470per 100 000
United Kingdom	2000	0.10	…
United Kingdom	2010	0.17	…
Japan	1965	…	54.2%
Japan	1975	…	56.4%
Japan	1985	…	62.0%
Japan	1995	…	68.9%
Japan	2005	…	114.3%
Developing countries			
China	1989	1.45	…
China	2000	4.0	…
Malaysia	1962-1966	…	147.7per 100 000
Malaysia	1967-1971	…	175.8per 100 000
Malaysia	1977-1988	…	298per 100 000
Iran	2005	…	138.4per 100 000
Iran	2007	…	241per 100 000

In the United Kingdom, the highest prevalence was observed in an even younger age group (15 to 59 years) than in the United States, although the mean age of patients with an upper tract calculus remained constant over a 10-year period at 49 years.[20] Similar to the United States, calculus disease was 2.43 times more prevalent in males than in females.[20] In Italy, the age group of 65 to 74 years had the highest prevalence (6.7%).[18] Similar to reports from other western countries, males were more prone to develop urolithiasis than females (4.53:3.78) although no significant changes was seen overtime. Like in the United States, a positive correlation existed between an increase in the male-female ratio and age.[18] In Germany, the highest incidence of kidney calculi occurred in the age group of 50 to 64 years, but compared to data provided from previous years, the rise in prevalence was mostly caused by the age group of greater than 50 years.[19] The male-female ratio of urolithiasis was 1.4:1, although the peak age at which females were suffering from their first

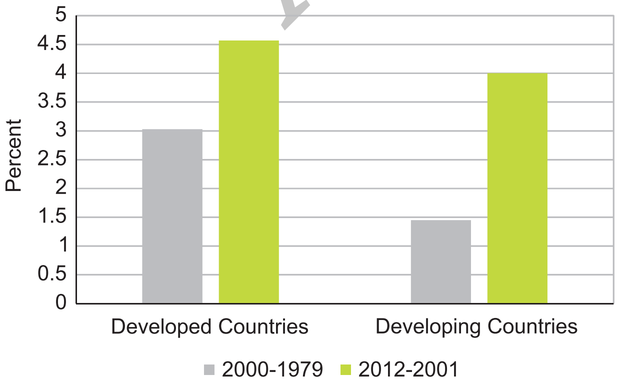

Figure 3. Increase in urolithiasis prevalence in the developed and developing worlds over time.

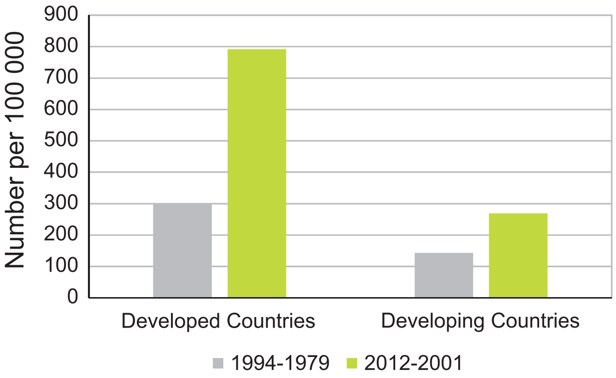

Figure 4. Increase in urolithiasis incidence in the developed and developing worlds over time (per 100 000 population).

episode of urolithiasis was much lower than in males (35 versus 50 years).[19]

In Japan, the peak age of a first episode of upper urinary tract calculi in both men and women shifted to an older age, with men shifting from 20 to 49 years in 1965 to 30 to 69 years in 2005, and women shifting from 20 to 29 years in 1965 to 50 to 79 years by 2005. The male-female ratio was 2.5:1. There were no significant changes over time in this ratio.[21] In Korea, adjustment of the upper calculus incidence by population number in each age group showed that the highest incidence occurred in 60 to 69 years old, with male being more affected (1.8:1). Again, no remarkable change over time has been reported from this country.[22]

Age and Sex Distribution in Urinary Calculus Disease in Developing Countries

In the developing countries, the reports seem to indicate that people start suffering from kidney calculi at a younger age than in the developed countries. The latest comprehensive report from China showed that the highest age-specific prevalence of kidney calculi in males occurs later in life than in females (70 years versus 50 to 59 years). The overall prevalence of male-female ratio was 1.6:1, although great variations existed between north and south China, with the male-female ratio of 2:1 in southern China.[24] Notably, the south includes the areas of the calculus belt in this geographically expansive country. In Iran, the main presentation of kidney calculi starts in the 4th decades of life with a peak in the age group of 50 to 59 years old having the highest prevalence (8.2%) and incidence (154.5 per 100 000).[27] The male-female ratio was relatively narrow 1.38 :1. This ratio seems to be lower than those reported by other Asian countries including Thailand (1.6:1), Iraq (2.5:1), and Saudi Arabia (5:1).[27] Turning our attention to another calculus belt area, namely Saharan and sub-Saharan Africa, a local study from Burkina Faso showed the highest peak of kidney calculus incidence in the 4th decade of life with a male-female ratio of 1.91:1.[31]

It seems that not only the prevalence of kidney calculus is increasing but also the age and sex distribution of this disease is changing. Although calculus disease is still more prevalent in men than women, females seem more likely to be affected than previously. This seems in varying degrees true for both the developed and the developing countries. People in the latter are more likely to develop kidney calculi at younger ages though.

Calculus Composition

The chemical composition of calculi has changed substantially over the past decades worldwide. Again, this change has been attributed to many factors including environmental, dietary, and lifestyle changes. As an example, struvite or infection-related calculi which are made up of magnesium ammonium phosphate were common, whilst today this kind of calculi are rarely seen in developed countries, an observation which might be due to better control of urinary tract infections.

Calculus Composition in the Developed World

A comprehensive study that compared the trends of calculus composition over 30 years in Australia showed that except for a significant decrease in struvite calculi (14% in the 1970s to 12% in the 1980s and 7% in 2011), the frequency of other kinds of calculi remained almost unchanged, with calcium oxalate being the dominant type (68% in both 1970s and 1980s, 64% in 2011), followed by uric acid calculi (17% in the 1980s, 16% in the 1970s, 16% in 2011).[32]

Studies from Japan indicated that frequency of calcium oxalate/calcium phosphate calculi, as the commonest type of calculi, increased in a 40-year period (83.7% in 1965 to 92% in 2005), whilst the frequency of struvite calculi decreased in both men (7.5% in 1965 to 1.4% in 2005) and women (23.3% in 1965 to 5.1% in 2005). The proportion of uric acid calculi remained essentially unchanged (4.6% in 1965 to 5.5% in 2005).[21] Similarly, comparison of calculus composition in Spain showed an increasing trend in calcium oxalate/calcium phosphate, as the most frequent one, in the period between 1979 to 1998 (71.9% in 1979 to 76.5% in 1987 to 81.2% in 1998) and a decreasing trend in struvite calculi (12.5% in 1979 to 9.8% in 1987 to 6.7% in 1998).[33] In Germany, evaluation of 24 085 urinary calculi indicated the calcium-containing calculi as the predominant type of calculus in both sexes. An increase in the prevalence of this type of calculus occurred during the period of 1977 to 2006 (from 82% to 86% in males and from 79% to 84% in females). Infection-associated calculi, as the 2nd most frequent kind of calculi, showed attenuation

(4.9% to 3.3% in males and 13.5% to 9.2% in females), while uric acid calculi, as the 3rd most common type of calculi, remained almost stable.[19] In the United States, more than 70% of calculi are calcium oxalate/calcium phosphate, followed by uric acid (8% to 14%) and struvite calculi (2% to 6%)[14]; however, overtime, analysis of calculus composition showed that between 1970 and 2003, the incidence of calcium phosphates calculi has increased about 3 times in both sexes.[34]

Calculus Composition in the Developing World

Differences in socio-economic, environmental, and dietary circumstances between developed and developing worlds cause a different clinical picture in terms of the chemical composition of the calculi. In Algeria, the most frequent type of calculus is calcium oxalate followed by calcium phosphate, struvite, and uric acid calculi. However, overtime evaluation of calculus type frequency indicated an increase of calcium oxalate and uric acid (61.2% to 67% and 6.2% to 8.8%), attenuation in phosphate calculi (24.4% versus 16.7%), and no significant changes in struvite.[35]

In Iran, a study showed that most patients (85.6%) presented with a mixed composition of calculi.[36] Infrared spectroscopy performed in 1980s in Iran showed that the most common components of urinary calculi were whewellite (81.5%), apatite (69%), weddellite (40.7%), and ammonium acid urate (24.4%).[37] The most common pure calculus was uric acid and the most common component of calculi was whewellite followed by weddellite.[38] Infected calculi comprised 6.5% of all calculi.[39] More recent data from Iran showed a different picture indicating that the commonest kind of urinary calculus is calcium oxalate (80.2%) followed by uric acid (16.2%) and calcium phosphates (2.4%).[40]

In India, calcium oxalate monohydrate forms 90% of calculi, while struvite calculi are found in 1.4% of the calculi. Uric acid and apatite calculi comprise less than 1% of all calculi.[41] In Saudi Arabia, the majority of the calculi are calcium oxalate (78%), uric acid (19%), and phosphate calculi (3%.[30] In Tunisia, calcium oxalate monohydrate is the most frequent calculus component (59.5% in young adults and 43.7% in the elderly), followed by uric acid calculi (11.5% in young adults and 36.4% in the elderly) and struvite calculi (3.8%).[42] In China, the commonest type of urinary calculi is calcium oxalate (78.3%) followed by struvite (14.6%), uric acid (3.6%), and calcium phosphate (3.4%).[43] In Taiwan, overtime studies from 1956 to 1999 showed that the incidence of calcium oxalate as the most frequent type of calculi (87.3%) has increased gradually.[44]

Overall, it seems that uric acid calculi are still more prevalent in the developing than in the industrialized countries. Moreover, there is a progressive increase in calcium oxalate and calcium phosphate calculi even in developing countries where previously these kinds of calculi were less frequent. A summary of reported urinary calculus types in developed and developing countries is presented in Table 2.

Pediatric Urolithiasis

The prevalence of calculus disease in children is much lower than in adults; however, its incidence greatly varies with different regions. Generally, in children, upper tract calculi are more common than lower tract calculi and are usually associated with urinary tract anomalies and infections rather than with metabolic disturbances.

Traditionally, urolithiasis in children would be characterized by a common occurrence of bladder calculi in developing countries and relatively rare kidney calcium calculi in developed countries. However, similar to adult urolithiasis, a shift in both incidence and composition of calculi has been observed in children, too.[45] In the United States, the incidence of pediatric urolithiasis increased by 4% per calendar year throughout 1984 to 2008, with a significant increase in calcium phosphate calculi (18.5% versus 27%).[46,47] In France, in the period between 1994 and 2012, the proportion of infectious calculi decreased in the past 2 decades.[48] Calcium oxalate/calcium phosphate are still the most frequent types of calculi found in children in developed countries (60% in Turkey, 61% in the Netherlands, and 48.7% in Croatia).[49,50]

A shift in incidence, composition, and location of calculi has been reported from developing countries as well. A comprehensive review study performed by Naseri,[51] containing data from 20 different Asian countries involving 12 913 children, showed that from 3977 analyzed calculi, 983 (24.9%) were pure calcium calculi, whereas 1579 (40%), 411 (10.4%), 38 (0.95%), and 288 (7.35%) were mixed calcium, uric acid or urate, cysteine, and struvite calculi,

Table 2. Reported Urinary Calculus Types in Developed and Developing Countries*

Country	Year	Calculus Type, %		
		Calcium Oxalate/Calcium Phosphate	Uric acid	Struvite
Developed countries				
Australia	1970	68	17	14
Australia	1980	68	16	12
Australia	2011	64	16	7
Japan	1965	83.7	4.6	7.5 (M), 23.3 (F)
Japan	2005	92	5.3	1.4 (M), 5.1 (F)
Spain	1979	71.9		12.5
Spain	1987	76.5		9.8
Spain	1998	81.2		6.7
Germany	1977	82 (M), 79 (F)		4.9 (M), 13.5 (F)
Germany	2006	86 (M), 84 (F)		3.3 (M), 9.2 (F)
Developing countries				
Algeria	1990	61.2 (O), 24.4 (P)	6.2	28.
Algeria	2006	67 (O), 16.7 (P)	8.8	28
Iran	2006	80.2 (O), 2.4 (P)	16.2	
India	1996	90	< 1	1.4
Saudi Arabia	2012	78 (O), 3 (P)	19	
China	2014	78.3 (O), 3.4 (P)	3.6	14.6

*M indicates male; F, female; O, calcium oxalate calculi; and P, calcium phosphates calculi.

respectively. Interestingly, uric acid calculi which are uncommon among American children were frequently reported in Asian children.[51]

A nationwide study from Taiwan that investigated the trends of newly diagnosed incidence of pediatric urolithiasis from 1998 to 2007 indicated a decline in annual newly diagnosed incidences for boys (107.2 per 100 000 versus 38 per 100 000) and girls (98.9 per 100 000 versus 37 per 100 000).[52]

In Tunisia, calcium oxalate as the most frequent calculus component decreased (59.4% in 1994 versus 12.5% in 2006) in favor of an increase in phosphatic, phospho-calcic, and ammonium urate calculi (12.5% in 1994 versus 25% in 2006). The frequency of struvite calculi also increased from 15.6% to 37.5%.[53] A recent report from Pakistan demonstrated that the predominant location of urinary calculi in children has shifted from the bladder to the upper urinary tract over a 13-year period from 1987 to 2000. Bladder calculi were present in 60% of cases in the mid-1980s, but decreased to 15% in the mid-1990s.[54] In Iran, the incidence of upper tract calculi in children is reported to be higher than lower tract calculi (84.5% versus 15.5%).[55] A single-center study in Iran showed the higher rate of kidney calculi compared to bladder calculus in children (90.6% versus 2.4%).[55] Accordingly, another study that analyzed the demographic findings in 271 children aged 2 months to 16-years with urinary calculus revealed that nearly all (99%) calculi lay in kidney.[56] The main constituents of calculi in the upper urinary tract were calcium oxalate followed by ammonium acid urate, whilst in the lower urinary tract ammonium acid urate and oxalate were seen with equally often.[57]

DISCUSSION

Recent studies show changes of the profile of calculus disease over the last decades. Our review demonstrates that there has been a documented increase in the prevalence and incidence of urolithiasis in the last decades in both the developed and the developing worlds. This increase has affected both sexes, but is more pronounced in females.

The rise in the prevalence and incidence of urinary calculi seems to be more pronounced in developing countries that go through an extensive and fast social and economic development. Although many factors may contribute, the improvement of socio-economic condition plays undoubtedly an important role. An observation that may supports this importance is the very high prevalence of calculi in the more affluent countries of the Middle East countries, such as the United Arab Emirates and Saudi Arabia, compared to their poorer neighbors living under the same environmental conditions.[30] Of course, other factors such as the hot climate in these countries will further aggravate the condition as it is known that the peak incidence of calculus formation is in late summer, which is likely related to relative dehydration secondary to hot weather.[30]

Changes in calculus composition provide further clues for the importance of socio-economic factors. An increased affluence is associated with a higher consumption of animal protein and sodium, which in turn leads to an increase in urinary calcium, uric acid and oxalate, whilst lowering both urinary pH and citrate concentration.[58,59] All these changes contribute to urolithogenesis. The adaptation of a Western diet in many developing countries works very much along these lines.

The impact of global warming also should be considered when discussing the worldwide increase in urinary calculi. Two recent studies done by Evans and Costabile[60] and Doumerc and colleagues[61] have shown the relationship between exposure to high temperatures and the subsequent development of kidney calculi. In their studies, a mean time to calculus formation of 90 days following deployment was reported. Another study performed in the United States, analyzed medical records of more than 60 000 adults and children with kidney calculi between 2005 and 2011 in connection with weather data and found that the risk of kidney calculus presentation increased in all the cities when mean daily temperatures rose.[62] A recent study that used mathematical modeling suggests that as the mean annual temperatures increase in the United States, the percentage of the residents living within a region at high risk for calculus disease will grow from 40% currently to 56% by 2050 and 70% by 2095.[63] A modeling study performed in Iran anticipated that climate change can lead to an average increase of 4.3% to 9% in the urolithiasis prevalence based on type of model employed.[64]

Metabolic factors including overweight, insulin resistance, and metabolic syndrome may as well contribute to an increase in urinary calculi as there is a correlation between increased body mass index and the change in urinary excretion of risk factors for calcium based calculi. A recent report from the NHANES showed that obesity and diabetes are strongly associated with a history of kidney calculi.[15] Siener and colleagues studied 24-hour urine samples in adult patients and observed a significant positive correlation between increasing body mass index and increasing urinary sodium and uric acid excretion.[65]

Finally, the availability of new and more accurate diagnostic tools may contribute to an increased diagnosis rate of symptomatic and/ or asymptomatic urolithiasis. This is certainly true for the developed world, with the developing world fast catching up in terms of medical technology. Mainly, these are the increased use of computed tomography and ultrasonography with a much higher calculus detection rate than the conventional radiography.[66]

CONCLUSIONS

Literature from developing world is scarce and scattered and sometimes difficult to come by. This paper collected and compared in a ready- to-consume manner the evidence from both worlds in an easy-to-read comprehensive fashion for the reader. Although it compares existing literature, it provides a fact-to-fact comparison which can underline trends and developments between the two worlds. According to the available literature, the incidence and prevalence of kidney calculi is increasing globally. Many factors including aging of the population, changes in dietary habits, global warming, and employment of accurate diagnostic tools seem to be involved in this increase. The same trends can be found in developed and developing worlds alike, albeit arriving in the latter with delay.

CONFLICT OF INTERESTS

None declared

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