THE SRI LANKA JOURNAL OF UROLOGY

Established 2000

Volume 7, No. 1, December 2006

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THE SRI LANKA ASSOCIATION OF UROLOGICAL SURGEONS ISSN 1391-6343

Printed by Ananda Press, Colombo 13.

Sri Lanka Journal of Urology, 2006, 7, 14-18

Original Article

Upper urinary tract stones: a case-control study of fluid intake in first-time stone formers

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Abstract

Introduction Nephrolithiasis is a common disorder with a reported prevalence of 12% in industrialized countries. The recurrence rate of first-time stone formers has been reported to be approximately 50%. An increased urine volume (at least 2 litres / day) achieved by a high fluid intake exerts an efficacious preventive effect on the onset and recurrence of urinary stones. The objective of this study was to determine the daily fluid intake in first-time stone formers from the Dry and Wet Zones of Sri Lanka taking into consideration the nature of occupation and the level of physical activity.

Patients and method A prospective case-control study was carried out on adult men with newly diagnosed previously untreated upper urinary tract (radio-opaque kidney and ureteric) stones over a 9-month period in a urology unit at the National Hospital of Sri Lanka. Data were collected using a pre-tested interviewer administered questionnaire by trained staff documenting geographical location of workplace / residence, nature of occupation (indoor / outdoor), level of physical activity at work (heavy / moderate / light / sedentary) and the average daily fluid intake prior to diagnosis. A smaller control group of non-stone patients were also studied.

Results Sixty six males (mean age 36.6 years, Sd, range 18-59) considered as first-time stone formers were studied during the 9-month period. A control group (mean age 37.3 years, range 20-55) consisting of 15 non-stone patients were also evaluated.

Fifty nine (89.4%) first-time stone formers were between 20 and 50 years of age. Thirty four (51.5%) of first-time stone formers drank less than 2 litres of fluid daily with 26 (39.4%) patients drinking less than 1500 ml. Only 7 (10.6%) patients were deemed taking the appropriate daily fluid intake (3000-4000 ml) depending on the occupation and physical activity. Fifty seven (86.4%) patients were from the Wet Zone. The mean daily fluid intake in patients from the Wet and Dry zones were 2182 ml and 2117 ml respectively. The mean daily fluid intake for all first-time stone formers was 2160 ml in contrast to 2835 ml in the control group.

Conclusions Geographical differences in the mean daily fluid intake between the Wet and Dry Zones were not observed in this study. Over half the first-time stone formers consumed less than 2L of fluids per day, thereby convincingly demonstrating that chronic dehydration is a key factor in the development of kidney stones in Sri Lanka.

Supersaturation of the urinary environment with stone-forming constituents (calcium, oxalate, phosphate) is a pre-requisite for idiopathic calcium nephrolithiasis. Increased fluid consumption results in excretion of a higher volume of urine, which is less supersaturated and benefits all stone formers.

Geographical location also appears to influence stone formation in Sri Lanka, with a perceivable high prevalence in the Dry Zone, predominantly North Central, and Northern Provinces, and the Hambantota District in the south.

Chronic dehydration has been identified as a cause of stone formation in 19% of patients attending a metabolic stone clinic in the United Kingdom (1). Chronic

dehydration from greater exposure to sunlight and outdoor occupations (eg. cultivation) may be responsible for the increased rates of nephrolithiasis in the Dry Zone. Sun exposure can lead to more concentrated urine by increasing insensible water loss due to sweating.

The present study was done to determine the daily fluid intake in men from the Dry and Wet Zones of Sri Lanka taking into consideration the nature of occupation and the level of physical activity.

Patients and methods

A prospective case-control study was carried out over a 9-month period from mid-September 2004 in a urology unit at the National Hospital of Sri Lanka, Colombo. Adult men with newly diagnosed previously untreated upper urinary tract stones (radio-opaque kidney and ureteric stones) admitted for extracorporeal shockwave lithotripsy (ESWL) or intracorporeal pneumatic lithotripsy (IPL) were included. Female patients were excluded.

Data were collected using a pre-tested interviewer administered questionnaire by a trained group of registered nurses. A control group (mainly patients admitted for varicocele surgery or a non-stone urological condition where advice on water intake was unlikely) was administered the same questionnaire.

The geographical location of the workplace / residence, nature of occupation (indoor / outdoor), level of physical activity at work (heavy / moderate / light / sedentary) recording the number of hours and the average daily fluid intake immediately before the diagnosis of stone disease was made were documented (see Appendix).

Results

Sixty six males (mean age 36.6 years, SD, range 18-59) considered as first-time stone formers were studied during the 9-month period. A control group consisting of 15 non-stone patients (mean age 37.3 years, range 20-55) were evaluated during the same period. One incompletely filled questionnaire was rejected.

Fifty nine (89.4%) first time stone formers were between 20 and 50 years of age.

Table 1 shows fluid intake of stone formers in relation to the occupation and the level of physical activity. Seven (10.6%) first-time stone formers were deemed taking the appropriate daily fluid intake (3000-4000 ml) depending on the occupation and physical activity. Five (7.6%) patients were considered to consume excess fluid (>4000ml/d) and 34 (51.5%) of first-time stone formers took less than 2 litres of fluids daily with 26 (39.4%) patients drinking less than 1500 ml.

Table 1. Daily fluid intake of stone-formers

Category	Volume (ml)					
	<999	1000-1499	1500-1999	2000-2999	3000-3999	>4000
All patients (n = 66)	3	21	10	20	7 (10.6%)	5
Indoor Light Activity (n =20)	2	5	3	7	1	2
Indoor Moderate Activity (n =22)	-	7	3	10	1	1
Indoor Heavy Activity (n =7)	-	3	1	-	2	1
Outdoor Moderate Activity (n =9)	1	2	2	2	2	-
Outdoor Heavy Activity (n = 8)	-	4	1	1	1	1
Controls (n.=15)	-	2	1	7	4	1

Table 2. demonstrates the mean daily fluid intake according to the occupation and level of physical activity. The median value for daily fluid intake of the patients engaged in outdoor heavy activity was 1475 ml (mean 2159 ml; range 1050-4925 ml). In 5 of these 8 patients (62.5%) the daily fluid intake was 1500 ml or less.

Forty six (69.7%) patients were from the Western Province. Fifty seven (86.4%) patients were from the Wet Zone and the rest from the Dry Zone. The mean daily fluid intake in patients from the Wet and Dry zones were 2182 and 2117 ml respectively (Table 3). The mean daily fluid intake for first-time stone formers was 2160 ml in contrast to 2835 ml in the control group (where all except one was from the Wet Zone).

Table 2. Mean daily fluid intake according to nature of occupation and the level of physical activity in stone formers

Category	No. of patients	Mean volume (ml)
Indoor, light activity	20	2030
Indoor, moderate activity	22	2180
Indoor, heavy activity	7	2607
Outdoor, moderate activity	9	2058
Outdoor, heavy activity	8	2159
Total (Stone-formers)	66	2160
Controls	15	2835

Table 3. Mean daily fluid intake according to geographical distribution in stone formers

Region	No. of patients	Mean volume (ml)	Range (ml)
Colombo District	21	2010	550-4250
Gampaha District	18	2167	900-6600
Kalutara District	7	1936	900-4550
Ratnapura District	7	2186	1100-4925
Southern Province (except Hambantota)	4	3275 2675*	1750-6000
Hambantota District (Dry Zone)	2	1200	1050-1350
Puttalam District (Dry Zone)	3	1550	1250-2000
Other districts (Dry Zone)	4	3000	1500-3750
Wet Zone	57	2182	550-6600
Dry Zone	9	2117	1050-3750
All districts (stone formers)	66	2160	550-6600
Controls	15	2835	1100-7400

* Median

Appendix (part of the questionnaire)

Outdoor Activity	No. of Hours	Indoor Activity	No. of Hours
Heavy (H)	.....	Heavy (H)	.....
Moderate (M)	.....	Moderate (M)	.....
Light (L)	.....	Light (L)	.....
Sedentary (S)	.....	Sedentary (S)	.....

Average Daily Fluid Intake (before diagnosis)

	No.		No.
1. Cups (150 ml)	.....	5. Coca Cola bottles	.....
2. Small glasses (175 ml)	.....	6. Coca Cola buddy	.....
3. Large glass/ mug (300 ml)	.....	7. Mega bottles (1.5L)	.....
4. Elephant House bottles	.....	8. Others (specify)	.....
		Total Intake =	.....

Discussion

Ninety per cent of first-time stone formers were between 20 and 50 years of age in this study.

There is evidence that stone formers consume less fluid than individuals not afflicted with this disorder (2,3). The relative risk of kidney stone formation decreased with increased fluid consumption: less than 1275 ml, 1.0; more than 2537 ml, 0.52. In the present study, the mean daily fluid intake for first-time stone formers was 2160 ml when compared with the control group (2835 ml). However, the control group in this study is fundamentally flawed due to the low numbers recruited and not being a group of normal healthy subjects.

There is no evidence to support the theory that increasing fluid intake might have a deleterious effect, because this could lower the concentration of urinary inhibitors. Increasing fluid intake actually has been demonstrated to have a positive effect on two urinary inhibitors, citrate and Tamm-Horsfall protein. Hydration augments urinary citrate excretion (4). Urinary dilution has been found to increase the inhibitory activity of Tamm-Horsfall protein in calcium oxalate monohydrate crystal aggregation in the urine of stone formers (5).

There is ample evidence that increased fluid consumption to achieve a daily urine output of 2 litres or more can reduce the risk of stone formation (6). Borghi and co-workers undertook a prospective study in which first-time adult calcium oxalate stone formers were assigned randomly to either receive instruction to consume enough fluid to generate a urine volume of 2L / day or more (group 1) or be told that they had an isolated stone event and that no changes in fluid intake were needed (group 2). During follow-up recurrences were noted within 5 years in 12 of 99 group 1 patients and in 27 of 100 group 2 patients ($p= 0.008$). The average interval for recurrences was 38.7 +/- 13.2 months in group 1 and 25.1 +/- 16.4 months in group 2 ($p= 0.016$). The baseline 24-hour urine volume in group 1 ranged from 2127 to 2654 ml, during the five one-yearly follow-up collections. In contrast, the baseline urine volume for group 2 ranged from 1005 to 1258 ml. The relative supersaturation of calcium oxalate, brushite, and uric acid decreased significantly in group 1 but remained unchanged in the other cohort at each 1-yearly follow-up interval. In the present study no attempt was made to measure the daily urine output. However, in an adult man the insensible water loss from faeces and sweat is normally about 1 litre / day. Thus, to produce a urine output of 2 litres / day a subject must drink 3 litres / day of fluids total. That amount translates to two 'Mega' bottles or four 'cordial' bottles of water or other beverages or ten large (300 ml) glasses or ten mugfuls of fluids. If a subject sweats excessively, more fluids must be drunk to achieve a urine output of 2L / d. Any patient with fluid consumption below this level may have a low urine output. Patients should be encouraged to drink 3 L of fluid per day with the goal of producing at least 2L of urine. (6,7). Desired fluids are water, potassium-containing fruit juices (eg. orange, grapefruit) and citrate-containing soft drinks (eg. Lemonade, Sprite, 7-Up). Less desirable fluids are tea (because of high oxalate content) and milk (because of high calcium content). However, the amount of fluid is probably more critical than the type of fluid.

In the present study only seven (10.6%) first-time stone formers were deemed taking an optimal daily fluid intake (3000-4000 ml) depending on the occupation and physical activity. Over half the first-time stone formers consumed less than 2L / d of fluids with approximately 40% drinking less than 1500 ml. In the outdoor occupation with heavy physical activity category 62.5% drank 1500 ml or less daily. This study, therefore, demonstrates that chronic dehydration due to low fluid intake and hot climate is contributing significantly to nephrolithiasis in the vast majority of first-time stone formers in Sri Lanka. In a study of 708 patients with urolithiasis in the United Kingdom, chronic dehydration was the likely cause in 132 (19%) patients (1). The cause of chronic dehydration were hot climate (62%), with hot occupation and low water intake almost equal in second place.

Borghi and co-workers investigated the prevalence of stone disease in machinists at a glass plant chronically exposed to a hot environment and massive sweating, with 8.5% (20 of 236) having urolithiasis compared with 2.4% (4 of 165) controls working in normal temperature (8). None of the 7 indoor heavy physical activity patients in the present study were engaged in a hot occupation with excessive sweating.

Geographical differences in the mean daily fluid intake between the Dry and Wet Zones were not observed in this study conducted at a tertiary referral centre. However, a hot climate, greater exposure to sunlight and predominantly outdoor occupations in the agricultural districts of the Dry Zone warrant a relatively higher fluid intake than in the Wet Zone if the daily urine output of 2 litres or more is to be achieved. Similar studies in provincial hospitals will substantiate that chronic dehydration is a greater contributory factor in stone formation in the Dry Zone.

The data presented in this paper indicate that there is compelling evidence that chronic dehydration is demonstrably a key factor in the development of kidney stones in Sri Lanka.

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