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Nutrition and urinary calcium stone formation in northwestern India: a case control study

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Abstract The nutrient intake of 69 stone formers (SFs) from three subsets of the local population (urban 22, rural tribal 22 and rural nontribal 25) and 69 age, sex, weight and socioeconomically matched control subjects (NSs) (urban 20, rural tribal 22 and rural nontribal 27) was studied. Simultaneously their timed 24-h urine samples collected over a similar period were analyzed. In general caloric and protein intake was low in all the groups but was strikingly low in the rural subjects. Intake of all nutrients was lowest in the tribal group. Although no difference was observed in diet between NSs and SFs in the same population subjects, SFs had higher urinary excretion of oxalic acid and calcium and lower excretion of citric acid and excreted more saturated urine. Notably magnesium intake was normal in both NSs and SFs, but mean excretion of magnesium was lower than normal in all the groups, suggesting its defective absorption. The influence of dietary intake of protein, carbohydrate, fat, fiber, calcium and oxalic acid on urinary excretion of calcium, oxalic acid, uric acid, inorganic phosphorus, magnesium and citric acid was examined using the chi-square test. No association was observed, thus suggesting that this low nutrient intake did not influence the lithogenic process. Thus, the overall observations suggest: (a) poor nutrition, (b) no effect of diet on urinary stone disease, (c) no difference in the nutrient intake between NSs and SFs and (d) a higher excretion of promoters and a lower excretion of inhibitors in SFs than in NSs.

Key words Hyperoxaluria · Nephrolithiasis · Diet · Hypercalciuric · Tribal population

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Introduction

The birth of stones in the urinary conduit is considered to be the net result of multifactorial defects [24] and diet has been implicated as one of the major culprits. Indeed, there is a growing consensus that the increase in renal stone disease in the wealthy industrialized countries, despite the best medical care and awareness, is mainly due to the progressive dietary changes related to affluence. Some excellent studies in this regard have been reported in the literature [2–5, 9, 17, 20, 34, 45, 46]. However, similar systematic studies in the developing populations of the world are scarce and even those available have been concerned with primary bladder stone disease [46], which is a separate etiologic entity. To the best of our knowledge no detailed study on dietary patterns in renal stone disease in India has been reported in the literature.

Important dietary ingredient factors reported to influence the disease are energy-dense nutrients, calcium, oxalic acid, purines, magnesium and fiber [47]. However, all these dietary factors may not be operating simultaneously in the same population; they may differ from one population to another; and these could fluctuate widely in populations, from extreme poverty at one end of the scale to affluence. The major problem of affluent groups has been their nonvegetarian diet rich in animal protein, fat, refined carbohydrates, purines and calcium (Ca) and low in fiber [5, 9, 33, 47]. On the other hand, the problem of developing and underdeveloped populations has been their imbalanced vegetarian diet which is usually poor in quality and quantity of protein [42] and rich in oxalic acid (OA) [35–38]. Robertson et al. [33] reported the beneficial effect of a vegetarian diet in that it decreases OA excretion. In contrast, Marangella et al. [23] observed that a vegetarian diet increased urinary OA excretion and calcium oxalate saturation.

Some workers have observed a clear-cut difference between the diets of normal subjects (NSs) and stone formers (SFs) [17, 20, 33], whereas others have not [14, 45]. The overall conclusion which can be derived from these two different types of reports is that there could be: (a) a fundamental difference between the diet of NSs and SFs or (b) no difference between the diet of the two groups but altered intestinal absorption. The present study addresses itself to the first alternative.

Material and methods

Patients and controls

The 69 selected idiopathic calcium SFs were from those detected in a field survey we conducted or from patients attending the General Hospital, RNT Medical College, Udaipur, for treatment. None of the selected subjects was taking any medication at the time of study or in the preceding week. They were divided into two groups: rural ($n = 47$) and urban (UR, $n = 22$). The rural group was further subdivided into two subsets: tribal (RT, $n = 22$) and nontribal (RNT, $n = 25$). There were two, five and one female patients in the UR, RNT and RT groups, respectively. All the patients remained ambulatory during the period of study.

The NSs (UR, $n = 20$, RNT, $n = 27$ and RT, $n = 22$) were carefully selected to match for dietary habits, environment, age, weight and socioeconomic status.

Collection of food samples and study of dietary habits

The subjects were instructed to pour one-fourth of all their food items and drinks, including water, into steel containers and bottles, respectively, both prewashed with double-distilled water. All the subjects were assured about confidentiality of the information provided for or derived from the study because many persons did not want their data disclosed for social and religious reasons.

Collection of urine samples

Twenty-four-hour urine samples were collected in clean glass containers containing chloroform as preservative. For the estimation of saturation, a fresh sample was collected 4 h after breakfast.

Diet analysis

Diet samples were homogenized, dried to make them moisture free and finally ground to powder. Samples were analyzed for protein, fat, carbohydrate and minerals (Ca, Mg, iP, Na and K). The methods employed for analysis were standard procedures recommended by the Indian Council of Medical Research [30]. Dietary oxalate was estimated by the method described by Hodgkinson [15]. Total fiber was calculated by deducting the amount of nutrients, whereas quantity of crude fiber was obtained by treating a fat-free diet with acid (1.25% w/v H_2SO_4) and alkali (1.25% w/v NaOH). The sample was dried, weighed and then ashed in a muffle furnace at 600 °C for 3 h. The weight of crude fiber represented the dried weight of the sample minus weight of ash.

Urinalysis

The urine samples were transported to the laboratory, kept in a refrigerator at 4 °C and analyzed immediately or within 3 days for Ca [11], OA [16], creatinine, Mg, inorganic phosphorus, uromucoid [25], uric acid [5], citric acid (CA) [31], Na and K (flame photometry).

The urinary inhibitor activity against calcium oxalate crystallization was measured by the method of Lonsdale [22] as modified by Sur et al. [44]. The data reported here are in terms of micrograms calcium deposited on glass fiber, which indirectly represents the urinary supersaturation. Calcium oxalate risk index (CORI) was calculated according to the following formula [1]:

$$\text{CORI} = \frac{(\text{calcium/creatinine})^{0.71} \times (\text{oxalate/creatinine})}{(\text{magnesium/creatinine})^{0.14} \times (\text{citric acid/creatinine})^{0.10}}$$

Statistical analysis

Statistical analysis was carried out by employing a simple unpaired Student's t-test to ascertain the difference between NSs and SFs and between the population groups. A chi-square test was employed to ascertain the association between nutrient intake and urinary excretion of some promoters and inhibitors of calculus formation in NSs and SFs, using the following formula [43]:

$$\chi^2\text{Cal} = \frac{\Sigma(Ui - Ei)}{Ei}$$

where Ui and Ei are the observed and expected frequencies of ith cell. The calculated chi-square values were compared with tabulated values at the appropriate degree of freedom to test the significance of association.

Normocalciuria was defined as excretion of $\leq$200 mg Ca/24 h on a daily calcium intake of $\leq$400 mg Ca. Normo-oxaluria was defined as oxalic acid excretion of $\leq$40 mg/24 h on an oxalic acid intake of $\leq$200 mg/day.

Results

The daily nutrient intakes of RT, RNT and UR SF and their respective controls (NSs) are given in Table 1. The total protein, carbohydrates and fat intake were in the following order: UR > RNT > RT. In rural subjects the intake of total protein and fat was very low. The sodium intake in the rural group was slightly higher than in the UR group. Although a significant difference was noticed in the intake of dense nutrients from one population subset to another (Table 2), no significant difference in the nutrient intake was observed between NSs and SFs of the same population group.

The urine chemistry of the subjects is given in Table 3. SFs excreted significantly higher Ca and OA. CA excretion was significantly lower in SFs of the RT and UR groups than in NSs but the differences was not significant in the RNT group. The urinary profile of SFs did not show any discernible pattern from one population to another.

The association of dietary factors and urinary stone risk factors was examined separately for NSs and SFs using the chi-square test. No evidence was found of an

Table 1 Age and daily intake of food factors by normal subjects and stone formers (means ± SE)

Parameters	Rural tribal (RT)		Rural nontribal (RNT)		Urban (UR)	
	Normal subjects (n – 22)	Stone formers (n – 22)	Normal subjects (n – 22)	Stone formers (n – 25)	Normal subjects (n – 20)	Stone formers (n – 22)
Age	35.4 ± 1.42	35.68 ± 1.42	37.37 ± 1.66	37.64 ± 1.82	41.0 ± 2.80	41.5 ± 2.51
Total calories	1311.0 ± 157.0	1420 ± 140	1650 ± 100	1772 ± 138	2096 ± 74	2412 ± 124
Total protein (g)	25.8 ± 2.7	28.7 ± 1.1	32.6 ± 3.4	37.1 ± 1.9	43.4 ± 2.6	47.9 ± 1.3
Carbohydrate (g)	276.0 ± 18.3	288.0 ± 23.9	341.4 ± 28.1	367 ± 33.0	421.0 ± 31.9	486.0 ± 21.4
Fat (g)	10.0 ± 0.8	12.1 + 00.9	15.8 ± 0.5	18.2 ± 1.6	24.2 ± 1.9	27.8 ± 1.1
Total fiber (g)	19.6 ± 4.6	17.0 ± 5.2	20.7 ± 4.9	18.2 ± 5.4	21.6 ± 4.1	23.2 ± 7.4
Crude fiber (g)	7.3 ± 0.8	6.2 ± 0.9	8.7 ± 0.8	7.1 ± 0.8	8.0 ± 0.4	7.2 ± 0.3
Oxalate (mg)	122.6 ± 11.9	144.9 ± 6.9	119 ± 10.3	151.2 ± 23.1	136.4 ± 11.4	160.2 ± 20.1
Calcium (mg)	433.0 ± 27.0	450.0 ± 32.0	425 ± 10	431 ± 23	518 ± 38	460 ± 15
Phosphate (mg)	936.0 ± 58.0	899 ± 69	1021 ± 73	979 ± 58	1104 ± 84	1019 ± 49
Magnesium (mg)	188.9 ± 14.4	191.3 ± 11.5	179.2 ± 17.9	182.3 ± 12.0	208.0 ± 14.1	226.3 ± 11.5
Sodium (mg)	4728.0 ± 249.0	4814 ± 288	5001 ± 179	4892 ± 155	4348 ± 99	4501 ± 110
Potassium (mg)	1234 ± 64	1190 ± 77	1113 ± 94	1195 ± 80	989 ± 80	1016 ± 49

Table 2 Statistical evaluation to ascertain differences in daily intake of various food factors by normal subjects and stone formers

	Urban vs rural nontribal		Urban vs rural tribal		Rural nontribal vs rural tribal	
	Normal subjects	Stone formers	Normal subjects	Stone formers	Normal subjects	Stone formers
Total calories	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total protein	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Carbohydrate	<0.05	<0.05	<0.01	<0.01	<0.005	<0.05
Calcium	<0.05	<0.05	NS	NS	NS	NS
Phosphorus	NS	NS	<0.05	<0.05	NS	NS

The differences in the daily intake of fiber, oxalic acid, Mg and K were nonsignificant in all groups

Table 3 Urine chemistry of normal subjects and stone formers (means ± SE, *n* number of cases)

Parameters	Rural tribal (RT)		Rural nontribal (RNT)		Urban (UR)	
	Normal subjects (n–22)	Stone formers (n – 22)	Normal subjects (n – 27)	Stone formers (n – 25)	Normal subjects (n – 20)	Stone formers (n – 22)
pH	6.0 ± 0.8	6.0 ± 0.7	6.0 ± 0.3	5.7 ± 0.9	6.2 ± 0.8	5.9 ± 0.7
Volume (ml)	1086 ± 97	1348 ± 112	1266 ± 106	1211 ± 126	1428 ± 122	1584 ± 150
Creatinine (mg)	879 ± 50	1220 ± 119	1059 ± 73	1166 ± 78	1139 ± 86	1078 ± 53
Calcium (mg)	110.4 ± 8.4	176.1 ± 19.5*	126.6 ± 6.5*	182.3 ± 7.8*	142.5 ± 8.3	190.5 ± 13.2*
Oxalic acid (mg)	24.8 ± 2.8	43.3 ± 4.2*	27.9 ± 2.0	40.1 ± 3.1*	34.5 ± 2.6	50.5 ± 3.3*
Uric acid (mg)	284 ± 34	323 ± 35	394 ± 22	422 ± 23	326 ± 21	423 ± 27
Uromucoid (mg)	109.3 ± 10.8	120.2 ± 17.1	115.9 ± 8.8	132.6 ± 12.4	112.5 ± 8.9	129.2 ± 9.2
In.phosphorus (mg)	505 ± 62	616 ± 88	510 ± 44	537 ± 28	543 ± 31	762 ± 37*
Magnesium (mg)	54.5 ± 5.9	36.2 ± 3.0	60.4 ± 3.6	45.9 ± 2.2	50.5 ± 2.0	39.5 ± 2.5
Citric acid (mg)	556 ± 60	305 ± 41*	512 ← 43	354 ± 26	505 ± 39	280 ± 13
Sodium (mg)	2022 ± 217	3048 ± 376	3235 ± 264	3372 ± 261	3125 ± 243	3236 ± 255
Potassium (mg)	825 ± 99	925 ± 112	833 ± 20	834 ± 61	726 ± 31	902 ± 62
CORI	– 1.97 ± 0.41	– 1.68 ± 0.55	– 1.75 ± 0.37	– 1.84 ± 0.3	– 1.87 ± 0.42	– 1.66 ± 0.4
Supersaturation[a] (μg)	112.3 ± 26.8	497.3 ± 174.1*	112 ± 28.0	465.4 ± 181.1*	118.4 ± 33.7*	456.9±181.9*

* $P < 0.05$

[a] Represented by amount of calcium deposited on glass fiber

association between dietary intake of protein, carbohydrate, fat, fiber, Ca and OA with the urinary excretion of Ca, OA, uric acid, Mg and CA. The SFs were subdivided into normocalciuric (NC), normo-oxaluric (NO), hypercalciuric (HC), hyperoxaluric (HO), normocalciuric + normo-oxaluric (NCNO) and hypercalciuric + hyperoxaluric (HCHO). Neither of the groups differed in their intake of Ca and OA (Tables 4–6). Notably, hypercalciuric UR and RNT subjects had a higher excretion of uric acid. No difference was observed in CORI between NSs and SFs overall (Table 3). However, when CORI of NS was compared with corresponding SF groups with recognized risk factors, significantly higher values were noted in urban HO, tribal HO, HC and NCHO groups. No significant difference was observed in the remaining groups. Urinary saturation was significantly higher in all the SF groups than in their corresponding controls.

Discussion

India has been on the road to progress for over 4 decades. Interestingly, prevalence studies have indicated a concomitant rise in the prevalence of renal stone disease [19, 28, 29, 36, 41]. Prevalence is high in the Udaipur and Jodhpur regions of Rajasthan [10, 28, 29], compared to other parts of India. Besides other etiologic factors, dietary habits have also been under investigation [7, 27, 35, 37] and SFs have not shown any difference from the normal population in this respect [29, 37, 41]. These surveys also indicate that high total protein including animal protein and Ca intake are not the etiologic factors, and fiber intake is adequate since a vegetarian diet is rich in farinaceous food [7, 18, 27]. However, oxalic acid intake could be an important determinant in this region as well as in other parts of India [35, 38]. In this study we evaluated quantitative nutrient intake along with urine chemistry to examine the three main issues in relation to urolithiasis: (a) nutrient intake and urine chemistry in various subgroups of the local population, (b) the differeces, if any, in nutrient intake and urine chemistry of NSs and SFs in the same subset of population and (c) the association, if any, between the nutrient intake and urinary excretion of stone risk factors.

Our data indicate that the caloric intake and consumption of dense nutrients are lowest in the RTs, which are strikingly low according to the criteria of the Indian Council of Medical Research [12, 13]. This community in the rural area of this region still adheres to its primitive social and dietary customs and the majority of persons live below the poverty line, which is very much reflected in their overall nutrient intake. By habit all of the community are nonvegetarians, but are forced to subsist on vegetarian food due to the unavailability or high cost of nonvegetarian foods

Table 4 Intake and excretion of some food factors in different categories of urban stone formers (means ± SD)

Category	No. of subjects	Intake (24 h)			Excretion (24 h)			CORI	Super saturation[a] (μg)
		Calcium (mg)	Oxalic acid (mg)	Protein (g)	Calcium (mg)	Oxalic acid (mg)	Uric acid (mg)		
Normocalciuric + normo-oxaluric	10	463.3 ± 67.1	173.0 ± 54.8	46.3 ± 5.8	137.1 ± 56.3	37.1 ± 21.2	288.0 ± 133.8	− 1.912 ± 0.380	406.0 ± 152.2
Normocalciuric	17	451.3 ± 89.4	161.3 ± 50.3	47.2 ± 6.6	165.6 ± 49.3	48.5 ± 21.2	370.1 ± 318.8	− 1.670 ± 0.432	409.6 ± 148.9
Normo-oxaluric	13	464.1 ± 63.9	155.4 ± 42.3	46.8 ± 6.0	175.6 ± 89.2	45.4 ± 10.8	395.3 ± 273.9	− 1.877 ± 0.369	420.2 ± 137.4
Hypercalciuric	5	490.8 ± 62.3	156.5 ± 20.0	50.3 ± 5.5	275.3 ± 48.6	57.2 ± 15.1	601.9 ± 328.2	− 1.639 ± 0.322	616.8 ± 210.0
Hyperoxaluric	9	465.2 ± 111.9	167.2 ± 53.5	49.5 ± 7.0	212.0 ± 58.3	57.9 ± 15.9	462.5 ± 421.3	− 1.371 ± 0.227*	509.6 ± 231.1
Hypercalciuric + hyperoxaluric	2	533.5 ± 30.4	161.3 ± 26.6	42.5 ± 4.4	232 ± 25.2	60.6 ± 6.3	501.4 ± 362.9	− 1.461 ± 0.169	839.5 ± 58.2

* Significantly higher than in normal subjects
[a] Represented by amount of calcium deposited on glass fiber

Table 5 Intake and excretion of some food factors in different categories of rural nontribal stone formers (means ± SD)

Category	No. of subjects	Intake (24 h)			Excretion (24 h)			CORI	Super saturation[a] (μg)
		Calcium (mg)	Oxalic acid (mg)	Protein (g)	Calcium (mg)	Oxalic acid (mg)	Uric acid (mg)		
Normocalciuric + normo-oxaluric	12	442.3 ± 33.3	143.4 ± 93.9	36.5 ± 8.2	112.9 ± 48.7	20.1 ± 10.8	392.0 ± 222.3	− 1.927 ± 0.226	370.8 ± 102.8
Normocalciuric	19	427.4 ± 100.6	154.4 ± 85.3	35.6 ± 9.0	170.9 ± 45.5	38.6 ± 20.1	349.6 ± 97.8	− 1.884 ± 0.312	389.3 ± 119.6
Normo-oxaluric	14	436.4 ± 119.3	158.9 ± 85.9	34.0 ± 7.7	168.7 ± 88.3	30.3 ± 10.4	437.7 ± 234.2	− 1.913 ± 0.251	465.5 ± 177.4
Hypercalciuric	6	444.1 ± 32.6	141.4 ± 37.7	42.0 ± 11.6	218.5 ± 61.5	44.9 ± 12.0	647.8 ± 229.9	− 1.717 ± 0.260	774.3 ± 88.4
Hyperoxaluric	11	425.3 ± 63.2	141.1 ± 63.7	41.0 ± 11.7	199.6 ± 88.7	52.6 ± 9.4	400.2 ± 255.4	− 1.756 ± 0.356	547.6 ± 21.7
Hypercalciuric + hyperoxaluric	4	435.8 ± 115.6	141.8 ± 45.0	46.2 ± 12.2	261 ± 67.8	49.4 ± 3.1	633.0 ± 271.8	− 1.658 ± 0.156	705.3 ± 133.6

[a] Represented by amount of calcium (μg) deposited on glass fiber

Table 6 Intake and excretion of some food factors in different categories of rural tribal stone formers (means ± SD)

Category	No. of subjects	Intake (24 h)			Excretion (24 h)			CORI	Super saturation[a] (μg)
		Calcium (mg)	Oxalic acid (mg)	Protein (g)	Calcium (mg)	Oxalic acid (mg)	Uric acid (mg)		
Normocalciuric + normo-oxaluric	13	407.0 ± 77.0	130.3 ± 44.3	26.3 ± 4.9	103.0 ± 40.0	24.1 ± 10.2	283.0 ± 154.0	− 1.939 ± 0.511	406.0 ± 180.0
Normocalciuric	20	445.0 ± 78.0	144.0 ± 32.2	28.0 ± 4.9	164.0 ± 37.0	39.8 ± 21.5	317.0 ± 139.0	− 1.736 ± 0.527	454.0 ± 113.0
Normo-oxaluric	13	444.0 ± 80.0	138.3 ± 33.0	28.3 ± 4.0	154.0 ± 40.0	27.6 ± 10.3	297.0 ± 184.0	− 1.980 ± 0.541	400.0 ± 189.0
Hypercalciuric	2	505.0 ± 79.0	153.5 ± 21.9	35.4 ± 7.4	294.0 ± 17.0	78.3 ± 36.9	384.0 ± 74.0	− 0.812 ± 1.059*	838.0 ± 209.0
Hyperoxaluric	9	458.0 ± 74.0	152.2 ± 26.6	31.6 ± 6.4	194.0 ± 79.0	62.2 ± 21.3	354.0 ± 104.0	− 1.636 ± 0.444*	57.0 ± 215.0
Hypercalciuric + hyperoxaluric	2	505.0 ± 79.0	153.5 ± 21.9	35.4 ± 7.4	294.0 ± 17.0	78.3 ± 36.9	384.0 ± 74.0	− 0.812 ± 1.059*	838.0 ± 209.0

* Significantly higher than in normal subjects
[a] Represented by amount of calcium deposited on glass fiber

including milk. The RNT group are only marginally better placed and their diet too reflects the same constraints. Even in the UR group, who are best placed and have the best health awareness, nutrient intake is poor. Thus the present data further confirm the observations of our previous surveys [7, 29, 41].

The intake of total protein including animal protein is very low in this region compared to that of the populations of affluent countries [8, 9, 17, 20, 26, 34, 45]. The low consumption of animal proteins is partly due to the influence of the Jain region, which completely forbids the consumption of nonvegetarian foods. Ca intake is also lower than in western subjects [8, 9], but almost comparable to that of the Japanese population [17]. Total fiber intake is comparable [8, 18]. The intake of fiber could be highly variable depending upon the type of diet. For example, Breslau et al. [4] reported it to be 63 ± 3, 54 ± 3 and 13 ± 2 g/day for vegetarian, ovo-vegetarian and animal diets, respectively. The OA intake is slightly higher than in some reports [20] but comparable to others [32, 37]. It would be pertinent to point out that an oral questionnaire about dietary habits carried out simultaneously revealed that the frequency of consumption of OA-rich vegetables, especially spinach, amaranth, chenopodium and portulaca, is still relatively high due to their easy availability at cheaper cost, substantiating our observations reported 2 decades ago [35].

In a recent door to door survey for SFs covering 38 805 subjects, we observed a prevalence of 136, 274 and 924/100 000 population in RT, RNT and UR populations, respectively [41]. Interestingly, the present study indicates that intake of dense nutrients is also of the same order, giving a false impression that the differences in diet could be associated with the rise in the prevalence of the disease, because this does not appear to be applicable in this population. The diet clearly reflects an inadequacy rather than an excess of proteins and calcium. This is in contrast to the western population, where the excess of these nutrients is considered to be mainly responsible for an alarmingly high prevalence, which often exceeds 5000/100 000 population [21, 42].

No difference is visible in the nutrient intake of NSs and SFs, but differences are conspicuous in urine chemistry. SFs excreted significantly higher quantities of OA and Ca. Ca and Mg excretion was significantly lower or tended to be lower. Hyperoxaluria is an important etiologic factor in this population [27, 29, 30, 32, 39]. Hypomagnesuria and hypocitraturia have also been observed in earlier series [10, 27, 29, 41].

The possible association between nutrient intake and urinary metabolites was examined using the chi-square test. No association between dietary proteins, carbohydrates, fats, Ca, OA, Na and fiber with urinary stone risk factors was noticeable. It can, therefore, be deduced that none of the nutrients at this low level of intake influenced the urinary parameters.

Calcium oxalate risk index (CORI) has been found to be a good predictor of stone risk [1, 40]. In this series it tended to be generally higher in SFs than NSs in all the three subsets of the population. The urinary saturation was significantly higher in all SF groups than in the corresponding controls. It was still higher in hypercalciuric and hyperoxaluric patients. All the observations taken together give an inkling that there are factors other than those examined here which largely determine the propensity for urinary crystallization.

Since oxaluria and calciuria are the two most commonly prevalent risk factors in this population, the stone formers were subdivided into six groups, viz., NC, NO, HC, HONC + NO and HC + HO. CORI was still higher in patients with overt risk factors but did not attain a significant level in all instances, probably due to the smaller number of patients in each category.

In conclusion, the data clearly indicate that nutrition is poor in this population, that there is no difference in the intake of examined nutrients between the NSs and SFs, that SFs excrete urine in which there is a greater likelihood of stone formation, and that the etiopathogenesis of urinary calculus generally takes place sometime after enteric absorption.

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