Urological Research 7, 157-160 (1979)

Urological Research

Stone Incidence as Related to Water Hardness in Different Geographical Regions of the United States*

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Accepted: August 31, 1978

Summary. A survey of 1974 discharge data from United States hospitals shows an apparent increase in urolithiasis. A negative correlation has been found between the geographical distribution of the relative frequency of hospital discharges, a diagnosis of urolithiasis, and reported water hardness.

Key words: Urolithiasis, water hardness, calcium, magnesium, geographical distribution.

A persistent and yet unresolved question surrounds whether water "hardness", which is essentially due to magnesium and calcium in water, might be a significant factor in urinary stone formation. The object of this brief review is to show trends concerning this subject by means of past and current survey data.

Worldwide, those areas of established high incidence of stone disease, such as India and Thailand, have been noted to be regions devoid of calcium rich soil (1). Such soil orders typically give rise to "soft" surface waters and thereby reduce, to some extent, the average daily calcium intake by individual consumers of surface waters. Several recent reports have focussed attention on the potential existence of a negative relation between calcium intake and the incidence of urinary stone disease (1, 3, 11). Laboratory tests on animals have further demonstrated that a high intake of calcium can be effective in preventing formation of calcium phosphate stones (7). Also, dietary magnesium supplementation is an accepted clinical mode of prophylaxis for calcium oxalate stones (6). From these remarks, a correlation between calcium and magnesium ingestion and stone disease would appear to exist. Thus, it seems reasonable to pursue the study of a relationship between water hardness and stone disease.

A principal question in any such study is whether or not the daily ingestion of calcium and magnesium in drinking water can significantly alter the progress of stone disease. On this point, little information is available to assist the investigator in establishing a quantifiable answer. Some data, which can be used as an inverse correlative measure, are based on a survey by the U. S. Department of Agriculture, and indicate that there is little geographic variation in the small percentage of households that meet the U. S. recommended daily allowances (RDA) for calcium obtained from dairy products and other foodstuffs (4). This would suggest, therefore, that the major source of geographical variation of calcium intake could be provided by variations in individual water consumption. The current U. S. RDA for calcium is 800 mg (8). Assuming a daily water intake of 2 liters, one can calculate that as much as 330 mg, or 41% of the calcium RDA can be obtained by drinking very hard water. In addition, on the basis of data to be presented, 2 liters of very hard water will supply 106 mg of magnesium, which is more than 60% of a recommended dietary magnesium supplement therapy for preventing calcium oxalate stones (6).

MATERIAL AND METHODS

Data displayed graphically in this survey of stone incidence in the U. S. are based on 1952 data reported

* This work has been supported by National Institutes of Health grant number 1-P50-AM-20586-01

0300-5623/79/0007/0157/$01.00

1952 SURVEY

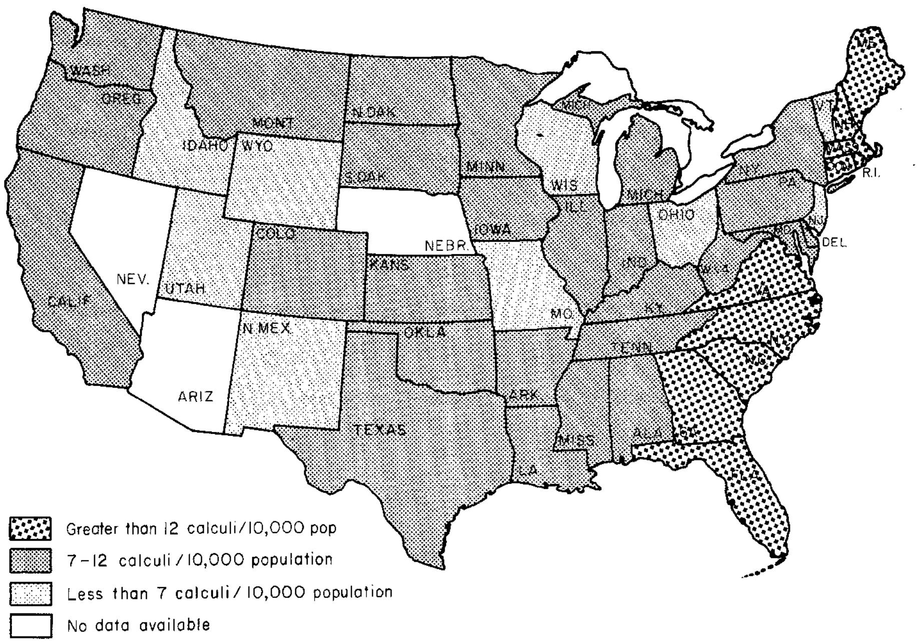

Fig. 1. Geographical representation of the results of the hospital discharge survey by Boyce, Garvey, and Strawcutter (2)

by Boyce, et al. (2) and 1974 data reported by Sierakowski, et al. (10). In these two surveys, data had been collected on the incidence of hospital discharges of adult calculus patients and on the estimated annual average incidence of urinary calculi in adults relative to the population. This information was generated in the 1952 survey, from 537 responses to a questionnaire sent to 4000 registered general hospitals in the United States and in 1974, from 1765 responses from a total 6500 mailings to hospitals. For both surveys, data based on census figures from U.S. Government decade collections (1950 and 1970, respectively) were used for the population centers surveyed and the participating hospitals. The results were then analysed using standard statistical methods. Geographical maps showing incidence of stones per 10,000 population were developed by dividing stone incidence into three categories (see Figs. 1 and 2).

For the water hardness data presented herein, information on the average hardness of water from community systems was obtained from the 1963 Water Atlas of the United States (12) and the 1962 U.S. Geological Survey (5) (see Fig. 3).

RESULTS

Results of comparing the 1974 study (Fig. 2) with the 1952 study (Fig. 1) show that the two studies are not highly correlated, r = 0.56. An interesting aspect is an apparent increase in the calculated occurrence of stone formation per 100 population in the U.S. (from 9.4 in 1952 to 16.4 in 1974). The difference in the means is statistically significant ($P < 0.01$), and the average increase by state was 75%, with only two states showing a decline in stone formation. The reason for this general increase is not clear. A correlation analysis considering population, available physicians, hospital beds, and combinations of these factors failed to show significant relationships with apparent stone frequency (10).

Two outstandingly common features were prevalent in both hospital discharge surveys. These are the high rate of stone disease in the population of the Carolinas and the increased rate in all of the Southeastern United States, the area that has the softest water.

A correlation analysis of the 1952 hospital discharge data and water hardness data relevant to that period yielded a correlation coefficient of -0.78 for the relation between the average relative rate of hospital discharges for urolithiasis in a state and the average tabulated water hardness (9). The large negative correlation coefficient was totally unexpected.

DISCUSSION

Many inadequacies exist in the survey data we collected and interpreted to establish the trends

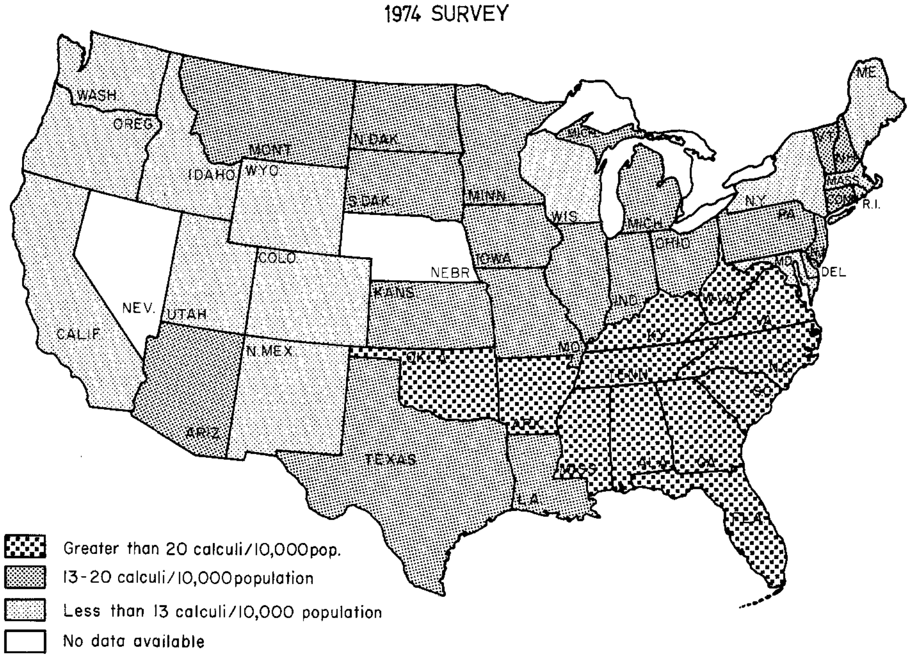

Fig. 2. Geographical representation of the results of the hospital discharge survey by Sierakowski et al. (10). Note that the category boundaries in this figure differ from those in Figure 1

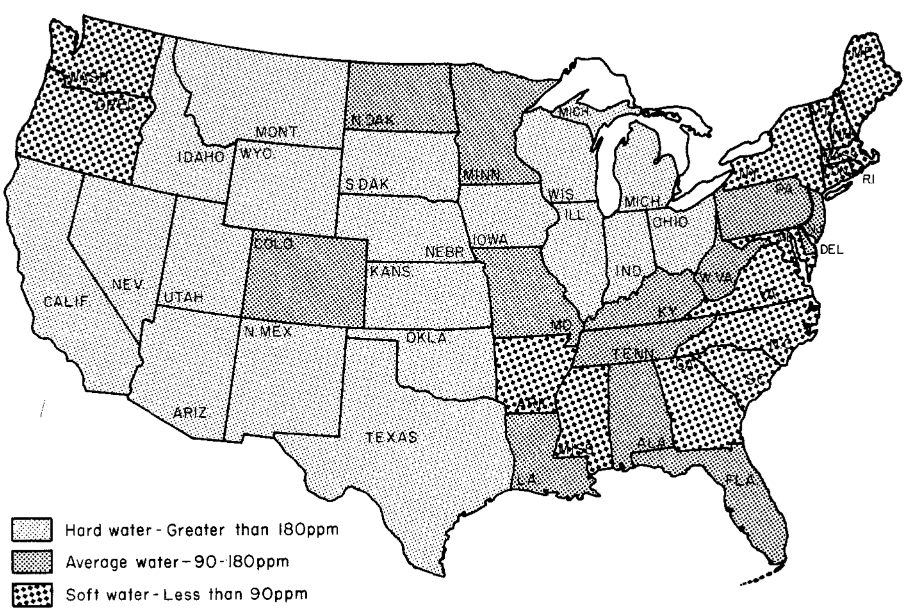

Fig. 3. Geographical representation of finished water hardness in the United States

shown in the preceding sections. Among these indadequacies are the following: 1) the frequency of hospital admissions for stones depends partially on local clinical customs; 2) the failure of approximately two-thirds of the hospitals asked to respond to the more recent survey may have introduced an undetected bias into the data; 3) the water quality data were from water atlas tables ~10 years older than their publication date, were regional, and omitted from consideration the water actually ingested by the consumer; 4) secondary sources of liquid other than water may have been consumed in quantities sufficient to be significantly important in stone formation; 5) processing variables introduced by filtration procedures between original water source and consumer may be significant (e.g., water softeners); and 6) a high geographical resolution by regions should be established to interpret correlations between stone incidence and water quality.

To remove some of these deficiencies, we are currently conducting a regionally intensive study, focussing on the states with the highest and the lowest incidences of stone disease in their population. A preselected group of subjects, consisting of 1200 stone-forming patients and 1200 non-stone-forming subjects, has been drawn from participating regional hospitals. These participants are cooperating by supplying necessary clinical data about the subjects' dietary habits, and by furnishing samples of the principal liquids that they ingest daily. In each case, water is always one of the principal liquid sources collected; and this information, when encoded and processed, should provide a more complete correlative measure of stone intensity and its relationship to water hardness.

REFERENCES

1. Anderson, D. A.: Historical and geographic differences in the pattern of incidence of urinary stones considered in relation to possible etiological factors. In: Proceedings of the Renal Stone Symposium, Leeds, England. Hodgkinson, A., Nordin, B. E. C., (eds.), pp. 7-31. London: J. & A. Churchill Ltd. 1968
2. Boyce, W. H., Garvey, F. K., Strawcutter, H. E.: Incidence of urinary calculi among patients in general hospitals, 1948 to 1952. Journal of the American Medical Association 161, 1437 (1956)
3. Chulkeratoma, S., Van Reen, R., Valyasevi, A.: Studies of bladder stone disease in Thailand. XV. Factors affecting the solubility of calcium oxalate. Investigative Urology 9, 246 (1971)
4. Dietary levels of households in the South. Washington, D. C., U. S. Department of Agriculture, Report No. 6, p. 11. Spring 1965
5. Dufor, C. N., Becker, E.: U. S. Geological Survey Water Supply Paper No. 1812, p. 87, 1962
6. Gershoff, S. N., Prien, E. L.: Effect of daily MgO and vitamin B_6 administration to patients with recurring calcium oxalate kidney stones. American Journal of Clinical Nutrition 20, 393 (1967)
7. Gill, W. B., Finlayson, B., Vermeulen, C. W.: Prevention of urinary calculi in rats by adding calcium to diet. Journal of Urology 82, 256 (1959)
8. Recommended Daily Allowances (8th revised edition). National Academy of Sciences, National Research Council Publication No. 2216, Washington, D. C. (1974)
9. Sierakowski, R., Hemp, G., Finlayson, B.: Water hardness and the incidence of urinary calculi. In: Colloquium on Renal Lithiasis. Finlayson, B., Thomas, W. C. (eds.), pp. 213-221. Gainesville: University of Florida Press 1976
10. Sierakowski, R. L., Finlayson, B., Landes, R. R., Finlayson, C. D., Sierakowski, N. A.: The frequency of urolithiasis in hospital discharge diagnoses in the U. S. Investigative Urology 15, 438 (1978)
11. Singh, P. P., Kothari, L. K., Sharma, D. C., Saxena, S. N.: Nutritional value of foods in relation to oxalic acid content. American Journal of Clinical Nutrition 25, 1147 (1972)
12. Water Atlas of the United States (2nd edition), Port Washington, New York: Water Information Center, Inc. 1963

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