

Urolithiasis in railroad shopmen in relation to oxalic acid exposure at work

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LAERUM E, AARSETH S. Urolithiasis in railroad shopmen in relation to oxalic acid exposure at work. *Scand J Work Environ Health* 11 (1985) 97–100. It is well known that the urinary excretion of oxalic acid is one of the main determinants for urinary stone formation. From 1950 to 1978 a saturated oxalic acid solution was used in a repainting and cleaning process for railroad cars in Norwegian railroad workshops. With the use of a questionnaire, the cumulative prevalence of urolithiasis-induced colic episodes was registered in the Sundland railroad depot. Forty-two (11.9 %) out of 353 male workers not exposed to oxalic acid reported having had one or more such stone colic episodes. The corresponding figure for 15 individuals who had a very high exposure to oxalic acid was 8 (53.3 %). Also workers in other departments, occasionally exposed to oxalic acid, had an increased stone colic prevalence rate, a finding suggesting a positive dose-response relationship. There was an increased frequency of stone colic episodes in the age group 40–69 years. Seven heavily exposed workers in the paint shop reported initial pollakiuria and slight dysuria during the exposure. The study indicates a causal relation between urinary stone formation in the investigated railroad shopmen and their exposure to oxalic acid at work.

Key terms: cleaning process, dose-response relationship, questionnaire, urinary stone colic.

A substantial increase in the frequency of stones in the upper urinary tract has been shown in several epidemiologic studies in the industrialized world during this century (5).

Urolithiasis is more common in occupational groups with low physical activity or in those exposed to high temperature and increased fluid loss (3, 7). In a Czechoslovakian survey urinary calculi had a high incidence in teachers, health workers, and railroadmen (6).

From studies on the pathogenesis of urinary stone disease it is well known that the urinary excretion of oxalic acid is one of the main determinants for stone formation (9). It is therefore interesting that over a period of several years a saturated oxalic acid solution was used in a repainting and cleaning process used on railroad cars in Norwegian railroad workshops. Those employed in the occupational health service noticed that, in one such workshop, a high proportion of the workers exposed to oxalic acid suffered from urinary calculi.

The aim of the present investigation was to study the association between the cumulative prevalence of urolithiasis and oxalic acid exposure in shopmen working at the Sundland railroad depot.

Materials and methods

The Sundland railroad workshop is situated in Drammen, a medium-sized town in central Norway. It consists of the following five sections: the wagon, machine, and welding departments and the diesel engine repair shop and the locomotive depot.

Altogether 409 persons (excluding clerical staff) were working in these five areas in 1981. One hundred and forty workers were employed in the wagon department, and, of these, 25 persons were responsible for the painting and outside cleaning of the cars (called the paint shop).

Exposure to oxalic acid

From 1950 to the end of 1977 a saturated solution of oxalic acid (approximately 4–5 kg of crystalline oxalic acid per 10 l of boiling water) was used in the paint shop for the outside cleaning of metal carriages. Abundant amounts of this solution were applied with brushes and subsequently washed off with boiling water. During this procedure steam containing oxalic acid was formed and inhaled by the workers. The exposure to this steam lasted about 2–3 h/d.

In addition a saturated oxalic acid solution was used by the same workers in the outside painting work of the wooden (teak) cars. After the old varnish was removed, the wood was bleached with oxalic acid. When the wood had completely dried, the crystalline oxalic acid was removed with wire brushes. Dust containing oxalic acid crystals was formed during this process. The duration of this additional exposure to oxalic acid was estimated, on the average, to be 1 h daily.

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Table 1. Cumulative prevalence rate of urinary stone colic episodes related to periods with concomitant oxalic acid exposure, and its degree, at work.

Exposure to oxalic acid	Number of cases with stone colic	Population (N)	Prevalence rate ^a (%)
High exposure 3—4 h a day (paint shop)	8	15	53.3*
Low-moderate exposure 1—8 h a week (not in the paint shop)	8	25	32.0**
No exposure	42	353	11.9
Total	58	393	14.8

^a Differences between the groups were statistically significant, * $p = 0.05$, ** $p < 0.001$ (Fisher-Irwing's exact test).

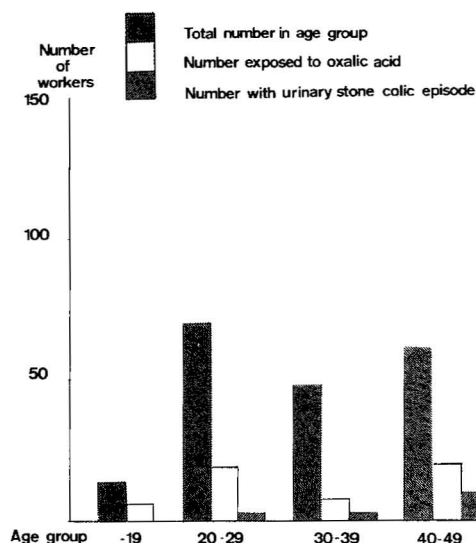


Figure 1. Age distribution of the studied workers.

Leather gloves were used by the workers when applying the oxalic acid solution. These did not, however, prevent the skin from getting soaking wet throughout the whole procedure. Fifteen out of the 25 workers in the paint shop were exposed to oxalic acid as described.

Workers not involved in the work of the paint shop used oxalic acid only occasionally as a solvent. This amount of exposure could last from 1 to 8 h/week.

Oxalic acid was no longer used after 1977, mainly because all the wooden cars were replaced by metal ones. Since then tartaric acid, along with "Master cleaner," which contains 1 % oxalic acid, has been used.

Registration of cases with urolithiasis

The registration took place during 1981. A medical questionnaire with a detailed description of urolithiasis-induced colic and how it could be diagnosed was distributed by the foremen to all 409 of the workers, who were asked to give detailed information about the number and dates of all (lifetime) definite episodes of urinary stone colic (ie, those verified by a physician). If there was any doubt about the diagnosis, the individual was called in by the medical of-

ficer for further questioning. Cases that were still doubtful after this questioning were not included.

Seven workers involved in the painting and cleaning of the cars from 1950 to 1977 were asked, by personal interview, if they (or others) had noticed specific symptoms from the respiratory or urinary tract during the exposure to steam or dust containing oxalic acid.

Results

Three hundred and ninety-three (96 %) of the 409 workers (all males) returned the questionnaire. Forty-two (11.9 %) out of 353 workers not exposed to oxalic acid reported having had one or more episodes of verified urinary stone colic. Eleven of them (3.1 %) had experienced such colic during 1981. The corresponding figures for 15 individuals heavily exposed to oxalic acid in the paint shop were 8 (53.3 %) and 4 (26.7 %), respectively. The difference between the workers in the paint shop and the group not exposed to oxalic acid is highly significant statistically ($p < 10^{-5}$, Fisher's exact test).

Table 1 shows the prevalence rate of workers with urinary stone colic episodes related to the degree of

exposure to oxalic acid. There is a marked increase in this prevalence rate with increasing exposure to oxalic acid.

The median duration of the exposure to oxalic acid in the total group was 7.5 years at the time of the investigation, with a range of 1–28 years. This duration was similar for the paint shop group. Ninety-four percent of all stone colic episodes were experienced during a period of concomitant oxalic acid exposure.

The age distribution is shown in figure 1. There was a relative increase in the frequency of stone colic episodes in the age group 40–69 years.

Only four individuals in the total group had experienced colic episodes during 15 years before 1950, when oxalic acid was introduced in the workshop. Twenty-one workers quit their job during the period 1950–1977. It is not known that any of them had had urolithiasis. Fifty-one individuals entered the cohort during the same period, without there being any significant alteration in the stone colic prevalence rate.

A familial occurrence of stone colic episodes was reported for 4 (16.0 %) of the 15 workers exposed to oxalic acid in the "paint group" and for 31 (8.8 %) of the 353 other individuals. Of these, all 4 in the former and 10 in the latter group had had urolithiasis-induced colic.

A selected group of seven persons from the paint shop, who had had the most severe, and long lasting, exposure to oxalic acid, reported that they constantly experienced pharyngeal irritation and coughing when inhaling the steam containing oxalic acid. They also spontaneously reported a troublesome pollakiuria and slight dysuria, which regularly occurred during the first 20–30 min of exposure. Curiously, two of the men had also experienced the same urinary symptoms after eating rhubarb, which is known to have a high content of oxalic acid.

Discussion

When a questionnaire study is performed, it is essential that a sufficient number of recipients cooperate. In the present study only 4 % of the workers did not return the form, which is a low figure.

A methodological problem with this study was how to work out a way of measuring the degree of exposure to oxalic acid. As the exposure could vary considerably from time to time for the individual workers, the decision was made simply to ask how many hours daily or weekly there had been regular exposure. However, the exposure to oxalic acid was very high in the paint shop, as compared to all known every day or occupational situations (2), and much higher than in the other departments.

Another methodological problem was whether to use an anamnestic reported episode of stone colic as a reliable indicator of urinary stone disease. It is

known that other conditions, such as intestinal colic, pyelonephritis, and back pain, can be misinterpreted as urolithiasis (3). The reliability of reported stone episodes that occurred perhaps some 20 years ago must also be questioned.

From a recent study performed on general-practice patients with recurrent urolithiasis, all of whom live in the same county in Norway, it was found that the patients had had a total median number of six colic episodes. The median number of urinary stones formed was 5.2, indicating thus that every stone, on the average, provokes one colic episode (3, 4). There seems to be no apparent reason why a similar relationship should not exist for the present urolithiasis patients. In the same study (3) almost 80 % of all the stone colic episodes, recorded by 11 local practitioners, were classified as verified, i.e., confirmed by radiography, surgery, or stone passage. The urolithiasis diagnosis was made by a physician in the present study, and therefore the diagnosis should probably not have a significantly lower precision.

Twelve percent of the workers not exposed to oxalic acid had experienced urinary stone colic on one or more occasions. This figure is in accordance with the findings from several other studies from Scandinavian countries, reporting a cumulative prevalence between 10 and 15 % for middle-aged men (5).

The stone colic prevalence rate of 53 % in the group with high oxalic acid exposure in the paint shop was considerably higher than expected. The same applies to the incidence rate of 26.7 % in 1981. Only two cases per year per 1 000 inhabitants were observed in the quoted study from the same county in Norway.

This considerably increased frequency of urinary calculous disease among the workers in the paint shop cannot be explained by the presence of positive heredity (see the Results section). Other risk factors, such as increased fluid loss/low fluid intake, low physical activity, increased intake of animal protein or any other nutritional factor (7, 8), are also not likely to be more prominent among the present workers, even if this possibility has not been investigated.

The workers also had an increased frequency of stone colic episodes during 1981, when the use of oxalic acid had been withdrawn. This occurrence may be explained by previously formed concretions, which continue to induce colic, or by the fact that previously formed microcalculi served as nuclei for further stone formation. There seems to be no obvious evidence that all these workers should consist of a selected group with a stronger tendency towards stone formation as compared to the unexposed group.

In the light of the preceding considerations the exposure to oxalic acid appears to be the most probable explanation for the increased incidence of urolithiasis in the exposed workers.

The positive dose-response relationship between oxalic acid exposure and the stone colic prevalence rate (see table 1) also suggests a causal association.

It is known that oxalic acid is a fat-soluble substance and consequently appears to be permeable through most biological membranes (2). It is therefore possible that oxalic acid might have been absorbed via the respiratory tract and lungs, as well as through the skin, in the present workers. To the best of our knowledge no such study has been published so far.

A linkage between oxalic acid exposure and urinary stone formation is also confirmed by the fact that, in general, 60–80 % of all analyzed urinary concrements are composed of calcium oxalate alone or in combination with calcium phosphate (1).

In conclusion, this study indicates a causal association between occupational oxalic acid exposure and the prevalence of urolithiasis in railroad workshop employees.

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