Exposure to benzene among Workers in a Petroleum Transport Company

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Abstract: Exposure to Benzene among Workers in a Petroleum Transport Company: I. Figà-Talamanca, et al. Dip.to Biologia Animale e dell’Uomo, Università di Roma “La Sapienza”—The paper reports on the environmental and biological monitoring of a group of 25 male petroleum transport workers. Environmental benzene exposure was monitored through personal sampling devices during one eight hour shift. Biological monitoring involved measurement of benzene and its metabolite trans, trans muconic acid in the urine at the beginning and at the end of the shift on a Monday and again on a Friday. The mean air concentration of benzene detected in the breathing zone of workers exceeded the threshold limit values (TLV) of the American Conference of Governmental Industrial Hygienist (ACGIH) (TLV=1.6 mg/m³) for workers supervising the loading operations of autocisterns. The values observed among the drivers of multiple autocisterns were just below the TLV, whereas those of the drivers of single cisterns were definitely below the TLV. The biological monitoring revealed that the excretion of benzene increases as exposure increases during the work shift, and reaches the highest concentrations at the end of the work week. The excessive exposure of loading supervisors and drivers of multiple cisterns was also confirmed by the findings of the biological monitoring.

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Exposure to benzene in the work setting has been regulated by a special law in Italy since 1963, but there still remain some work settings where the environmental concentration of benzene is not sufficiently monitored.

This is particularly true of open air work as is the case of petroleum transport companies. Workers here are involved in loading and unloading of autocisterns and in transporting them to retail gas stations. The degree to which these operations expose workers to benzene fumes has not been evaluated previously. The objective of the present study was to monitor the exposure to benzene among the workers in a petroleum transport company, by measuring the air concentration of benzene in the breathing zone of workers and by determining the degree of absorption through the concentration of benzene and of its metabolites in their urine.

Materials and Methods

The study focused on twenty-five male workers of a large petroleum transport company aged between 25 and 50 yr of age. All the men were in good health and had been working at the job for at least three years. All participants were smokers. In terms of their tasks, two of them were involved only in the loading operations on the site of the company, while all others worked as drivers of autocisterns. The company used two different types of autocisterns: those with a single container (eleven drivers) and those with multiple containers (twelve drivers). Each container holds a smaller amount of liquid and allows the transport of one product at a time (i.e. benzene super, benzene Pb-free, or diesel gas oil). Multiple containers are much more capacious, and are used to transport more than one product at a time. The drivers are responsible for all loading and unloading operations for both types of autocisterns, but the period during which they are in a place where they may be exposed to benzene fumes is much longer in the case of autocisterns with several containers.

Exposure to benzene was determined by sampling the air in the breathing zone of the worker, and by measuring the concentration of benzene and its metabolite trans-muconic acid in the urine samples provided by each worker. All determinations were made by gas...
chromatography (HRGC 5160 Mega series), with chemicals of analytical reagent grade. The quantitative determinations were derived from calibration curves (relative response of peak area versus mass of the compound) prepared from standard solutions.

The environmental benzene exposure was monitored through personal sampling devices (pumping 0.2 liters of air per min), attached near the breathing zone of each worker during one eight hour shift. The benzene concentration in the air was measured by gas chromatography after extraction with carbon disulfide from the activated charcoal in the vials in the personal sampler.

During the same period workers provided four samples of urine: one in the early morning before reaching the work site and one at the end of the work shift, on two separate days of the week (Monday and Friday). The urine samples were immediately frozen and later used for the determination of benzene and its metabolites.

After preparation of a standard, the benzene concentration in the urine was determined by thermal desorption (70 °C for 1 h) after the addition of 20 gr of sodium sulfate for each 50 ml of urine.

Among the possible metabolites of benzene found in the urine, we decided to measure trans-trans muconic acid, because of its specificity and reliability. The urine samples were purified and the biomarker was determined by the HPLC method, equipped with a Shimadzu /Lc-9a pump (1 ml/min) and an Aypersil ODS 250 × 4.6 mm column maintained at 40°C, with a UV (Gibson) spectrophotometer (wavelength 259 nm).

**Results**

The mean values, SD and range of air benzene concentrations (in mg/m³) detected in the breathing zone of workers divided according to their job are shown in Table 1. Not all values were below the 1.6 mg/m³ threshold limit value of the ACGIH. It appears that exposure was higher among the two workers whose job was to supervise loading operations on the site of the company, and were therefore continuously present during these operations. The concentration in the breathing zone of the drivers of multiple autocisterns was just below the TLV-TWA of the ACGIH.

Table 2 shows the results of the mean urine benzene determinations (µg/l) in the three groups of workers in the four different samples collected: Before starting work on a Monday, and at the end of the work shift on Monday. Before starting work on Friday and at the end of the shift on Friday. The concentration of benzene increases during the day on the first day of the week for all three groups. The increase is more marked among the drivers of multiple cisterns and in the two men supervising the loading. On Friday morning all workers had accumulated higher concentrations of benzene in their urine. At the end of the day the concentrations increased further reaching 48.4 µg/l among loading supervisors, and 46.2 µg/l among drivers of multiple cisterns. We note again that these two groups are the most exposed. Clearly these results suggest that benzene accumulates in the body of these workers during the working week.

The trans-trans muconic acid concentrations in the urine samples were determined only at the end of the working week, because concentrations in the other samples were below the detectable levels. Exceptions to this were four drivers of multiple cisterns who showed the presence of metabolites in all urine samples. The levels observed at the end of the week (Table 2) confirm the previous observations. By Friday afternoon,
all workers excreted the metabolite, but the levels were higher among the two groups with higher exposures: The loading supervisors and the drivers of multiple cisterns.

Discussion

It is possible to monitor exposure to benzene by measuring benzene in expired air, in the blood and urine, and by dosing its metabolites in the urine. The expired air concentration reflects recent exposure, whereas urine concentration of metabolites at the end of an eight hour shift indicates exposure during the shift. Most metabolites are eliminated within 48 h of exposure; workers in fact have low levels of exposure on Monday morning and these values increase during the workshift and during the following days.

The blood benzene concentration has been ascertained in occupationally exposed individuals but also among non exposed controls, and has been found to increase significantly among smokers even in the control group3).

The biological indicators used to monitor benzene exposure are metabolites such as phenol, S-Phenylmercapturic acid, and trans, trans-muconic acid. The biologic exposure limit (BEI) of phenol suggested by the ACGIH until 1996 was 50 mg/gr creatinine in the urine at the end of the shift. In the new 1997 limits, the biologic indicator was changed to S-phenylmercapturic acid with a BEI of 0.025 mg/gr. creatinine. The corresponding concentration of trans, trans-muconic acid in the urine is 1.6 mg/L. The levels of exposure considered safe for exposed workers have progressively declined, as the toxicity and carcinogenicity of benzene have been demonstrated. In 1997 the ACGIH reduced the ambient TLV-TWA from 32 mg/m³, to the present 1.6 mg/m³. At the same time benzene was moved from the ACGIH list of suspected cancerogens (A2), to the list of confirmed human cancerogens (A1)4).

The objective of our study was to monitor the degree of exposure to benzene of a group of workers through the evaluation of benzene in the work ambient air as well as in their organism.

For the latter we evaluated the unmetabolized benzene excreted in the urine and the metabolite trans, trans-muconic acid. Both of these indicators have been shown to be sensitive even in situations of low exposure (2).

The results of the concentration of benzene in the breathing zone of the workers showed that the exposure does exceed the TLV-TWA for at least some individuals. In addition, the range of values observed suggest that the peak values exceed the 1.6 mg/m³ mark.

The benzene values in the urine observed cannot be compared with an established “standard”, as this is not available, but the values recorded for one week are very informative. They reveal a consistent pattern of increasing concentrations from the beginning to the end of the shift, and from the beginning to the end of the working week. The evaluation of the trans, trans-muconic acid further confirms this pattern. Whereas many workers excreted very low or undetectable quantities of the metabolite during the week, by the end of the week the values had increased, reflecting considerable exposure. Trans, trans-muconic acid in the urine is a specific indicator of benzene exposure, and its concentration among non exposed individuals in the general population, is near or below the detection level2). In fact, the values for trans, trans-muconic acid shown in Table 2 confirm that the exposure was much higher than the present TLV-TWA (1.6 mg/m³) and closer to the previous, and much higher TLV-TWA (32 mg/m³). According to the German Technical Exposure Limits (TRK), a concentration of trans, trans-muconic acid of more than 7 mg/l corresponds to more than 20 mg/m³ of benzene in the ambient air5).

The problem seems to be particularly evident in workers who supervise the loading and unloading operation, and among those who drive multiple autocisterns. Since all workers were smokers, it was not possible to explore the role of smoking in the concentration of benzene in the organism, but smoking is more likely to be a confounding factor in populations who are not professionally exposed to benzene (i.e. in the general population), where benzene concentrations in biological fluids is relatively low. The progressive increase in benzene in urine during the work exposure in our population, as well as the differences in the concentration according to the type of job performed, support the conclusion that this occupational group is exposed to benzene at levels which exceed acceptable limits.

References