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Evaluation of the contribution of smoking to total blood polonium-210 in Saudi population

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Abstract

A preliminary study of ^{210}Po concentrations in the blood of some smokers and nonsmokers is presented in order to evaluate the contribution of smoking to total blood ^{210}Po in Saudi population. Blood samples were collected from 30 volunteers and analyzed by high resolution α-spectrometry using a radiochemical technique. The technique is based on the separation of polonium from other components of the sample by wet ashing with an HNO_3/H_2O_2 oxidizing mixture and spontaneous deposition on a silver disc under the relevant conditions for α-particle counting. The results indicated that a significant fraction (about 30%) of blood ^{210}Po is related to smoking.

1. Introduction

Phosphate rocks contain 0.1–0.4 lb of uranium/ton of rock (UNSCEAR, 1988). Natural uranium can substitute for Ca in the phosphate rock structure, and over a period of time, accumulates in the phosphate reserves. Therefore, U and U long-lived decay products (^{226}Ra, ^{210}Pb and ^{210}Po) are present in fertilizers manufactured from phosphate rock (Shreve, 1967). High phosphate fertilizers are used for tobacco farming in industrial countries. Tobacco was found to concentrate ^{210}Po from the soil (Singh and Nilekani, 1976). This radiotoxic isotope is found in the soil and in the tobacco leaves and increases with the repeated application of phosphate fertilizer to the soil (Singh and Nilekani, 1976, Marmorstein, 1986). The higher the phosphate levels in the fertilizer used, the higher the concentration of ^{210}Pb and ^{210}Po in the tobacco leaves. Since the 1960 s investigators have reported (Kilthau, 1996) that ^{210}Po and ^{210}Pb are present in the gaseous and particulate phases of tobacco smoke and contribute to cancer risk due to their deposition in the lungs. The nuclides are absorbed into the blood and distributed to the different body organs, thus increasing the local radiation exposure. About 10% of the ^{210}Po of cigarettes was found in the main stream smoke filter and about 18% in the butt (Mussalo-Rauhamaa and Jaakkola, 1985). The released ^{210}Po is much more radiotoxic than the β-emitter ^{210}Pb, and the radiation dose to man has been widely studied because of the high incidence of lung cancer among smokers (Rajewsky and Stahlhofen, 1966; Martell, 1974; Marmorstein, 1986; Gairola et al., 1993). It has been

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suggested (Marmorstein, 1986) that ^{210}Po which emits α-radiation accounts for many, if not all, cigarette smoke-induced lung cancer. There are different environmental pathways to ^{210}Po intake by man. It has been reported (Kilthau, 1996; Marmorstein, 1986) that the content of other carcinogens in today's tobacco has been greatly reduced by changes in tobacco processing methods and modern cigarette filters, but have little effect on reducing radioactivity. In addition to smoking, other pathways for ^{210}Po intake may be through diet and/or ^{222}Rn gas inhalation which is naturally released from the ground and building materials into the atmosphere. It has been reported (Little and McGandy, 1966; Bulman et al., 1995) that a significant fraction of the isotope present in food is absorbed into the blood. It is time to renew the study and reporting of the radiation health hazards of tobacco smoking. This article presents a preliminary study, which forms the first ever report on the evaluation of the contribution of smoking to the total blood ^{210}Po in Saudi population.

2. Experimental

2.1. Volunteers

Blood samples (30 of 10 ml) were collected from volunteers who, after the aims and risk of the study had been fully explained, had given their full consent to the procedure. Of the total, 18 samples were from smokers and 12 samples were from non-smokers. All the individuals were males and their ages ranged from 18 to 50 years old and 4–20 years as smoking period. The smoking rate was roughly 10–30 cigarettes/day.

2.2. Methodology

Owing to the high volatility of polonium under dry ashing conditions, 10 ml of the blood sample were spiked with ^{208}Po tracer, and wet ashed with a 1:1 conc. HNO_3/30% H_2O_2 oxidizing mixture to destroy the organic material and release free polonium ions into solution (Shaheed et al., 1997). The solution was gently evaporated to near dryness and 5 ml of conc. HCl were added with continuous gentle heating and again evaporated to near dryness. The last step was repeated twice to ensure complete nitrate removal. The medium was diluted with 0.5 M HCl to about 100 ml. Ascorbic acid, 40 mg, was added as a reducing agent to prevent any inhibitory effect of ferric ions from the blood. The solution was placed in a modified plating cell and the polonium isotopes were allowed to deposit spontaneously on a silver disc by the method of Vittum et al. (1950) as modified by Holtzman (1960) for 4 h at 90–98°C with continuous stirring. The silver disc was removed carefully, rinsed with distilled water, dried and left for 2 h after plating to allow decay of short-lived polonium isotopes. The silver disc is then ready for counting using high resolution α-spectrometry.

2.3. Modified spontaneous plating cell

According to Radford et al. (1963), the cell was made from commercial baby feeding bottle with the bottom removed. A silver disc (2.5 cm diameter) rested on a Teflon base disc and was held in the screw top of the bottle by a Neoprene gasket. A plastic cover with a center hole for the stirrer was used to reduce evaporation from the inverted bottle.

2.4. Sample measurement

The samples were measured by using the 5.116 and 5.305 MeV alpha peaks of ^{208}Po and ^{210}Po, respectively. The samples were counted for a total elapsed time (48–72 h) adequate to get a minimum of 15–20 counts above the background for ^{210}Po. The chemical yield of ^{210}Po was determined by the material balance technique, using ^{208}Po as a radiotracer for high precision. The uncertainties given with the final results are standard deviations resulting from propagation of all random uncertainties incurred anywhere in the entire measurement process. Small sample size and very low counting rate resulted in comparatively higher uncertainty values. The lower limit of detection (LLD) of the α-spectrometry system was 0.5 pCi/l of blood based on 72 h counting time and 10 ml sample size. This is equivalent to about 15 counts above the counts of the blank sample. The chemical yield of spontaneous Po deposition was $84 \pm 9\%$. The detector efficiencies were ranged from 29.4 to 31.3%.

2.5. Apparatus

A Canberra model 7404 'QUAD ALPHA' α-spectrometry system was used. It consists of four 450 mm^2 silicon surface barrier detectors located in the same vacuum chamber (with partitions). The modified output of the four detectors was sent to the multichannel analyzer (2084 channel total memory). The MCA had an internal mixer/router so that the output of each detector was stored in 512 channels of the memory (one quadrant). A motor-driven single-stage mechanical vacuum pump provided adequate evacuation (10^{-2} mm Hg) of the vacuum chamber of the system.

3. Results and discussion

Results of ^{210}Po analysis in blood of both smokers

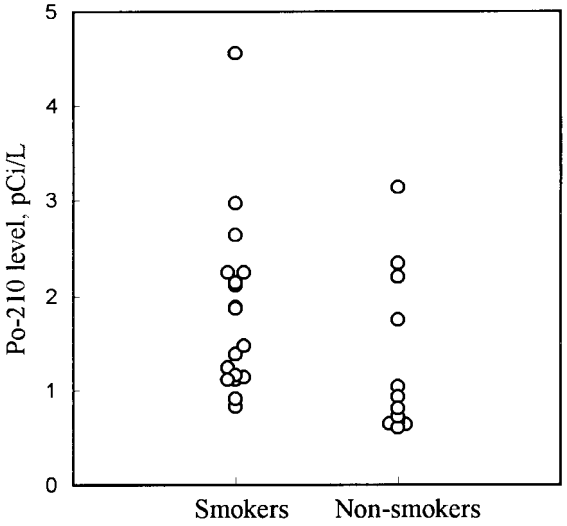

Fig. 1. Polonium-210 concentration measured in 10 ml blood samples from healthy volunteers.

and non-smoker groups are given in Fig. 1. Although most smoker samples show comparatively higher levels than those of non-smokers, some samples show reverse findings. In addition, a significant difference exists between the ^{210}Po concentration in the blood of each group. In addition to variation in smoking rate, this variation in concentration may in part result from dietary factors and radon gas exposure conditions.

The activity levels of ^{210}Po ranged from 0.91 to 4.56 pCi/l of blood in smokers with an average value of 1.83 ± 0.63 pCi/l. Non-smoker samples showed activity levels ranging from 0.61–3.14 pCi/l with an average value of 1.29 ± 0.61 pCi/l. From these average values for smokers compared to non-smokers, a significant fraction (about 30%) of the ^{210}Po in bloodstream appears to be related to smoking and the residual part is related to other environmental factors. Other studies (Little and McGandy, 1966; Henshaw et al., 1984) compared ^{210}Po levels in blood of smokers and non-smokers and concluded that 50–55% of blood ^{210}Po is related to smoking. Little and McGandy (1966) reported that the average ^{210}Po concentration in smokers was 1.72 pCi/kg of blood, compared to 0.76 pCi/kg in non-smokers. Considering the uncertainties given in the present study on the mean values for smokers and non-smokers, it may be concluded that the results would not statistically significantly differ from the above data reported by others, although they appear to have slight differences.

Generally, the results encourage a more comprehensive study to understand all possible local factors that may affect ^{210}Po intake in the Saudi population and lead to variations in ^{210}Po concentration in the blood of the different individuals. Many factors such as period and rate of smoking, type and origin of tobacco commonly used and ^{210}Po level in tobacco can be studied. In addition, dietary factors due to the available and commonly used foodstuffs consumed by each individual, including drinking water, must be considered.

4. Conclusion

This preliminary study indicates that in the Saudi population a significant part (about 30%) of ^{210}Po in blood is related to smoking. Its average concentration in smokers was 1.83 ± 0.63 pCi/l compared with 1.29 ± 0.61 pCi/l for non-smokers. Other environmental factors, such as ^{222}Rn gas inhalation and dietary factors, may make significant contributions. The values reported here can also serve as a base-line to evaluate concentration found in blood of individuals possibly exposed to high environmental levels of ^{210}Po or its parent isotopes.

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