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Relationship between Caesium (^{137}Cs) load, cardiovascular symptoms, and source of food in "Chernobyl" children – preliminary observations after intake of oral apple pectin

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Summary

Seventeen years after the nuclear power accident at Chernobyl, most of the radio-contamination among the population of Southern Belarus is caused by incorporation of long-lived radioisotopes. The varying levels of ^{137}Cs observed among children in this area are explained by the source of their food, especially by the consumption of contaminated milk produced privately.

We stratified children from rural areas of Belarus (caesium [^{137}Cs] contamination >5 Ci/km^2) by their ^{137}Cs loads into three distinct groups (group 1, <5 Bq/kg body weight [BW]; group 2, 38.4 ± 2.4 Bq/kg BW; group 3, 122 ± 18.5 Bq/kg BW). We determined the relationship between the ^{137}Cs load and the children's main source of food and recorded their cardiovascular symptoms. Cardiovascular symptoms, ECG alterations, and arterial hypertension were significantly more frequent in children with high ^{137}Cs burden than in children with very low ^{137}Cs burden.

Children with moderate and high ^{137}Cs loads (groups 2 and 3) received apple pectin, a food additive, for 16 days. Apple pectin significantly decreased ^{137}Cs loads in these groups (39% and 28%, respectively). ECG alterations improved, while cardiovascular symptoms and hypertension did not change in any group.

Key words: Chernobyl nuclear power accident; caesium contamination; cardiovascular symptoms; hypertension; apple pectin

Introduction

Seventeen years after the nuclear power accident at Chernobyl, 60% to 80% of the artificial irradiation of the population of Southern Belarus is caused by incorporation of long-lived radioisotopes. It is known that the varying ^{137}Cs loads observed among children in this area are explained by the source of their food, especially by the consumption of contaminated milk produced privately.

^{137}Cs mainly concentrates in endocrine glands, pancreas, thymus, and heart. In these organs, levels 10 to 100 times higher than those in other organs are found in children [1].

In addition to gamma rays, ^{137}Cs also emits beta rays that are considerably more cytotoxic than gamma rays, but they reach cells only below a millimetre range. Spectrometric assessment of gamma rays liberated by ^{137}Cs allows to determine the average total whole-body load.

In contaminated areas of Chernobyl, children suffer from more chronic and severe diseases compared to those living in less contaminated areas. Recurrent respiratory and gastrointestinal infections as well as endocrine disorders and cataracts are common. Other frequent findings include increased fatigue or apathy and chest pain associated with cardiovascular symptoms, such as unstable blood pressure or arterial hypertension. Abnormal electrocardiograms (ECGs) showing sinus arrhythmia, repolarisation, and conduction abnormalities appear to be most frequent among children with high ^{137}Cs loads [2].

Autopsies performed in the Gomel area showed that heart disease and cases of sudden death were often associated with high levels of ^{137}Cs in the myocardium. Histological studies revealed degenerative alterations and focal necrosis of cardiomyocytes, with interstitial oedema but little inflammatory or vascular changes present in most cases. Similar cardiomyopathy was experimentally induced in rats exposed to ^{137}Cs [3, 4].

There is considerable interest in the search of an agent capable of lowering the radioactive burden after accidental exposure to radioactive

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isotopes, eg, ^{137}Cs. The American Food and Drug Administration (FDA) has been actively encouraging the pharmaceutical industry to develop ferrocyanide (Prussian blue), a drug that binds ^{137}Cs in the gut, thus enabling excretion of the complex in the faeces [5, 6]. In the Chernobyl area, Prussian blue is generally mixed into cattle feed to reduce the ^{137}Cs concentration in milk.

Pectins are polysaccharides found in different fruits and roots. Apple pectin is widely used in the preparation of jelly, jam, and pastry. Pure pectin tablets are used in the treatment of heavy metal intoxication. Oral apple pectin inhibits the incorporation of both ^{137}Cs and Sr-90 in rats fed with radio-contaminated food [7]. The safety of apple-pectin preparations and their activity in heavy metal intoxication in humans were shown by Gres et al. [8]. In a double-blind, placebo-controlled trial, oral apple pectin powder, given for 23 days to children receiving radioactively clean food, lowered the ^{137}Cs burden by some 60%, while the "clean" diet alone lowered the burden by only 14% [9]. Since 1996, different apple pectin preparations have been used in the Chernobyl regions of the Ukraine and Belarus to protect children in the most contaminated areas. So far, some 70,000 children in Belarus have received up to four 1-month pectin courses per year.

School children living in areas contaminated with ^{137}Cs (5–15 Ci/km^2) receive radiologically clean food at school and have the possibility of spending a holiday at a sanatorium (the initial duration of 4 weeks has been shortened to 3 weeks 2 years ago for economical reasons). There, the children are medically supervised and receive good food and daily multivitamins.

We aimed to establish a correlation between the degree of radio-contamination and regular intake of privately produced food in 'Chernobyl' children stratified by their ^{137}Cs loads. Moreover, we studied the frequency of cardiovascular symptoms in relation to the ^{137}Cs load. Additionally, the effect of apple pectin on ^{137}Cs burden and cardiovascular symptoms was determined.

Patients and methods

Study design and patients

The study was conducted at the sanatorium Silver Spring of Svetlogorsk, where about 900 school children from radio-contaminated areas of the Gomel province were spending a 3-week holiday. Radiometrists of the Belrad Radioprotection Institute measured the children's ^{137}Cs loads using an established anthropogammametric method (Screener-3M) with electronic registration [9].

In the presence of parents and a member of the Ethics Committee, all children were informed about the trial. The children gave their oral consent and the mothers their written consent.

The children were allocated to three groups, depending on their C-137 loads measured at entry. Overall, 94 children (46 boys and 48 girls), aged 7 to 17 years, volunteered to participate. Apart from the varying ^{137}Cs levels, the groups were comparable with respect to age and gender distribution (table 1).

The 31 children of group 2 with moderate ^{137}Cs burden (average 38.4 ± 2.4 Bq/kg BW) and the 30 children of group 3 with high burden (average 122 ± 18.5 Bq/kg BW) received apple pectin powder (one spoonful of Vitapect®; approx. 5 g [containing 16% pectin], taken with water or milk during meals) twice a day for 16 days.

Assessments

^{137}Cs loads were determined at the beginning and end of the study. To explain the varying ^{137}Cs burden in individual children, their eating habits and source of food were recorded. A paediatrician examined the children at study entry and after the 16-day intake of pectin powder. The assessment was blind, ie, the paediatrician did not know the ^{137}Cs loads of the children.

At the beginning and the end of the study, ECGs were recorded. Subjective complaints were elicited and arterial blood pressure was determined after moderate exercise (ie, 10 knee-bends).

Statistical analyses

Student's t-test was used for comparisons between groups.

Table 1

Demographic data and percentage of children consuming privately produced food.

Groups (No. of children; average ^{137}Cs load at entry)	boys / girls	average age (years; boys/girls)	privately produced food N (% of total)
Group 1: low radio-contamination (n = 33; <5 Bq/kg body weight)[a]	16/17	10.8/12.5	19 (58%)[c]
Group 2: moderate radio-contamination (n = 31; 38 ± 2.4 Bq/kg body weight)[b]	17/14	12.8/12.2	22 (71%)
Group 3: high radio-contamination (n = 30; 122 ± 18.5 Bq/kg body weight)	12/18	12.7/12.7	30 (100%)

[a] All values were below the precise spectrometric detection limit (5.0 Bq/kg body weight).
[b] ^{137}Cs burden in this group was similar to that of children taking part in the first controlled study of pectin versus placebo [9].
[c] The proportion of children receiving privately produced food was statistically significantly lower in group 1 than in either groups 2 or 3 ($p < 0.05$).

Results

Correlation between baseline ^{137}Cs load and source of food

The difference in ^{137}Cs loads between the groups appeared to be explained, at least in part, by the source of the children's food (table 1). The proportion of children receiving a privately produced diet was statistically significantly lower in group 1 than in either group 2 or group 3 ($p < 0.05$).

Effect of pectin on ^{137}Cs load

As shown in figure 1, the average reduction of ^{137}Cs loads after pectin intake for 16 days amounted to 39% in children with moderate radio-contamination (group 2), and to 28% in children with high ^{137}Cs radio-contamination (group 3). The reduction from baseline was statistically significant in both groups ($p < 0.05$).

Subjective findings

Subjective complaints reported by many children included pain in the region of the heart, headache, weakness, irritability, and nasal bleeding. As shown in table 2, such complaints were expressed by 10 children (30%) in group 1, 12 children (39%) in group 2, and 19 children (63%) in group 3. In addition, 10 children (30%) in group 3 (high radio-contamination) reported permanent fatigue and depressive mood. At the end of the stay at the sanatorium, the children had practically no subjective complaints any longer.

Cardiovascular symptoms

At baseline, abnormal heart sounds were noted in 16 children (48%) in group 1, 26 children (84%) in group 2, and 27 children (90.0%) in group 3 (table 2). The difference between group 1 and each of the other two groups was statistically significant ($p < 0.05$).

At study entry, arterial hypertension (defined as arterial blood pressure exceeding the age-relevant upper limit by 20 mm Hg) was present in 3 children (9%) in group 1, 8 children (26%) in group 2, and 15 children (50%) in group 3 (table 2). The difference between group 1 and each of the other two groups was statistically significant ($p < 0.05$). Hypotension was present in up to 10% of children, with the highest percentage noted in group 3 (figure 2).

During the observation period, the percentages of children with hypertension did not change in any group.

ECG findings

At study entry, pathological ECG findings were noted in 17 children (52%) in group 1, 26 children (84%) in group 2, and 29 children (93%) in group 3 (table 2). The difference in percentages of pathological ECG findings between group 1 and the other two groups was statistically significant ($p < 0.05$).

Nine children (group 1, n = 6; group 2, n = 2; group 3, n = 1) refused the second ECG without giving any reason. The percentage of altered ECGs in group 1 (no pectin given) remained unchanged after the study (52% vs. 51%), although the children received quality food and vitamins. In groups 2 and 3, ECG alterations improved only slightly (72% vs. 87% in group 2; 79% vs. 93% in group 3; see figure 3). However, the pooled pectin groups (groups 2 and 3 combined) exhibited a statistically significant reduction ($p < 0.05$).

Tolerability

The pectin powder was well tolerated by all children.

Figure 1

^{137}Cs loads before and after pectin intake for 16 days are shown for groups 2 and 3 (group 1 did not receive any pectin, the ^{137}Cs loads remained <5.0 Bq/kg BW). Group 2, moderate radio-contamination: ^{137}Cs loads decreased from 38 Bq/kg BW to 23 Bq/kg BW (39% reduction; $p < 0.05$). Group 3, high radio-contamination: ^{137}Cs loads decreased from 122 Bq/kg BW to 88 Bq/kg BW (28% reduction; $p < 0.05$).

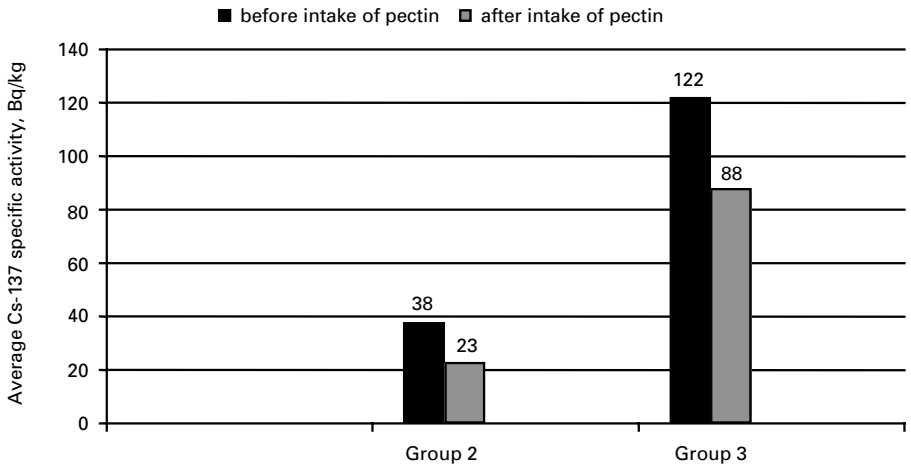


Table 2

Clinical findings at study entry.

Groups (N)	subjective complaints N (%)	arterial hypertension N (%)	abnormal heart sounds N (%)	altered ECGs N (%)
Group 1 (n = 33)	10 (30%)	3 (9%)[a]	16 (48%)a	17 (52%)[a]
Group 2 (n = 31)	12 (39%)	8 (26%)	26 (84%)	26 (84%)
Group 3 (n = 30)	19 (63%)	15 (50%)	27 (90%)	28 (93%)

[a] The difference between group 1 and group 2 or group 3 was statistically significant ($p < 0.05$).

Figure 2

The percentages of normotensive, hypertensive, and hypotensive children at study entry are shown. Group 1: low radio-contamination (n = 33; <5 Bq/kg BW); group 2: moderate radio-contamination (n = 31; 38 ± 2.4 Bq/kg BW); group 3: high radio-contamination (n = 30; 122 ± 18.5 Bq/kg BW).

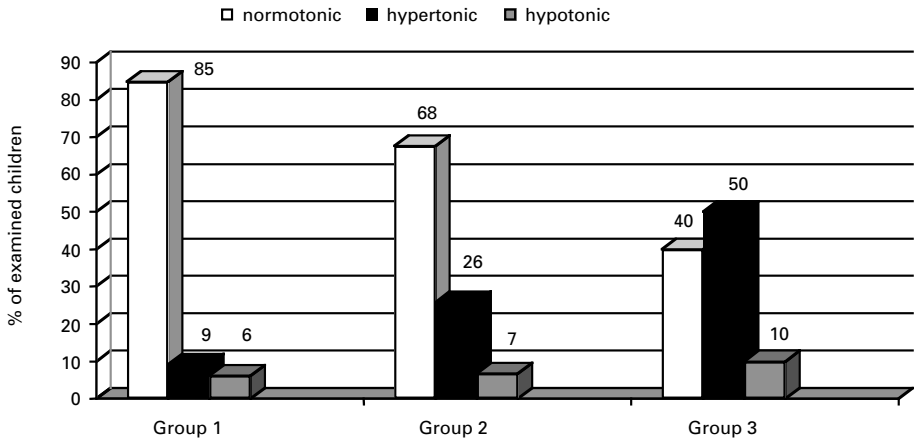
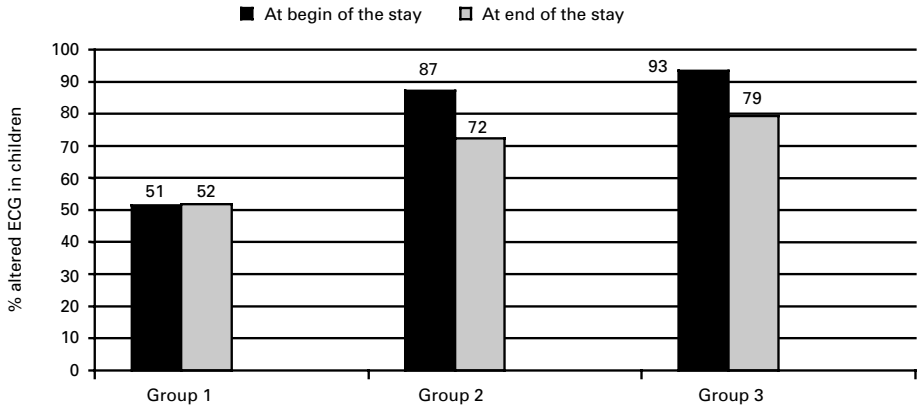


Figure 3

Percentages of altered ECG patterns at study entry and study end are shown for groups 1, 2, and 3. Group 1 did not receive any pectin. Changes in pathological ECG patterns in group 2 and group 3 were only moderate and did not reach statistical significance. The percentages calculated for the pooled pectin groups (groups 2 and 3 combined) showed a statistically significant improvement from baseline after the 16-day pectin course ($p < 0.05$).



Discussion

This preliminary study showed a clear correlation between baseline ^{137}Cs burden and the feeding habits of the children from the Gomel area. All highly radio-contaminated children (group 3) were fed on privately produced food probably containing high levels of ^{137}Cs. It is well known that privately grown vegetables and milk produced at home represent a major risk of radioactive contamination. The use of ashes as fertilisers from highly contaminated wood collected in the forests leads to an increase in the ^{137}Cs burden in the alimentary chain, ashes contributing also to an external irradiation in the kitchen, close to the fireplace. Mushrooms and wild berries consumed at home are another important source of radioactive contamination, but this factor is difficult to quantify based solely on questioning of the children and their families.

In addition, there was a correlation between baseline ^{137}Cs loads and pathological cardiovascular findings, with the largest number of cardiovascular symptoms and ECG changes noted in group 3 (high radio-contamination). Pectin administration for 16 days had little effect on cardiovascular variables but resulted in some improvement of pathological ECG patterns. The effect on ECG changes was statistically significant only if the two groups receiving pectin were pooled.

At baseline, a relatively large proportion of children had abnormal heart sounds. In children with a higher ^{137}Cs burden (groups 2 and 3), the frequency of abnormal heart sounds was much higher than in the children with low radio-contamination. The reason for this difference remains unclear.

Pectin intake reduced the ^{137}Cs burden by 39% and 28% in the groups with moderate and high radio-contamination; however, the absolute reduction was higher in group 3. The treatment duration of 16 days appears to be too short to lower the ^{137}Cs burden more effectively, especially in children with high ^{137}Cs contamination at baseline.

To determine if prolonged pectin administration significantly improves the clinical status of children, we are planning an extended prospective, placebo-controlled, double-blind study with pectin in a larger population of children with varying levels of radio-contamination.

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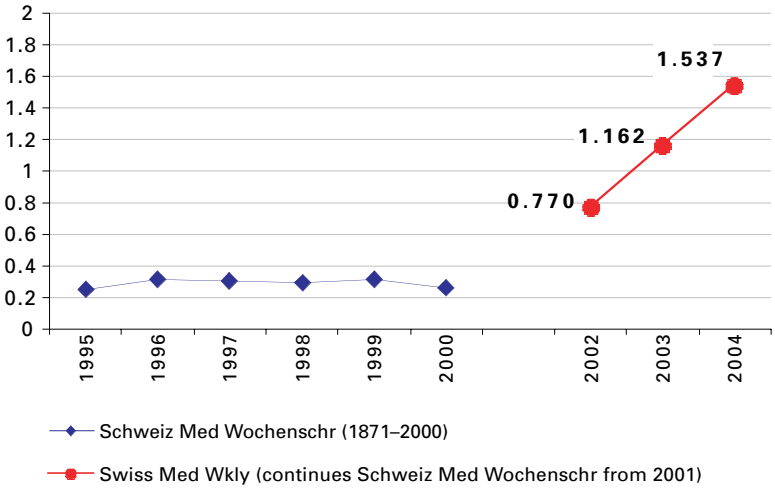

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