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Environmental health aspects of lead

Die gesundheitlichen Aspekte der Umweltverschmutzung durch Blei

Les problèmes sanitaires posés par le plomb présent dans l'environnement

METABOLISM AND DISTRIBUTION OF RADIOACTIVE AND STABLE LEAD IN MAN

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Abstract

The literature concerning the metabolism and the distribution of radioactive and stable lead in animal and human organisms was reviewed. The available data have been summarized in tables so that a comparison between results obtained using either radioisotopes of lead or stable lead could be made. The purpose of such comparison was to ascertain whether the information obtained with radiolead could clarify the metabolic processes of stable lead in man. The usefulness of the experiments performed with radioactive tracers seems unquestionable; the results of studies on the retention and excretion of radiolead in animals and in humans are, in general, confirmed by direct observations made on the behaviour of stable lead in man. Some inconsistencies might be due to differences in the experimental conditions. However, the critical examination of the literature on both radioactive and stable lead reveals that the mechanism of lead absorption in man is not completely known. Precise information, for instance, on transfer coefficients of lead through the respiratory and gastro-intestinal tracts is not reported in the literature. The analysis of the various studies on lead metabolism has shown where additional research is required. Some specific points to be clarified, also through experiments with radiolead, are suggested.

In an attempt to evaluate the hazards resulting from exposure to atmospheric lead from automobile exhausts, the Commission of the European Communities has organized a Seminar on "Human lead metabolism", held at Luxembourg, 25-27 April 1972.
One of the points reviewed* was to ascertain whether radioactive and stable lead behave similarly so that the experiments performed with radioisotopes of lead in animals and humans may provide useful information on the metabolism of stable lead in man.

Data from the literature on lead distribution in the human body and on the retention and excretion of the element in animal organisms and in man, are shown in Tables I and II.
It seems evident, in general, that the results of experiments performed with radioactive tracers are confirmed by those on the behaviour of stable lead in man. However, metabolic differences may occur for carrier-free radiolead and for stable lead introduced into the organism at normal or abnormal levels.

Despite the relative abundance of data found in the literature, transfer coefficients of lead through the respiratory and gastrointestinal tracts are not known with a sufficient degree of precision. Data on storage of lead in the different compartments of the organism are also far from being consistent. The absorption and retention values given by some authors have always a range of variation, sometimes rather large ; they do not provide, therefore, a completely satisfactory basis for the establishment of permissible levels of exposure.
Many important questions, therefore, concerning the toxicological aspects of environmental contamination due to lead are still without satisfactory answer. Experiments with lead radioisotopes which in the past were performed with the aim of estimating the degree of exposure to radiolead for the establishment of radioprotection rules, might be usefully pursued to fill in the subsisting gaps concerning stable lead.

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* A detailed text of this review, published elsewhere, is available on request.

The choice of the radioisotope and the experimental conditions should be, of course, carefully studied in order to obtain results and conclusions which give a valid contribution to the elucidation of the toxicity mechanism of lead.

The analysis of the various studies on lead metabolism has shown where additional research is required. The following list includes the main subjects to be further studied also with the use of radiolead :

1) Form of Pb circulating in plasma (in vivo studies not performed). Nature of binding to plasma constituents.
2) Relationship between Pb in blood and in soft tissues and between Pb in blood and in total exchangeable Pb pool.
   Factors influencing the relation of Pb in blood to Pb in soft tissues e.g. age, sex, blood type, etc...
3) Mechanism of Pb transportation across the intestinal mucosa into systemic circulation.
4) Mechanism of deposition of Pb in bone or metabolic factors modifying the interaction of Pb with bone.
5) Effects of interruption of Pb absorption on reduction of Pb body burden.
   Factors influencing mobilization of Pb in the body.
6) Fate of inhaled Pb. Absorption rates for particles of less than 1 μ (radioisotopes of lead could be particularly useful).
7) Effects of lead on enzymatic systems.

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TABLE I

Distribution of radioactive and stable lead in man

Tissue	% of body burden		N° reference (see list)
	^{210}Pb	Stable Pb	
Bone	63.0	83.0	2, 3
	58.0		5
	80.0		5 (other authors)
	79.0		13
	80.0		13 (other author)
		70.0	5 (ICRP)
		90.0	12 (other author)
		91.0	23
		95.0	27
Liver	1.7	3.1	2, 3
	2.8		5 (other author)
	1.5		5 (other author)
	2.2		13
		5.1	5 (ICRP)
Spleen	0.14		5
		0.2	5 (ICRP)
Muscle	17.0		2
	13.0		5 (other authors)
	4.4		13
		4.6	2
		7.7	5 (ICRP)
Soft tissues(all)	30.0		5
		30.0	5 (ICRP)
Blood	2.0		5
	1.6		13
		2.4	5 (ICRP)

TABLE II

Retention and excretion of radioactive and stable lead

Mode of administration	Retention (% of dose)	Excr (ratio Feces/Uri
Ingestion	^{210}Pb in rats : 5% (Ref.1) (parenteral administr.) ^{212}Pb in humans : 1.3%, 8.1%, 16.0% (Ref.14) Stable Pb in humans : 8% (Ref.2) Stable Pb in humans : 10% (Ref.19)	^{210}Pb in humans : Feces
Inhalation	^{210}Pb in rats : 32% (Ref.1) ^{210}Pb in dogs : 25%, 15% (Ref.10) ^{210}Pb in dogs : 25% (Ref.12) ^{212}Pb in humans : 25% (Ref16)+ ^{212}Pb in humans : 60%, 34% (Ref.17)+ (initial retention) Stable Pb in humans : 25-30% (Ref.19) Stable Pb in humans : 35-54% (Ref.20) (Pb particles:0.05-1.2 µ) Stable Pb in humans : 39%, 47% (Ref.22)+	^{210}Pb in dogs : Feces/U ^{210}Pb in dogs : Feces/U ^{212}Pb in humans : Urine (24 h ^{212}Pb in humans : Feces (72 hrs after administr
Injection	^{210}Pb in rats : 24% (Ref.1) ^{210}Pb in rats : 45% (Ref.4) ^{210}Pb in dogs : 49%, 38% (Ref.11)	^{210}Pb in rats : Feces/U ^{210}Pb in baboon : Feces ^{210}Pb in dogs : Feces/U ^{212}Pb in humans : Urine (0 - Feces (0 - ^{212}Pb in humans : Urine (0 -

+ lung deposition = inhalation minus exhalation, as specified by authors