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THE CONCENTRATION OF LEAD IN PLASMA, WHOLE BLOOD AND ERYTHROCYTES OF INFANTS AND CHILDREN

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DESPITE the efforts directed toward the prevention of accidental lead poisoning in infants and children, ingestion of lead still constitutes a serious and frequent hazard to health. The more severe forms of plumbism in children are associated with high mortality rate and marked frequency of disabling sequelae affecting the nervous system. In addition, aftereffects in the form of chronic nephritis appear to be much more frequent and important than generally recognized.[1-3] Recently published data indicate that current methods of treatment have thus far not significantly altered the mortality rate, although the incidence of neurologic sequelae may have been reduced.[4] Earlier diagnosis and immediate removal from exposure, together with prompt specific and supportive therapy, should give still better results.

Clinical experience suggests that many children may be virtually asymptomatic for long periods of time even though the concentration of lead in the blood is abnormally high. This condition represents latent chronic lead poisoning. Continued exposure to lead, intercurrent febrile illness, or acidosis may transform the latent into the active type of lead poisoning.[5, 6] It is important, therefore, to recognize asymptomatic latent lead poisoning characterized by abnormally high concentrations of lead in the blood. The literature on lead poisoning reveals disagreement as to what constitutes an abnormally high concentration of lead in the blood of children. It is the purpose of this paper to present the results of a study of the concentration of lead in the blood of 103 children in relation to their age. The children, ranging in age from 5 hours to 13 years, were selected from the pediatric wards, nurseries and outpatient departments of the Jefferson Medical College Hospital. Inclusion in the survey required that the child have a normal temperature and give no history of pica, previous lead poisoning, or symptoms suggestive of lead poisoning.

METHODS

As a rule, 10 ml of blood were collected in a defatted syringe, transferred to a centrifuge tube, and centrifuged at 1550 rev/min for 30 minutes. A modified dithizone method previously described by Rieders[7, 8] was used. Since this method is employed routinely in this laboratory and since it was difficult to obtain larger samples, only one determination was made on each sample.* In 82 of the 103 cases, the content of lead of compacted erythrocytes (containing about 3% plasma) and of the plasma was determined separately; to provide a total blood value, the results were combined. From each of the remaining 21 subjects, less than 3 ml of blood had been drawn, and only whole blood was examined.

RESULTS

In 53 of the 82 cases studied for lead in erythrocytes and plasma, lead was not detected in the plasma. Concentrations of 0.009 mg/100 ml or less were found in 22 cases; hemolysis had taken place in seven samples in which more than 0.009 mg/100

* The standard deviation for replicate determinations of lead in a given specimen of blood is approximately 5% by this method.

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ml was in evidence. These findings agree with previous reports.[9] The range for erythrocytes was 0.003-0.144 mg/100 ml. and for whole blood, 0.003-0.054 mg/100 ml.

The concentration of lead in the blood of the 103 children examined did not seem to be related to sex or race. In order to evaluate the role of age, the subjects were divided into three groups. Group I included infants ranging from 5 hours to 6 months of age. This group had, in all probability, absorbed only minimal amounts of lead other than that present in the food. In Group II were infants and children from 6.1 months to 4 years of age. These were children in the teething age who test their environment with their mouths. Group III consisted of children more than 4 years of age. The log-log relationship between age and content of lead of whole blood and erythrocytes, respectively, is shown in Figures 1 and 2. The ranges and medians in the three groups were determined and compared. Since it has been shown that the distribution curve for concentrations of lead is log-normal,[10] the use of the arithmetic mean is precluded. Geometric means could have been used, but it was thought that the median would be more meaningful. The ranges and medians of Group II were practically identical with those of Group III, and these two groups were therefore combined in all further calculations. Various ranges and medians are shown in Table I. The distributions of concentrations of lead in whole blood and erythrocytes in Group I were displaced significantly to the left of the distributions in the

TABLE I

MEDIANS AND RANGES OF CONCENTRATIONS OF LEAD IN THE BLOOD OF 103 CHILDREN

	Whole Blood (mg/100 ml)	Erythrocytes (mg/100 ml)
Median Group I	0.018	0.034
Median Groups II and III	0.027	0.063
Range Group I	0.003–0.051	0.010–0.09
Range Groups II and III	0.005–0.054	0.008–0.144
Groups II and III Middle 90%	0.015–0.040	0.026–0.105
Groups II and III Middle 50%	0.020–0.034	0.046–0.082
Number of subjects Group I	73	65
Number of subjects Groups II and III	28	17
Total number of subjects	103	82

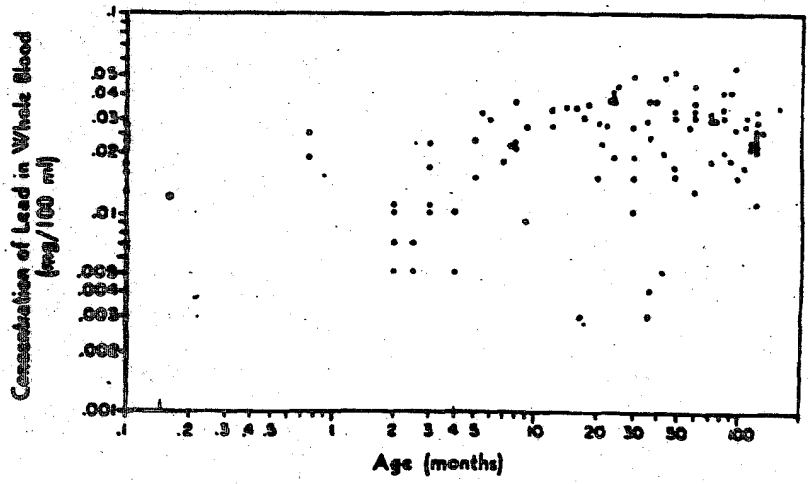

FIG. 1. Relationship between concentration of lead in whole blood and age of 103 children.

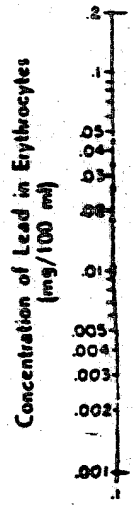

FIG. 2. Rel...

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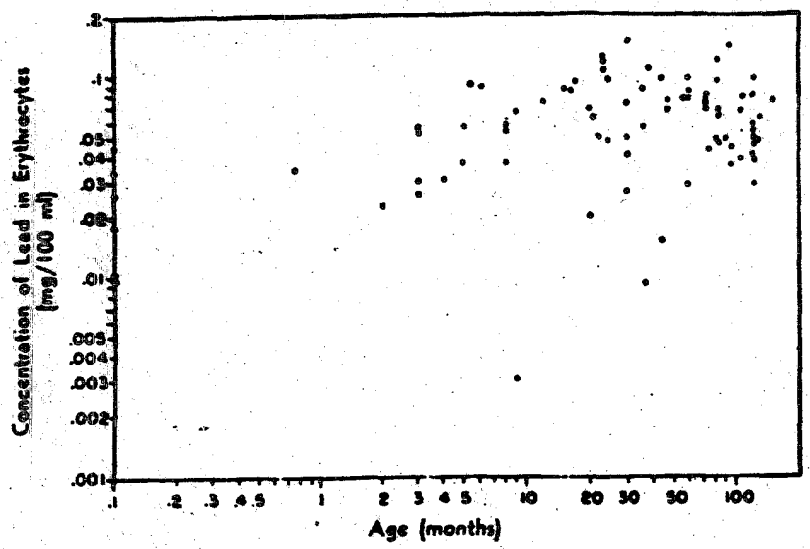

FIG. 2. Relationship between concentration of lead in erythrocytes and age of 82 children.

combined group (II and III). The rank test[11] demonstrated a highly significant difference (probability of $H < 0.001$). After 6 months of age, the concentration of lead in the blood remained independent of age, approaching the "normal" values reported for adults.

DISCUSSION

As mentioned above, there is no unanimity in regard to normal concentrations of lead in the whole blood of children. Most clinical investigators[1, 12-14] consider values below 0.06 mg/100 ml normal, while some[15] accept 0.08 mg/100 ml as the upper limit of normal. Much of the difference of opinion is due to the use of different analytic methods and techniques and the fact that the discrepant findings in adults have been applied to children. In a recent paper, Bradley *et al.*[16] state that the upper level of normal in whole blood is 0.05 mg/100 ml. This figure agrees with our findings in infants and children 6.1 months of age and older while, according to the results of this investigation, the figure for younger infants is significantly lower.

Appreciable amounts of lead were found in the whole blood (0.007-0.028 mg/100 ml) and erythrocytes (0.010-0.044 mg/100 ml) of newborn infants. This raises the question of transport of lead from the maternal into the fetal circulation. Since there is little or no proof that, in a normal pregnancy, maternal blood cells enter the fetus in a sizable number, it is in all probability the maternal plasma in which minute amounts of lead are carried to the fetus. Several investigators[17, 18] have detected lead in fetal tissues. Studies on experimental animals have shown that lead moves into the circulation of the placenta and then into the fetus,[19] although there is no accumulation of lead in the placenta.[20] This transfer of lead is made as though no barrier existed between the blood of the mother and the blood of the fetus.[20]

With increasing age, a significant rise in the content of lead of the erythrocytes occurred within Group I. This increase was not reflected in the lead level of the whole blood, possibly as a result of a declining ratio of cells to plasma. Further studies of individual infants at fixed intervals during

the first 6 months of life are necessary to confirm and to explain this observation.

SUMMARY

The concentration of lead in the blood of 103 infants and children without history of pica or lead poisoning, ranging in age from 5 hours to 13 years, was studied. The children were divided into three groups according to age: Group I, 5 hours to 6 months of age; Group II, 6.1 months to 4 years of age; Group III, older than 4 years.

The values obtained in Group I were significantly lower than those obtained in Groups II and III. Groups II and III showed approximately the same content of lead in whole blood and erythrocytes. The median values in Group I were 0.015 mg/100 ml of whole blood and 0.034 mg/100 ml of erythrocytes. In the combined Groups II and III median values in whole blood were 0.027 mg/100 ml, and in erythrocytes 0.065 mg/100 ml. The range in Group I was 0.005-0.031 mg/100 ml of whole blood and 0.010-0.090 mg/100 ml of erythrocytes. In the two groups more than 6 months of age, the range for whole blood was found to be 0.003-0.054 mg/100 ml, and for erythrocytes 0.003-0.144 mg/100 ml. 90% of the values were between 0.015 and 0.040 mg/100 ml (whole blood), and between 0.023 and 0.103 mg/100 ml (erythrocytes).

Significant amounts of lead were found in the whole blood (0.007-0.028 mg/100 ml), and erythrocytes (0.010-0.044 mg/100 ml) of newborn infants.

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SUMMARIO IN I

Le Concentration De P Sanguine Integre, I De Infantes E

Le ingestion de plomb tinua representar un ser hygienic. Un alte mortal mentia de sequellas inval nervose es characteristic de plumbismo in juvenil tardive in le forma de v pare esser multo plus fre importante que lo que es noscite. Nove methodos t reducite le incidentia de s usque nunc illos non ha de maniera significative.

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Le litteratura concernente per plumbo revela diverger a qual nivellos de plumb patientes pediatric debe es anormalmente alte.

Le presente reporto co concentration de plumbo i infantes e juveniles sin h venenamento per plumbo dividuos examinate varian a 13 annos. Le subjectos es gruppos secundo lor etate a 6 menses; Gruppo II, 6 a e Gruppo III, 4 annos a 13

SUMMARIO IN INTERLINGUA

Le Concentration De Plumbo In Plasma, Sanguine Integre, E Erythrocytos De Infantes E Juveniles

Le ingestion de plumbo per juveniles con-sona representar un serie e frequente risco hygienic. Un alte mortalitate e un alte frequentia de sequellas invalidante in le systema nervose es characteristic del plus sever grados de plumbismo in juveniles. In plus, effectos cadive in le forma de chronic nephropathias pare esser multo plus frequente e multo plus importante que lo que es generalmente recognoscite. Nove methodos therapeutic ha forsan reducite le incidentia de residuos nervose, sed usque nunc illos non ha alterate le mortalitate de maniera significative.

In despecto del presentia de alte concentrationes de plumbo in lor sanguine, multe infantes e juveniles pote remaner asymptomatic durante longe periodos de tempore usque iste latente typo de saturnismo se tranforma in le typo active. Per consequente il es importante recognoscer saturnismo latente asymptomatic per demonstrar anormalmente alte concentrationes de plumbo in le sanguine.

Le litteratura concernite con invenenamento per plumbo revela divergente opiniones relative a qual nivellos de plumbo in le sanguine de patientes pediatric debe esser considerate como anormalmente alte.

Le presente reporto concerne le studio del concentration de plumbo in le sanguine de 103 infantes e juveniles sin historia de pica o invenenamento per plumbo. Le etates del individuos examinate variava ab 5 horas usque a 13 annos. Le subjectos esseva dividite in tres gruppos secundo lor etate: Grouppo I, 5 horas a 6 menses; Gruppo II, 6,1 menses a 4 annos; e Gruppo III, 4 annos a 13 annos.

Esseva empleate un modification del methodo a dithizona (in uso routinari a iste laboratorio). In 82 del 103 casos, le contento de plumbo de compingite erythrocytos e del plasma esseva determinate separatemente. In solmente 22 de iste casos, minuscule quantitates de plumbo (0,009 mg per 100 ml o minus) esseva trovate in le plasma. In le caso de erythrocytos compingite le scala del valores esseva ab 0,003 a 0,144 mg per 100 ml e in le caso de sanguine integre ab 0,003 a 0,034 mg per 100 ml.

Le concentration de plumbo in le sanguine del 103 subjectos examinate non pareva esser relationate a sexo o racia. Le rolo del etate esseva revelate per le sequente constatation: Le valores obtenite in Gruppo I esseva significativemente plus basse que le valores obtenite in Gruppo II e Gruppo III. Gruppo II e Gruppo III monstrava approximativemente le mesme contento de plumbo in sanguine integre e in erythrocytos. Le valores median in Gruppo I esseva 0,015 mg per 100 ml pro sanguine integre e 0,034 mg per 100 ml pro erythrocytos. In Gruppo II e Gruppo III in combination, le correspondente valores esseva 0,027 mg per 100 ml de sanguine integre e 0,063 mg per 100 ml de erythrocytos. Le scala del valores in Gruppo I esseva ab 0,005 a 0,031 mg per 100 ml de sanguine integre e ab 0,01 a 0,09 mg per 100 ml de erythrocytos. In Gruppo II e Gruppo III in combination, le correspondente scalas esseva ab 0,003 a 0,054 mg per 100 ml de sanguine integre e 0,003 a 0,144 mg per 100 ml de erythrocytos. Novanta pro cento del valores esseva inter 0,015 e 0,04 mg per 100 ml de sanguine integre e inter 0,028 e 0,103 mg per 100 ml de erythrocytos.

Quantitates significative de plumbo esseva trovate in le caso de neonatos in le sanguine integre (0,007 a 0,028 mg per 100 ml) e in le erythrocytos (0,01 a 0,044 mg per 100 ml).