Research Forum

CALCIUM KINETICS IN VITAMIN-D DEFICIENCY RICKETS*

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An investigation of calcium kinetics in vitamin-D deficiency rickets was undertaken using Ca^{47} as a tracer. Three clinical groups were studied: (a) Untreated active rickets, (b) Treated rickets and healing rickets (the latter had radiological evidence of healing at the time of investigation), and (c) non-rachitic controls; in all cases the diagnosis was based on appropriate biochemical and radiological criteria. Treatment was given in the form of oral or intramuscular vitamin D2 or intravenous vitamin D3.

Plasma and excreta were assayed for radioactivity after intravenous administration of the isotope and results were analysed by the method of Bauer, Carlsson and Lindquist[1] to obtain values for exchangeable calcium pool size (E) and accretion rate (A). Ca^{47} appeared to be more slowly cleared from the plasma by active rachitics; this group also showed the smallest E values, the highest being found in treated rachitics (Table I). The A values in active rickets were low and rose after treatment. Mean values for A in 5 patients studied before and after treatment were 61·4 mg./kg./day and 180·9 mg./kg./day, respectively ($p<0.001$). A linear correlation was shown to exist between E and A values, i.e. increase in accretion rate was directly related to increase in exchangeable pool-size.

TABLE I. MEAN VALUES (AND S.E.) FOR EXCHANGEABLE CALCIUM POOL SIZE

	No. of subjects	*Weight (in kg.)*	*Exchangeable calcium*	
			mg.	*mg./kg.*
Non-rachitic	8	7·5	3010	422± 35
Rickets pre-D	16	6·6	1861	279± 39
Rickets post-D	11	7·5	7146	936±180
Healing rickets	5	7·3	4215	565± 87

External counting (radioisotope osteogram) was performed in the same groups of subjects over 3 selected areas, viz. upper fibula-tibial metaphysis (knee), midshaft, and lower fibula-tibial metaphysis (ankle). A lead-shielded collimated plastic phosphor in series with a photomultiplier tube and automatic scaler was used as the recording apparatus. A lead brick wall with an aperture greatly diminished the background contribution of total body activity.

Counts were recorded at least twice daily in the first 3 days, then daily for the remainder of the study (7 - 14 days). Some patients had frequent osteograms (5 - 10) in the first 21 hours after intravenous administration of the isotope. Local activity was expressed as % dose administered with reference to a standard counted on each occasion. A total of 300 osteograms at each site was obtained in 29 patients, of whom 3 were studied both before and after treatment.

Maximum activity was obtained within 12 hours by 23 of 27 patients who had 2 or more osteograms in the first 24 hours. In some patients this peak was reached as early as 2 hours after administration of isotope. There was no difference between the 3 sites or 3 groups of patients in the time of attaining maximum activity. The knee site accumulated isotope most avidly in all groups—even active rachitics.

Results of long-term studies were expressed as the ratio of ankle to midshaft (A/M) and knee to midshaft (K/M) counts (Table II).

TABLE II. RESULTS OF LONG-TERM STUDIES

	No. of subjects	*A/M*	*K/M*
Active rickets	11	0·9 ±0·01	1·24±0·04
Healing rickets	9	1·12±0·05	1·47±0·04
Controls	9	1·13±0·04	1·61±0·11

A/M=Ratio of ankle to midshaft; K/M=Ratio of knee to midshaft.

The differences between active rickets and the other 2 groups were statistically significant and illustrate the impaired uptake of the metaphyses in untreated rachitics. Following treatment there was an increase at all sites, which was relatively greater at the metaphyses. The mean A/M ratio increase from 0·9 to 1·12 is indicative of increased metaphysial activity following vitamin D.

Analysis of disappearance slopes from these bone sites showed no constant difference between the 3 sites and between the 3 groups of patients. The rapidity of the isotope disappearance suggests that an exchange process rather than resorption is responsible.

The persistence of higher plasma activity levels in untreated rachitics and their smaller exchangeable calcium pools are shown to be associated with impaired bone uptake of isotope. This situation is altered by the administration of vitamin D, when an increased exchangeable pool is found in association with increased accretion and elevated local bone uptake.

The exchangeable calcium pool is composed mainly of the exchangeable bone fraction. The increase in this pool following vitamin D is attributed to enlargement of the bone fraction which contains newly forming bone that allows free diffusion of divalent cations such as calcium.

The action of vitamin D is thought primarily to be on the superficial exchange properties of bone. This would include an action on osteoid, thereby allowing calcium an entrance to bone matrix by altering membrane permeability.

The linear relationship of accretion to exchangeable pool size tends to confirm the postulated action of vitamin D on superficial exchange according to the law of mass action.

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REFERENCE

1. Bauer, G. S. H., Carlsson, A., Lindquist, B. (1957): Acta Med. Scand., **158**, 143.