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DETERMINATION OF CALCIUM MINERALIZATION RATE IN HUMANS BY MEANS OF THE SLOPE OF FOREARM RETENTION CURVE AFTER INTRAVENOUS APPLICATION OF ^{47}Ca

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The purpose of this study was to determine calcium mineralization rate for the whole body a_T from the slope of the forearm retention curve after intravenous application of ^{47}Ca. The mineralization rate was determined in 17 subjects with generalized bone diseases. This method, which utilises the slope of the forearm retention curve, has the advantage of avoiding blood sampling and excreta collecting. The disadvantage of the method if compared with the method which includes blood sampling is a greater error in determining the accretion rate values. Namely blood is a more sensitive indicator of calcium metabolism than retention values of radioisotope in the body or in a part of the body (forearm in this case).

The kinetic parameters of calcium metabolism, the mineralization rate and the exchangeable fraction of calcium in the human body can be determined usually by following the retention curve in the body or in a part of the body and in the plasma after intravenous or oral application of ^{47}Ca (1—4). By taking two convenient time intervals on the experimentally obtained retention curves and by substituting the values read from the curves into the theoretically obtained *Bauer-Carlsson-Lindquist* (BCL) equations (5, 6) the parameters of calcium metabolism can be obtained.

However, it seems that the accretion rate as a more useful parameter of calcium metabolism can be obtained by using the slope of the radioisotope forearm retention curve, thus avoiding blood sampling and excreta collecting.

PRINCIPLES OF CALCULATIONS

The determination of the whole body calcium accretion rate a_T by means of the slope of the forearm retention curve N is based on the fact that regularly (except in some pathological cases) this curve shows an exponential drop from the third until the sixth day after radioisotope application. For the third and the sixth day, which limit the interval in which the accretion is observed (during which time the resorption is taken to be negligeable) the following equation is valid:

$$R_{F6} = R_{F3}\ e^{-N.t} \qquad (1)$$

where R_{F3} and R_{F6} are retention values for ^{47}Ca in the forearm on days 3 and 6 after application, N is the slope of the retention curve and t is the time in days after application. From the above equation it follows:

$$N = \ln \frac{R_{F3}}{R_{F6}} \cdot \frac{1}{t} \qquad (2)$$

RESULTS

Results obtained in 17 subjects are presented in Table 1, which gives values of the mineralization rate a_T for the whole body expressed as mg Ca d^{-1} and mg Ca $d^{-1}kg^{-1}$ obtained from the BCL time independent relations (3), and the corresponding slope N expressed as d^{-1} for each subject (last column) after intravenous application of about $25 \mu Ci^{47}Ca$ (4).

If slope N is graphically presented as a function of a_T a real and

Table 1.

Accretion rates a_T, $\acute{a}_T$ and the slope of the forearm retention curve N after intravenous application of ^{47}Ca

	Subject	a_T mg d^{-1} kg^{-1}	a_T mg d^{-1}	N d^{-1}
1.	M. M. f.	1806,72	26,00	0,00164
2.	B. J. m.	643,28	7,48	0,0485
3.	Ć. N. m.	876,52	12,89	0,0495
4.	T. K. m.	600,30	6,67	0,0435
5.	M. Si. m.	326,48	5,83	0,0407
6.	O. O. f.	439,56	6,66	0,0662
7.	K. I. m.	555,12	7,71	0,0550
8.	K. R. m.	439,56	6,66	0,0662
9.	Č. I. m.	574,70	8,21	0,0452
10.	P. B. m.	520,56	7,23	0,0522
11.	M. S. m.	568,32	5,92	0,0635
12.	V. T. f.	251,60	3,70	0,0608
13.	P. J. f.	447,85	8,45	0,0408
14.	P. I. m.	634,26	6,82	0,0454
15.	J. D. f.	189,80	2,60	0,0541
16.	B. V. m.	808,25	15,25	0,0377
17.	G. F. m.	349,98	6,14	0,0607
Mean:		592,81	8,55	0,0481

strong negative correlation is obtained (Figs. 1 and 2). This correlation is —0.876 if the slope is correlated with a_T expressed as mg(Ca)d $^{-1}$kg^{-1}. If the slope is correlated with a_T expressed as mg(Ca)d $^{-1}$ the correlation coefficient is —0.825. The 95% confidence limits of the regression line at several representative values of a_T were also calculated and represented by dotted curves. These dotted curves include the regression line 95 times out of 100.

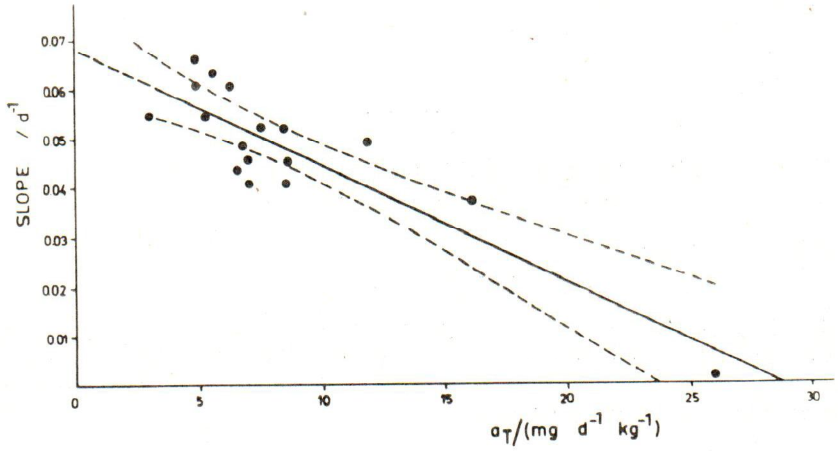

Fig. 1. *Graphical presentation of the slope N as a function of* a_T *expressed in mg Ca* $d^{-1}kg^{-1}$ *with* $r = -0.876$

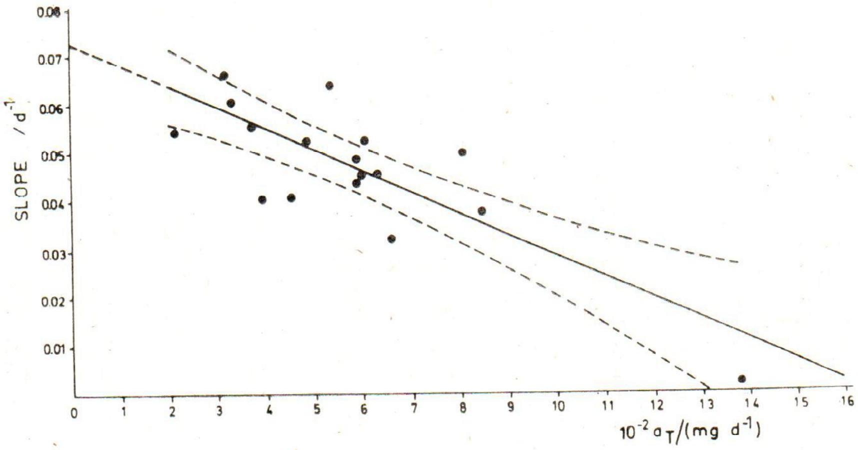

Fig. 2. *Graphical presentation of slope N as a function of* a_T *expressed in mg Ca* d^{-1} *with* $r = -0.825$

On the basis of the calculated correlations, the following equation is valid:

$$N = \overline{N} + m(a_T - a_T) \quad (3)$$

where N is the value of the slope, $\overline{N}$ the mean value of the slope, m is the coefficient of regression, a_T the total body mineralization rate expressed as mg(Ca)d $^{-1}$, a_T the average value expressed in the same way. Introducing the numerical values obtained by calculations (Table 1), equation (3) can be rewritten as:

$$N/d^{-1} = 0{,}0481 - 44\ a_T + 0{,}000044 \times 575 \quad (4)$$

and by deduction:

$$a_T/mg\ d^{-1} = 1668.182 - 22727\ N \quad (5)$$

and analogously for a_T expressed in mg (Ca) $d^{-1}kg^{-1}$:

$$N/d_T^{1} = 0{,}0481 - 0.0024\ (a_T - 8.52) \quad (6)$$

and by deduction:

$$a_T/mg\ d^{-1}kg^{-1} = 28.583 - 416.667\ N \quad (7)$$

Table 2 gives the values of a_T calculated in various ways (4). The four different ways of calculation of the parameter a_T show discrepances in some individual cases (poorest agreement when the slope is used), but the average values are very near.

Table 2

Mineralization rates a_T and a'_T after intravenous application of ^{47}Ca (calculated in different ways)

Subject	a_T/mg d^{-1}				a'_T/mg d^{-1} kg^{-1}			
	WB (100%— excreta)	a_F	A_F	Slope	WB (100%— excreta)	a_F	A_F	Slope
1. M. M. f.	1.380	1.840	1.781	1.632	26.00	27.92	26.99	27.90
2. B. J. m.	590	733	702	566	6.80	10.89	10.40	8.38
3. Č. M. m.	810	1.090	1.127	543	11.90	16.38	16.94	7.96
4. T. K. m.	590	382	414	680	6.61	5.49	5.99	10.46
5. S. M. m.	400	484	589	743	7.08	7.06	8.64	11.63
6. O. O. f.	322	402	356	164	4.87	5.80	5.09	1.00
7. K. I. m.	381	478	481	481	5.29	6.97	7.02	5.67
8. K. R. m.	488	442	437	482	5.67	6.41	6.33	6.83
9. Č. I. m.	600	726	721	641	8.58	10.78	10.69	9.75
10. P. B. m.	610	462	484	482	8.50	6.72	7.05	6.81
11. M. S. m.	540	529	497	225	5.68	4.96	7.25	2.13
12. V. F. f.	337	231	309	286	4.96	3.16	4.36	3.25
13. P. J. f.	453	542	299	741	8.54	7.95	4.22	11.58
14. P. I. m.	638	487	563	636	6.94	7.11	8.27	9.04
15. J. D. f.	216	216	313	439	2.96	2.94	4.42	6.04
16. B. V. m.	850	780	794	811	16.1	11.62	11.82	12.88
17. G. F. m.	330	318	288	289	6.34	4.51	4.05	3.29
Mean:	560.88	596.55	597.35	575.18	8.52	8.63	8.80	8.54

DISCUSSION AND CONCLUSIONS

There are many problems which concern the validity of the relationship used in this paper and the ability to measure quantities such as mineralization rate from the above relationship (eqn 2).

By measuring the forearm activity the presumed bone uptake is measured in the part of the body in which the bone compartment predominates. Accurate estimates of true bone content in humans are not yet available. Even the best external measurement of gamma-emitting bone tracers are only semiquantitative (6, 7).

Although the retention of radioisotope introduced into the body is a far less sensitive parameter of metabolic changes than plasmatic values, the idea of determining calcium accretion rate by means of the slope of radioisotope forearm retention curve, thus avoiding blood sampling and excreta collecting still seems feasible.

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Sažetak

ODREĐIVANJE BRZINE MINERALIZACIJE KALCIJA U ČOVJEKU POMOĆU NAGIBA KRIVULJE RETENCIJE NAKON INTRAVENSKE PRIMJENE ^{47}Ca

Svrha ovog rada bila je određivanje brzine mineralizacije za cijelo tijelo a_T pomoću nagiba krivulje retencije radioizotopa u podlaktici nakon intravenske primjene ^{47}Ca. Brzina mineralizacije na ovaj način određena je na 17 ispitanika s difuznim koštanim bolestima. Ta metoda, koja primjenjuje nagib krivulje retencije u podlaktici ima prednost u tome što se pomoću nje izbjegava skupljanje uzoraka krvi i ekskreta. Mana je metode ta što unosi veće pogreške u računanje tog parametra metabolizma kalcija od metode koja zahtijeva vađenje uzoraka krvi, jer je krv znatno osjetljiviji pokazatelj metaboličkih promjena kalcija u organizmu od vrijednosti radioaktivnosti zadržane u podlaktici nakon primjene radioizotopa.

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