Effects of Varying Rates of Sodium Excretion on Na^{22} Kinetics.* (26387)

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The present investigation was undertaken to ascertain the feasibility of estimating daily total exchangeable sodium with Na^{22} as part of an experiment involving bioassay of diurtic agents(1). Threefoot, Burch and Reaser (2) studied the serum and urinary biological decay curves of Na^{22} in control subjects and in patients with congestive heart failure and the nephrotic syndrome. They found that the presence of edema fluid, variation in sodium intake and administration of mercurial diuretics and desoxycorticosterone acetate (DCA) influenced the slope of these curves. Under similar conditions we have calculated daily total exchangeable sodium and serum specific activity and have compared their technic with the chemical measurement of serum and urinary sodium.

Materials and methods. Eleven male patients from the medical wards of the Philadelphia General Hospital were selected for this study. Eight of these patients had well-controlled diabetes mellitus, and were selected because of the better facilities for accurate urine collections and dietary supervision which were available on their ward. Nine patients showed no clinical evidence of abnormal fluid retention; one had edema due to the nephrotic syndrome and another congestive heart failure.

Caloric intake was maintained at a constant level in the individual patient and ranged from 1945 to 3370 calories. Sodium intake was *ad libitum* but appeared to be fairly constant for individual subjects as judged by the small fluctuations in daily urinary sodium excretion during the control periods. After an initial control period of one week, sodium chloride (178 to 258 meq Na), DCA 30 mg and hydrochlorothiazide, 150 mg, were administered individually or in combinations daily for 3 to 7 days. Subsequent control periods between administration of the above agents were 3 to 7 days duration.

Twenty microcuries of Na^{22} were given intravenously to each patient and 24 hour urine collections were obtained daily for 10 to 48 days. Serum and urine samples were analyzed daily for sodium with a flame photometer and for Na^{22} radioactivity with a well type scintillation counter. The cumulative urinary excretion of Na^{22}, which was ex-

TABLE I. Characteristics of Patients.

Case No.	Age	Body wt, kg	Na_E, meq	Na_E/kg body wt	Na^{22} U½, days	Na^{22} S.A.½, days	Control Na excret., meq/day	Avg % change daily in Na_E over 1st week
1	55	52.0	3043	58.5	9.4	6.8	227 ± 44‡	+4.1
2	40	56.2	3361	59.8	11.3	6.6	213 ± 44	+4.5
3	63	75.9	2995	39.3	19.3	17.5	131 ± 29	+ .4
4	63	70.5	3088	43.8	13.0	11.7	197 ± 43	+ .5
5	59	57.0	3113	54.6	13.0	8.1	186 ± 57	+2.0
6	65	75.1	3877	51.6	23.5	12.1	130 ± 42	+1.9
7	56	69.3	3519	50.8	20.8	8.8	135 ± 11	+3.4
8*	40	74.1	3135	40.7	31.7	30.6	79 ± 18	+ .1
9†	55	75.2	3240	43.1	73.4	167.0	20 ± 3	− .1
10	63					13.5		
11	56					26.2		

* Nephrotic syndrome. † Congestive heart failure. ‡ Mean ± S.D.

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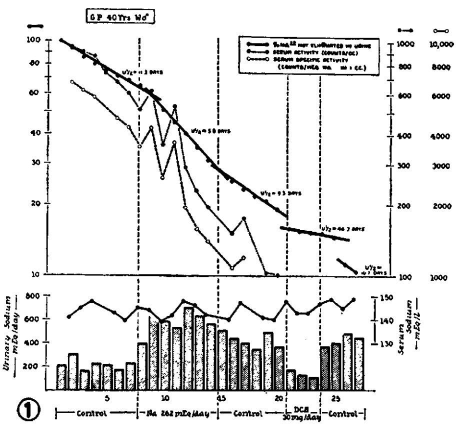
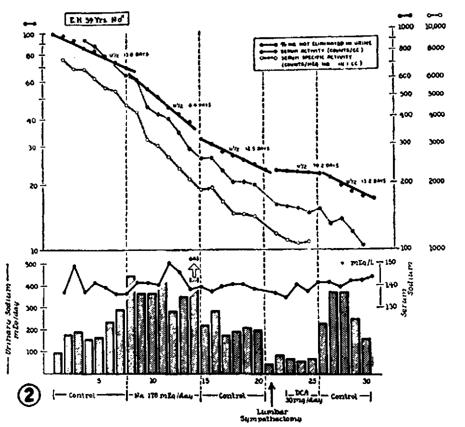
pressed in terms of per cent of injected Na^{22} was plotted as an exponential function according to the method of Threefoot, Burch and Reaser(2). Serum radioactivity (counts per minute per ml serum) and serum specific activity (S.A.) (serum radioactivity per meq sodium per ml serum) were plotted as the fraction of the administered dose against time on a semi-logarithmic graph. Total exchangeable sodium (Na_E) was calculated daily by dividing the specific activity of the serum into the amount of Na^{22} present in the body, using as an approximation the assumption that all excretion of radioactivity occurred *via* the urine(2). U ½ was defined as the time in days required to eliminate 50% of the administered radioactivity in the urine. S.A. ½ was defined as the time in days to eliminate 50% of the serum specific activity after equilibrium distribution.





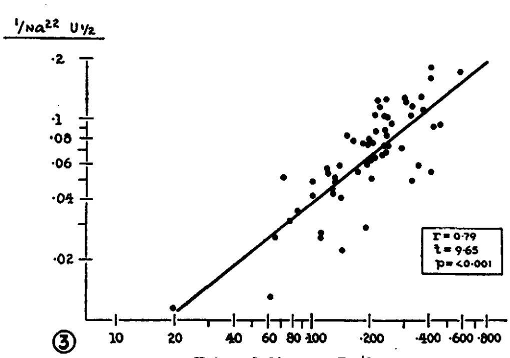


FIG. 1. Relation of biological decay curves of Na^{22} to serum and urinary sodium in case 2.

FIG. 2. Relation of biological decay curves of Na^{22} to serum and urinary sodium in case 5.

FIG. 3. Urinary sodium excretion and $1/Na^{22}U½$ plotted on a logarithmic scale.

Results. In Table I are summarized data obtained in these experiments. As has been noted previously(2), the Na^{22}U½ is usually greater than the S.A. ½. In 4 patients, initial Na_E was normal, in 5 it was elevated (normal range, 32 to 49 meq per kg body weight(3). Calculation of Na_E during the first week showed an average daily increase of +1.9% (range, –0.1 to +4.5%). Thereafter, acute changes in sodium excretion produced by various agents were not generally reflected by trends in Na_E.

Biological decay curves, serum sodium and urinary sodium are depicted for 2 patients (Fig. 1, 2). Slopes derived from the curves of urinary excretion clearly reflected the changes in sodium excretion. Large doses of sodium chloride or diuretic therapy which increased sodium excretion steepened the slopes, while administration of DCA promoted sodium retention and flattened the slopes. Serum radioactivity concentration and specific activity paralleled each other. These parameters were quite variable over short periods so that when sodium excretion was altered by drugs the slopes could not be derived. Initial observations suggested that a rise in the slope of serum specific activity above the control slope might occur with DCA administration. For this reason, DCA was given to subjects 10 and 11 while serum radioactivity was high, *i.e.*, after 7 days, but the above response was not confirmed.

The reciprocal of the derived U½ was plotted against sodium excretion for the same periods. There was good correlation, r = 0.79 (Fig. 3). A slightly higher correlation, r = 0.90, was obtained when the test period was divided by the control period immediately preceding it. Radioactivity in the urine samples diminished to such low levels after 30 days that reliable slopes could not be constructed.

Discussion. Daily estimation of total exchangeable sodium by a single injection of Na^{22} over prolonged periods would be a welcome addition to our investigative armamentarium. Unfortunately, the progressive rise in Na_E, coupled with inability to correlate levels of Na_E with acute changes in sodium excretion makes this approach impractical. Compared to our finding of an average daily increase of 1.9% in Na_E. Miller(4) *et al.* found a 1.0% increase over a week's period in 4 subjects maintained on a low salt diet. Since external counts over the patella remained constant while serum specific activity diminished, they postulated that this increase in Na_E might be due to increasing exchange of Na^{22} with bone sodium. However, other causes which might account for the rise in Na_E include extrarenal loss of sodium, calculation of serum specific activity when equilibrium has not been attained, and errors in urine volume measurements, all of which may lead to large cumulative errors.

The biological decay curves of serum Na^{22} radioactivity and specific activity paralleled each other. Because of wide daily fluctuations, these curves were not very valuable in depicting alterations of sodium excretion during the short periods used in this study. On the other hand, the cumulative urinary excretion curves of Na^{22} showed good correlation with daily sodium excretion. However, no additional information was provided by the former determination over the latter.

Summary. Biological decay curves of Na^{22} excretion showed good correlation with urinary sodium excretion during alteration of sodium excretion by sodium chloride, DCA and hydrochlorothiazide over periods of 3 to 7 days. During these short intervals, biological decay curves of serum radioactivity and serum specific activity were too variable to allow correlation with urinary sodium excretion. Daily total exchangeable sodium shows a progressive rise and cannot be used to reflect acute changes in sodium balance.

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Effect of Water Deprivation on Nasal Mucous Flow.* (26388)

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The combined action of mucous cells and ciliated cells to form a moving blanket which collects particles and transports them to given places for disposal is present throughout the invertebrate and vertebrate phyla(1). In the respiratory tract of vertebrates this mechanism functions to keep the surfaces free of debris. Most of our knowledge concerning its malfunction relates to the effects of noxious gases and other "external factors" (5). Initially through a chance observation, we have found that degree of systemic hydration of herring gulls and chickens has a marked effect on movement of the mucous

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