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Relationship of Weight, Venous Pressure and Radiosodium (Na^{22}) Excretion in Chronic Congestive Heart Failure.*

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During the course of tracer studies with Na^{22} † in 2 patients with chronic congestive heart failure and one normal subject, the relationship of weight, venous pressure and sodium excretion was observed.

Each subject received an intravenous injection of a tracer dose of Na^{22} (activity of 12,500,000 counts per minute¹). Over a 2-month period, all urine samples were collected separately and the concentration of radiosodium determined for each, as well as for daily samples of blood serum. All counts were corrected so as to correspond to an initial injection of Na^{22} with an activity of 20,000,000 counts per minute per 100 lb body weight. Weights and venous pressures² were recorded daily.

Results. (1) *Behavior of weight, venous pressure and sodium excretion with the subjects on a low sodium diet.* In all 3 subjects during a 22-day period of low sodium intake (<1.7 g NaCl/day), the weight and venous pressure varied concordantly, although the daily changes were not always concordant (Fig. 1, 2, and 3). The associated changes in sodium excretion were inversely related to those of weight and venous pressure. The patient whose weight and venous pressure were decreasing excreted the largest per cent of the injected Na^{22} during this period, while the

least was excreted by the patient whose weight and venous pressure were increasing.

(2) *Effect of adding sodium chloride to the diet.* Twelve grams of NaCl per day were added to the diet of the normal subject and the patient with congestive heart failure who was recovering (Patient No. 1). This resulted in a marked increase in the sodium clearance and in the sodium excretion of the normal subject, but there was only a slight increase in the clearance without an increase in the total Na^{22} excretion in the patient with heart failure. There was a slight increase in the weight and venous pressure associated with the decrease in total Na^{22} output in the patient with congestive heart failure.

(3) *Effect of Mercurhydrin (mercurial diuretic).* The most pronounced effects of Mercurhydrin (the sodium salt of methoxyoximercuripropylsuccinylurea with theophylline)‡ were an increase in sodium clearance and a decrease in weight in all subjects. Other effects included an increased excretion of water and sodium, usually with a proportionately greater increase in sodium excretion than in water output. Often there was a decrease in venous pressure. It may be noted that frequently during the periods following the diureses due to Mercurhydrin, the excretion of sodium and water was less than had occurred during and just prior to the diureses.

(4) *Relation of sodium excretion to fluid output.* In general, the day to day fluctuations in the excretion of water and of sodium were concordant, the latter fluctuating more, particularly following Mercurhydrin.

(5) *General trends.* During the 60-day period of observation both the venous pressure and weight remained within a constant range

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¹ Reaser, Paul B., and Burch, George E., *Proc. Soc. Exp. Biol. and Med.*, 1946, **63**, 543.

² Burch, G., and Winsor, T., *J. A. M. A.*, 1943, **123**, 91.

‡ Supplied by Lakeside Laboratories, Milwaukee, Wis.

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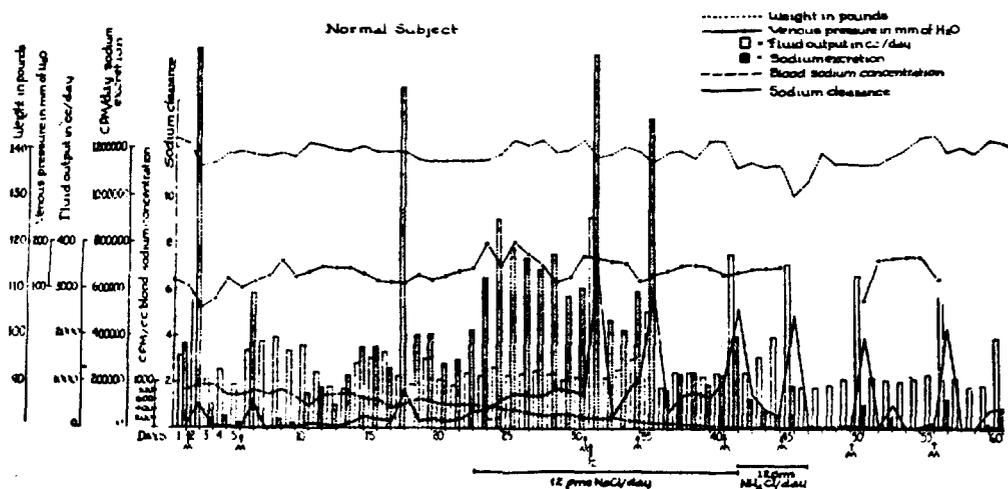


FIG. 1.

Variations in weight, venous pressure, fluid output, radiosodium (Na^{22}) excretion, blood radiosodium concentration and blood radiosodium clearance in a normal 37-year-old negro male. The weight and venous pressure showed daily variations within a narrow range. The addition of 12 g of NaCl per day to the diet resulted in an increase in blood radiosodium clearance and total radiosodium excretion. Intramuscular injections (2 cc) of Mercurhydrin (M) resulted in increases in radiosodium clearance, fluid output and radiosodium excretion. One-half the injected radioactive sodium was excreted in 30 days and 69% was excreted by the end of the study (60 days). The subject was on a low sodium diet except from the 22nd to the 41st day. On the fifteenth day K^{42} was administered for other study purposes.

for the normal subject (Fig. 1), decreased in the patient recovering from failure (Fig. 2) and increased in the patient decompensating (Fig. 3).

The normal subject excreted 50% of the injected Na^{22} in the urine in 30 days and 69% by the end of 60 days (Fig. 4). The patient rapidly improving had excreted 50% in 25 days and 64% by the end of 60 days, while the patient decompensating had excreted only 42% at the end of the 60 days.

For a period of 5 hours following one of the injections of Mercurhydrin (on the 35th day) several serial determinations of weight and venous pressure were made. The behavior of weight, venous pressure, water output, Na^{22} excretion and Na^{22} clearance were similar for the briefer period to that described for the longer intervals. That is, weight and venous pressure were concordant and were inversely related to fluid and Na^{22} excretion and clearance.

Comments. The findings in this study were in accord with the generally accepted ideas of congestive heart failure, that is, the pa-

tients with congestive heart failure were found to excrete less than normal amounts of Na and water during the period that the failure was advancing, but during the period of improvement the excretion of salt and water exceeded that observed in the normal subject. The patient recovering from congestive heart failure excreted more sodium when on a low sodium diet than when on a high sodium one, while the reverse was true for the normal subject (Fig. 1, 2). Mercurial diuretics, digitalis and ammonium chloride were among the other agents, the influences of which were observed during the 60 days of continuous study.

While it was shown that changes in weight and venous pressure were concordant, but both varied inversely with the sodium and water excretion, a change in weight or venous pressure or sodium excretion could not be shown to precede a change in either of the other. Thus, from the data obtained, it is quite unlikely that a mere increase in intracapillary hydrostatic pressure is responsible for these changes. It could not be demonstrated that either sodium retention or in-

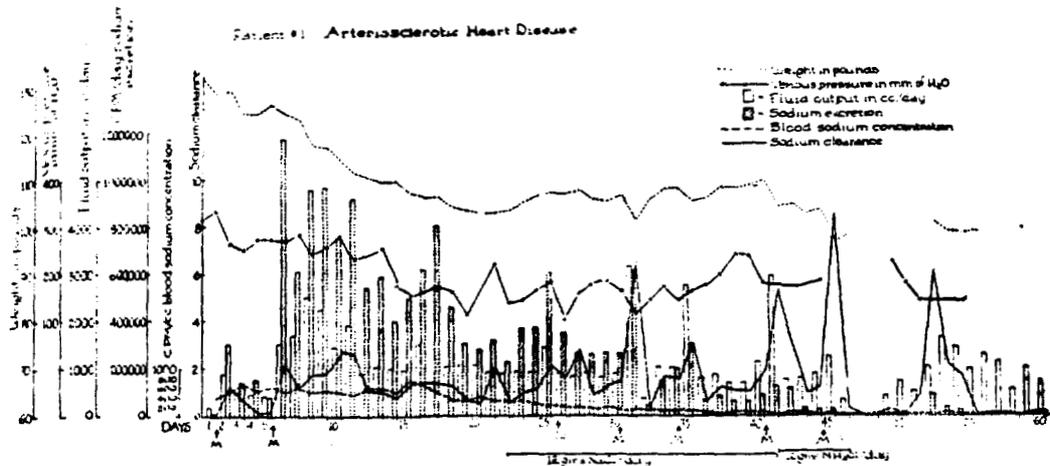


FIG. 2.

Variations in weight, venous pressure, fluid output, radiosodium (Na^{22}) excretion, blood radiosodium concentration and radiosodium clearance in a 62-year-old negro male with senile arteriosclerotic heart disease in congestive heart failure (Functional Class IV) who improved under treatment. Weight and venous pressure decreased concordantly associated with an excretion of radiosodium exceeding that of the normal subject. Addition of 12 g of NaCl per day to the diet caused a concordant increase in weight and venous pressure concurrent with a decreasing excretion of radiosodium. Intramuscular injections of Mercurhydrin (M) in 2 cc doses caused increases in radiosodium clearance, total sodium excretion and total water output. One-half of the injected radiosodium was excreted in 25 days and 64% by the end of the study (60 days). The patient was on a low sodium diet except from the 22nd to 41st day. On the 15th day K^{42} was administered for other study purposes.

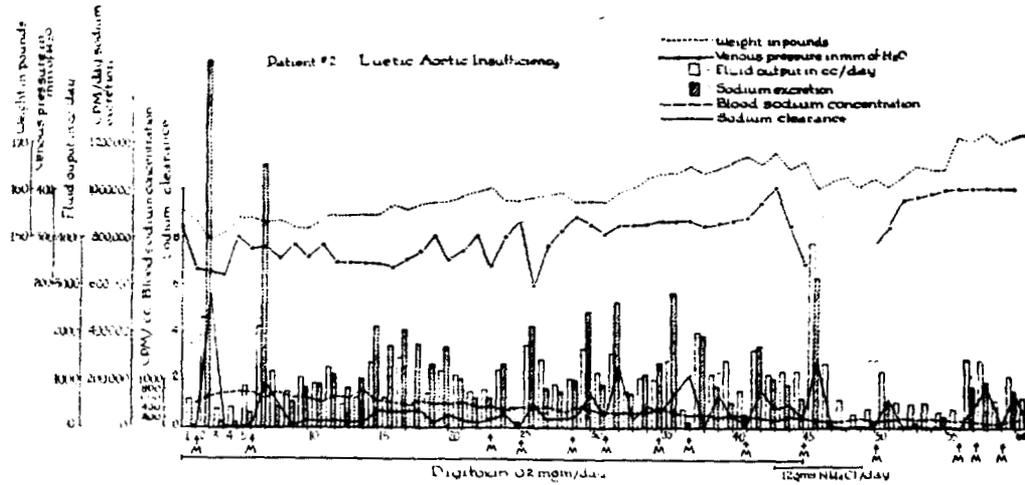


FIG. 3.

Variations in weight, venous pressure, water output, blood radiosodium (Na^{22}) concentration, radiosodium clearance and radiosodium excretion in a 46-year-old negro male with luetic aortic insufficiency admitted in congestive heart failure who decompensated further while under observation. The weight and venous pressure increased concordantly. The rate of excretion of radiosodium was less than that of the normal subject; only 42% of the injected Na^{22} was excreted in the 60 days. Intramuscular injections of 2 cc of Mercurhydrin (M) produced an increase in radiosodium excretion, blood radiosodium clearance and water output. The patient was on a low sodium diet during the entire study and digitalized during the first 45 days. On the 15th day, K^{42} was administered for other purposes.

RADIO SODIUM EXCRETION

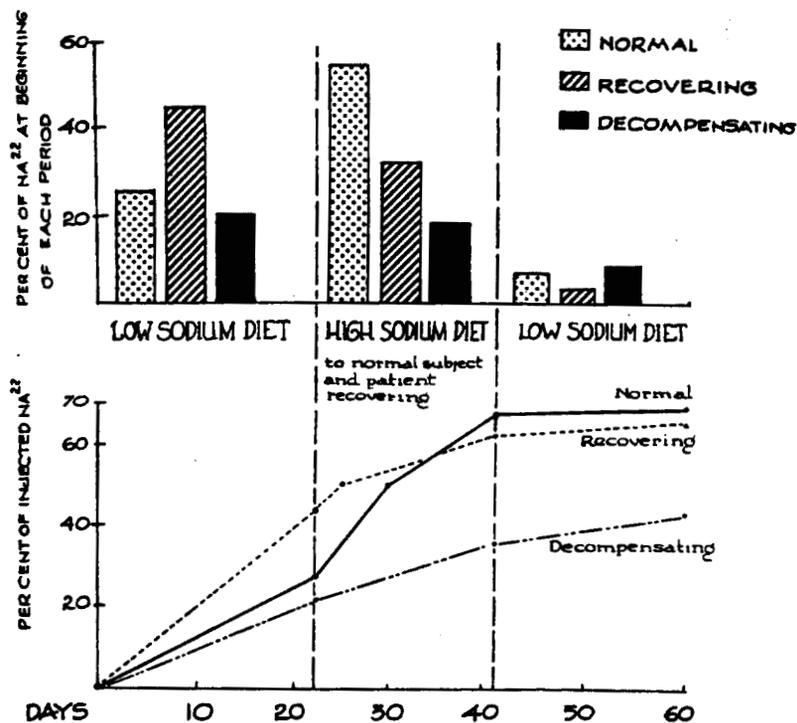


Fig. 4.

The rate of excretion of radiosodium (Na^{22}) as per cent of the total injected dose for the subjects studied. The study may be divided into 3 periods, (1) during the first 22 days the subjects were on a low sodium diet, (2) during the next 19 days the normal subject and the patient recovering from heart failure were receiving 12 g of NaCl per day, and (3) during the remaining period of the observation all 3 subjects were on a low sodium intake. The histograms show the relation of radiosodium output in the normal subject to that of the patients with heart disease, both while on a low sodium diet and while receiving 12 g of NaCl per day. These latter per cent values represent proportions of the amount of Na^{22} in the body at the onset of each of the 3 periods.

crease in venous pressure was the primary factor in edema formation or that edema predisposed to either of these factors. The actual

mechanisms of the retention of Na and water in congestive heart failure remain unknown.