

reabsorption is, according to these workers, limited by the rate at which the tubules are presented with vitamin C by glomerular filtrate, any excess over the maximum rate being excreted in the urine. They state that the nature of the reabsorptive process is such that clearance of vitamin C attains a constant and minimal value. Heinemann (1938) also has said that the elimination of the vitamin in urine following a test dose depends on plasma concentration and the amount filtered from the plasma to the glomeruli, together with the rate of tubular reabsorption.

Thus with a quantitative increase in plasma vitamin C one would expect a sudden rise in concentration of this vitamin in urine. This suggestion is well supported in the literature. Friedman et al. (1940) made 69 observations on 19 subjects in 27 experiments to determine the mechanism of excretion of vitamin C by the kidney at varying plasma ascorbic acid concentrations. The urine was obtained by catheter every 30 to 60 minutes and blood samples were taken frequently during the test period. An increased excretion of vitamin C was observed when plasma concentrations went above 1.5 mg. per cent but below this value excretion of vitamin C was small, 97 to 99.5 per cent being reabsorbed. There was, however, always a constant small amount of reducing substance thought to be ascorbic acid in all urine, independent of plasma concentrations of the vitamin.

Faulkner and Taylor (1938) made studies on the renal threshold for ascorbic acid in a patient with pulmonary tuberculosis. Loss in the urine of ascorbic acid amounted to 200 mg. in 24 hours when the subject was ingesting 500 mg. per day but decreased to 10 mg. in 24 hours after several weeks of low intake with an accompanying decrease in plasma concentrations. When 100 mg. were given orally for 13 days the excretion remained unchanged and plasma continued to fall. When ingestion was increased to 200 mg. daily, plasma values after 8 days were slightly higher and a parallel rise in urinary values occurred. Plasma increased further with an increase in intake to 300 mg. per day and the urinary output rose but losses of vitamin were not large. Faulkner and Taylor conclude from these and other data that the renal threshold for ascorbic acid is about 1.4 mg. per cent.

Lewis and associates (1943) estimated the renal threshold for 12 normal adults and found that the critical plasma concentration of vitamin was between 1.1 and 1.3 mg. per cent or higher. This renal threshold estimate is similar to that of Friedman et al. (1939) who report that in 19 subjects an increase in excretion of vitamin C occurred above plasma concentrations of 1.5 mg. per cent. Higher and lower values for the renal threshold of ascorbic acid may be found in the literature, but the majority of data would suggest that an increase of plasma ascorbic acid above 1.4 mg. per cent would be reflected in a quantitative rise in urinary excretion.

E. Methods of Study of Requirement for Vitamin C

Several methods have been used to estimate human requirement for vitamin C. These include (1) measurement of capillary fragility, (2) urinary excretion of ascorbic acid, and (3) the concentration of ascorbic acid in blood (Smith, 1938).

1. Capillary fragility

Göthlin was the first to use capillary fragility as a measure of ascorbic acid nutrition. He recorded the resistance of blood capillaries at varying intakes of vitamin C and from his results concluded that 19 to 27 mg. per 60 Kg. of body weight was the adult requirement (Smith, 1938) for preventing symptoms of scurvy.

Smith has defined blood capillary strength as a measure of the quantity of vitamin C that is necessary to maintain the integrity of the capillary system but observes that it is more nearly adapted to the determination of a severe tissue depletion than to measure degree of depletion.

The measurement of capillary resistance has been widely replaced by direct chemical tests which determine ascorbic acid concentrations in blood and urine.

2. Urinary excretion

a. Twenty-four-hour excretion of vitamin C. A widely-used method of measuring vitamin C nutrition is that of the

24-hour excretion of ascorbic acid as determined by the indophenol titration method (Smith, 1938). However, the estimates found in the literature for a normal 24-hour urinary excretion of the vitamin are so varied that it is difficult to adequately evaluate them. It seemed expedient therefore, for the sake of clarity, to organize some of the material available in table form. Table 1 lists excretion values for vitamin C in mg. per 24 hours in relation to intake in mg. per 24 hours.

As will be seen from the table, excretion values reported at the same intake of ascorbic acid vary with different investigators. For example, Roberts and Roberts (1942) report an excretion of 85 mg. in 24 hours for 4 subjects at an intake of 75 mg.; Levcowich and Batchelder (1942) report a 13-mg. excretion of vitamin C in 24 hours for 8 subjects at an intake of 87 mg.; while Halli et al. (1939) obtained an average excretion of 15 mg. at intakes varying from 50 to 100 mg. per day.

Table 1, however, gives some indication that excretion of ascorbic acid does not begin to rise to any extent until intake of the vitamin has exceeded 100 mg. and that thereafter urinary loss of vitamin C may be considerable. Since vitamin C is a threshold substance, the increased excretion of it at intakes over 100 mg. might indicate either that increased ingestion exceeds tissue rate of absorption or that body stores are already saturated by the high intake. In either case, the excess over what is actually required is filtered