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USE OF RADIOACTIVE SODIUM IN THE STUDY OF PERIPHERAL VASCULAR DISEASE

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In living animals sodium is uniformly distributed throughout extracellular body fluids, the sodium ion passing freely back and forth across capillary membrane. When radioactive sodium is administered by mouth, intravenously, or interstitially, it rapidly appears throughout the body. Since it emits penetrating radiation, its presence in a part of the body can be detected by bringing near it a sensitive detector of radiation such as a Geiger counter. Counting tubes can be of different dimensions, and shielded to admit radiation only from a particular region. (1)

Radioactive sodium was used by Hubbard, Preston, and Ross to determine the velocity of blood flow in infants and young children. The material was injected into one antecubital vein and the time of its arrival at the opposite hand determined by a Geiger counter. (2) Their series was small, and the results quite variable, but were at least as satisfactory as those obtained by other methods.

This use of the material would readily suggest itself to anyone concerned with circulation times, and similar studies were initiated independently by Smith and Quimby in connection with work on patients suffering from peripheral vascular disease (3). The material was injected into an antecubital vein, with the window of the shielded Geiger counter against the sole of the foot, and arm-to-foot circulation times measured. After a small group had been tested in this manner, it seemed that no valuable correlation could be established between clinical condition and circulation time. However the work led to the development of a test which has proved very useful.

As equilibrium of radiosodium concentration is built up between plasma and extracellular fluid, the counting rate of the Geiger counter at the foot increases, because the blood continues to bring sodium to the capillaries, where some of it diffused out into the interstitial fluid and remains there. A curve can be plotted showing increase in counting rate with time after administration of the material, and it has been found that the shape of this curve can often be correlated with clinical condition. In individuals with no known vascular disturbance, the "build-up" curves, calculated on the basis of 100 microcuries of radiosodium administered, all fall within a relatively narrow region, which may be called the normal range. For patients with various vascular disorders, the curves may be within, above, or below this region. A very low curve may be due to arterial obstruction, arteriosclerosis, hypertension, spasm, degeneration of capillaries, or combinations of these factors (or others). A very high one is due either to inflammation (increased blood supply) or to relaxation of vessel walls by nerve block, sympathectomy, or other reason. Numerous illustrative curves have been published; several will be shown and discussed. These curves have been useful in diagnosis, prognosis, and selection of therapy, in many conditions involving the peripheral circulation. Repeated tests on the same individual give information regarding the course of the disease and the efficacy of various therapeutic measures. (4). Of particular value has been the establishment of a suitable level for amputation, by demonstrating the presence of adequate blood supply. It has been possible to reduce considerably the number of above-the-knee amputations in cases of diabetic gangrene and similar conditions, with consequent increase in economic and psychologic salvage.

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The production of venous thrombosis has been attributed to a tendency to stasis in the blood vessel. Wright, Osborn, and Edmonds, in London, have adapted the procedure just described to a measurement of the rate of venous flow in the legs, by injecting the isotope into a vein in the dirsum of the foot, and observing its arrival at the groin. (5) Graphic recording of count rate was essential, since

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the average normal foot to groin time was about 18 seconds. Comparison of these times observed for women in the first stage of labor and again about a week post partum reveal a very marked slowing of the circulation during labor. (6) Data are not presented for the rates just prior to the onset of labor; it would be of interest to have several readings on a patient during the course of her pregnancy.

For study of circulation in a circumscribed tissue region, Kety developed a method which is in a sense the reverse of that of Smith and Quimby. (7) That is, sodium clearance is measured, rather than sodium build-up. In this procedure, a smaller amount of the isotope is used, and the whole body radiation correspondingly reduced. The material is injected into the tissue in question (in his published material the gastrocnemius muscle). A shielded Geiger counter, with a suitable window, is placed directly over the site of injection, and the decrease in counting rate recorded. When the observed values are plotted on semi-logarithmic paper, with the number of counts per minute as ordinate and minutes as abcissa, a linear expression of the rate of disappearance of the sodium from the muscle is obtained. The slope of the line is related to the condition of the tissue. Kety has given a straightforward mathematical analysis of his procedure. The method has been used by Elkin and his group, and appears to be applicable to a considerable variety of problems. (8)

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