Studies of Human Peripheral Blood Flow: The Effect of Injection Volume on the Intramuscular Radiosodium Clearance Rate

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The effects of changes in injection volume on the intramuscular radiosodium clearance rate was investigated in six normal young men. The clearance rate was found to be quite sensitive to the volume of solution injected, and an increase in the rate of clearance corresponding to a decrease in volume was uniformly noted. Rigid control of the injection volume is necessary when this method is used for regional blood flow measurements.

The development of practical methods of measuring regional blood flow has been the aim of a number of investigators, particularly since the use of isotopic tracer technics has become more widespread. The work in this field has been ably reviewed by Wright and by McGirr. In general, the approaches to a study of peripheral and/or regional blood flow have taken two principal pathways.

The first general method consists of the measurement of the build-up of activity at a given site following the intravenous injection of a radio-isotope. Smith and Quimby have pioneered this method, employing sodium as the isotope, and have used it extensively in the study of peripheral vascular disorders. Others, however, have questioned the sensitivity of the method. From our own observations, this lack of sensitivity may be due in part to the complications caused by the distributive events occurring elsewhere in the body after intravenous injection of radiosodium.

The second principal method of approach in the study of regional blood flow consists of the measurement of the rate of disappearance of a radioisotope following its local injection, as proposed by Kety. The clearance rate obtained by this method reflects some function of the circulation, because experimental alteration of blood flow produces the expected changes in clearance rate. The rate of clearance is slowed by the application of a tourniquet and by the local injection of adrenaline. The clearance rate is increased by exercise, by reactive hyperemia, by hyperthyroidism, and by the local injection of histamine.

When the intramuscular clearance method has been applied to the study of peripheral vascular disease, overlapping values and lack of sensitivity have also been noted. As reported herein, our own observations with this method have shown that the clearance rate following intramuscular injection is very sensitive to the volume of solution injected. Rigid control and standardization of the injection volume is of utmost importance when this test is applied to a study of regional blood flow.

Methods

Young normal males between the ages of 20 and 30 years were placed in a prone position and isotonic sodium chloride labeled with approximately 5 microcuries of radiosodium was injected intramuscularly with a 23 gage needle at comparable sites and depths of both right and left muscles, usually the gastrocnemius but occasionally the gluteus maximus. A standard 1.0 ml. volume was always injected on one side, and volumes varying from 0.005 ml. to 1.0 ml., but containing the same amount of radioactivity, were injected on the opposite side. Immediately after injection, shielded external counters were used to record the activity remaining at the injection sites.
Prior to these bilateral injections it was established, with detectors on both extremities and with radiosodium injected on only one side, that dilution of the sodium\(^{24}\) which enters the circulation from the injected side was so great that no appreciable background effect was noted by the counter over the opposite extremity.

![Figure 1](image)

**Fig. 1.** Changes in intramuscular radiosodium clearance rates produced by varying injection volumes in six normal young men. Ordinates are normalized activities in counts per minute. Abscissas are expressed as minutes following injection. The initials of the subject and the volume and site of injection are indicated on each graph.

### Results

In six subjects so determined, a discrepancy in the rate of clearance corresponding to an alteration in volume was uniformly noted as illustrated in figure 1. The rate of disappearance of the standard 1.0 ml. injection in different individuals showed moderate variation, but when smaller volumes were injected in the same individual, a consistent increase in the disappearance rates was produced whose magnitude was dependent on the smallness of the volume injected. However, when identical volumes were used in the same individual, the clearance rates were practically identical (figure 1).

So that data from all subjects could be studied, the time necessary for the curves to fall to 50 per cent of their initial activity has been used as the basis of comparison. Figure 2 summarizes the data obtained in the six subjects, and demonstrates the correlation between the removal rate and the size of the injection volume for the group as a whole.

### Discussion

Presently available data do not completely establish the cause of the variation in clearance rates observed with varying injection volumes. However, several possible mechanisms may be involved either singly or in combination. Among these is the mechanical compression of adjacent capillary beds by a large injection volume. This might be expected to lead to a progressive increase in clearance rate as the
compressing volume decreases with time; however, such a rate change is not observed.

The total quantity of electrolyte which must be removed by a relatively limited capillary bed may be pertinent. In this regard, because of the lack of proportionality between increases in surface area with increases in volume, slower clearance rates with larger injection volumes would be expected. Finally, the relatively long diffusion path for sodium from the center of the injection bubble may be a rate-limiting factor.

**Summary and Conclusions**

1. The effect of changes in injection volume on the intramuscular radiosodium clearance rate was investigated in six normal young men.
2. An increase in the rate of clearance corresponding to a decrease in volume was uniformly noted.
3. Rigid control of the injection volume is indicated when this method is used for regional blood-flow measurements.

**Sumario Español**

El efecto de cambios en volumen de inyección en la velocidad de disipación del radiosodio intramuscular fue estudiado en seis hombres jóvenes. El promedio de disipación se encontró ser muy sensitivo al volumen de solución inyectada y un incremento en la velocidad de disipación correspondiente a un decremento en el volumen se observó uniformemente. Es necesario un control rígido del volumen a inyectarse cuando este método se usa para la determinación de la circulación regional.

**References**

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