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ON THE AVAILABILITY FOR EXCHANGE OF SKELETAL WATER, SODIUM, AND CALCIUM

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The isotope technique has made possible measurements of the magnitude and the rate of exchange of various constituents between the tissues on one hand and the serum (extracellular water) on the other. The present paper is concerned with the exchange of bone water, bone sodium, and bone calcium.

BONE WATER

Human bone contains 10–50 per cent water on the fresh weight basis, with the lower figures for cortical bone, and the higher figures for cancellous bone. When bone from other species are analysed about the same figures are met with. This bone water is all completely exchangeable as evidenced with intravenously administered D_2O as indicator. The rate of exchange is rapid, over 90 per cent of the bone water being exchanged within 4 hours and 100 per cent exchange within 24 hours, see *Edelman et al.* 1954. Significant differences in the rate and magnitude of this exchange between different samples of bone seem hard to measure.

BONE SODIUM

About one half of the body sodium is located in the skeleton and of this skeletal sodium 20–50 per cent (in rats) is ascribable to the bone water. As measured with Na^{22} dilution technique, this *bone water sodium* is all exchangeable at a rate which compares with that established for bone water. *The excess sodium of bone* does not all exchange

with serum sodium. Thus, following the subcutaneous administration of Na^{22} to adult rats, it was found that about 40 per cent of this excess sodium rapidly (within 8–16 hours) exchanges with serum sodium. Even if the equilibration period is stretched over 120 hours (in rats, *Bauer* 1954 a) or 1 month (in dogs, *Edelman et al.* 1952), no further exchange is found. There does not seem to exist differences in the rate and magnitude in the exchange of excess bone sodium for different samples of bone.

If radiosodium is administered to actively growing rats, radiosodium is incorporated in the non-exchangeable part of the bone sodium but not through an exchange process but along with formation of new bone mineral.

BONE CALCIUM

On a fresh weight basis bone contains 15–30 per cent calcium. Recent investigations have demonstrated that only a small fraction of the bone calcium is exchangeable with the serum calcium. Thus, 16 hours following the administration of Ca^{45} to *adult* rats, the specific activity of the tibia shaft calcium was not more than about 1 per cent of the serum calcium specific activity (*Bauer* 1954 a). As at least 50 per cent of the activity recovered from the shafts at this interval can be assumed to have been incorporated in the non-exchangeable part of the bone salt (see *Bauer* 1954 b), the actual amount of exchangeable bone calcium is probably less than 0.5 per cent of this total calcium content of the tibia shafts investigated. Judging from similar calculations on incisors and cancellous bone it seems probable that the exchangeable calcium calculated on the entire skeleton does not exceed 1 per cent. A figure of this order has been reached also by other workers (*D. H. Tomlin*, personal communication). The rate of exchange is probably in the same range as that of sodium and water in bone.

CONCLUSIONS

There is a definite difference in the *magnitude* of the exchange with serum between the three bone constituents water, sodium, and calcium. Thus bone water exchanges completely, bone sodium exchanges only to about 40 per cent, and calcium only to about 1 per cent of the non-water bone sodium and calcium, respectively. On the other hand, a comparison of the *rates* of exchange of bone water, bone sodium, and bone calcium does not reveal any such differences between these three bone constituents.

SUMMARY

The rate and magnitude of exchange between serum and bone of water, sodium, and calcium is discussed in the light of recent information derived from isotope experiments.

RESUME

On a trouvé qu'un échange de sodium, d'eau et de calcium se fait entre le sérum et l'os. La vitesse et la grandeur de cet échange sont vues à la lumière de l'information obtenue par des recherches à l'aide d'isotopes radioactifs.

ZUSAMMENFASSUNG

Die Geschwindigkeit und das Ausmass des Austausches von Wasser, Natrium und Calcium mit Serum und Knochengewebe wird hier im Lichte neuer, durch die Isotopenuntersuchungen gewonnene Erkenntnisse besprochen.

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