Simultaneous Multi-Isotope Investigation of Renal Function

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Various labelled diagnostic materials (Hippuran, diethylene-triamine-penta-acetate, human serum albumin) were simultaneously administered to individuals exhibiting normal and pathological renal function in order to investigate the renograms of these compounds, as mutual reference tracers, helping each other in their correct interpretation, and to follow the movement of these tracers between their compartments. Three different radionuclides (\(^{125}\text{I}, ^{131}\text{I}, ^{58}\text{Co}\)) used as labels were also investigated concerning their separate measuring possibilities under in vivo and in vitro circumstances. Dual ratio adjustment was carried out according to tracers Hippuran* left kidney and sides right kidney. So we got "secondary quotients" the values of which remained nearly constant in normal cases during renography. The values of the quotient, however, changed in pathological conditions. In addition to the kidneys, simultaneous measurements of the isotope pairs were made over the cardiac and shoulder regions to detect the concentration changes of the tracers. It was found that the normal direction of the gradual activity decrease in the early excretion phase is: shoulder (representing mainly the extravascular compartment) — blood — kidney; in pathological cases the most striking activity decrement can be observed in the blood. Both the activity differences found at the various measurement points in vivo and the differences of the ratios between the identical in vivo—in vitro data refer to deviations of the Hippuran and Co-DTPA pools.

In isotope renography efforts have been made not only at qualitative description of the curve, but also to get quantitative data. After initial attempts [1, 2] it has become customary to analyse the renogram representing the concentration changes of a single substance, radio-Hippuran [3—10, 12—15]. The pioneer work of the quantitative analysis may be attributed to Horgan et al. [11], but their average parameters cannot in general be applied to individual cases.

It was our aim to investigate simultaneously several functions of the kidneys without repeatedly inconveniencing the patients. The changes of these renal functions were plotted against time, compared to each other and to the tissue levels of the tracers by administering simultaneously different kinds of isotopes (\(^{125}\text{I}, ^{58}\text{Co}, ^{131}\text{I}\)) in different chemical bonds: Hippuran, diethylene-triamine-penta-acetate (DTPA) and human serum albumin (HSA). Thus we got simultaneous information about tubular secretion, glomerular filtration and blood flow of the kidneys.
Methods

A four-channel radiocirculograph (EFKI-type) was used. Two channels suitable for one isotope-pair were selected at each measuring point of the kidneys.

Various isotope-pairs were used from the above mentioned isotopes. The signals of the harder gamma-emitting isotope originating from each detector were conducted directly to the two channels of the EFKI-radiocirculograph and after having been measured in an integral operating mode they were recorded and stored on tape. The integration was performed above the spectral region of the softer gamma-emitter.

The low-energy member of the isotope-pair was measured by branching off the signals of the above inputs and conducting each into the analyzer of an NK—108 type energy-selective scaler (Gamma Factory, Budapest). The gain of the scaler, the base line and the width of the channel were chosen in a way that they should correspond with the photopeak of the softer gamma-emitter and that the overlap of the harder one should be minimal (1/8—1/12 of the values measured in its own channel). The information obtained in this differential operating mode was likewise carried onto a tape-recorder. The symmetrical adjustment of the channels was carefully checked. In the case of combination with a third isotope, the signals arriving from a third detector (e.g. shoulder region level) were separated in two NK—109 type energy-selective ratemeters (Gamma Factory, Budapest) so that, in addition to the third isotope, we could also measure one member of the isotope pair registered by the radiocirculograph (in vivo reference measurement). The tissue concentration changes of the two latter isotopes can be compared with the level changes taking place in the blood by means of subsequent in vitro measurement. In case of radioactive HSA which tends to achieve a constant plasma level the in vivo and in vitro reference measurements offer themselves of their own accord.

Under in vivo circumstances not only the administration but also the separate spectral detection of the gamma-emitting isotope components must be carried out simultaneously according to the above arrangement. Such a separation can be successful and unequivocal only if

1. one of the isotopes ($^{58}\text{Co}$) can be measured in an integral energy region entirely separated from the other two partners,

2. if the other isotope ($^{125}\text{I}$) does not disturb the third partner ($^{131}\text{I}$) in its measurement channel.

Fig. 1 shows the relative spectral selection and overlap relating to the $1 - 1 \mu\text{Ci}$ standards of the isotopes used. It can be seen that the activity of $^{125}\text{I}$ and $^{131}\text{I}$ origin is not measured practically in the $^{58}\text{Co}$ integral measurement region, neither can the activity of $^{125}\text{I}$ be measured in the channel of the photopeak of $^{131}\text{I}$. In this channel the overlap from the $^{58}\text{Co}$ is only 12% of the activity of the $^{131}\text{I}$ standard.