Deconvolution Analysis of the Dynamic Renal Scan

Deconvolution analysis of the renogram has become a topic of current interest and could become useful in the determination of functional nephron mass. Recently Diffey et al. (*1*) proposed a matrix algorithm for performing this deconvolution, where the result is thought to represent the impulse response function of the renal system. Their procedure followed from the assumption that the renogram represents the convolution of the renal impulse response with the renal input function. The authors identified this input function with the cardiac time–activity curve, which represents the activity contained in the blood. This was a poor assumption.

The activity contained in the blood decreases with time, and the change in this activity represents the negative of the amount of activity entering the renal system. Thus, the renal input function depends on how the blood activity changes and is given by the negative time derivative of the blood–activity curve. This can also be shown mathematically since the distribution of a renally excreted radiopharmaceutical can be compartmentally modeled and described by differential equations (*2,3*).

During my attempts to reproduce previous work (*4*) in this area, I too was frustrated by the tendency for the resultant impulse response function to take negative excursions. When the deconvolutions were repeated using the correct renal input function, the problem did not recur. In addition, only minimal low-pass filtering was required, as opposed to the data-bounding methods employed by the authors.

C. ROBERT APPLEDORN
University of New Mexico School of Medicine
Albuquerque, New Mexico

REFERENCES

1. DIFFEY BL, HALL FM, CORFIELD JR: The ^{99m}Tc-DTPA dynamic renal scan with deconvolution analysis. *J Nucl Med* 17: 352–355, 1976

2. APPLEDORN CR: A letter to the editor. *Br J Radiol*: to be published

3. DEGRAZIA JA, SCHEIBE PO, JACKSON PE, et al.: Clinical applications of a kinetic model of hippurate distribution and renal clearance. *J Nucl Med* 15: 102–114, 1974

4. KENNY RW, ACKERY DM, FLEMING JS, et al.: Deconvolution analysis of the scintillation camera renogram. *Br J Radiol* 48: 481–486, 1975

Reply

We thank Dr. Appledorn for his interest in renal deconvolution and his comments on our work (*1*). We feel, however, that he is mistaken in his premise that the input function is the negative time derivative of the blood activity. It appears that he is confusing the principles of compartmental analysis, where the activity removed by the kidney is indeed given by the negative time derivative of the blood activity curve, with the technique of deconvolution applied to linear time-invariant systems.

The basis of deconvolution lies in the assumption that the kidney must be regarded as a linear system. This means that the amplitude of the renogram is taken to be directly proportional to the administered dose, or the activity contained in the blood. The class of linear systems is defined by the principle of superposition (*2*). If $y_1(t)$ and $y_2(t)$ are the responses when $x_1(t)$ and $x_2(t)$ are the respective inputs, then the system is linear if and only if

$$T[x_1(t) + x_2(t)] = T[x_1(t)] + T[x_2(t)] = y_1(t) + y_2(t), \quad (1)$$

where $T[x(t)]$ is defined as the operator that maps an input sequence $x(t)$ into an output sequence $y(t)$.

This principle will hold if the input sequence is taken as the blood activity curve and the output sequence is taken as the observed renogram, as described in our paper. If, however, the input sequence is taken as the negative time derivative of the blood activity curve, Eq. 1 will, in general, not hold and deconvolution may no longer be applied.

We suggest that the reason why Dr. Appledorn appears to perform satisfactory deconvolution, with reduced occurrence of negative excursions in the calculated retention function, arises from the observation that in practical renography the blood activity curve is closely approximated by the sum of two exponentials (*3*). The negative derivative of this function will yield a double exponential with a more rapid reduction in relative amplitude than the blood activity curve. The retention function exhibits negative excursions since the rate of removal of tracer from the kidney exceeds the rate of input from the blood. However, if the input function which is used decays more rapidly than the blood activity curve, the resultant negative excursions in the retention function will be diminished, but by operations that we regard as invalid assuming the present linear model of the kidney.

B. L. DIFFEY
J. R. CORFIELD
F. M. HALL
Kent and Canterbury Hospital
Canterbury, Kent, United Kingdom

REFERENCES

1. DIFFEY BL, HALL FM, CORFIELD JR: The ^{99m}Tc-DTPA renal scan with deconvolution analysis. *J Nucl Med* 17: 352–355, 1976

2. OPPENHEIM AV, SCHAFER RW: *Digital Signal Processing.* Englewood Cliffs, N.J., Prentice-Hall, 1975, p 11

3. FLEMING JS, GODDARD BA: A technique for the deconvolution of the renogram. *Phys Med Biol* 19: 546–549, 1974

Gallium-67 Scanning of Tuberculous Peritonitis

Dr. Steinbach's report of tuberculous peritonitis shown on ^{67}Ga-citrate scan (*1*) prompted us to review a similar case in our files. The essentially identical distribution of ^{67}Ga in our patient has led us to submit the following case report as additional data supporting Steinbach's finding that ^{67}Ga is concentrated in the lesion of tuberculous peritonitis.

The patient, a 40-year-old black man, was admitted to an outlying hospital where a workup for a 2-day history of nausea, vomiting, and right upper quadrant abdominal pain led to a diagnosis of right lower lobe pneumonia with pleural effusion. Despite antibiotic therapy, the abdominal pain and temperature elevations to 104°F persisted. Upon transfer to our hospital, the patient was found to be febrile but in no acute distress. Signs of right pleural fluid were