The Second Renal Peak Phenomenon—Significance of an Observed Aberration of Renal Blood Flow and Function Curves: Report of Three Cases

Erol M. Beytas and Michael W. Hanson

Duke University Medical Center, Durham, North Carolina

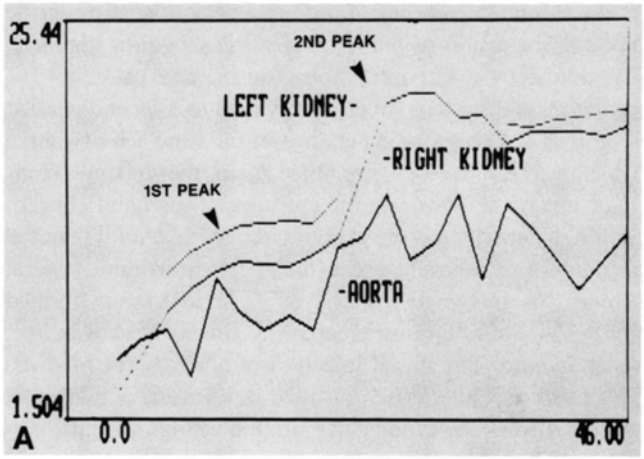
Computer-generated curves from ^{99m}Tc DTPA renal studies provide information about renal blood flow and function. The characteristic appearance of these curves can be altered by a variety of pathologic and/or artifactual conditions. One such alteration can be the appearance of a "double peak" in any portion of the curve. Three such occurrences are presented. In each case, with careful review of the dynamic computer images and discussion with the technologist, a plausible explanation of the curve aberration could be determined. The appearance of a second peak in the renal curves requires careful review of the computer-acquired images for visualizing entry of additional tracer into the venous circulation.

Radionuclide techniques are used for the analysis of renal functional status (*1,2*). Renal perfusion and function can be evaluated and differentially compared. The information obtained from the dynamically acquired computer images can provide data as visual correlation in addition to the generated curves and numerical values. The combination of these data from the study can result in a better understanding of the findings for appropriate conclusions.

Three separate occurrences of a double peak of activity that appeared in either the renal blood flow or renal function portion of the analysis curves of a ^{99m}Tc DTPA renal study are described. The aberrant appearance of these curves could be explained in each case on the basis of technical reasons.

Case 1

Posterior renal images were acquired on a large field of view gamma camera with a general all-purpose collimator following the i.v. injection of 15 mCi (855 mBq) of ^{99m}Tc DTPA. A tourniquet was placed proximal to the injection site to allow for venous filling. After the DTPA was injected, the tourniquet was released. The dynamic study was acquired at a rate of 2 secs/frame. The immediate images were acquired for a total count rate of 750 K. Each static image thereafter



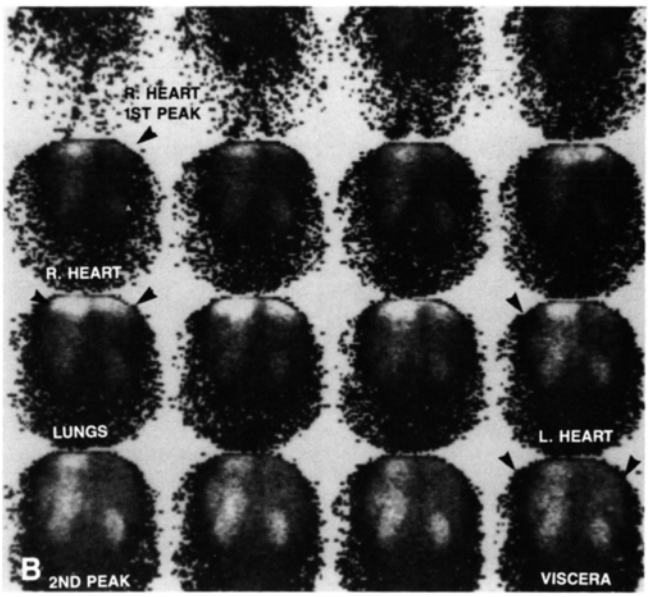


FIG. 1. The time-activity curve (A) demonstrates a peak at ~ 12 sec followed by a second peak at ~ 30 sec. Computer images (B) demonstrate sequential appearance of the right heart, lungs, left heart, and visceral activity.

For reprints contact: Erol M. Beytas, MD, Div. of Nuclear Medicine, P.O. Box 3949, Duke Medical Center, North Durham, NC 27710.

was acquired for the same length of time required to obtain the 750 K count immediate image.

The first occurrence is noted in Figure 1. The time-activity curves demonstrate an initial rise to a brief plateau at ~ 12 sec. This is followed by a rise to a second peak at ~ 30 sec. The characteristic change is noted in the aorta and both kidneys. The dynamic computer images, particularly when played in a closed cine loop format, demonstrate the entrance of a second concentration of activity into the venous circulation. This occurrence can be identified by the sequential appearance of the right heart, lungs, left heart, and the visceral activity that is additive to the initial bolus of administered activity. In this instance, the ^{99m}Tc DTPA was injected directly into a peripheral vein, but subsequently, the needle and syringe were flushed by withdrawing blood from the puncture site back into the syringe and then reinjecting.

Case 2

The second occurrence of a double peak appearing in the blood flow portion of the renal curve is shown in Figure 2. The time-activity curves demonstrate the first peak at ~ 11 sec with a plateau that subsequently rises to a second peak at ~ 45 sec. A corresponding change in the time-activity curve over the spleen can be seen. Once again, the dynamic computer images demonstrate the entrance of a second concentration of activity into the venous circulation, with sequential appearance of the right heart, lungs, left heart, and visceral activity. In this instance, the ^{99m}Tc DTPA was injected through an indwelling intravenous (i.v.) line instead of a direct venapuncture. The initial injection of activity was followed by a flush of saline, which resulted in releasing activity that was retained in the venous line into the venous system.

Case 3

The third occurrence of a double peak occurs in the renal function portion of the curve, in contrast to the dynamic flow portion, and is shown in Figure 3. The time-activity curves demonstrate a normal peak at ~ 3 min followed by a brief decline until a second rise beginning at ~ 10 min is noted and peaks around 15 min. The reappearance of activity also is identified over the liver and spleen occurring slightly before the resurgence within the kidneys. The dynamic computer images demonstrate the entrance of the second concentration of activity, identified primarily by a transient increase of activity over the liver and spleen regions. In this instance, the radiotracer was injected through an indwelling catheter. At 10 min into the study, the same i.v. line was flushed with saline, and immediately thereafter lasix was given through the same i.v. catheter. This dual injection between 10 and 14 min of the study resulted in flushing residual ^{99m}Tc DTPA from the i.v. line into the venous circulation.

DISCUSSION

Meaningful analysis of renal perfusion depends on the delivery of an adequate bolus of activity to the distal aorta and renal arteries. This portion of the study is highly vulnerable to the technique used to inject the tracer. Prolonged injections or infiltrations at the injection site can affect significantly the ability to extract useful information from the first one minute of the study. Techniques exist to correct for aberrations of bolus shape, primarily by deconvolution of the bolus from the kidneys (*3*). The Oldendorf injection technique is a method to maximize the likelihood of obtaining a good bolus of activity (*4*). Normally, activity reaches the kidneys ~ 1 sec after the bolus has passed the origin of the renal

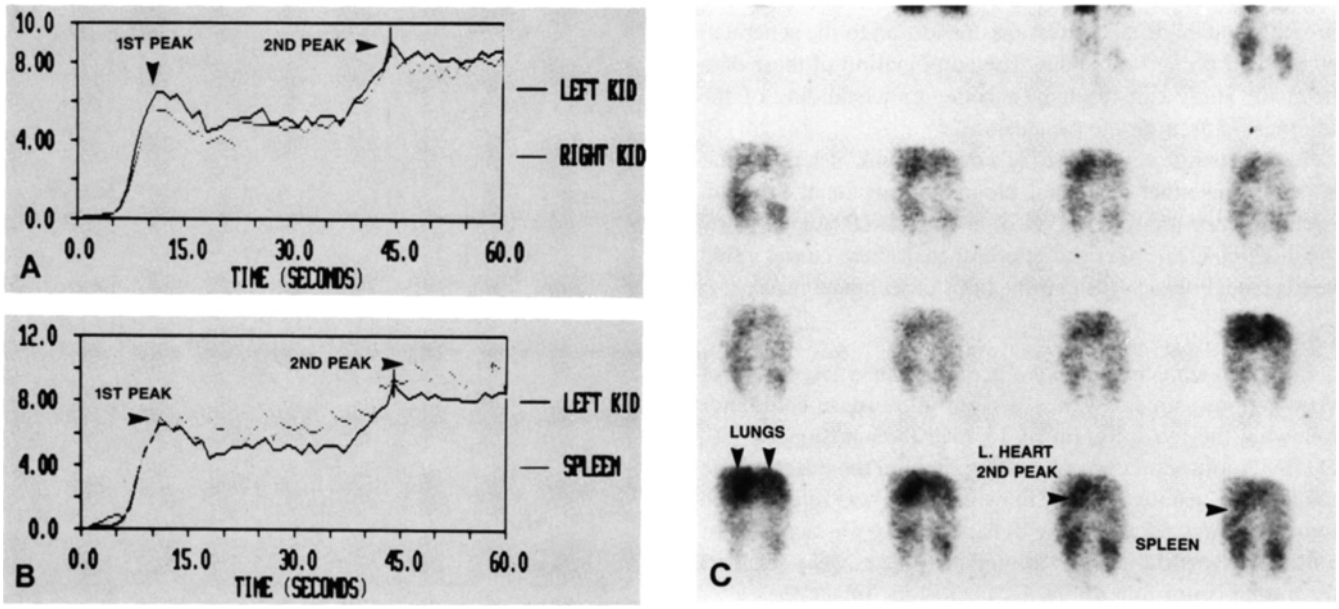


FIG. 2. Time-activity curve (A) demonstrates two peaks: one at ~ 11 sec, the other at ~ 45 sec. A corresponding change in the time-activity curve (B) over the spleen can be seen. Computer images (C) demonstrate sequential appearance of the right heart, lungs, left heart, and visceral activity.

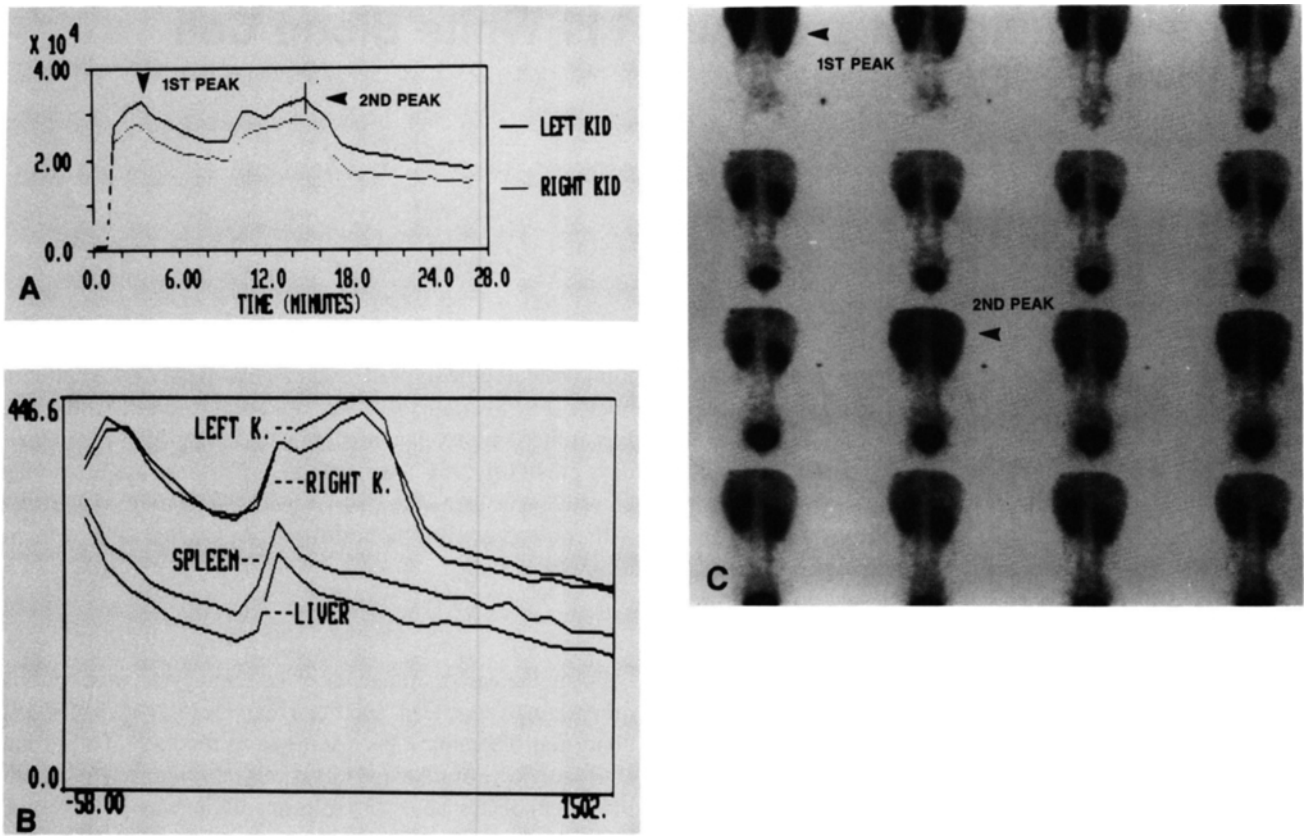


FIG. 3. Time-activity curve (A) demonstrates a double peak during the renal function portion of the curve. The curve peaks at 3 min followed by a decline and a subsequent second peak at ~ 15 min. The reappearance of activity also is identified over the liver and spleen (B) before the resurgence in the kidneys. Computer images (C) demonstrate transient increase of activity over the liver and spleen.

arteries (*2*). Subsequently, activity will peak in the kidneys, usually within 5 min, and then gradually diminish over the remaining 30–50 min of the normal ^{99m}Tc DTPA renogram study. Many factors, whether secondary to normal renal variations, renal pathology, computer malfunction, artifacts, or technical difficulties, can alter the expected appearance of these components of the curves.

The second peak in the renal curve in each case was due to a variable time delayed injection of additional ^{99m}Tc DTPA into the circulation. In the first instance, the injection was via a peripheral vein. Withdrawing blood from a vein after injection of any radiopharmaceutical is a common practice used to reassure the technologist that the injection has not infiltrated and to flush any residual radiopharmaceutical from the syringe. However, evidence for a successful injection can be ascertained from the dynamic images, and the usually desired flush of residual radionuclide in these instances is undesirable. Therefore, this practice should be avoided when performing dynamic studies.

A direct venapuncture in a median basilic vein in a fully extended arm should be used for injection whenever possible. However, at times, this vein is not accessible and for the second and third patient an indwelling i.v. line was used as the access route. In both instances, activity retained in the i.v. tubing was injected into the circulation by a flush of saline or saline and lasix. The only difference in these two patients was the length of time between the first and second injections, resulting in appearance of the second renal peak at different points on the time-activity curves. When the technologist has no alternative to using the patient's indwelling i.v. line for a dynamic study, the most distal injection port available should be used. The i.v. line should not be flushed immediately after the bolus injection. If no alternative injection site other than the same indwelling i.v. line is available for the later administration of lasix, then the technologist should indicate on the film that it was administered as such.

Three separate occurrences of an aberration in the expected appearance of either the renal blood flow or renal function curves have been presented. In each instance, an explanation of the phenomenon could be determined by knowledge of the technical aspects of the case and careful review of the computer-acquired images.

REFERENCES

1. Harbert J, DaRocha AFG. *Textbook of Nuclear Medicine Vol. II: Clinical Applications.* Philadelphia: Lea and Febiger; 1984:481–521.

2. Mettler FA Jr, Guiberteau MJ. *Essentials of Nuclear Medicine Imaging,* 2nd ed. Orlando, FL: Grune and Stratton; 1986:284–301.

3. Kuruc A, Treves S, Parker JA. Accuracy of deconvolution algorithms assessed by simulation studies: Concise communication. *J Nucl Med* 1983; 24:258–263.

4. Oldendorf WH, Kitano M, Shimizu S. Evaluation of a simple technique for abrupt intravenous injection of radioisotope. *J Nucl Med* 1965;6:205–209.