circulating free levels. In a recent publication, Vining et al. reached the same conclusion, although their T_4 assay lacked the sensitivity to measure salivary T_4 accurately (*2*).

MICHAEL K. ELSON
REX B. SHAFER
JOHN E. MORLEY
VA Medical Center
Minneapolis, Minnesota

REFERENCES

1. ELSON MK, MORLEY JE, SHAFER RB: Salivary thyroxine as an estimate of free thyroxine: Concise communication. *J Nucl Med* 24:700-702, 1983
2. VINING RF, MCGINLEY RA, SYMONS RG: Hormones in saliva: Mode of entry and consequent implications for clinical interpretation. *Clin Chem* 29:1752-1756, 1983

Re: The Derivation of the Gamma-Variate Relationship for Tracer Dilution Curves

Mr. Davenport should be commended for his elegant derivation of the gamma-variate function for indicator dilution curves (*1*). I have, however, one minor question: Pursuant to Eq. 18, the statement is made, "Since the total amount of tracer injected at the beginning of the vessel is assumed to be unity, we must have

$$\int_0^\infty C(\alpha, \beta, t)dt = 1 \ldots$$

However, since the quantity $C(\alpha, \beta, t)$ is a concentration, should not the integral extend over a volume that in turn is evaluated at $t = 0$? Perhaps the author should have said that, by convention, the area under the gamma variate is taken to be unity.

MICHAEL D. HARPEN
University of South Alabama
Mobile, Alabama

REFERENCES

1. DAVENPORT R: The derivation of the gamma-variate relationship for tracer dilution curves. *J Nucl Med* 24:945-948, 1983

Reply

Dr. Harpen is correct in pointing out that Eq. (18) refers to a concentration rather than an amount. There are a couple of ways of resolving this discrepancy. One is to stipulate that the area under the curve be unity, as Dr. Harpen suggests. Another would be to multiply by the volume of distribution, V, and set the product equal to unity. Since the initial amount of tracer injected at $t = 0$ is diluted in the volume, V, of a theoretical mixing chamber, the result would be the same.

ROBERTSON DAVENPORT
University of Michigan Medical Center
Ann Arbor, Michigan

Re: New Perspectives in Localizing Enlarged Parathyroids by Technetium-Thallium Subtraction Scan

We read with great interest the recent report by Ferlin et al. (*1*) on imaging parathyroid adenomas by combined technetium and thallium subtraction scans. The relatively noninvasive nature of the combined scanning technique, with its high success rate, offers an attractive imaging modality in these patients. Previous imaging modalities—including barium esophagrams, thyroid angiography, and venous sampling for parathormone levels—have all had varying success rates in locating parathyroid adenomas. Recently, higher success rates have been achieved with high-resolution TCT scanning and high-resolution ultrasound scanning. Intravenous digital subtraction angiography (i.v. DSA) may also prove to be a useful adjunct in parathyroid imaging. Levy et al. reported i.v. DSA to be positive in six of seven patients (*2*). Patient selection may have been responsible for this high success rate. We have evaluated a prospective, consecutive series of 13 patients with parathyroid adenomas, and i.v. DSA identified only four.

In view of these difficulties in imaging parathyroid adenomas, Ferlin's results seem encouraging. We utilized their combined scanning technique to locate correctly a 4-g parathyroid adenoma in a patient with persistent elevated calcium and PTH levels (Fig. 1). However, in reviewing the Methods and Materials section of their paper, we noted that their patients were first given 1 mCi of pertechnetate and then were given thallium. From a purely tech-

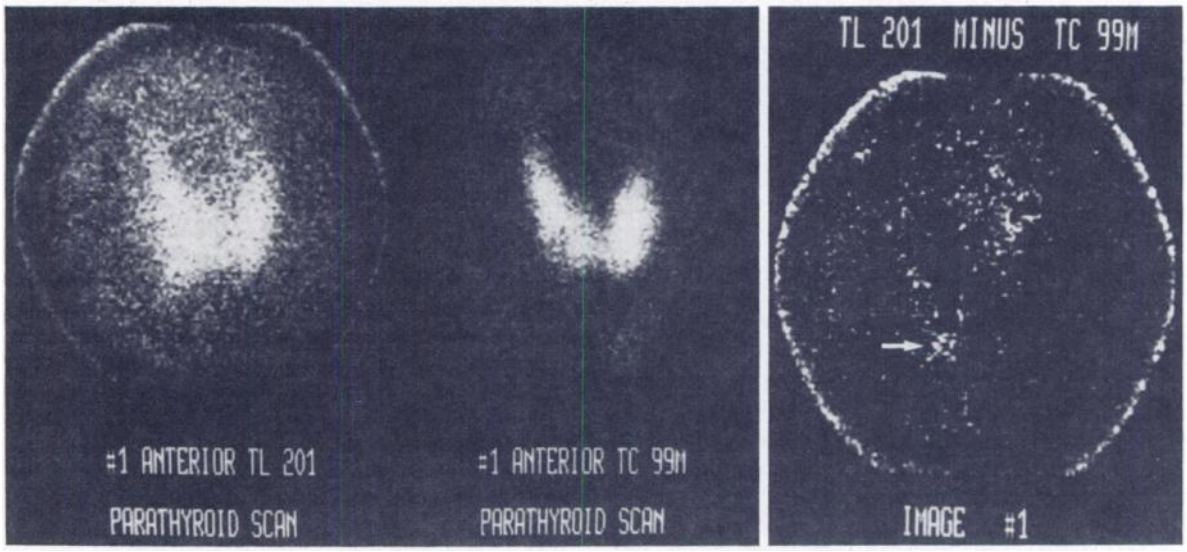

FIG. 1. Thallium pinhole thyroid scan shows increased uptake in right lower pole of thyroid (left). Tc-99m pertechnetate scan shows small defect in same area (center). Subtraction image confirms presence of thallium-avid nodule at lower pole of right lobe of thyroid (right). Surgery confirmed 1.5-cm parathyroid adenoma in this area.

nical point of view, it would be more advantageous to image the patient with thallium first, because of the lower-energy emission of thallium (80-keV mercury x-rays) and because of the small amount of thallium uptake by thyroid. Once a thallium image is obtained, then the patient can be given the [Tc-99m]pertechnetate and imaged on the technetium window. If the technetium is given first, significant Compton scatter will occur at about 80 keV, and may thus obscure small adenomas that are thallium-avid.

GARY G. WINZELBERG
JERROLD D. HYDOVITZ
Shadyside Hospital
Pittsburgh, Pennsylvania

REFERENCES

1. FERLIN G, BORSATO N, CAMERANI M, et al: New perspectives in localizing enlarged parathyroids by technetium-thallium subtraction scan. *J. Nucl Med* 24:438-441, 1983
2. LEVY JM, HESSEL SJ, DIPPE SE, et al: Digital subtraction angiography for localization of parathyroid lesions. *Ann Intern Med* 97:710-712, 1982

Reply

We were interested to read Winzelberg's letter, and while we agree about the Tc-99m Compton interference, it must be remembered that Tl-201 likewise invades the technetium window with its gamma emission at 167 keV, although to a lesser extent than Tc does in the thallium window. We prefer to inject the Tc-99m first for purely practical reasons: in order to avoid prolonging the time that the patient is required to remain immobile with the neck extended, under the gamma camera, waiting for optimum Tc-99m uptake in the thyroid. Immobility is essential for the correct carrying out of the image-subtraction technique.

It is for this very reason that, at the end of the examination, while both radionuclides are present, we register an image on the Tc-99m peak, which is used for subtraction from the thallium in those patients whose movement during the examination could falsify the subtraction result. We must also point out that in our patients (over 60 cases now tested), all the thallium-positive parathyroid adenomas lying in a retrothyroid position appeared as photopenic technetium areas, thus reducing interference from the latter. In our opinion, the only limitation of this technique lies in the resolution of the equipment.

With regard to the use of other imaging techniques, we refer you to the account of our comparison with ecography (*1*). Since ecography equipment with higher resolution has become available only recently and, although we have no precise data, we feel that use of both these techniques improves diagnostic accuracy and that they complement each other.

G. FERLIN
N. BORSATO
M. CAMERANI
B. SAITTA
Hospital Castelfranco
Veneto, Italy

REFERENCE

1. FERLIN G, BORSATO N, CAMERANI M, et al: Double-tracer (^{99m}Tc-^{201}Tl) scintigraphy and ultrasonography in the detection of enlarged parathyroids. In *Proceedings of the Third World Congress of Nuclear Medicine and Biology*. Raynaud C, ed. Paris, Pergamon Press, 1982, pp 1269-1273

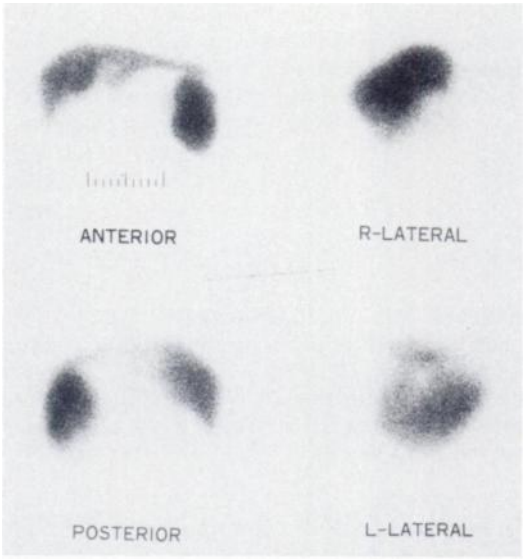

FIG. 1. Tc-99m phytate study shows splenomegaly and abnormal distribution of colloid. In portal area, radioactivity is markedly decreased.

Detection of an Extrahepatic Portal Shunt by Per-rectal Portal Scintigraphy with Tc-99m RBC

A 55-yr-old man was admitted to our hospital because of general fatigue. A dilated vein in the umbilical region and liver dysfunction had been pointed out to the patient 4 yr before at another hospital.

Examination of the skin revealed a vascular spider on the anterior chest wall and a large superficial vein in the umbilical area.

The results of blood chemistry were: platelets 82,000, bilirubin 1.8 mg/dl, alkaline phosphatase 132 milliunits/ml, gamma globulin 35.4%, and ICG (15 min) 38.7% (N <10%).

A Tc-99m phytate liver image performed 1 wk after admission showed a contracted liver with decreased uptake presumably in the portal area and enlarged spleen (Fig. 1). To investigate the portal circulation and liver blood flow, we performed per-rectal portal scintigraphy with red blood cells labeled in vivo with [Tc-99m]pertechnetate. After an enema, a catheter was introduced into the upper portion of the rectum. Ten milligrams of pyrophosphate (2 mg $SnCl\text{-}2H_2O$) was then injected intravenously. The pertechnetate, 15 mCi (555 MBq) in 3 ml, was infused through the catheter along with 25 cc of air, after which scintiphotos were obtained every 20 sec with a gamma camera. In the early phase (within 100 sec after infusion of pertechnetate), the portal vein was observed as a dark focus in the liver area, after which the radionuclide moved down into the lower abdomen (Fig. 2). Subsequently, contrast angiography of the inferior mesenteric artery was performed, and it revealed an enlarged and tortuous portal vein in the venous and portal phases; the contrast medium then flowed abnormally into the lower abdomen (Fig. 3).

Noninvasive per-rectal portal scintigraphy is a clinically useful method for analyzing the portal circulation in liver disease. Newman and Cohen (*1*) reported on the measurement of portal circulation time using the per-rectal method with ether. Recently, several authors (*2-6*), using radionuclides, have measured portal circulation time and portal shunt index in liver disease.

We have analyzed portal shunt and the detection of varices using per-rectal portal scintigraphy with Tc-99m RBCs. This method provides better visualization of the portal vein system, because in vivo labeling of RBCs with pertechnetate keeps a high percentage