jnm/ PRELIMINARY NOTE

# SUBTRACTION TECHNIQUE FOR THE DETECTION OF SUBPHRENIC ABSCESSES USING $^{67}$Ga AND $^{99m}$Tc

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***Gallium-67 has been found to localize in inflammatory lesions as well as in liver and spleen. Positive detection of suspected subphrenic abscesses remains a difficult clinical diagnostic problem. The present publication introduces the detection of subphrenic abscesses with $^{67}$Ga using a modern scanner subtraction technique with $^{99m}$Tc.***

***Patients with clinical symptomatology of a subphrenic abscess and positive correlated roentgenologic findings were scanned at 30 hr following an i.v. injection (35 μCi/kg) of $^{67}$Ga-citrate. Fifteen minutes prior to the 30-hr scan, 2 mCi of $^{99m}$Tc-sulfur colloid and human albumin microspheres were injected intravenously.***

***A dual 5-in. total-body rectilinear scanner with dual pulse-height analyzer (PHA) subtraction was used in this study. One pulse-height analyzer (A) was energy calibrated for the 184- and 300-keV gamma rays of $^{67}$Ga. The second pulse-height analyzer (B) was calibrated for the $^{99m}$Tc 140-keV gamma ray. When the (B) PHA output was subtracted from the (A) PHA output, a subtraction photoscan resulted. The elimination of liver, spleen, and lung due to the $^{99m}$Tc content enhanced the $^{67}$Ga uptake in subphrenic abscesses.***

***The results of this preliminary report indicate the usefulness of $^{67}$Ga and $^{99m}$Tc in combination with the subtraction technique as an important aid in the diagnosis of subphrenic abscesses.***

While investigating bone localization of $^{67}$Ga, Edwards and Hayes (*1*) found soft-tissue tumor localization. Since then, $^{67}$Ga has contributed to the visualization of a variety of different neoplasms and non-neoplastic diseases (*2,3*). Gallium-67 localization in inflammatory lesions was initially reported by Lavender, et al (*4*). Further investigation of inflammatory lesion localization has been noted by Nelson, et al (*5*), Higasi, et al (*3*), and Blair, et al (*6*). Detection of abdominal abscesses by $^{67}$Ga localization has been most recently demonstrated by Harvey, et al (*7*) and Littenberg, et al (*8*).

Localization of suspected subphrenic abscesses remains a difficult clinical diagnostic problem. Conventional diagnostic roentgenology and radioisotope scanning (*9–11*), as an approach to this problem, are not always productive and a more effective noninvasive technique is needed.

The present publication introduces the detection and delineation of subphrenic abscesses with $^{67}$Ga using modern scanner subtraction techniques.

## MATERIALS AND METHODS

Gallium-67 is a cyclotron-produced radioisotope which decays by electron capture with a physical half-life of 78 hr. It yields gamma rays suitable for scanning with energies of 93, 184, 300, 393 keV (*12*), respectively. The $^{67}$Ga-citrate was obtained as a sterile, pyrogen-free commercial product from Diagnostic Isotopes, Inc., Upper Saddle River, N.J. A dose of 35 μCi/kg (2–2.5 mCi) was administered to the patient intravenously.

Technetium-99m decays with a 6-hr half-life emitting a 140-keV gamma ray. Technetium-99m-sulfur colloid and $^{99m}$Tc-labeled human albumin microspheres were used as liver, spleen, and lung scanning agents, respectively. These imaging agents were prepared in our Nuclear Medicine Laboratory prior to the intravenous injection.

A Raytheon dual 5-in. total-body rectilinear scan-

Received Oct. 23, 1973, original accepted Nov. 30, 1973.

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ner with pulse-height analyzer subtraction feature was used in this study. A high-energy 19-hole broad focus collimator with 4-in. focal distance was used to collimate both the $^{67}$Ga gamma-ray energies as well as the gamma ray from $^{99m}$Tc. The photoscans were displayed without minification on 14 × 17 Kodak safety RP film with 2-mm line spacing.

Patients with clinical symptomatology of a subphrenic abscess and positive correlated roentgenologic findings were scanned. The optimum time for imaging the abscess localized by the subtraction technique was found to be 30 hr after the injection of $^{67}$Ga. Fifteen minutes prior to the 30-hr scan, 2 mCi of $^{99m}$Tc-sulfur colloid and 2 mCi of $^{99m}$Tc-labeled microspheres were injected intravenously.

All signal pulses corresponding to $^{67}$Ga- and $^{99m}$Tc-gamma interactions from the anterior-positioned 5-in. detector were directed to each of two pulse-height analyzers, (A) and (B). The (A) pulse-height analyzer by way of energy selection permitted the $^{67}$Ga 184- and 300-keV photopeak counts to be recorded on a photoscan. This photoscan demonstrates the distribution of $^{67}$Ga. The (B) pulse-height analyzer window was calibrated to accommodate counts of the 140-keV photopeak of $^{99m}$Tc. Each pulse-height analyzer, (A) as well as (B), was normalized to 100% over the area of greatest activity from the liver. A subtraction photoscan was produced by subtracting the output of the (B) pulse-height analyzer from the (A) pulse-height analyzer. The subtraction scan and the $^{67}$Ga photoscan were produced simultaneously. Rescanning the $^{99m}$Tc distribution yields a third photoscan of the liver, spleen, and lung. An average information density of 500 was maintained on the scans.

## RESULTS

Clinical symptomatology for a subphrenic abscess was noted in five patients, each of whom demonstrated suspicious subphrenic roentgenographic findings. The results of the scan showed positive $^{67}$Ga concentrations in three patients with a right subphrenic abscess and in one patient with a left subphrenic abscess. One patient failing to visualize a $^{67}$Ga concentration seemed normal.

Figure 1A demonstrates $^{67}$Ga uptake in the liver, spleen, and other distributions but fails to show a concentration in the region of suspected abscess. In Fig. 1B, where the liver and spleen are subtracted, the right subphrenic abscess with its concentration of $^{67}$Ga is easily visualized.

Figure 2A shows a $^{67}$Ga scan with uptake in liver and spleen. The increased uptake along the left superior abdominal wall leads one to suspect splenic uptake or abscess concentration. Figure 2B demonstrates subtraction of the liver, spleen, and lungs revealing this increased uptake to be a left subphrenic abscess displacing the spleen medially.

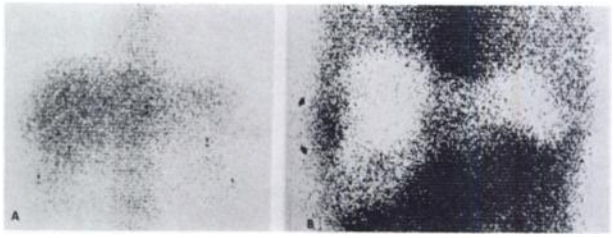

**FIG. 1.** (A) Anterior photoscan demonstrates $^{67}$Ga uptake in liver and spleen with no apparent abscess uptake. (B) Same anterior view scanned, but with liver and spleen subtracted, revealing enhanced right subphrenic abscess.

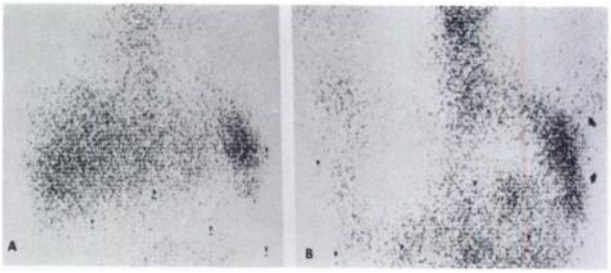

**FIG. 2.** Spleen or left subphrenic abscess shown in (A) revealed to be left subphrenic abscess on subtraction photoscan (B).

It should be noted that this scanning procedure produced two photoscans simultaneously: a $^{67}$Ga-$^{99m}$Tc subtraction scan and a $^{67}$Ga scan. An optional liver, spleen, or lung $^{99m}$Tc photoscan can be performed if desired.

## DISCUSSION

The differential diagnosis of subphrenic abscess as a focus of infection in a septic patient can be a difficult diagnostic problem even with the current radiographic and scanning procedures available. Although the present procedure (*9,10*), involving liver-spleen and lung scanning, offers diagnostic value its basic concept of "cold spot" or displacement criteria is not as desirable as "hot spot" scanning. Gallium-67 abscess localization offers this latter feature. Instruments used in nuclear medicine were conceptually designed to detect the presence of radioactivity rather than its absence.

In the past, visualization of subphrenic abscesses, due to the close proximity to liver, spleen, and lung, has been a diagnostic problem. In this respect, the subtraction technique has proven to be very beneficial. Concern over target-to-background ratio is not totally eliminated, but with the use of the subtraction technique it is less than in previous studies (*7*).

It has been estimated that 10–15% of a gallium

dose is excreted through the intestines (*13*). Although some activity is noted in the colon in 30 hr, this does not present a problem in interpretation of the subtraction scan. The colon artifact, however, can be eliminated or reduced through the use of laxatives or enemas.

The results of this preliminary report indicate the usefulness of $^{67}Ga$ and $^{99m}Tc$ in combination with the subtraction technique as an important aid in the differential diagnosis of subphrenic abscesses.

ACKNOWLEDGMENT

The authors would like to acknowledge the encouragement and support in the writing of this paper of David Preston, Department of Diagnostic Radiology, Kansas University Medical Center, Kansas City, Kansas, and John Selby, Nuclear Medicine Service, Veterans Administration Hospital, Lexington, Kentucky.

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The first Radiopharmaceutical Scientists' Forum addressing a current scientific problem of concern will be held Monday afternoon, June 10th at 4 p.m. at the Town and Country Hotel in San Diego. A business meeting will follow the program. This meeting has been scheduled to coincide with the Society of Nuclear Medicine Annual Meeting so as many radiopharmaceutical scientists as possible can attend.