The Complementary Role of Gallium Citrate Imaging and Computed Tomography in the Evaluation of Suspected Abdominal Infection

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Fifteen patients with a suspected abdominal abscess were examined by both gallium-67 and computed tomographic scanning. The Ga-67 scan was a useful screening examination, correctly identifying all eight cases of infection, whereas the CT scan missed one case of a pericecal phlegmon. Misdiagnosis of infection by Ga-67 scan occurred in 2/8 cases without infection but the CT scan correctly identified all noninfected patients. While this series is too small to decide whether there is any significant difference in the ability of the two procedures to suggest the correct diagnosis, it is felt that Ga-67 and subsequent CT scans may be complementary in that a Ga-67 scan can initially locate the abnormality and thus direct the CT scan, which can confirm the diagnosis or avoid a misinterpretation of the Ga-67 scan. Computed tomography also provides more anatomical detail, better location of the lesion, and demonstrates lesions noninfectious in nature.


Gallium-67 scanning is a sensitive indicator of intra-abdominal infection. A sensitivity range of 58–100% has been reported for detection of abdominal inflammatory disease with a sensitivity greater than 80% in most series (1–5). Specificity has been exceptionally high, ranging from 93 to 100%, with overall diagnostic accuracy between 84 and 100% (1–5). Falsely positive Ga-67 scans for infection in the abdomen are generally due to misinterpretation because of the presence of colonic activity or abdominal tumor. Serial imaging over several days with interspersed bowel cleansing helps avoid confusion with colonic uptake, but this delay is undesirable in the management of the acutely ill patient.

Computed tomography (CT) is a new, rapid, noninvasive method for evaluation of suspected intra-abdominal inflammation. We report here our early experience with the combined use of Ga-67 and CT scans for evaluation of suspected abdominal inflammation, and suggest a complementary approach to the use of these procedures.

MATERIALS AND METHODS

We have performed a retrospective study of all cases examined by both Ga-67 and CT scan for suspected intra-abdominal inflammation between June 1976 and January 1977. Fifteen cases had adequate followup and form the basis of this evaluation.

Total-body gallium scans were performed using 5–8 mCi of Ga-67 citrate injected intravenously 24 hr before imaging. Routine magnesium citrate and cleansing enemas were given on the evening before the initial examination. A repeat scan was usually performed, following an additional enema, between 48 and 96 hr to help distinguish Ga-67 activity in bowel from activity elsewhere in the abdomen. All initial total-body scans and subsequent abdominal views were performed with a gamma camera (15")
crystal) equipped with a moving table and using three separate pulse-height windows to detect the 93-keV, 185-keV and 300-keV photopeaks of Ga-67.

Thirteen of the fifteen CT scans were performed using a prototype of the EMI 5000 CT body scanner and two using a prototype GE body scanner. The EMI unit has a 20-sec scan time with a $320 \times 320$ image matrix and $160 \times 160$ display matrix. The GE unit has a 5-sec scan time with a $320 \times 320$ image and display matrix. CT examination was limited to regions of suspected abnormality on the basis of a prior abnormal Ga-67 scan or physical examination. Scans at intervals of 1 cm were obtained, bracketing the region of interest. In three cases, 150–300 cc of 25% meglumine diatrizoate were administered as an i.v. infusion and the area of interest rescanned. In one case 240 cc of a 3% solution of Gastrografin were administered orally to aid the delineation of the intestinal tract.

Both the CT and Ga-67 results are based on scan interpretations noted at the time of the original examination. No attempt was made to interpret the scans in the absence of clinical information. In all cases the final diagnosis was established by operative proof or compelling clinical data. A diagnosis of abscess on the CT scan was made when one of two findings was observed: (a) a tissue region of lower-than-expected density, often with a rim of enhanced density following injection of i.v. contrast material, or (b) a collection of gas bubbles not characteristic of the pattern seen in a normal bowel lumen.

**RESULTS**

A summary of the history, scan findings, and followup of each patient is presented in Table 1. Seven of the 15 patients had had recent abdominal surgery. Gallium-67 scanning was performed before the CT scan in 12 patients, including seven of the eight patients in which inflammation was surgically confirmed.

Ten patients underwent laparotomy to establish a diagnosis: in eight an abscess or phlegmonous infection was found; the ninth had a solitary plasmacytoma of the liver, and the tenth had a noninfected subcapsular splenic hematoma. In the five patients with no surgical confirmation, the subsequent clinical course indicated that no abdominal inflammation had been present. Two had rapid resolution of symptoms without therapy. Two had needle biopsies, one suggesting pulmonary tuberculosis and the other sarcoidosis as the cause of symptoms. The fifth patient was diagnosed and followed by CT for a subcapsular hepatic hemorrhage.

Table 2 compares the scan interpretations with the final diagnoses of presence or absence of abdominal infection. In the eight patients with surgically proven infection, CT scanning was correct in seven and Ga-67 scanning correct in all eight. Computed tomography failed to demonstrate a pericecal phlegmon secondary to perforated carcinoma of the ascending colon.

One gallium scan (Patient #15) was incorrectly interpreted as a left subdiaphragmatic abscess, owing to confusion with uptake in a left lower lobe infiltrate. Computed tomography established the correct diagnosis of a subcapsular splenic hematoma with an associated pneumonia. Patient #9, with a solitary plasmacytoma of the liver, had an abnormal accumulation of gallium within the liver—as would be expected. Although the gallium scan correctly pointed to this patient's problem and led to a correct diagnosis and therapy, this case had to be included among those in Table 2, in which gallium was positive but no infection found. Computed tomography scan was negative for infection in this case but failed to diagnose the tumor. One patient with a negative Ga-67 scan had a CT scan showing a subcapsular hepatic hematoma following a liver biopsy.

**DISCUSSION**

Patients with fever of unknown origin, with or without accompanying abdominal pain, often present a perplexing clinical problem. If an abdominal abscess is suspected, confirmation and location by a noninvasive imaging procedure is highly desirable because surgical drainage is often necessary. This review of 15 patients demonstrates the advantages and disadvantages of Ga-67 scanning and CT scanning for suspected abdominal abscess, and suggests that they frequently provide complementary information.

Whole-body gallium scanning is a useful screening procedure because of its high sensitivity, its resultant view of the entire body on a single image, its noninvasive nature, and its relatively low radiation dose.

Its major disadvantages are the time delay needed to obtain a complete study and the relatively poor spatial resolution of the resulting images. Whereas 6-hr delay studies have been advocated (6), we find these difficult to interpret due to high background activity. We therefore feel the 24-hr study is the earliest with which a reliable diagnosis can be made.

Gallium scanning is especially valuable as the first screening procedure when used in conjunction with CT scanning. When the gallium scan is positive, it permits one to obtain subsequently a guided CT scan of the general region of the abnormality. This minimizes the number of CT cuts needed, thereby de-
<table>
<thead>
<tr>
<th>Patient No.</th>
<th>History</th>
<th>Ga-67 scan</th>
<th>CT scan</th>
<th>Followup</th>
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<tbody>
<tr>
<td>3. 81 y.o.</td>
<td>M. with panophthalmitis and acute onset of RLQ pain and fever.</td>
<td>9/25/76: Marked abnormal uptake RLQ.</td>
<td></td>
<td>Operation demonstrated carcinoma of ascending colon which had perforated causing phlegmonous periceliac inflammation.</td>
</tr>
<tr>
<td>4. 78 y.o.</td>
<td>F. with LLQ pain, fever and pneumaturia. Presumed diverticulitis with enterovesical fistula.</td>
<td>9/24/76: Abnormal uptake along left iliac wing and left pelvis.</td>
<td>10/6/76: Low-density mass in left iliacus and left psoas muscles consistent with abscess.</td>
<td>Operation: 11/24/76: Drainage of a large right flank abscess.</td>
</tr>
<tr>
<td>5. 47 y.o.</td>
<td>F. S/P pelvic exenteration for cervical carcinoma with Bricker loop ileostomy and colostomy. Post-operative fever.</td>
<td>11/19/76: Abnormal uptake in region of ileotomy stoma on the right; extending medially, inferiorty and posteriorly.</td>
<td>11/23/76: 13-cm-long right retroperitoneal abscess along right paraspinal space, largest in region of lower pole of right kidney. 12/9/76: Hepatosplenic megaly; ascites. No abscess.</td>
<td>Operation demonstrated diverticulitis and ileopsoas abscess.</td>
</tr>
<tr>
<td>8. 2 y.o.</td>
<td>M. with regional enteritis, multiple pelvic fistulas, fever, and RUQ pain.</td>
<td>10/4/76: Two right-lobe hepatic lesions. (Abnormal Ga-67 uptake was appreciated only in conjunction with sulfur-colloid liver-spleen scan.)</td>
<td>10/5/76: Multiple low-density defects in right lobe of liver, consistent with abscess.</td>
<td>Operation: hepatic abscess in right lobe drained.</td>
</tr>
<tr>
<td>9. 56 y.o.</td>
<td>M. with polycystic renal disease, S/P cadaver renal transplant. Fever of unknown origin.</td>
<td>7/16/76: Marked uptake in lateral aspect of right hepatic lobe, consistent with abscess, infected cyst, or tumor. (Sulfur-colloid liver scan showed corresponding focal cold defect.)</td>
<td>7/19/76: Polycystic kidney with calcifications. Multiple hepatic low-density areas felt to be hepatic cysts. A poorly defined low-density region in lateral aspect of R hepatic lobe was noted.</td>
<td>Operation: large solitary plasmacytoma found in lateral aspect of right hepatic lobe. Multiple hepatic cysts also were identified.</td>
</tr>
<tr>
<td>10. 30 y.o.</td>
<td>M. with sclerosing cholangitis. Indwelling T-tube and steroid therapy for one year. Acute onset of right pleuritic chest pain and fever.</td>
<td>10/29/76: Abnormal uptake in right chest. Abdomen normal.</td>
<td>10/28/76: Right pleural effusion, no hepatic or RUQ abscess noted. Study suboptimal due to artifacts from clip and T-tube, and lack of abdominal fat.</td>
<td>Pleural biopsy: Caseating granulomas. Patient started on antimycobacterial drugs. Cultures from skin around T-tube grew staph. aureus; bile cultures were negative.</td>
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TABLE 1 (continued)

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<thead>
<tr>
<th>Patient No.</th>
<th>History</th>
<th>Ga-67 scan</th>
<th>CT scan</th>
<th>Followup</th>
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<tr>
<td>11.</td>
<td>64 y.o. M. S/P diverting colostomy for perforated colonic diverticulum. Exploratory laparotomy on 6/22/76 showed left subphrenic abscess and duodenocutaneous fistula. Recurrent fever and sepsis postoperatively.</td>
<td>7/21/76: Abnormal left subphrenic uptake consistent with abscess. Abnormal right and LUQ uptake related to indwelling drains.</td>
<td>7/23/76: Left subphrenic abscess. Extent was unclear due to inability of patients to drink gastrografin.</td>
<td>Operation: laparotomy 7/30/76 demonstrated subdiaphragmatic abscess communicating with a lesser-sac abscess.</td>
</tr>
<tr>
<td>13.</td>
<td>54 y.o. F. S/P colonic surgery for volvulus; subsequent stitch abscess LUQ pain and cystic LUQ lesion on ultrasound.</td>
<td>7/20/76: Normal.</td>
<td>7/30/76: Normal. Fluid and air-filled jejunal in LUQ.</td>
<td>Followup CT scan 9/7/76: Decreased subcapsular low-density region and decrease in density of extraperitoneal fluid felt compatible with resolving hematoma. Fever resolved without treatment.</td>
</tr>
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</table>

Computed tomography scanning may not be useful in detecting an inflammatory lesion that has not developed into a true abscess. Patient #3 had a perforated carcinoma of the ascending colon with a surrounding inflammatory phlegmon. The Ga-67 scan (Fig. 1A) showed a persistent diffuse accumulation in the region of the ascending colon, but the CT scan was normal (Fig. 1B). Furthermore, whereas retroperitoneal collections of gas bubbles are easily recognized as infectious in origin by CT scan, those found within the peritoneal cavity may be difficult to distinguish from bowel gas. Administration of water-soluble oral contrast material, as in Patient #12 (Fig. 2), can be used to help differentiate intra- from extraluminal gas.

Computed tomography scan can provide significant additional information when complementing the gallium scan. The superior anatomical detail present on most CT scans of the abdomen allowed us to decreasing the time required to obtain and process the CT images (about 2-4 min per slice for most CT scanners currently employed), as well as decreasing the radiation dose and the expense of the procedure.

In this series seven of eight cases with subsequent proven infection, and five of seven without infection, had the CT scan following a gallium scan. CT scans were performed and interpreted with knowledge of the results of these Ga-67 scans; therefore, it is difficult to determine how much this may have biased the results in favor of the CT scan. Abscess, hematoma, and noninfected cysts can all present a similar CT appearance. Absence of gallium in an abnormal region on CT can be used as evidence against an abscess. For example, Patient #14 had a CT scan showing an extracapsular and intracapsular hepatic zone of abnormal low density; the negative gallium scan in this region helped suggest the correct diagnosis of a noninfected hematoma.

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TABLE 2. COMPARISON OF OPERATIVE AND CLINICAL EVIDENCE OF INFECTION WITH SCAN RESULTS FOR PATIENTS IN TABLE 1

<table>
<thead>
<tr>
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<th>CT positive</th>
<th>CT negative</th>
<th>Ga-67 positive</th>
<th>Ga-67 negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgically proven abdominal infection (eight cases)</td>
<td>7</td>
<td>1*</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Surgically proven or clinically negative for abdominal infection (seven cases)</td>
<td>0</td>
<td>7</td>
<td>2†</td>
<td>5</td>
</tr>
</tbody>
</table>

* Patient #3.
† Patients #9 and #15.

define whether the abscess was intraperitoneal or retroperitoneal, and to describe precisely which organs, tissues, or muscle bundles were involved and to what extent. This anatomic detail is particularly important after recent abdominal surgery, where the extent of a second surgical incision and procedure may be minimized by a more precise preoperative guide. Patient #5 had an abnormal accumulation of gallium over the right lower portion of the abdomen following pelvic exenteration and ileostomy. The CT scan showed an enlarged, low-density mass confined to the right psoas muscle, whereupon a large psoas abscess was easily found and drained. Patient #7 (Fig. 3A) had a diffuse area of abnormal gallium uptake in the region of the pancreatic bed; a CT scan (Fig. 3B) showed a well-circumscribed, low-density mass in the tail of the pancreas. A tail abscess was subsequently drained.

Computed tomography may be useful in detecting those cases where gallium accumulation is in a neoplasm rather than an abscess. Patient #9 had a solitary hepatic plasmacytoma that was positive on Ga-67 scan (Fig. 4A) but incorrectly diagnosed as an abscess. The CT scan (Fig. 4B) showed a low-density mass in the liver, clearly differentiating it from a neoplasm.

FIG. 1. Patient #3. Pericecal phlegmon due to perforated carcinoma of ascending colon. (A) Gallium-67 scan (anterior view) demonstrates abnormal uptake in left orbit due to patient’s panophthalmitis (small arrow). Intense RLQ activity (large arrow) persisted over 96 hr. (B) CT scan shows gas in expected position of cecum (arrow), but no definite abnormality is noted.

FIG. 2. Patient #12. Retrogastric abscess. CT scan shows water-soluble contrast material in gastric lumen (small arrow), clearly differentiating stomach from retrogastric collection of gas present in abscess (large arrow).
density liver lesion that was poorly margined and that increased in CT number (density) following i.v. injection of urographic contrast material. Both these features, although not found in all neoplasms, are uncharacteristic of abscess.

Computed tomography is also helpful in preventing incorrect scintigraphic diagnosis due to poor spatial resolution or interpretive errors. Patient #15 had a Ga-67 scan misinterpreted as a subdiaphragmatic abscess (Fig. 5A). A directed CT scan of the LUQ (Fig. 5B) showed a lesion thought to be typical of a subcapsular hematoma of the spleen, together with infiltration of the lower lobe of the left lung. An uninfected splenic hematoma was found at surgery. In retrospect, the gallium-based diagnosis of abscess resulted from confusion caused by activity in the left lower-lobe pneumonia and in the splenic flexure of the colon.

The best possible image quality should be sought in Ga-67 scanning to help avoid interpretive errors. In our series Ga-67 scanning identified all eight proven infections, but Haaga et al. (7) reported only 6/9 (67%) positive scans in which CT scanning identified all 9 lesions. Most falsely negative Ga-67 scans are probably due to confusion with colonic activity. Technique is a major factor, however, in the ability to detect lesions. Haaga and associates do not describe their method of Ga-67 scanning, but the illustrated material indicates that a rectilinear scanner was used. In our series all scans were done with a large-field Anger camera using all three major peaks of Ga-67. This, combined with a Ga-67 dose of 5–8 mCi i.v., results in improved image quality compared with lower-dose, rectilinear-scans made with a single pulse-height window (8).

Failure to obtain a separate liver-spleen scan in addition to the Ga-67 scan may also result in misinterpretation. Patient #9 demonstrates the importance of combined Ga-67 and Tc-99m sulfur colloid liver-spleen scanning when intrahepatic abscess is suspected. The gallium scan alone (Fig. 6) might be interpreted as normal, but the Tc-99m sulfur colloid
Patient #15. Subcapsular splenic hematoma. (A) Gallium-67 scan (posterior view) demonstrates area of decreased tracer uptake in left upper quadrant. Contiguous areas of increased uptake were present in left lower lobe pulmonary infiltrate (small black arrow), colon (large black arrow), and compressed splenic parenchyma (white arrow). This was initially misinterpreted as a subdiaphragmatic abscess with "rim" of activity surrounding cold central portion. Absence of complete rim of activity should have raised doubts about this interpretation. (B) CT scan shows a linear margin, characteristic of subcapsular lesions, that separates the lateral, low-density hematoma from normal spleen medially. Increased density in posterior portion of left lower lobe of lung (arrow) represents infiltrate noted on chest radiographs. It resulted in Ga-67 uptake in this region.

Liver-spleen scan demonstrated two focal areas of decreased uptake in the right lobe of the liver (Fig. 6). Since Ga-67 showed no such defects, these areas were considered gallium-positive. The CT scan and surgery confirmed the presence of liver abscess.

ACKNOWLEDGMENTS

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