# $^{67}$Ga SPECT in detection of infection and inflammation

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## Abstract

BACKGROUND: The aim of this study was to assess the value of $^{67}$Ga SPECT in detection and localisation of sources of infection/inflammation.

MATERIALS AND METHODS: This study was performed on 24 patients (25 examinations) with suspected infection/inflammation. All patients underwent both planar and tomographic studies. There were 10 studies of abdomen and pelvis, 11 lower leg scans and 4 studies of upper chest and neck. We used a two-head gamma camera in each case. A planar whole body scan was performed with slow scan speed (10 cm/min), followed by a SPECT acquisition 48 hours after i.v. injection of 100-200 MBq $^{67}$Ga. Tomographic reconstruction was performed using a Ramp back-projection filter. These images were then smoothed using an automatically applied count optimised post-projection 3D Metz filter. Attenuation correction and scatter correction were not performed. Images were displayed as re-orientated transverse, coronal and sagittal slices. Planar and SPECT studies were assessed by two physicians trained in Nuclear Medicine, blinded to clinical details and compared with final pathological results.

RESULTS: All planar and SPECT studies were of good quality. Overall diagnostic accuracy was as follows: sensitivity 100% specificity 67%, PPV 90% and NPV 100%. SPECT examination provided additional information about unexpected sources of confirmed infection on a site basis but did not find any additional patients which were not detected on planar examination. Localisation of sites of infection was more easily achieved with SPECT than planar imaging alone, especially when the transaxial slices were compared with CT or MRI.

CONCLUSIONS: We recommend $^{67}$Ga SPECT study as a tool to improve the accuracy of scintigraphy in detecting the number of sites of infection and their localisation.

**Key words: SPECT; $^{67}$Ga; infection and inflammation**

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## Introduction

Currently $^{67}$Ga has a wide range of clinical use and is probably an under-utilised technique. Gallium scan is cheaper than a CT scan and is able to pick up a wide range of inflammatory and/or infected diseases (1). $^{67}$Ga SPECT has been shown to be more sensitive than planar imaging in several adult and paediatric studies (1, 2). Clinical indications of $^{67}$Ga citrate scanning include the infectious complications after median sternotomy, myopericarditis, abdominal abscesses, tuberculosis and osteomyelitis of the spine (3–8). It can also be used in the identification of lung pathology such as fibrosing alveolitis, post bleomycin and radiotherapy and pneumonia (9, 10). $^{67}$Ga citrate is however non-specific and has been found to have uptake in non-infected granulomatous process such as sarcoidosis, and malignant disease, for example lymphomas (1). However it remains a very useful agent particularly in the identification of chronic infection, a classic example being external otitis most frequently observed in elderly diabetic patients where early diagnosis is necessary for successful treatment (11).

$^{67}$Ga citrate imaging can provide quantitative information about infection/inflammation activity that is often not apparent from morphological images alone. This can be very useful in monitoring the effect of any treatment. In some situations $^{67}$Ga imaging offers many practical advantages over $^{111}$In or $^{99m}$Tc HMPAO labelled leukocyte imaging. For example no cell labelling is required and it can be used on patients with few or no working white cells (patients immunosuppressed or/and chronic infection).

New digital gamma cameras have helped to improve the quality of images produced from $^{67}$Ga citrate. If in addition a multidetector SPECT camera is used, then reasonable image times can be obtained and there are sufficient counts to perform quality SPECT, even of multiple sites. Also when displayed as volume rendered images it seems to be very helpful diagnostic tool (1, 8, 12).

Therefore the aim of this study was to assess the value of $^{67}$Ga SPECT in detection and localisation of sources of infection/inflammation and to compare the results with planar imaging.

## Patients and methods

The study was performed on 24 patients (25 examinations) with suspected infection/inflammation lesions in different parts of the body. The mean age of patients was 59 years (range 30–80). Of the 25 SPECT examinations, 10 were abdominal and pelvic scans; 10 of the knees and the lower part of the leg, 5 of the upper thoracic cavity and neck. Clinical suspicious mostly concerned the pyogenic abscesses localised in the abdomen (10 cases), and the thorax (5 cases). Suspicion of osteomyelitis consists of 10 cases of knee, foot and vertebral osteomyelitis (Table 1).

Each examination was performed using intravenous 100–200 MBq $^{67}$Ga (Mallinkckrodt, Nuclear Medicine, Petten, Netherlands) 48 hours later. All studies were performed on a two-head gamma camera (Picker Prism 2000XP, Picker, Cleveland, OH, USA) interfaced to a computer workstation Odyssey VP (Picker Inc., Cleveland, OH, USA). A medium energy parallel collimator was used in each case. Three photopeaks, 90, 180 and 390 keV were used for both planar and SPECT acquisitions. A planar whole body scan was performed with slow scan speed (10 cm/min.). Tomographic images were acquired in 64x64 matrix. The tomographic data were acquired continuously in 30 steps, over 180 degrees for each head of the gamma camera. Data acquisition was 30s per one step. Tomographic reconstruction was performed after uniformity correction: obtained from a $^{67}$Ga flood source, using a standard Ramp backprojection filter (FBP) the images were then smoothed using an automatically applied count optimised post-projection 3D Metz filter after reconstruction. Attenuation correction and scatter correction were not performed. At this stage the data were re-orientated into orthogonal slices. Slice thickness was 9.34mm in each case. Images were displayed as transverse, coronal and sagittal slices.

In some patients with osteomyelitis suspicion a standard 3-phase bone scan was performed before the $^{67}$Ga citrate study. Sites of uptake greater then background and outside of physiological uptake of $^{67}$Ga were reported as showing positive accumulation. Images were read independently by two physicians with experience in these types of investigations, blinded to clinical details. All studies were confirmed at surgery, microbiology and/or histopathology as well. Four patients with negative results had clinical follow-up for more then 6 months.

**Table 1. Data of all patients considering age, clinical suspicious and final result of $^{67}$Ga citrate study**

| Patient | Sex | Age | Clinical suspicious | Final result |
|---|---|---|---|---|
| 1 | m | 64 | abdominal abscess - bilary reconstruction | tp |
| 2 | f | 78 | chest infection - haemodialysis | tn |
| 3 | f | 51 | abdominal abscess - post operative of liver | fp |
| 4 | f | 51 | FUO, pyrexia | tp |
| 5 | f | 66 | right TKR - infection | tp |
| 6 | m | 80 | osteomyelitis left lower leg | tp |
| 7 | f | 39 | abdominal tuberculosis | tp |
| 8 | f | 35 | kidney abscess | tn |
| 9 | m | 25 | shunt V-P abscess | tp |
| 10 | f | 77 | right TKR - infection | tp |
| 11 | f | 50 | abdominal abscess - diverticulum | tp |
| 12 | f | 75 | osteomyelitis right ankle | tp |
| 13 | m | 30 | abdominal and thoracic adenopathy - tuberculosis | tp |
| 14 | f | 77 | FUO myelodysplasia - spleen abscess suspicious | fp |
| 15 | m | 77 | endocarditis after right TKR infection | tp |
| 16 | m | 77 | right TKR infection | tp |
| 17 | m | 51 | osteomyelitis left ankle | tp |
| 18 | m | 69 | pericarditis | tn |
| 19 | m | 33 | osteomyelitis left femur | tp |
| 20 | m | 59 | osteomyelitis | tp |
| 21 | m | 51 | both TKR infection | tp |
| 22 | m | 81 | left TKR infection | tp |
| 23 | m | 61 | vertebral osteomyelitis - tuberculosis | tp |
| 24 | f | 66 | osteomyelitis left leg | tp |
| 25 | f | 52 | vertebral osteomyelitis | tn |

Abbr: FUO — fever of unknown origin, V-P shunt — venous-portal shunt, TKR — total knee replacement, tp — true positive study, tn — true negative study, fp — false positive study

## Results

All $^{67}$Ga planar and SPECT studies were of diagnostic quality. Of the 25 studies the results were as follows: 19 true positive examinations, 4 true negative examinations, 2 false positive studies. There were no false negative studies (Table 1, 2). However on

**Table 2. Results of $^{67}$Ga citrate study, including two patients with true positive studies evaluated correctly in SPECT studies with additional sources of infection. Also one case with false positive study with both planar and SPECT including another focus of tracer accumulation seen in SPECT study**

| | Site of $^{67}$Ga accumulation | | |
|---|---|---|---|
| Patient | SPECT | Planar | Result |
| 1 | right abdomen, below liver | right abdomen, below liver | tp |
| 2 | normal | normal | tn |
| 3 | anterior abdomen | anterior abdomen | fp |
| 4 | periaortic nodes | periaortic nodes | tp |
| 5 | right TKR (both components) | right TKR (both components) | tp |
| 6 | left tibia | left tibia | tp |
| 7 | iliac or sacroiliac area | iliac or sacroiliac area | tp |
| 8 | normal | normal | tn |
| 9 | abdominal abscess | abdominal abscess | tp |
| 10 | femoral component of TKR | femoral component of TKR | tp |
| 11 | first focus within left abdomen | focus of | tp |
| | second within low left abdomen | abdominal uptake | tp |
| 12 | right lateral ankle | right lateral ankle | tp |
| 13 | sites within abdomen and thorax left mediastinum | sites within abdomen and thorax | tp |
| 14 | first abdomen – spleen | left abdomen | fp |
| | second left abdomen - spleen | spleen | fp |
| 15 | both components of right TKR | both components of right TKR | tp |
| 16 | heart accumulation | heart accumulation | tp |
| 17 | right medial ankle | right medial ankle | tp |
| 18 | normal | normal | tn |
| 19 | proximal tibia | proximal tibia | tp |
| 20 | synovial membrane of right knee | whole right knee joint | tp |
| 21 | both TKR | both TKR | tp |
| 22 | tibial component of left TKR | tibial component of left TKR | tp |
| 23 | abdominal abscess | abdominal abscess | tp |
| 24 | left lateral ankle | left lateral ankle | tp |
| 25 | normal | normal | tn |

Abbr: V-P shunt — venous-portal shunt, TKR — total knee replacement, tp — true positive study, tn — true negative study, fp — false positive study a site by site basis there were additional sites of infection seen on the SPECT study, confirmed as infection not seen on the planar studies. Therefore site by site the sensitivity of the SPECT study was 100% compared with 93% for the planar imaging. SPECT imaging proved to be most useful in the abdomen where it was possible to identify the presence and site of infection compared with organs containing physiological activity of $^{67}$Ga. This was particularly true around the liver (Figure 1, 2). It enabled normal struc-


**Figure 1 A.** 61-year-old patient with history of liver transplant and suspicious of abdominal abscess. Planar A-P (left side and P-A right side) $^{67}$Ga study with focal accumulation of tracer below left save of liver toward spine.

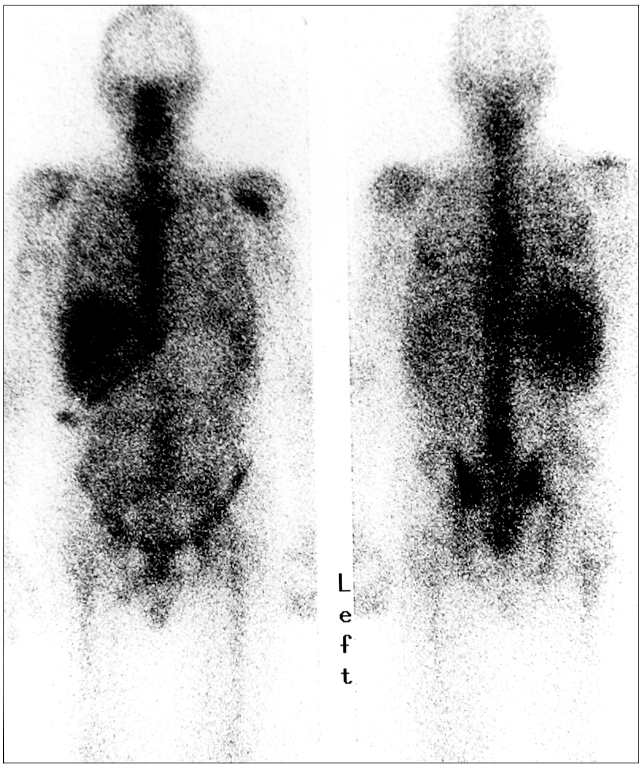


**Figure 2 A.** 64-year-old patient with previous history of bilary tree reconstruction, presented symptoms and signs of abdominal abscess. Standard planar A-P and P-A views with focal uptake of $^{67}$Ga below right lobe of the liver.

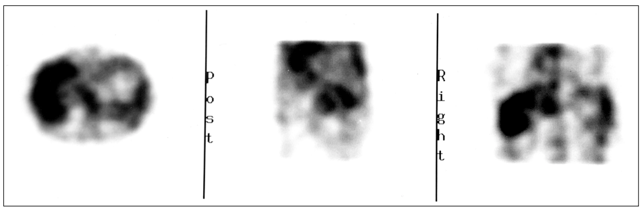


**Figure 1 B.** Standard SPECT study presentation as transverse, sagittal and coronal views, show clear cut uptake of $^{67}$Ga below the left lobe of the liver toward the spine (best seen in transverse and coronal views).

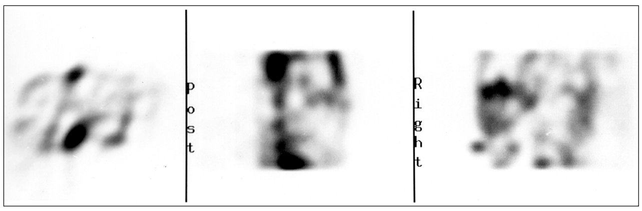


**Figure 2 B.** SPECT study with clear focal uptake of the tracer just below right lobe of the liver. Surgical operation confirmed pathology.

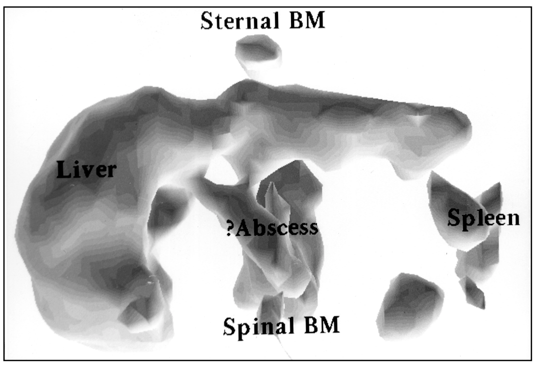


**Figure 1 C.** 3-D reconstruction of SPECT study with physiological uptake of the tracer within liver, spleen and spinal bone marrow. Additional pathological uptake below left lobe of the liver. Confirmed by pathology.

tures such as the colon to be readily identified. This could be enhanced by the use of three-dimensional (3-D) imaging and rotating the 3-D images in all three planes on the screen using an interactive graphic display. In the legs SPECT imaging clearly differentiated between the low grade uptake often seen around healing bone. This was most usefully seen in a patient post surgery for a knee replacement. There was a generalised increase uptake of $^{67}$Ga uptake along the edges of the femoral and tibial components of the prosthesis but in addition a more intense focal uptake was seen at the site of infection (Figure 3).

## Discussion

Taken on a patient by patient basis there is no difference in the results of planar and SPECT imaging. However the results of this study did show that on a site by site comparison SPECT is able to pick up more lesions than planar imaging. The advantage of SPECT imaging is the ability to separate activity in overlying tissues and also the improved contrast between the pathology and normal activity, which is described as an increase in contrast resolution. Our findings were similar to results of other studies using SPECT in $^{67}$Ga citrate imaging (1–3, 5, 8,12). One advantage in reading the scintigraphic SPECT data presented as transaxial, coronal and sagittal is that it can be used when comparing the results of the $^{67}$Ga citrate study and other forms of cross-sectional imaging such as CT or MRI. It may even be possible to combine data, using image registration techniques, though this was not done in our study. This study also confirms that $^{67}$Ga citrate can be used in a wide range of infections at different sites of the body and by using SPECT even infection within the abdomen can be identified. In some patients, for example those with vertebral osteomyelitis, suspected tuberculosis and those who are immunosuppressed either by previous drug treatment or AIDS, scintigraphy with $^{67}$Ga citrate is the method of choice (1, 8).

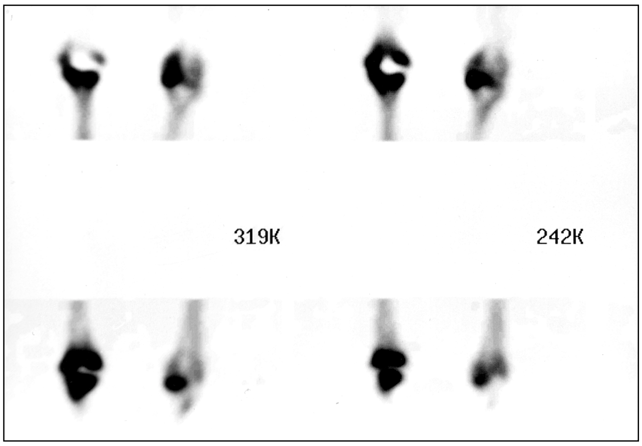


**Figure 3A.** 77-year-old female patient with history of bilateral TKR. Currently clinical presentation of infection or loosening right TKR device. Standard bone SPECT as coronal view ($^{99m}$Tc MDP) with focal uptake around right femoral component of TKR and signs of ”hot patella” on the left.

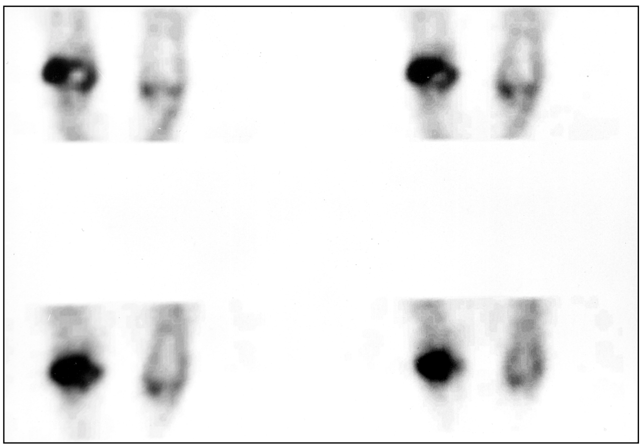

**Figure 3B.** $^{67}$Ga SPECT (coronal view) with clear cut uptake around a femoral component of TKR device. Confirmed as infection of right TKR.

Also it seems to be very useful in those patients with orthopaedic implants, when MRI cannot be used because of peri-metal signal drop out, and CT scans are not very helpful due to artefacts and often not conclusive results (1). In our group, 5 patients, those presenting with suspected infection around TKR devices, were all correctly diagnosed. Another use is in those patients with chronic osteomyelitis, which often consists of low grade of inflammation/infection and poor rate of migration of leukocytes, where $^{111}$In or $^{99m}$Tc HMPAO labelled leukocyte studies are often not very useful. Cases of acute osteomyelitis can be detected by commercially used polyclonal or monoclonal antibodies or labelled leukocytes (1,13–15). The low specificity of $^{67}$Ga scan (67%) in our study confirms that though $^{67}$Ga citrate is sensitive it may be positive in a range of non-infective conditions and sites of focal uptake must always be confirmed by aspiration or biopsy. A further disadvantage of $^{67}$Ga study is that the poor imaging characteristics of this radioisotope have to be overcome by good quality of collimation, digital data collection and the use of a specific $^{67}$Ga uniformity flood source for correction of data before SPECT reconstruction. This flood source should be repeated on a minimum 3 monthly basis (1).

This study clearly shows that both planar and SPECT $^{67}$Ga citrate imaging are sensitive in the localisation of a wide range of infection. SPECT, using modern gamma-camera technology, can find some additional sites of infection and also improve the localisation of infection. However as the specificity of the test is only 67% all sites of abnormal $^{67}$Ga citrate should have their nature confirmed by biopsy.

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