Cold spot in the uniform Co-57 image may not necessarily be due to photomultiplier tube failure or variations in photomultiplier tube tuning: A technical note

Sir,

The reason for cold spot in the uniform Co-57 image has been reported as the variation in photomultiplier tube (PMT) tuning or PMT failure.\(^1\) In this report, we found that this problem can also be related with the electronic board that stores the correction maps (such as uniformity, energy, and sensitivity) and applies necessary correction on the acquisition data acquired during the static or dynamic acquisition with the gamma camera.

On performing the routine daily extrinsic uniformity test on Symbia E Dual Head Gamma Camera (Symbia E, Siemens Medical Solutions, Illinious, USA), we found a cold spot on gamma camera with detector head 2. The uniformity test was performed with Co-57 flood source (Co-57, Serial Number: 1717–119, 10 mCi, Reference date: 1-February-2014, from Eckert and Ziegler Isotope Products, Medical Imaging Laboratory, 24937 Avenue Tibbits, Valencia, California 91355, USA). The uniformity image was acquired in 256 × 256 matrix size for 500 k counts on individual detector. The image we obtained is depicted in Figure 1. Initially we thought that the cold spot might be either because of failure of one of the PMTs corresponding to that position or the corresponding PMT may be out of tune in comparison to their surrounding PMTs. We later shut down the system and restarted it. Even then the cold spot persisted. Hence, the system engineer’s support was taken to resolve this issue. We later performed several interventions to sort the issue. The interventions we performed and the corresponding results we obtained are elaborated in Table 1. As detailed in Table 1, The PMT tuning was performed and still the cold spot persisted. Before coming to conclusion that PMT number 57 has failed and it needs replacement, the acquisition electronic board (AEB) was replaced. After replacing another spare electronic board, the intrinsic and extrinsic Co-57 flood source image were acquired and we obtained the uniform image without the cold spot.

The basic electronics of a gamma camera takes signals from all the PMTs and produces three signals, two of which define the X and Y coordinate of the detected gamma rays, and the remaining one defines the energy of the at event (Z). The unstable PMT leads to variation in the PMT response and non-linearity in the X, Y positioning pulses along the field of view (FOV). This can lead to non-uniform image.\(^2\) The variation in uniformity across the FOV can also be due to the hygroscopic nature of the NaI (Tl) detector. NaI (Tl) captures the water vapor and becomes yellow leading to decrease in light transmission in that area.

The AEB is the place where the linearity correction, energy correction, sensitivity corrections are stored and are applied on the fly. The block diagram of AEB and how it communicates with the PMT and the preamplifier (Preamp) is shown in Figure 2. On the crystal, the PMT is attached, and from each PMT the signal drives to the AEB. Each detector has AEB and from both the AEB communicates with each other and from one AEB the final signal of both the detector is sent for further processing and display of the image. Detector 1 has AEB, PMT/Preamp, OEM power supply PS (receives the AC input from MEDU [board] and sends output to AEB), high voltage module (HVM) that supplies voltage to the PMT/Preamp. There is a command control which communicates with AEB and HVM to and fro, to acknowledge proper supply of voltage). PMT/Preamp output goes to AEB, information about the PMT and Preamp temperature also goes to AEB. AEB communicates with PMT/Preamp through command/control signal. On the crystal, PMT/Preamp is attached. AEB receives data through flex interconnect. AEB of detector 1, detector

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**Figure 1:** The Co-57 flood image, 20% symmetric window, 256 × 256 matrix size and 500 k counts. A discrete, semicircular cold indentation can be appreciated in the lower region of the field of view. Semi-circular pattern delineated by borders of increased count. This was due to a defect in the electronic board which stores and applies correction factors on static and dynamic images.
Letters to Editor

2 and SNAC computer each has one Ethernet card, through which they communicate. AEB receives voltage supply from low voltage supply. Whatever detector 1 has, detector 2 also has the same equipment or whatever applies to detector 1 also applies to detector 2. Either of detector 1 or detector 2 can be made master or slave. Suppose detector 2 is a master, and then the signal from detector 1 and detector 2 will be collected at detector 2 and collectively it will be transferred to SNAC. The data that displayed on the PPM through SNAC it is also transferred to the console computer for further processing. There may be a problem with the connector available on the AEB that cannot be verified on site on the AEB level. That is why the AEB was replaced with the board.

The appearance of hot and cold spots in the flood image may be due to the variation in PMT tuning or PMT failure.[3] From Figure 2, it is clear that problem can also be in the AEB, or the cable that is driving the signal from the PMT to the AEB. This report highlights the importance of considering the problem with AEB can also be a reason for the cold spot in the uniform Co-57 image apart from the usual reasons like the variation in PMT tuning or PMT failure.

Table 1: Serial interventions performed and the results obtained

| Interventions performed | Results |
|-------------------------|---------|
| Acquisition repeated    | Cold spot persisted at the same position |
| System was restarted and acquisition performed afterwards | Cold spot persisted at the same position |
| Engineer was informed, and with engineer, intrinsic uniformity with 99 mTc point source was performed | Cold spot persisted at the same position |
| PMT tuning performed and after PMT tuning, intrinsic uniform image acquired | Cold spot persisted at the same position in Intrinsic uniformity image |
| Diagnostic test was performed by engineers, that check the offset value of the PMT, that matches the current value of PMT gain with that of the stored in the lookup table | Cold spot persisted at the same position in Intrinsic uniformity image |
| Intrinsic uniform point source image, the position of the PMT reported was verified by putting lead shield around PMT number 57 mentioned on the crystal surface | PMT number 55 was identified as the PMT having the problem |
| AEB of detector 2 was replaced with the new AEB (the spare part AEB) and the intrinsic uniformity was acquired | Confirmed the PMT number 55 have problem |

PMT: Photomultiplier tube, AEB: Acquisition electronic board
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Microbial infection imaging: A novel diagnostic approach

Sir,

The diagnosis of infection is essentially dependent on direct demonstration of the pathogen and its antigenic or genetic signatures. Whereas, host reactions, such as, antibody production, pathological changes in tissue and cellular or biochemical alterations of blood also provide indirect evidence of infection that are often nonspecific in nature. The role of conventional anatomical imaging (sonography, radiography, etc.) in the detection of infection is limited by its inability to delineate the early pathological changes without significant anatomical aberrations.

Infection imaging is a unique scintigraphic technique which facilitates rapid detection of infective foci by locating areas with higher leucocytes density. A variety of approaches, including Ga-67 citrate, radiolabelled autologous leukocyte and radiolabelled leukocyte targeting molecules that is, monoclonal antibodies against leukocyte antigens, have been used in these scans.

However, these scans cannot differentiate infections from sterile inflammation and also has a limited role in granulocytopenia.

Microbial imaging is a novel technique, developed over the last decade, to precisely locate microbes in tissue using a wide array of radiolabelled molecules targeting microbial cells, that is, antimicrobial agents (Tc-99m labelled fluoroquinolones, ceftizoxime, ethambutol, isoniazid, fluconazole), antimicrobial peptides (Tc‑99m labeled ubiquitin, human neutrophil peptide, human lactoferrin), bacteriophages and bacterial growth factors (In-111 labelled biotin).

The ideal radioconjugate for this purpose should be a stable compound which is radiochemically pure, nonantigenic, nontoxic to microbial and human cells, with rapid clearance and least nonspecific binding and accumulation in human tissue, while having substantially high specific interaction with microbial target sites in planktonic growth as well as in biofilms.

Until date, no radiopharmaceutical has achieved all these essential properties. Ubiquicidin 29–41 peptide fragment tagged with Tc-99m is the commonest probe used to study bacterial and fungal infections in human as well as in animals. There is growing concern on limiting the use of antibiotics as probes since it may result in drug resistance in pathogenic bacteria.

Despite small mass, large surface -to-volume ratio of bacterial cell ensures extensive radioconjugate binding on its surface in comparison to granulocytes. However, the bacterial load in the host remains as a critical factor. There is insufficient evidence to support the use of radiopharmaceuticals in increasing dose to improve the sensitivity of detection in case of low infective load of bacteria.

Currently, microbial infection imaging is restricted to acute bacterial infections, mycobacterial infections and candidiasis [Table 1].

Imaging of filamentous fungi, parasitic...