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Three Cases of Rare Systematic Errors Due To Unstable PM Tube Gain in Gated Myocardial Perfusion Imaging

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ABSTRACT

Introduction: Myocardial perfusion imaging (MPI) is a valuable diagnostic tool for the diagnosis of coronary artery disease (CAD) and is susceptible to a variety of artifacts, which degrade image quality and decrease diagnostic accuracy. Pitfalls and Artifacts in nuclear medicine imaging are not rare and could be classified into issues related to patients, equipment, and technologist. One of these artifacts is unstable PMT gain, which is rare and related to equipment. It is crucial for nuclear physicians to be aware of potential artifacts and their potential effect on image quality. This knowledge helps them to prevent or correct these artifacts if possible and if not, consider the potential effect of these artifacts on image pattern and quality. Some of these artifacts are preventable by routine quality control procedures, but some other artifacts may occur regarding quality control procedures.
Material and Methods: Three different female subjects 55, 57, and 61 years old with a history of atypical chest pain were referred to our department for myocardial perfusion imaging. MPI was performed according to standard protocols and stress, and rest phases were done.
Results: These three cases had different patterns of perfusion abnormalities due to interruption of count detection for a few seconds in some frames during acquisition that was due to voltage drop that leads to unstable PM tube gain.
Conclusion: Systematic errors due to voltage drops are not common, and they are not routinely sort of suspicion to artifactual perfusion abnormalities but they may cause misinterpretation of reports of MPI, and we should be aware of them.

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Introduction

Myocardial perfusion imaging (MPI) remains an essential part of cardiology and is widely applicable because of its availability [1]. MPI plays a significant role in diagnosis of coronary artery disease as well as prognosis and risk stratification [2]. Optimal image quality in nuclear medicine is essential for precise interpretation [3]. Quality of images is susceptible to multiple pitfalls and artifacts, which are not rare and may result from variety of causes. Most of these undesirable outcomes are preventable by applying quality control procedures [4]. Systematic errors in nuclear medicine equipment are one of the device-related artifacts, which affect the resulted projected images and may lead to misinterpretation. One of the rare systematic error is unstable PMT gain, which results from untunned PMTs with voltage drop as the most common reason. Routine quality control tests like weekly evaluation of uniformity, checks PMT uniformity and detects untunning of PMTs, and is crucial to detect these artifacts. Also, precise evaluation of raw data for each patient, helps the nuclear physician to evaluate the quality control of study and detect the potential artifacts. We present three cases of a rare systematic error called unstable PMT gain with different patterns in stress perfusion images of these patients.

Materials and Methods

Three patients including 55, 57, and 61 years old females with history of chest pain were referred to our department for myocardial perfusion imaging. MPI was performed as per standard guidelines in 2-days stress/rest protocol and 740 MBq 99m Tc-MIBI was injected for stress and rest phases each, according to EANM procedural guidelines for radionuclide myocardial perfusion imaging with SPECT and SPECT/CT[5]. Projected images were acquired by a single head gamma camera (MIE) in SPECT mode, matrix 64*64, zoom 4 and 32 frames. The camera was equipped to a LEAP (low energy all purpose)collimator. Projected images were reconstructed by filtered back projection (FBP).

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Results

Reconstructed stress images in one of these patients revealed mild hypoperfusion in the anteroseptal wall with no apparent hypoperfusion in the rest phase (figure1).

Stress images of the other patient showed unusual pattern with severely decreased radiotracer uptake in the anterior wall along with elliptical form of heart in the short axis with normal perfusion with no apparent hypoperfusion in the rest phase (figure2).

The third patient had hotspot in the apex and lateral wall along with hypo perfusion in the rest of the LV (left ventricle) myocardium in the stress phase with no apparent hypoperfusion in the rest phase (figure3).

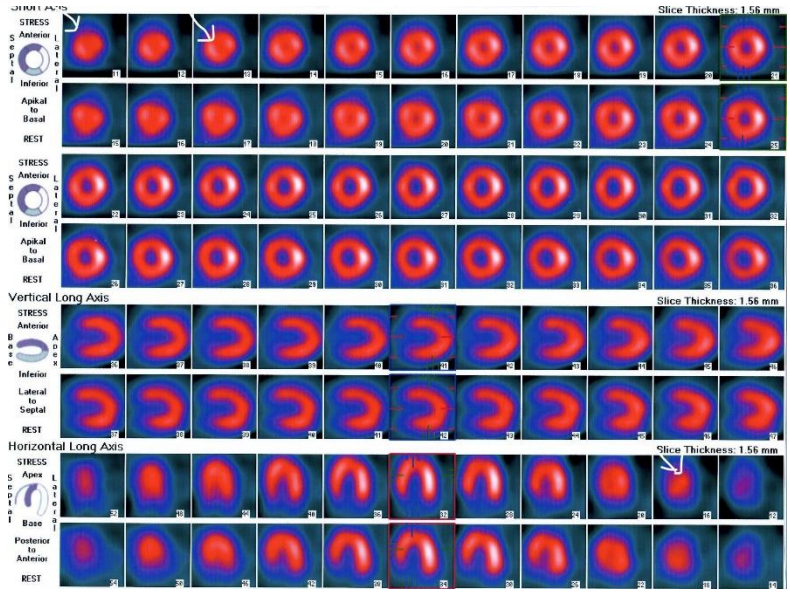

Figure 1. Stress phase of the first patient (mild reversible perfusion defect in the anteroseptal wall)

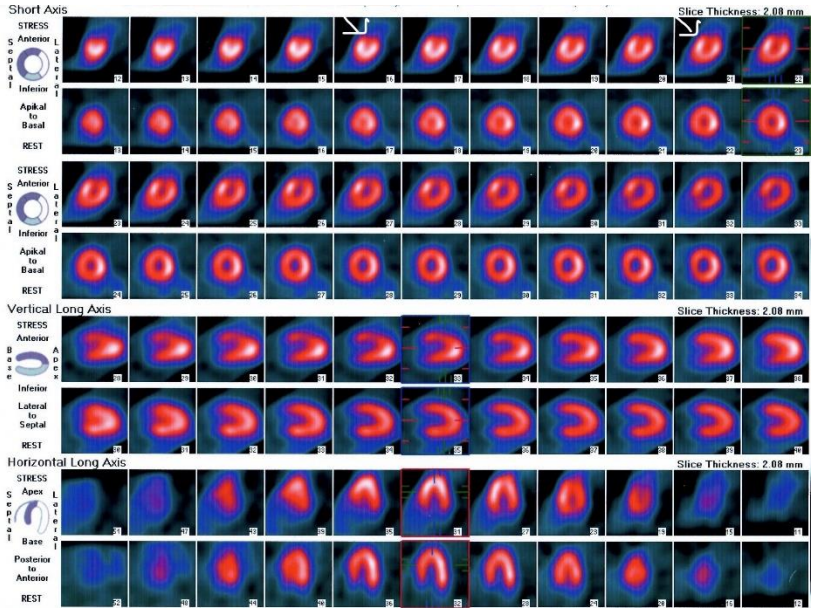

Figure 2. Stress phase of the second patient: severe reversible perfusion defect in the anterior wall with elliptical form of heart

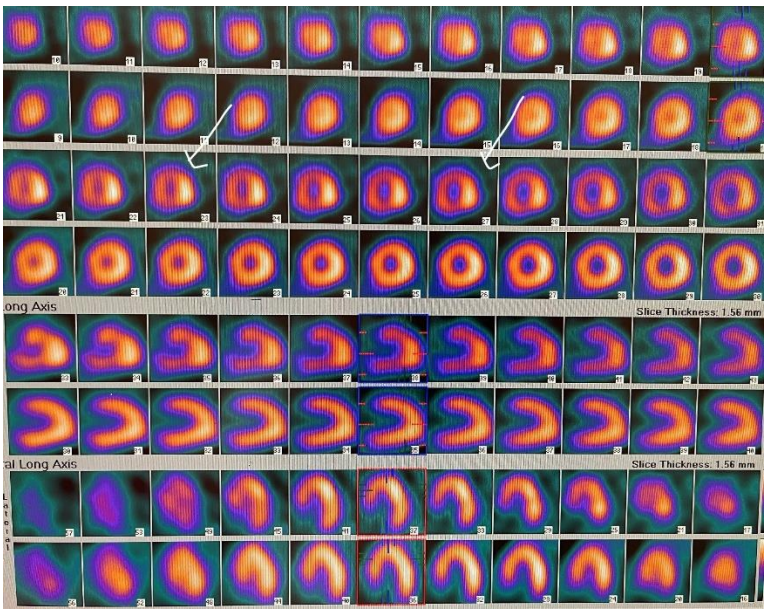

Figure 3. Stress phase of the third patient: hotspot in the apex and lateral wall with reversible perfusion defects in the rest of the myocardium

Raw data images were screened for evaluation of artifacts (patient related like motion artifact, breast repositioning, etc and instrument related) and an interesting finding was visualized. Rotating projection images in stress phase of all three patients revealed low count in some of the frames with normal counts in other frames. This artifact was seen in some other patients in stress and/or rest phases with variable degrees and was not recognized by technologist before. Suspicion of some sort of systematic errors in nuclear medicine equipment raised. In weekly quality control of instrument and uniformity verification, PMTs were not tuned and due to multiple occurrence of this artifact, voltage drop, which is the most common reason of untunned PMTs, was suspected, and after correction of this problem, PMT tuning was reacquired and our suspicion was confirmed. This rare systematic error which could be called unstable PMT gain, disrupts the performance of the PMT and interrupts count detection for a few seconds in some frames. This error was fixed and stress phase of these three patients were repeated. Stress perfusion in these three patients revealed normal perfusion and normal axis with no hotspot artifact.

Discussion

Whereas MPI is a valuable diagnostic tool, potential pitfalls and artifacts compromise its utility [6, 7]. Pitfalls and artifacts may cause false positive or false negative results, which make drastic changes in patient's management[8]. Therefor it is crucial to prevent these artifacts and identify them to minimize undesirable outcomes [9]. Nuclear medicine artifacts could be classified into issues related to patients, equipment and technologist. Several quality control procedures are performed to prevent these unwanted results. Even with all the quality control procedures done on a regular basis, some other artifacts may occur which needed to be recognized. Systematic errors related to equipment may occur regarding to regular quality control, making artifacts and subsequently leads to misinterpretation [10]. The overall SPECT image quality is determined by a mixture of the detector performance, collimator dimensions, system design, and image reconstruction algorithm. Basic image quality tests, such as spatial resolution, sensitivity, and energy resolution are performed with simple phantoms or procedures[11].

There is a rare systematic error in nuclear medicine equipment called unstable PMT gain that should also be considered in mind.

We presented three cases with this kind of error with different patterns in the resulted perfusion images. This artifact was due to untunned PMTs, which was detected by uniformity verification test. The most common reason for this problem is voltage drop, which was happened occasionally in our equipment and not in all frames and all patients; therefore this artifact was only seen in some patients. This artifact is detectable by weekly uniformity test; however, visualization of raw data images is crucial to detect these artifacts. Our cases implies the importance of routine quality control and also observation of raw data images before interpretation and it is suggested to perform routine quality control procedures and screening of raw perfusion images to prevent undesirable effects on image quality.

Conclusion

Several artifacts may compromise MPI utility for diagnosis of CAD. Awareness of these artifacts helps the nuclear physician to check them out and if possible, correct them. If these artifacts cannot be eliminated, consideration of effects of these artifacts on image quality, improves the interpretation preciseness. Three different patterns in three patients of our department in only one phase of their nuclear procedure, implies the

significance of routine quality control procedures to prevent undesirable artifacts and also visualization of raw data images is strongly recommended to recognize any unwanted artifact for precise interpretation and appropriate patient management.

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