Pitfalls in classical nuclear medicine: myocardial perfusion imaging

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Abstract. Scintigraphic imaging is a complex functional procedure subject to a variety of artefacts and pitfalls that may limit its clinical and diagnostic accuracy. It is important to be aware of and to recognize them when present and to eliminate them whenever possible. Pitfalls may occur at any stage of the imaging procedure and can be related with the γ-camera or other equipment, personnel handling, patient preparation, image processing or the procedure itself. Often, potential causes of artefacts and pitfalls may overlap. In this short review, special interest will be given to cardiac scintigraphic imaging. Most common causes of artefact in myocardial perfusion imaging are soft tissue attenuation as well as motion and gating errors. Additionally, clinical problems like cardiac abnormalities may cause interpretation pitfalls and nuclear medicine physicians should be familiar with these in order to ensure the correct evaluation of the study. Artefacts or suboptimal image quality can also result from infiltrated injections, misalignment in patient positioning, power instability or interruption, flood field non-uniformities, cracked crystal and several other technical reasons.

1. Introduction
Myocardial perfusion imaging (MPI) has established its utility and its clinical importance in the diagnoses of several medical conditions throughout the years and today is one of the most common examinations requested at a nuclear medicine department. It is important though to be aware that a variety of artefacts and pitfalls that might occur at any stage during imaging and nuclear medicine physicians should be familiar with these in order to ensure a correct evaluation of the study. In this short review most of these artefacts and pitfalls will be addressed.

2. Clinical artefacts and pitfalls
2.1. Soft tissue attenuation artefact
Attenuation is the decrease in intensity of a photon signal along its path to the detector. During nuclear cardiac imaging, non-uniform attenuation occurs as photons pass through tissues of varying densities. Artefact extent varies with the location of soft tissue, overall patient body size, and depth of target organ. In particular:
- Breast usually causes defects in the anterior wall but if breasts are pendulous, lateral defects may also occur,
- Obesity is usually associated with lateral wall fixed defects,
- Diaphragm causes inferior wall defects,
- Prone SPECT can reduce diaphragmatic attenuation but may lead to small anterior and anteroseptal defects.

2.2. Overlying visceral activity
SPECT reconstruction leads to apparent increased count densities in areas underlying visceral activity, since polar maps are normalized to areas with highest activity, bull-eye displays can be affected, as shown in figure 1.

![Figure 1](image)

**Figure 1.** (A) An example of a patient with intense visceral activity (arrowheads). (B) Image processing which includes this activity results in an artefactual reversible defect (arrow) on perfusion images. (C) The artefactual defect disappears when the study is reprocessed correctly showing a normal study.

2.3. Myocardial hot spots
Myocardial hot spots are due to increased myocardial thickness near the anterior and posterior papillary muscles, exacerbated by left ventricular hypertrophy. Bull-eye reconstruction can therefore be affected.
2.4. Artefacts due to patient’s anatomy
Anatomical variants or other medical conditions can affect cardiac imaging:
- Apical variants (apex displaced laterally or rarely septally) make selection of the apex difficult and may lead to bull-eye reconstruction errors,
- LBBB causes reversible septal defects. ECGs should be viewed for conduction abnormalities before the stress test and if present always do adenosine or dipyridamole stress test,
- Left ventricular hypertrophy (LVH) can simulate lateral infarction,
- Dextrorotation can cause lateral wall defect and Levorotation a septal wall defect. If the condition is known beforehand there should be a 360° SPECT performed,
- In cases of dextrocardia the 180° SPECT acquisition should range from –135° to +45° [1].

2.5. Motion artefacts
Patient motion during myocardial perfusion SPECT can produce artefactual perfusion defects. Motion artefacts appear to be a greater problem with axial than lateral movement and are accentuated if movement occurs in the middle of rotation. Horizontal motion typically causes septal and lateral artefacts and vertical motion may cause anterior and inferior wall artefacts [2].

2.6. Upward creep artefact
During exercise, the heart is displaced interiorly against the diaphragm as the thorax expands. During recovery, the heart "creeps" back up in the thorax leading to reversible defects in the inferoseptal wall. This artefact can be avoided if we wait for about 15 min before starting the stress imaging [3].

3. Technical artefacts and pitfalls
3.1. Radiolabeling errors
Inadequate binding of the technetium to the cold ingredient will result in free 99mTc in the stomach causing an artefact and non-imaging of the heart.

3.2. Infiltrated injection
In case of subcutaneous radiopharmaceutical infiltration, less radiopharmaceutical is taken up by the myocardium resulting in lowered counting statistics and a poor-quality study. Should the infiltrated injection occur during the second phase of a same-day Rest–Stress study, the stress scan will be predominated by activity from the first injection (for the rest imaging) and ischemia induced during the stress test may be masked [1].

3.3. Hot spots near the heart
Increased uptake adjacent to the heart could conceivably compromise evaluation of perfusion in adjacent LV. An example is seen in figure 2.

3.4. Metal and other attenuators
Before imaging, metal and other potential attenuators must be removed from the patient if they will project into the imaging field of view and potentially interfere with the study.

3.5. Contamination
Any contamination with the radiopharmaceutical on the patient or the equipment can project into the imaging field of view and interfere with the study.

3.6. Processing errors
- Incorrect parameter setting or incorrect axis alignment can lead to wrongful evaluation of the study,
- Filters that are too coarse may result in false positive studies and filters that are too smooth may result in false negative studies [4].
- A large number of beat rejections has a great impact on the gated data set and the QC of the gating data should always be checked before reporting a study.

![Figure 2](image_url)

**Figure 2.** A very “hot” and upward positioned gall bladder (arrow) projecting into the imaging field of view can compromise the imaging of the heart.

### 3.7. Center of rotation artefact

If the center of rotation is properly calibrated, a radioactive point source placed in the center of the camera orbit should project to the center of the computer matrix. If the calibration is incorrect a posteroapical (rightward +) or an anteroapical (leftward –) defect will result [5].

### 3.8. γ-ray scatter artefact

When imaging using $^{99m}$Tc, incident photons contributing to the final image may include photons scattered by as much as 45° to 60°, so care should be taken to clear away any external sources [6]. Unfortunately, several other technical and acquisition issues can arise (like flood field non-uniformities, power interruption to the camera, unexpected photopeak shift, cracked crystal etc) and is crucial to be ready to recognize them as soon as possible.

### 4. Conclusion

As with all medical procedures, rashness and lack of attention to details may lead to pitfalls that could be easily avoidable. Should artefacts occur they should be recognized and corrected on time. Using standard protocols, being thorough with the quality control of the equipment and the standard operating procedures in a department can help to prevent most of these artefacts and pitfalls.

### References

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