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Quality issues with nuclear medicine equipment: gamma cameras

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Introduction

The basic hardware element of nuclear medicine imaging systems (gamma cameras and PET full ring tomographs), is the photomultipliers (PMT). Its response is intrinsically dependent upon environmental parameters. Even if modern PMTs are compensated against temperature and humidity fluctuations, their large number (from about 50 to 90), together with the large number of electronic parts forming a modern fully digital detector make the system failure probability high. In addition, a drift in PMT output signal is a physiological symptom of aging of its internal parts (dynodes). For these reasons, the performance of Gamma Camera systems must be regularly monitored as part of the efficient and effective quality assurance program, in order to fulfill the Council Directive 97/43/EURATOM (1997), which aims at the patient radiation protection

Modern systems

Current generation gamma cameras may have a wide range of functions, including whole body scanning, SPECT, attenuation correction, and even PET imaging.

Quality control covers the imaging performance of all of these options. In addition to the basic detector performance, the digital image data processing raises important questions of accuracy and reliability.

Gamma camera systems may have up to 3 heads, and so quality control procedures need to be efficiently implemented in order not to take considerable, and impractical, amounts of time and energy to perform. Tests need to be sensitive, reliable and easy to perform.

Protocols

Various QA protocols have been produced over many years. The reference documents were issued by the International Atomic Energy Agency (IAEA) (1), by the American National Electrotechnical Manufacturer Association (NEMA) (2), and by the International Electrotechnical Commission (IEC) (3), (4), (5). NEMA and IEC protocols mainly developed tests which are useful in order to characterize system performances. Such tests are very accurate and consequently time consuming. For this reason they have to be performed as acceptance and reference tests, without a fixed schedule. Moreover, no limits of acceptability are indicated. On the other side, IAEA document reports a set of routine and operational tests which have to be performed on a regular basis, and gives tolerance intervals. The variety of the proposed documents encouraged writing of protocols from national bodies. In any case, one can find a general consensus about the main recommended tests. Systems limited to planar imaging requires a relatively soft operational checks set (daily peak position and uniformity, weekly spatial resolution, according to IAEA). SPET systems need more accurate planar uniformity and additional tomographic tests (uniformity, spatial resolution, centre of rotation offset, rotation speed, head sensitivity uniformity). WB systems ask for simple additional spatial resolution and scanning speed tests.

It has to be remarked that the IAEA recommended test frequencies had been conceived almost fifteen years ago, and that meanwhile the technological improvement allows a looser schedule.

Corrective actions

Quality control measurements provide data, but in addition these data must be interpreted and appropriate action taken when problems or potential problems are identified. The easiest corrective calibrations are usually left to the final user (physicist in general), and are the dual world of the QC world.



References

1. IAEA-TECDOC-602 Quality control of nuclear medicine instruments 1991
2. NEMA NU 1-1994 - Performance Measurements of Scintillation Cameras
3. IEC 60789 Characteristics and test conditions of radionuclide imaging devices - Anger type gamma cameras 1992
4. IEC 61675-2 Radionuclide imaging devices - Characteristics and test conditions - Part 2: Single photon emission computed tomographs 1998
5. IEC 61675-2 Radionuclide imaging devices - Characteristics and test conditions - Part 3: Gamma camera based wholebody imaging systems 1998