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Adult Gamma Camera Myocardial Perfusion Imaging: Diagnostic Reference Levels and Achievable Administered Activities Derived From ACR Accreditation Data

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Abstract

Purpose: The aim of this study was to glean from accreditation surveys of US nuclear medicine facilities the in-practice radiopharmaceutical diagnostic reference levels (DRLs) and achievable administered activities (AAAs) for adult gamma camera myocardial perfusion imaging (MPI).

Methods: Data were collected from the ACR Nuclear Medicine Accreditation Program during one three-year accreditation cycle from May 1, 2012, to April 30, 2015. Data elements included radiopharmaceutical, administered activity, examination protocol, interpreting physician specialty, practice type, and facility annual examination volume. Facility demographics, DRLs, and AAAs were tabulated for analysis.

Results: The calculated DRLs and AAAs are consistent with previously published surveys, and they adhere to national societal guidelines. Facilities seeking ACR accreditation are nearly evenly split between hospital based with multiple gamma cameras and office based with single gamma cameras. The majority of facilities use single-day, low-dosage/high-dosage ^{99m}Tc-based protocols; a small minority use ^{201}TlCl protocols. Administered activities show a consistency across facilities, likely reflecting adoption of standard MPI protocols.

Conclusions: This practice-based analysis provides DRL and AAA benchmarks that nuclear medicine facilities may use to refine gamma camera MPI protocols. In general, the protocols submitted for ACR accreditation are consistent with national societal guidelines. The results suggest that there may be opportunities to further reduce patient radiation exposure by using modified examination protocols and newer gamma camera software and hardware technologies.

Key Words: Myocardial perfusion imaging, diagnostic reference levels, patient radiation exposure

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INTRODUCTION

The revolutionary benefits of radiology and nuclear medicine (NM) on medical diagnosis have driven a large increase in the number of imaging examinations performed annually in the United States and across the world. This growth in examination volume caused an estimated sixfold increase in the US per capita effective radiation dose from medical sources between 1987 and 2009 [1]. The resulting

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public health concerns have catalyzed the diagnostic imaging communities to pursue organized strategies for lowering medical ionizing radiation exposure [2-5].

Regarding nuclear myocardial perfusion imaging (MPI), the explosion in volume is due in part to convincing data that the results can effectively stratify cardiovascular risk and provide incremental information compared with alternative diagnostic methods [6-8]. The nuclear cardiology community has responded to the mandate to lower patient radiation exposure by issuing examination-specific appropriate use criteria and describing examination protocol guidelines [9-12].

Regarding guidelines, the challenge is to create a protocol that recommends the lowest amount of radiation necessary to obtain images of diagnostic quality. To aid this process of dose reduction, two concepts have emerged: diagnostic reference levels (DRLs) and achievable administered activities (AAAs), also known as achievable doses (or dosages). In NM, DRLs and AAAs are administered activities of examination-specific radiopharmaceuticals, expressed in millicuries or megabecquerels.

DRLs were introduced by the International Commission on Radiological Protection (ICRP) in 1990 [13] and later refined in 1996 [14]. From the 1996 report,

> These levels, which are a form of investigation level, apply to an easily measured quantity, usually the absorbed dose in air, or in a tissue equivalent material at the surface of a simple standard phantom or representative patient.…The diagnostic reference level will be intended for use as a simple test for identifying situations where the level of patient dose [dosage] or administered activity is unusually high. If it is found that procedures are consistently causing the relevant diagnostic reference level to be exceeded, there should be a local review of procedures and the equipment to determine whether the protection has been adequately optimized.

By convention, DRLs are set at the 75th percentile of the distribution of dosages from a regional or national survey of imaging facilities. DRLs serve as guideposts that, when exceeded, inform imaging facilities that their protocols might need adjustment with respect to patient radiation exposure. Because DRLs have the greatest impact for only a minority of imaging facilities (ie, the 25% whose protocols exceed them), the concept of AAAs has been promulgated as a more widely applicable guideline. AAAs are set at the median (50th percentile) dosage of the surveyed population, and they represent dosages achievable by standard techniques using commonly available equipment [15]. In this study, we used the administered activities and other demographic data reported by imaging facilities in their applications to the ACR Nuclear Medicine Accreditation Program to (1) derive DRLs and AAAs for adult gamma camera MPI, (2) assess the range of imaging protocols for these examinations in current practice, and (3) compare the results with national and international guidelines.

METHODS

ACR Nuclear Medicine Accreditation Program

The application requires submission of two different examinations of each type performed on each gamma camera to be accredited. For each examination, a facility submits the radiopharmaceutical(s) and administered activities, gamma camera acquisition parameters, and final reports. In addition, the application includes physics data for each gamma camera, site demographic data, and the facility's written policies and procedures pertaining to each examination type. The quantitative data from each accreditation application are entered into a Microsoft SQLServer database (Microsoft Corporation, Redmond, Washington), which forms the current data set.

Data Set

Data spanning a three-year accreditation cycle from May 1, 2012, to April 30, 2015, for gamma camera MPI were extracted from the ACR accreditation program database. Only gamma cameras that passed initial, renewal, reinstate, or repeat cycles were included; appeals were excluded. There were 7,311 MPI examinations that met the inclusion criteria. The following data fields were queried: radiopharmaceutical, administered activity, examination protocol, interpreting physician specialty, practice type, and annual examination volume.

Data Tabulation

The results of the database query were transferred to Microsoft Excel, which was used to organize and analyze the data.

RESULTS

Demographics of Gamma Camera MPI

Table 1 summarizes demographic parameters describing the facilities included in this study.

The most common facility location is hospital based (50.2%), and these 1,289 facilities applied to accredit 2,151 cameras. Thus, on average, hospital facilities use more than a single camera for MPI. A significant minority is outpatient offices and clinics (40.6%) these 1,045