Tc-99m adherence and dose reduction in myocardial perfusion imaging

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INTRODUCTION

From the early 1980s to 2006, the proportion of ionizing radiation exposure of the US population attributed to medical imaging has increased from 15% to 48%. Nuclear medicine studies represent approximately one-quarter of that medical exposure.¹ Myocardial perfusion imaging represents a majority of those studies and is commonly indicated as an adjunct to cardiac stress testing in the appropriate patient. As clinicians and imagers we strive to balance the diagnostic quality of studies with effective radiation dose to our patients. Traditional approaches to striking this balance in radionuclide imaging include stress-only SPECT imaging with attenuation correction, appropriate selection of radiotracers and protocols, advanced iterative reconstruction methods, and utilizing multi-detector imaging systems.²

In this issue, Reynolds et al highlight how critical radiochemistry and administration technique of a radiopharmaceutical can be in myocardial perfusion imaging and dose reduction.³ They demonstrate how the variable adherence of Tc-99m Sestamibi in syringes alters the actual delivered dose to the patient and complicates efforts at reducing effective dose. The result is a prescribed dosage intended to overcome residual activity

and variable adherence in order to provide diagnostic quality imaging.

SYRINGE TYPE IS KEY

Generator-produced Tc-99m radiopharmaceuticals are routinely provided in basic, disposable, single-use plastic syringes by a radiopharmacy for medical imaging. Under 10 CFR 35.63 authorized users are able to prescribe a specific dose or a dose range for radionuclide imaging. The acceptable amount of variation in the administered dose compared to the prescribed dose is 20%.⁴

Some residual activity in the syringe after administration can be expected, given the dead space volume of the syringe. The dead space volume and specific activity of the radionuclide should not be ignored, and the primary etiology of residual activity in the syringe is the dead space volume.⁵ Many laboratories administer radiopharmaceuticals as provided by the radiopharmacy in 1 cc aliquots while others expand the volume to 3 cc prior to administration. This can have a significant impact on the residual activity due to radiotracer concentration in the dead space volume. Additionally, adherence of Tc-99m radiopharmaceuticals on plastic syringes has been reported and the larger concern is the variability of this adherence rather than the more systematic dead space volume issue.^{6,7}

Reynolds et al, systematically tested three different syringe designs including two or three parts with and without lubricant. By testing different syringe designs, they made a clear case to avoid the three-part lubricated syringe given the significantly variable residual activity and evidence of adherence. There was a dose-related effect demonstrated where higher doses resulted in less adhesion, thought to be related to saturation of binding sites at higher doses. However, they felt the lubricant was the major contributor to adhesion. Swanson et al had demonstrated this as well in 2013, attributing the adherence to the presence of a syringe lubricant or coating.⁸ The residual activity data across multiple types

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Fig. 1. Comparison of residual activity (%) across different syringe types. Error bars represent 1SD. Adapted from Reynolds et al³ and Swanson et al⁸.

of syringes from both investigators were compared (Figure 1). Both found a particular type of syringe to have significantly lower residual activity (orange bars). The presence of a lubricant in the syringe is not the sole mechanism of adherence but is postulated as the cause of variability. Specific activity of Tc-99m, the dwell time and prep time from dose to injection have also been implicated in post-injection residual adherence.^{3,8,9}

Variable adherence cannot be systematically corrected for by prescribing and preparing larger doses. Quality control is indicated at the laboratory level on the type of syringe being used. Given the variable and significant adhesion reported in lubricated syringes, a more rigorous pre- and post-injection assay seems appropriate if lubricated syringes will be used.

DOSE REDUCTION

The primary concern is to deliver an adequate radiopharmaceutical dose to the patient in myocardial perfusion imaging to generate an adequate signal to noise ratio under the As Low As Reasonably Achievable (ALARA) principle. Attempting to overcome the variability due to adherence by systematically increasing the prescribed dosage will result in excess administered dose in some patients and hinder efforts at reducing effective radiation dose.

Using the adherence and residual activity data noted above, laboratories should choose a syringe system that exhibits the least amount of adherence and prescribe a radiopharmaceutical dose that corrects for the systematic residual activity, primarily due to dead space. Swanson et al report a 20% reduction of dispensed dose, using a low residual activity and minimally variable syringe system, without any sacrifice of image quality.

In this issue, Reynolds et al provide further evidence that an optimal non-lubricated syringe system should be used to allow for a similar reduction in dispensed doses. Both studies also highlight the fact that current estimations of absorbed effective dose in myocardial perfusion imaging studies are overestimates as they are based on pre-injection assays and residual activity may be significant in some cases.

SUMMARY

The syringe system used to administer radiopharmaceuticals in myocardial perfusion imaging plays a key role in prescription of an appropriate dose and the diagnostic quality of the resultant images. Data suggest that lubricant-free syringes should be used to reduce variable adherence of Tc-99m radiotracers. Systematically prescribing doses to overcome variable adherence may result in higher absorbed doses than diagnostically necessary in some patients. Any effort at minimizing adherence of Tc-99m radiopharmaceuticals to the syringe system will reduce variability of the administered dose, allow for appropriate systematic reduction of prescribed dose under the ALARA principle, and result in more accurate estimates of absorbed effective dose. It is reasonable to expect that laboratories will assess the residual activity and variability of their particular syringe systems as part of a quality control process, then reassess if the syringe manufacturer or specifications change.

Disclosure

The author declares that there is no conflict of interest to disclose.

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