

Urinary voiding as a tool to reduce radiation exposure in the nuclear stress lab

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Abstract

Rationale: Nuclear stress testing is being increasingly justified in the cardiovascular risk stratification of patients. Radiation is an important consideration and attempts to minimize exposure should be implemented. Efficiency and cost effectiveness are cornerstones in the delivery of quality patient care and should also be considered when implementing change. **Methods:** We studied 88 consecutive patients who presented to our stress lab for pharmacologic nuclear stress testing. A single day rest and stress protocol with low level exercise was utilized for all patients. After the stress portion of the exam, we measured Geiger counter activity above the bladder area to establish a baseline. Patients were then allowed to void and repeat measurements were taken. **Results:** We detected a 16.9% reduction from baseline radiation levels above the bladder area post voiding. **Conclusions:** Urinary voiding is a simple, cost effective strategy at reducing radiation exposure in the nuclear stress lab.

Introduction:

Nuclear myocardial perfusion imaging (MPI) has been instrumental in the risk stratification of patients suspected of having ischemic heart disease. Furthermore, the widespread use of ^{99m}Techneium-labeled radiopharmaceuticals has improved the efficiency of the stress testing process (1). Despite advances in instrumentation such as cardiac Cadmium-Zinc-Telluride cameras (2) and improvements in signal processing such as iterative reconstruction (3), concerns regarding radiation safety remain. As more of these noninvasive myocardial perfusion tests are ordered, particularly multiple tests in the same patient, radiation exposure may not be negligible. Although individual risk is small, increasing use of myocardial perfusion imaging has the potential to impact future cancer risk for the greater population (4). Furthermore, if the recommendations outlined in the 2010 American Society of Nuclear Cardiology information statement are followed, the expectation is for a total radiation exposure of less than or equal to 9 millisieverts (mSv) in half of all myocardial perfusion imaging studies by 2014 (5).

^{99m}Techneium tetrofosmin is one of the most commonly used tracers in MPI studies. One particular area where ^{99m}Techneium-labeled radiopharmaceuticals have shown significant activity is the urinary bladder (6). Studies show for an administered dose of 11.1 MBq (0.3 mCi) of ^{99m}Techneium tetrofosmin the effective dose for a 3.5-hr bladder voiding period would be 9.9 mSv (1 rad) at rest or 7.9 mSv (0.8 rad) after exercise (6). Statistical limitations make it challenging to evaluate cancer risk in humans but based on the BEIR VII lifetime risk model it is predicted that approximately 1 in 100 individuals would develop cancer, solid organ or leukemia, from a dose of 0.1 Sv above background (7).

Understanding biodistribution and dosimetry is crucial to patient centered radiation safety measures and can lead to advances in quality improvement. After studying the biodistribution properties of 99m-Techneium tetrofosmin, we hypothesized that allowing urinary voiding prior to patient discharge from the stress lab would result in less radiation exposure. This simple, cost-free protocol adjustment has the potential to improve patient safety.

Material and Methods:

We studied 88 patients who presented to our nuclear stress lab. IRB approval was requested but the project was considered exempt by the board since there was no significant deviation from the established protocol and the project is considered quality improvement. The requirement to obtain informed consent was waived. The study qualifies for exemption 45 CFR 46.101(b)(1) from 45 CFR part 46 requirements published by the Office for Human Research Protections (8). Patient demographics are represented in (Figure 1). The majority of the patients were noted to be male between the ages of 60 and 79. More than half of our patients had a body mass index less than or equal to 30. Furthermore, a majority of the patients also had normal renal function.

88 consecutive patients who underwent a pharmacologic nuclear stress test were enrolled. Patients were included in the study only if they were able to void. All subjects underwent a single day, rest and stress, 99m-Techneium Tetrofosmin protocol conforming to the American Society of Nuclear Cardiology guidelines (9). Patients were instructed to fast for at least 3 hours and to avoid caffeinated products for 12 hours prior to the test. All MPI scans were acquired with a dedicated cardiac SPECT camera utilizing

Cadmium-Zinc-Telluride crystals and Tungsten collimators (D-SPECT, Biosensors International, Caesarea, Israel). Patients were given a standard intravenous dose of regadenoson 0.4mg (Lexiscan, Astellas Pharma Inc) and followed a low-level exercise protocol. Once the stress portion of the exam was performed, patients were instructed to eat to improve image quality and, for the purpose of this study, to resist the urge to void. Upon returning from their meal, a Geiger counter was used to detect radiation levels above the bladder area. Patients were then allowed to void. Radiation detection was then performed again immediately after voiding. Post stress images were then acquired and the standard protocol was then completed.

Exposure rate data were analyzed with respect to the excess lifetime risk of developing a radiation induced cancer based on our average administered dose of 1610 MBq (43.5 mCi) (stress and rest). Based on the International Commission on Radiological Protection Publication 103, Table A.4.1, for a population ages 18-64, the risk is approximately 17 cases per 10,000 individuals exposed to an average of 17 mSv (10).

Results:

Upon returning to the stress lab, study patients did comply with the request to not void during their break. Of the 88 consecutive patients measured, we detected an average of 0.13 mSv/hr above the bladder area prior to voiding and 0.108 mSv/hr immediately after voiding. This is a 16.9% reduction in patients receiving an average of 1610 MBq (43.5 mCi) of Tc99m tetrofosmin for their exam, including a rest dose of 320 MBq (8.6 mCi) and a stress dose of 1300 MBq (35.1 mCi) (Figure 2). An estimated lifetime risk of developing a radiation-induced cancer from using our proposed protocol is lowered from 17 to approximately 14 cases per 10,000 individuals.

Discussion:

Excellent cardiac uptake and retention, paired with efficient clearance from other organs, makes ^{99m}Techneium Tetrofosmin a choice agent for MPI (6). Significant activity is often observed in the urinary bladder based on previous biodistribution studies (6). Of note, previous studies also establish a higher rate of urinary clearance in the resting study when compared to the exercise imaging (6). Urinary voiding prior to the acquisition of the stress images is ideal. The patients have had the opportunity to hydrate during their brief break after the regadenoson injection. This also allows for more radiation waste to build up in the urinary bladder.

There are many ways to reduce radiation exposure in the cardiac stress lab (Table 1). Judicious stress test ordering and appropriate patient selection would be the obvious mechanisms for reducing radiation exposure. Some labs have opted for stress only imaging initially and then bringing the patient back for rest images only if needed. Certainly, the newer generation cameras along with more efficient acquisition and reconstruction technology is improving efficiency in the lab and reducing radiation exposure. However, the latest technology may be cost and resource intensive which may not be feasible for all labs. Each individual stress lab has to perform cost benefit analyses to see which dose reduction strategy is optimal for their unique situation.

We do note that our study population is older than the range given in the risk estimate by the International Commission on Radiological Protection. While we purport that the theoretical risk is reduced by 3 cases per 10,000 patients, this may be an overestimate.

Conclusion:

Our data suggests that adding a simple urinary voiding break to the standard stress protocol can also reduce patient radiation exposure. Although the small sample size of patients can certainly be considered a limitation of this study, future studies can easily enroll more patients without utilizing significant resources.

In an era when myocardial perfusion imaging is becoming more utilized, improving radiation safety and reducing patient radiation exposure is of paramount importance. Implementing a simple protocol adjustment and allowing the patient to void after adequate hydration can reliably reduce radiation exposure. This technique is not resource intensive and can be done with minimal to no cost.

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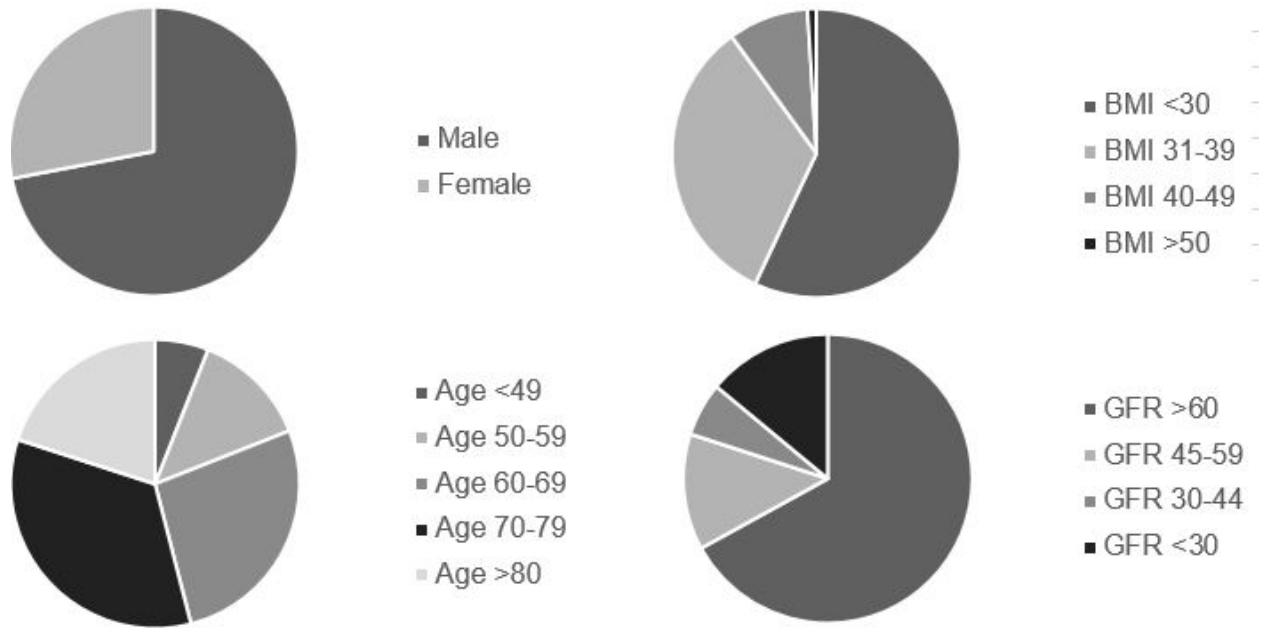


Figure 1. Patient demographics detailing gender, age, BMI and renal function

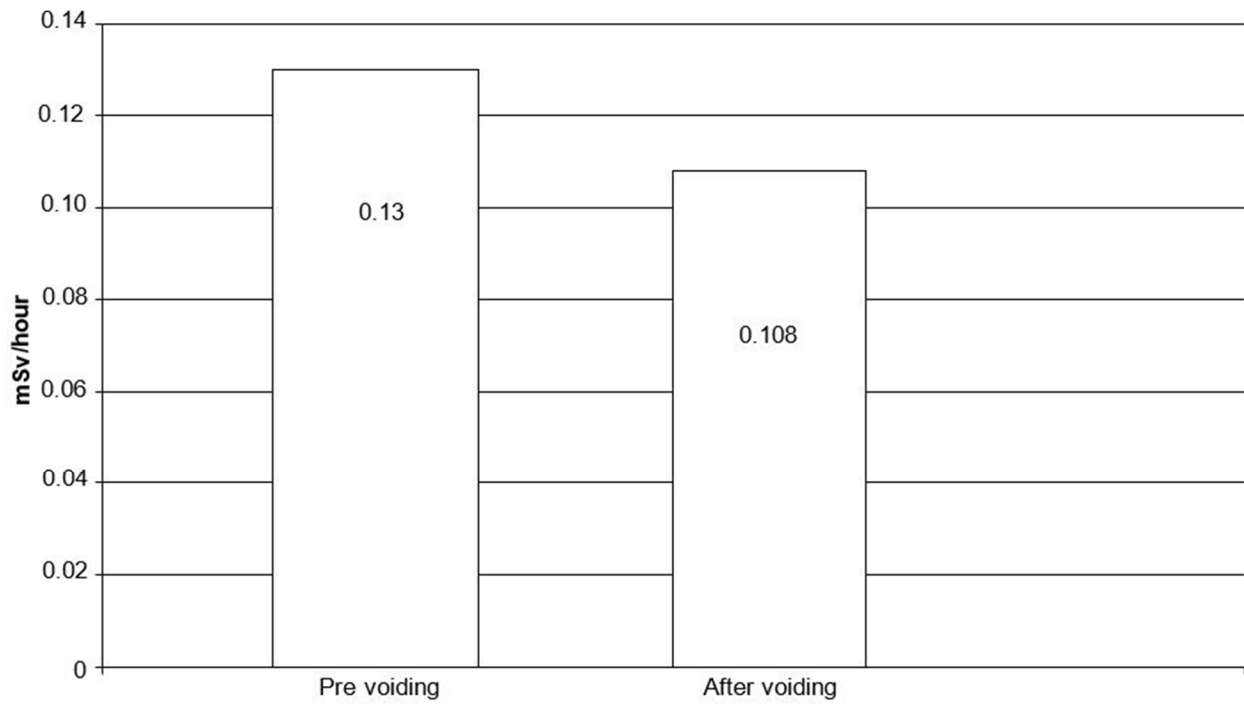


Figure 2: Dose reduction measured at the level of the bladder pre and post voiding.

Dose reduction strategy	Approximated dose reduction
Appropriate patient selection	Significant reduction
Stress only SPECT imaging	Significant reduction
Solid state cameras	50% (11, 12)
PET (3D mode of operation with lutetium oxyorthosilicate system)	Significant reduction
Iterative reconstruction	50-75% (13-16)
Multiple detector systems (17)	Significant reduction
Resolution recovery software	Significant reduction
Collimator (general purpose collimator acquisition)	50% (18)
Collimators for cardiac imaging (19-20)	Minor
Continuous acquisitions	5% (21)
Voiding	16.9%

Table 1. Outlining some of the strategies for dose reduction currently being utilized.