Diagnostic Radiopharmaceutical Exposure of Nurses in Health Care Units at a Large Research Hospital

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Objective: At large research hospitals a substantial number of inpatients receive diagnostic radiopharmaceuticals (DRPs). Our goal was to document the inventory of DRP assignments and to determine the radiation exposure received by nurses assigned to health care units containing a concentration of these patients.

Methods: Whole-body exposures were recorded (film badge) along with DRP type over a typical five-week period for 34 nurses assigned to the coronary care unit (CCU) and urology clinic. The number of DRP patients assigned hospital wide was compared to the total number of beds-in-service over the five-week study period. Comparison was made to the annual whole-body radiation exposure received by attending nuclear medicine technologists.

Results: The urology clinic and CCU had 9 and 10 patients who received diagnostic radiopharmaceuticals over the five-week study period. Bone (urology) and cardiac (CCU) DRPs dominated. Whole-body badges read M for all 34 nurses monitored. Hospital-wide, the percentage of beds/day occupied by a radiodiagnostic inpatient was <1%. The mean annual whole-body exposure for 14 nuclear medicine technologists was 230 mrem after collectively performing >7000 DRP studies.

Conclusion: The assignment of inpatients who have received DRPs at a large research hospital does not warrant the routine radiation badge monitoring of nursing personnel. This is further supported by the current trend to reduce inpatient hospital days as well as an increased scrutiny of DRP use.

Key Words: radiation exposure of nurses; diagnostic radiopharmaceuticals; radiation monitoring; radiation safety

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There are approximately 7.3 million diagnostic and therapeutic nuclear medicine tests performed in the U.S. annually (*1*). The majority of these tests involve the administration of radiopharmaceuticals. A portion of these patients are assigned to inpatient health care units. Personnel attending these patients are exposed to external radiation and potentially can be contaminated when handling patient blood and/or excreta. The latter probability has been reduced with the advent of universal precautions. However, the total external exposure would be a function of the integrated time necessary to complete nursing tasks typical of a particular unit.

While it is common practice to provide radiation detection badges to nurses assigned to radiotherapy patients, it is thought to be unnecessary for those assigned to radiodiagnostic patients. Nurses attending such patients are usually categorized as nonoccupational relative to their radiation safety classification. The purpose of this study was to determine the radiation exposure to nurses who routinely encounter radiodiagnostic patients in a large research hospital.

MATERIALS AND METHODS

This study was performed at a large research hospital with an active inpatient nuclear medicine service. The nursing staff was concerned about their radiation exposure from the radiodiagnostic patients encountered on a daily basis. While it was not reasonable to assign a radiation badge to every nurse working on each health care unit, it was possible to accomplish the study on the two wards where the majority of patients who received radiopharmaceuticals were assigned: the coronary care unit (CCU) and the urology clinic.

After explaining the study and obtaining informed consent, 37 full-time nurses were assigned whole-body radiation badges to wear at waist level over a five-week time period. The health care units selected were the seven-bed CCU (17 badges) and the 24-bed urology clinic (20 badges). The former patients routinely have nuclear cardiac scans and the latter bone scans. Both clinics had a greater share of inpatient diagnostic nuclear medicine studies when compared to other hospital clinics and thus represented the worst possible case relative to radiation exposure. For comparison, the annual exposure history of the nuclear medicine technologists and the total radiopharmaceutical study inventory were tabulated.

The exposure results were expressed as radiation dose equivalent in mrems (mSv). The nurses' badges were supplied and interpreted by Harvard University with a precision of ±10%

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TABLE 1
Radiation Exposure and Radiopharmaceutical Summary for CCU and Urology Clinic Nurses

Table 1A
Radiation exposure

CCU Nurse	mrem	Urology nurse	mrem
1	M	1	M
2	M	2	M
3	M	3	M
4	M	4	M
5	M	5	M
6	M	6	M
7	M	7	M
8	M	8	M
9	M	9	M
10	M	10	M
11	M	11	M
12	M	12	M
13	M	13	M
14	M	14	M
15	M	15	M
16	M	16	M
17	M	17	M
18*	5	18–20	Not returned

*on wall of CCU for five weeks
M = not measurable.

Table 1B
Radiopharmaceutical studies

week	Study	Type
		CCU
1	1	Kidney
2	1	Cardiac function
3	2	Myocardial perfusion (2)
4	4	Cardiac function (2), bone (2)
5	2	Myocardial perfusion (2)
		Urology clinic
1	3	Bone (1), kidney (2)
2	1	Bone (1)
3	0	—
4	4	Cardiac function (1), bone (3)
5	1	Bone (1)

and a threshold of detection of 1 mrem (0.01 mSv). The badges for the nuclear medicine technologists were supplied by the Landauer Company; precision was ±10% and threshold of detection was 10 mrem (0.1 mSv).

In conjunction with the exposure study, an investigation of the type and daily clinical placement of inpatients receiving radiopharmaceutical administrations throughout the hospital complex was undertaken. These data then were compared with the total number of beds on each clinic. Lastly, an annual summary of radiopharmaceutical usage was compiled.

RESULTS

The radiation exposures received by the nurses on the CCU and the urology clinics are shown in Table 1A. All the badges were M [(<1 mrem (<0.01 mSv)]. Table 1B lists the total number of patients administered radiopharmaceuticals during this time period on these clinical units. During the five-week study period the CCU had a total of 10 patients who received a radiopharmaceutical and the urology clinic, 8 patients. The type of radiopharmaceutical is also indicated and, as expected, more bone scans were recorded for urology (prostate cancer skeletal screening) and more cardiovascular studies for the CCU patients. A radiation badge left on the CCU wall at 6 feet from a patient bed accumulated 5 mrem (0.05 mSv) of radiation over five weeks.

The total number and type of scans performed hospital-wide per week are shown in Table 2. Hospital-wide, bone scans and multi-agent cardiovascular scans represented the majority of inpatient radiopharmaceutical studies. The average daily total

TABLE 2
Hospital-Wide Inpatient Radiopharmaceutical Studies (during five-week study period)

Week	Bone	Liver/ Spleen	Kidney	Myocardial perfusion	Cardiac function	Gastro-intestinal emptying	Red blood cell survival	Pulmonary embolism (V/Q)	Cerebral spinal fluid	Hepato-biliary	Infec-tion	Total number of studies/ wk	Percent of beds/ day*
1	15	8	4	7	13	0	0	2	3	0	3	55	1.12
2	11	3	1	7	5	1	0	2	0	1	0	31	0.63
3	11	3	0	5	8	0	2	2	2	0	0	33	0.67
4	14	2	1	7	17	0	0	1	0	0	0	42	0.86
5	13	11	1	10	21	0	0	1	0	1	0	58	1.18
													$\bar{x}$ = 0.89

*at the time of study Massachusetts General Hospital had a beds-in-service inventory of 983. The % total beds/day = [(# of studies per week/5)/983]100.

TABLE 3
Annual Summary of Inpatient Radiopharmaceutical Studies

Study	Number	Percent of total
Bone	743	19.90
Liver/spleen	78	2.10
Lung (V/Q)	527	14.10
Kidney	366	9.80
Cardiac function	962	25.80
Myocardial infarct	4	0.11
Myocardium	850	22.80
Hepatobiliary	46	1.20
CSF	8	0.21
Thyroid function	9	0.23
Infection	26	0.70
Research antibody	40	1.10
Testicular	18	0.47
Brain	4	0.11
GI bleed	10	0.27
Miscellaneous	41	1.10
Total	3,732	100.00

of DRP studies represented approximately 1% of the total beds available. The annual compilation of inpatient studies show a similar pattern (Table 3). Of the annual total of 3,732 inpatient studies, 48.7% were cardiovascular studies and 19.9% were bone scans. Table 4 lists the radiopharmaceuticals associated with the present study.

DISCUSSION

The lack of meaningful radiation exposure to nurses handling inpatients who receive diagnostic radiopharmaceuticals has been previously reported (*2–6*). When one considers typical nursing care times associated with an inpatient recently injected with 20 mCi (740 MBq) of ^{99m}Tc-diphosphonate (Table 5), the theoretical exposures agree with the results of the present study. As expected, surface contact yields the highest theoretical dose as a function of task. However the torso (badge placement) of the nurse is rarely at surface contact for the times indicated. The latter determinations also assume exposures immediately after ^{99m}Tc-diphosphonate administration. If contact is four hours post-imaging procedure, the exposures would be approximately 30% of those listed due to decay and urinary excretion (*7–8*).

The hospital employees at maximum risk from diagnostic radiopharmaceuticals are the nuclear medicine technologists. The technologists are responsible for the formulation and quality control of the radiopharmaceutical, its calibration, injection, and the performance of the scan. A summary of the annual radiation exposures received by the study nuclear medicine technologists, with radiopharmaceutical exam statistics, is shown in Table 6. All exposures are below the maximum permissible whole-body radiation dose (MPD) of 5,000 mrem (50 mSv) with the mean exposure being equivalent to 4.6% of MPD. This is in agreement with current reports (*9,10*). In this study, the work-week average exposure for the nuclear medicine technologists was 4.6 mrem (0.046 mSv).

Based on the results of this study, nurses need not be badged when handling radiodiagnostic nuclear medicine patients as part of routine tasks on the health care unit. This opinion is further reinforced by the current trend to reduce the time patients spend in the hospital and to scrutinize the number of diagnostic studies per patient.

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TABLE 4
Radiopharmaceuticals Associated with Study

Examination type	Radiopharmaceutical	Usual administered activity		mrem/hr @ 100cm*
Brain	^{99m}Tc DTPA	740.0 MBq	(20.0 mCi)	0.90
	^{99m}Tc 0_4Na	740.0 MBq	(20.0 mCi)	0.90
Hepatobiliary	^{99m}Tc IDA	185.0 MBq	(5.0 mCi)	0.25
Liver	^{99m}Tc sulfur colloid	185.0 MBq	(5.0 mCi)	0.25
Bone	^{99m}Tc phosphate	740.0 MBq	(20.0 mCi)	0.90
Lung perfusion	^{99m}Tc MAA	185.0 MBq	(5.0 mCi)	0.33
Lung ventilation	^{133}Xe	370.0 MBq	(10.0 mCi)	0.10
Thyroid	^{99m}Tc pertechnetate	185.0 MBq	(5.0 mCi)	0.25
	^{123}I	11.1 MBq	(300.0 μCi)	0.01
Renal	^{99m}Tc DTPA	740.0 MBq	(20.0 mCi)	0.90
Tumor/infection	^{67}Ga citrate	111.0 MBq	(3.0 mCi)	0.17
Cardiovascular/GI bleed	^{99m}Tc RBC	740.0 MBq	(20.0 mCi)	1.10
	^{201}Tl chloride	111.0 MBq	(3.0 mCi)	0.09
	^{99m}Tc phosphate	740.0 MBq	(20.0 mCi)	0.90
CSF	^{111}In DTPA	18.5 MBq	(0.5 mCi)	0.08
Research antibody	^{111}In MAB	140.0 MBq	(3.8 mCi)	0.61

*at time of administration; 1 mrem = 0.01 mSv

TABLE 5
Projected Nursing Care Times for Various Bone Scan Patient-Related Procedures

Classification	Task	Time (min)	Radiation exposure (mrem)* (20 mCi [740 MBq] ^{99m}Tc MDP)		
			Surface	30.5 cm	100 cm
Moderate care	Greet, shift rounds	2	0.30	0.10	0.03
	Complete visit	5	0.75	0.26	0.075
	Give medicines	2–5	0.3–0.75	—	0.03–0.02
	Straighten linen	2–5	0.3–0.75	—	0.03
	Backrub	2	0.30	0.10	0.03
Moderate to intense care	Patient assessment	5	0.75	0.26	0.075
	Ambulate to and from bathroom	5	0.75	0.26	0.25
	IV main (total care)	15	2.25	0.78	0.0225
	Piggyback IV dose and resetting main line	5	0.75	0.26	0.075
	Central venous pressure or subclavian dressing change (includes total parenteral nutrition)	20–45	3–6.75	1–2.30	0.03–0.675
	Access for and administer cardiac medicines	2–5	0.30–0.75	0.1–0.26	0.03–0.35
	Chest physiotherapy	20	3.00	1.00	0.03
	Endotracheal or track suctioning	10	1.50	0.52	0.50
	Troubleshoot problems (IV site)	5–10	0.75–1.5	0.26–0.075	0.075–0.15
	12-lead ECG	10	1.5	0.52	0.52

*1 mrem = 0.01 mSv

TABLE 6
Nuclear Medicine Technologist Annual Whole-Body Exposures and Radiopharmaceutical Summary

Annual radiation exposures		Radiopharmaceutical summary**		
Technologist	Exposure (mrem)*	Study	Number	Percent of total
1	180	Bone	1851	25.5
2	370	Brain	540	7.4
3	110	Liver	27	0.4
4	100	Lung V/Q	1240	17.1
5	480	Heart	1312	18.1
6	360	Gallium-67	559	7.7
7	520	WBC	76	1.0
8	400	Renal	153	2.1
9	100	Hepatobiliary	119	1.6
10	160	Miscellaneous	1387	19.1
11	90	Total	7264	100.0
12	90			
13	180			
14	80			

Mean ± s.d. = 230.0 ± 159.8 mrem.

*1 mrem = 0.01 mSv

**inpatient plus outpatient

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