RADIOLOGICAL IMPACT OF DIAGNOSTIC NUCLEAR MEDICINE TECHNOLOGY ON THE QUÉBEC POPULATION (PATIENTS AND WORKERS) IN 1989.

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ABSTRACT

Using the results of a six month survey on the doses received by non-monitored hospital workers from diagnostic nuclear medicine patients (DNMP) in three hospitals and published statistics on Québec's workers and hospitals, an evaluation of the radiological impact of DNMP has been calculated on the Québec's population. In 1989, diagnostic nuclear medicine accounted for 6 % of the diagnostic imaging acts. The diagnostic nuclear medicine gave an average of 6.4 mSv/act or a total of 2,800 Sv-man. The diagnostic nuclear medicine technologists community received 0.4 Sv-man and the non-monitored hospital workers 1.7 Sv-man from the DNMP in the same year.

INTRODUCTION

The nuclear medicine technology is a very powerful diagnostic tool. However, its use brings a new radioexposure source and environmental contamination inside the hospital. In the late eighties, according to the Québec's Ministère de la Santé et des Services Sociaux[1], the diagnostic usage of nuclear medicine was growing at a rate of 10 to 13 % per year. In 1989, this technology was available into 44 Québec's hospitals[2] and generated 440,000 nuclear medicine acts[3] paid by the Régime d'Assurance Hospitalisation du Québec (RAHQ). The diagnostic nuclear medicine patients (DNMP) are ambulatory inside the hospital and may influence the environmental radiation level.

In this study, we estimate the monitored and non-monitored hospital workers collective dose in hospital environment from DNMP as well as the effective dose per nuclear medicine act in 1989 using three major sources of information: a survey[1] [4] designed to measure and assess the radiological impact of DNMP on a selected group of non-monitored hospital workers, published[5] occupational doses in Québec and various statistics available on Canadian hospitals[2,6].

MATERIAL AND METHODS

A survey over 10 consecutive weekdays in three university hospitals (ICM: Institut de cardiologie de Montréal (171 beds), LAVAL: Hôpital Laval de Québec (340 beds), HDM: Hôtel-Dieu de Montréal (430 active beds)) succeeds to demonstrate that the nuclear medicine patients are highly ambulatory inside the hospital. Few minutes after their radioactive administration (RA), both in-patients and out-patients can go anywhere inside the hospital[4]. More than eighty-three percent (83%) of the patient movements occur in the first 24 hours. This time and motion study enabled us to identify hospital non-monitored groups (nurses, physicians, technologist, cleaners, secretary) who were likely to come regularly in the near environment of the DNMP.

Following this survey, we distributed 840 calibrated thermoluminescent[2] dosimeters (TLD) to selected workers in the three participating hospitals. Table I summarizes the distribution profile of TLD's holders in each hospital. TLD were worn during 6 consecutive months.

1: This work was produced under contract to the Atomic Control Board and Supply and Services Canada; contract No. 87055-8-4099/01-SS, project 6.105.1.

2: Chalk River Nuclear Laboratories, Chalk River, Ontario, Canada, K0J 1J0.

Concurrently, all RA were recorded: prescribed procedure, radioactivity administered, isotope, radiopharmaceutical, patient origin (in or outside hospital), date and hour of the RA.

RESULTS

Exposure to the patients

Table II summarizes the mean RA (MBq) per procedure for various nuclear medicine examinations and the average number of RA per week. During this six month survey which has recorded over 10,000 RA, we observed a large variation in RA between hospitals depending upon their activities and specialities.

The effective dose per unit of activity for normal adults[7,8,9] combined with the observed activity per RA and with the medical acts paid by RAHQ in 1989, leads to an overall estimate of 2800 Sv-man to the Québec's population by the diagnostic nuclear medicine technology or an average of 9.8 mSv for each of the 268,000 RA or 6.4 mSv per act. Table III summarizes the number of RA for each group of nuclear medicine procedures with the corresponding collective and individual effective dose (H_E). 75 % of nuclear medicine imaging devices is clustered in Montréal (55 %) and Québec (21 %) areas.

Table I:: Distribution of analysed TLD in each participating hospital.

WORKERS	ICM	LAVAL	HDM
Nurses	111	199	168
Physiotherapists	5	-	-
Inhalotherapists	8	25	33
Orderlies	24	17	61
Porters	3	12	9
Ultrasound tech.	3	4	5
Ultrasound Phys.	7	4	-
ECG Technologists	14	16	6
EEG Technologists	-	-	3
Neurophysiologists	-	-	3
Cleaners	8	17	15
Receptionists	4	7	9
Others	1	4	-
Total	188	305	312

Exposure to the non-monitored workers

From the 840 distributed TLD, 805 were returned for reading and report. Table IV summarizes the statistics on exposures of surveyed personnel and the surveyed fraction of the whole hospital personnel. The average value of this fraction was sixteen (16) percent.

Merging the average of the annual occupational doses given in Table IV, with published statistics[2,6] on the hospitals with a nuclear medicine service, we then estimate a collective dose of 1.7 Sv-man to the non-monitored hospital workers population coming in the near environment of the DNMP. This estimate assumes that only 16 % of the workers might be exposed to the diagnostic nuclear medicine patients, a very conservative hypothesis.

Table II:: Mean RA (MBq) and relative distribution (%) of the most frequent nuclear procedures in each hospital.

PROCEDURE	ICM	LAVAL	HDM
Bone scan	-	1110 (21)	1110 (24)
Brain Scan	-	1110 (3)	1110 (27)
Myocar.perf.(Tl^{201})	106 (24)	111 (25)	74 (9)
Myocar.perf.(Tc^{99m})	1002 (14)	-	-
Ventriculography	1313 (54)	924 (23)	1110 (5)
Liver scan	-	296 (1)	185 (6)
Lung scan	155 (1)	149 (9)	148 (5)
Thyroid	-	(5)	(5)
I^{131}		1.3	2.2
Tc^{99m}		260	74
All RA	920 (95)	589 (85)	842 (77)
RA/week	92	108	360

Exposure to the diagnostic nuclear medicine technologists

As published by Sont and al. [5], the average body dose (including all doses) to the nuclear medicine technologist was 2.35 mSv in the province of Québec during 1988. We assume that the average dose to those workers remained the same during 1989. In 1989, the province of Québec had 170 registered nuclear medicine technologists leading to a collective dose of 0.4 Sv-man.

DISCUSSION

The diagnostic nuclear medicine technology gives more effective dose per act to the patients and to the monitored and non-monitored hospital workers when compared to the radiological diagnostic imaging technology. The Québec's population received about 6200 Sv [10] or approximately 1 mSv per capita per diagnostic medical irradiation in 1989 or 0.5 mSv by radiodiagnostic act and 6.4 mSv per nuclear medicine act. The nuclear medicine technology accounts for only 6% of total medical acts paid by RAHQ and generated 45% of the patient effective dose. This estimate excludes therapeutic procedures (angioplasty, I^{131} therapy), dental and chiropractor radiology and was not weighted for patient age at the irradiation time.

Table III: Distribution of RA per organ groups and effective dose (H_E) corresponding in 1989.

	# RA	H_E (Sv)	H_E/RA (mSv)
Endocrine S.	45,722	817	17.8
Haematopoietic S.	7,129	190	26.6
Urinary S.	22,102	111	5.0
Digestive S.	24,711	85	3.4
Cardio-Vasc. S.	48,076	655	13.6
Respiratory S.	23,171	80	3.4
Nervous S.	25,491	229	8.9
Muscu. Squel.S	72,793	593	8.1
Others	1,983	45	22.6
Total RA	286,178	2804	9.8
	ACTS		H_E/act(mSv)
Total	439829		6.4

Table IV: Statistics related to non-monitored workers.

HOSPITAL	SAMPLE SIZE	BKG (mSv)	OCCUPATIONAL MEAN DOSE/6mo (mSv)	MEAN DOSE/Y (mSv)	RANGE 6 mo (mSv)	NUMBER WORKERS	% IN SURVEY	# γ CAMERAS	NM Tech DOSE/Y (mSv)
ICM	191	.49±.02	.08±.02	.16±.04	0-1.4	1000	19	3	3.8
LAVAL	307	.51±.06	.06±.06	.12±.12	0-.55	1800	17	3	2.9
HDM	307	.52±.01	.07±.01	.14±.01	0-1.25	2163	14	7	6.4*
	805	0.50	0.07	0.13		4963	16	13	4.4

*Best available estimate

Sont reports that the radiological technologists are exposed at an average of 0.13 mSv/year or about 0.4 Sv-man. We have calculated a collective dose of 0.4 Sv-man to the nuclear medicine technologists. According to Table VI, this group contributes for 8 % of the collective occupational dose in Québec. These monitored workers are the most exposed workers in medical environment in the province of Québec.

Table V: Québec nuclear medicine profile in 1989.

# Hospitals:	44
# γ cameras/Hospital	2.7 ± 1.6
# workers/Hospital	1832 ± 960
# Nucl. Med. Tech.	170
Mean occupational dose of Nucl.Med. Tech.	2.35 mSv

Mobile or fixed X-Ray machines are visible and known sources of irradiation, the DNMP is *incognito* for the majority of the workers. The unknown character of this human radioactive source may explain the observable range of radiological exposures (upto 1.4 mSv/6 months) on more than 90 % of the 805 workers monitored during the six month survey. These workers had a dose detectable by the TLD technology. From those data, we conclude that on average at least 14 % (90 % x 16 %) of the hospital workers population may receive a quantifiable irradiation by the usage of the nuclear medicine technology into an hospital. We estimate that the collective dose to that personnel (nurses, orderlies, porters, cleaners, physicians...) working in this environment is 0.13 mSv per capita during 1989, a dose comparable to the one of radiological technologists. According to Sont, all

workers of Québec monitored by the dosimeters of Health and Welfare Canada share a collective dose of 5 Sv-man. According to this analysis, the non-monitored hospital workers exposed by DNMP share a collective dose of 1.7 Sv-man.

This estimate excluded the general population exposure from the DNMP. The individual estimate may be different from one hospital to another depending upon the number of nuclear medicine patients, the technology acceptance, the isotope and the activity administrated, the management of the patient, the workers' duty and training.

Table VI: Individual (mSv) and collective dose (Sv-man) to monitored and non-monitored hospital workers in Québec.

	QUÉBEC
INDIVIDUAL	(mSv)
X-Ray technologist	.13
Nucl. Med. technologist	2.35
Monitored population	.24
Non-monit. population	.13
COLLECTIVE	(Sv-man)
X-ray technologists	.4
Nucl.Med. technologists	.4
Monitored population	5.0
Non-monit. population	1.7

CONCLUSION

When fully justified, the diagnostic nuclear medicine technology like any other technology using ionizing radiations has to be optimized in terms of the dose to the patient and to the workers' population. A slight decrease of the exposure rate at the origin, a better management of the radiation source or any adapted training may have a significant impact on the collective dose even if the average individual dose to the non-monitored personnel is low compared to the diagnostic nuclear medicine technologist. In the optimization process, doses to the diagnostic nuclear medicine technologists, to the patients as well as to the non-monitored hospital personnel has to be considered.

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