ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 4, July 2015

Personal Dose Monitoring At PINUM: Local Assessment, Critical Applications and Future Need

Prof. Dr. Muhammad Attique Khan Shahid1, Asma Khalid and Prof. Dr. Khadim Hussain2
1Principal, Govt. Postgraduate College, Jhang, Punjab, Pakistan
2Department of Physics, High Energy Physics, Punjab University, Lahore, Punjab, Pakistan

*Corresponding author's email: profkhan786@yahoo.com

Abstract
Nuclear Medicine is being widely used, now days, for different diagnostic purposes. The present study was conducted to find out the radiation exposure to nuclear medicine technologists from radioactive patients who have gone through different diagnostic examinations. This study was carried out as joint venture of Physics department and Punjab Institute of Nuclear Medicine (PINUM),Faisalabad (Pakistan). In order to carry out this activity, data was collected from the nuclear medicine diagnostic Examinations i.e., heart scans (Rest and Stress MIBI), bone scans, renal scans, liver scans, thyroid scans and Thallium Heart scans. The radiation exposure was recorded using pen dosimeter (Arrow-Tech W138) having range 0-200mR.Heart scan (Stress MIBI) was taken as standard as it showed maximum exposure (0.584 mR) and equivalent dose Corresponding to this exposure (5.85µSv) amongst all scans ALARA and TDS were recommended.

Keywords*: Radiation exposure, technologists, Dosimeters, Gamma camera, ALARA, TDS.*

I. Introduction

Health and Medical Physics has introduced a number of safe, non-invasive and cost-effective nuclear medicine diagnostic examinations so far in the Nuclear Medicine departments to diagnose different diseases and therefore, have assisted the physicians and Surgeons more accurately in radiotherapy. Radiations cause a number of different chemical and physical changes in the target material exposed to these Radiations [1-5]. Therefore, the potential benefit-risk ratio from these nuclear medicine examinations should be well known to the referring clinicians, radiologists, Cardiologists, nuclear medicine technologists and to some extent to the patients too [6]. The patients referred to the radiation therapy should be annually monitored on regular basis in order to be aware from the radiological quality and safety [7]. Such radiation therapies include dialogic procedures that require very long fluoroscopy times, radio labeled monoclonal Antibodies and intravascular branchy therapy [8]. Many studies have demonstrated that the exposure of nuclear medicine technologists arises primarily from radioactive patients rather than from preparation of Radio pharmaceuticals [9]. However, in order to devise strategies to reduce exposure to nuclear medicine technologist, it is necessary to identify the specific tasks within each procedure that result in the highest Radiation doses [10]. International Commission

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 4, July 2015

on Radiological Protection (ICRP) has set the limits on exposures to ionizing radiations which should not be more than 1 and 20mSv per annum for general public and nuclear medicine technologists, respectively. The Tc-99m is most widely used radioisotope in nuclear medicine diagnostic examinations and is employed in 80% of all nuclear medicine procedures. This meta-stable radioisotope of artificially-produced element technetium having almost ideal characteristics i.e., gamma energy and half life, for a nuclear medicine Scan. Punjab Institute of Nuclear Medicine (PINUM) is a nuclear medicine center in Faisalabad, providing the Facilities of nuclear medicine diagnostic examinations. A number of patients visit this hospital for different scans like liver, heart scan, thyroid, bones, renal and thallium heart scans. Therefore, the present research work was planned to evaluate the radiation exposure to nuclear medicine technologists from radioactive patients who have gone through these nuclear medicine diagnostic Examinations.

II. Materials and Methods

The materials used in this study were; pen dosimeter(Arrow-Tech W138) having range 0-200mR, survey meter, e-cam single head gamma camera (Siemens),Mo-99/Tc-99m radio nuclide narrator and record of registered patients for all scans. The diagnostic examinations used in this study were; heart scan (Rest and Stress MIBI), bone scan, rena lscan, liver scan, thyroid scan and thallium heart scan, moreover, the pharmaceuticals used for these examinations were MIBI (Methoxy-Isobutyl-Isonitrile), MDP (methylenephosphonate), DTPA (diethylenetriaminepentaacetic acid), Phytate, PlaneTc-99m (technetium 99m) and Thallium-201,respectively.The maximum injected doses for all scans and the rest time for patients after the dose administration, were fixed as per standards. The reading of exposure for each scan was measured in two phases; first, from the time of injecting a patient to his exit from the hot lab. Secondly, the reading was measured in the Gamma camera room during the scan until the exit of patient from the room. The time required for heart scan (Rest and StressMIBI), bone scan, renal scan, liver scan, thyroidscanand thallium heart scan was 20min, 25 min, 30min,30min, 5min and 20min, respectively. Total exposure for a complete scan was measured. The proposed procedure was revised for ten patients per scan in order to avoid personal, systematic or random errors.

III. Results and Discussion

Considering the stress MiBi as standard, results of all scans along with statistical analysis were depicted in the following tables and figures.

Table 2K-01 Comparison of mean exposure and standard deviation from all scans

SR.#	Scan	Mean Exposure	Standard Deviation
1	Heart scan (rest)	0.486	0.1796
2	Heart scan (stress)	0.584	0.1112
3	Thyroid scan	0.263	0.3799
4	Bone scan	0.518	0.3531
5	Liver scan	0.39	0.5147

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 4, July 2015

6	**Renal scan**	**0.285**	**0.4767**
7	**Heart scan (thallium)**	**0.364**	**0.1758**

Figure 2K-01

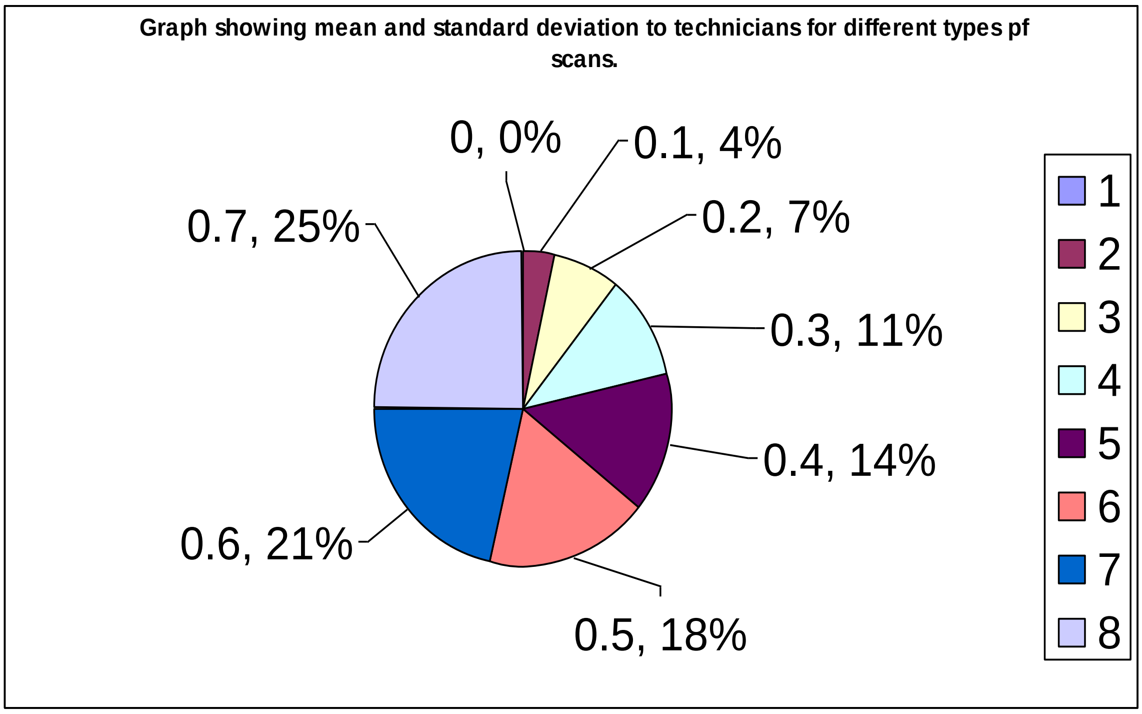

Table 2K-02

STATISTICAL ANALYSIS

Scans	Coefficient of variance (C.V)	Personal error (P,E)	Relative Personal Error (R.P.E)	Co-relation Ship(r)
REST MIBI	36.95%	3.85	o.116	42.42 (+ve)
STRESS MIBI	22.93%	3.79	o.118	Standard
THYRIOD	144.4%	3.96	0.13	78.37 (+ve)
BONE	68.16%	4.02	0.1117	39.80 (+ve)
LIVER	131.97%	2.59	0.172	52.87 (+ve)
RENAL	167.26%	3.60	0.124	72.35 (+ve)
THALLIUM SCAN	48.29%	2.01	0.223	56.64 (+ve)

(11-15)

In this project, the radiation exposure to the handling staff while performing a nuclear medicine procedure was evaluated. Exposure measurements were carried out with the pocket dosimeter Arrow- Tech Model 138 whose range was from 0 up to 200mR. Exposure from Heart scan (Rest MIBI, stress MIBI and Thallium heart scan), Bone scan, Thyroid scan, Renal scan, Liver scan was evaluated. Reading were scheduled from the time of injection to time of scan. At first the pocket dosimeter attached to the technician who administered injections. Second time the same pocket dosimeter was attached to the technician who was handling the patient in scanning procedure gamma camera room. The injection used for Rest MIBI labeled with Tc -99m isotope. The main dose injected to the patient was 740 MBq. After injection the patient was given rest of

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 4, July 2015

45 minutes. The total time for the scan was the approximately 20 minutes. The mean exposure evaluated from Rest MIBI was 4.86 µSv.

For Stress MIBI injected dose was same as for Rest MIBI. In the scan, the patient was injected during the stress procedure and the mean dose injected to the patient was 814 MBq. After the injection similar to Rest MIBI the patient was given a rest of 45 minutes. The maximum time for stress MIBI scan was also approximately 20 minutes like rest MIBI. The mean exposure evaluated from Stress MIBI was 5.85µSv. Similar type of study was performed at department of physics and Nuclear Medicine, City hospital Birmingham, UK. They reported that radiation doses were measured during rest (1.0µSv, n=18), and stress study (2.0µSv, n=16), giving a total dose of 5.5µSv per combined cardiac study and the average dose per radionuclide study is 1.5 µSv**.**

Mean exposure from Rest MIBI and Stress MIBI is high in the present study than the published results. Reason is that administered dose for Rest MIBI and stress MIBI is high. Administered dose in published results for Rest MIBI was 250MBq and for Stress MIBI was 750MBq where as in our study these doses were 750MBq and814MBq respectively. That is why the exposure from these scans is higher than the published results.

Injection for thyroid scans contain plain Tc-99m the injected dose was 111MBq. After injection the patient was given a rest of five minutes. The maximum scan time for thyroid scan was approximately 5 minutes. Mean exposure from thyroid scan was 2.56µSv. similar type of study was performed at Royal Brisbane hospital Australia. They reported that exposure from thyroid scan ranges from 0.2-0.4µSv(Lundberg et al, 2002).Exposure from thyroid scan in present study was greater than the published results because the administered dose was greater than and the maximum time for scan was greater forthis thyroid scan.The kit used for Bone scan was MDP. Injection contains MDP labeled with Tc-99m. and the injected dose for this scan was 740MBq. Patient was given rest of 3 hours after the injection. Scan time foe Bone scan procedure was 25 minutes. Mean exposure from bone scan evaluated was 5,18µSv. Similar type of study was performed by Clark et al. and they reported doses for individual scans including 3.5 µSv for a GHPS and 1.0 µSv for a bone scan. Assuming 40 minutes for a GHPS and 50 minutes for a bone scan.

Following the above procedure for Renal scan reading was taken from the time of injection but for this scan there was no rest time for the patient after being injected. DTPA kit used for Renal scan labeled with Tc-99m. and the injected dose for this scan was 74MBq. The patient was injected at the time of scan and was performed immediately after injection. The mean exposure from the Renal scan was 2.85µSv. similar type of study was performed by Clarke et al. the reported dose for Renal scan is 0.8µSv. assuming 1 hour time for a Renal scan. Exposure from Bone scan and renal scan is greater. Reason is the administered dose which is higher in the present study and the maximum time recorded for these scans were also greater. Another reason may be the shielding, which may not be proper in the proper in the present study.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 4, July 2015

For Thallium heart scan the same procedure is repeated as for Stress MIBI. Thallium dose of 90MBq injected to their patient during stress procedure. During Thallium heart scan after injection early views of the patients were taken from Gamma camera. After this, the patient was given rest of 45 minutes. The maximum time for this scan was approximately 20 minutes the mean exposure evaluated from this scan was 3.64 µSv. Similar type of study was performed by Gray *et al*. 2002 and they reported that doses to technologists for 201 TI and Thyroid scan were 0.2 -0.4 µSv. (Gray *et al*, 2002). Exposure 3.64 µSv was higher than the 0.4 µSv the reason behind that may be the higher administered dose and shielding may not be proper in the present study.

The dose injected for Liver scan was 185MBq. The kit use for this scan was phytone. Injection for this scan contained phytone labeled with Tc-99m. In Liver scan the patient was given rest of 15 minutes after injection. The scan procedure took 30 minutes to complete. The mean exposure evaluated from Liver scan is 3.9 µsv and the exposure from this scan was higher enough and should be reduced by modifying and improving handling of patient and by the implementation of time, Distance and Shielding rules for technicians. The time of contact with patient should be reasonably reduced.

For all, Stress MIBI gave the maximum exposure. The reason behind this was that the injected dose was maximum and hence during stress procedure the patient to the handling staff gave more exposure. Stress procedure was also performed during Thallium heart scan but in that case the injected dose was much lower than that injected for Stress MIBI. This result of maximum exposure from Stress MIBI could be compared with published dose estimates. The M.Lundberg *et al* reported that exposure to the technologists was highest from GHPS and Stress scans 1.52 µSv/h. The comparison of all scans was given in table 2K-01.After evaluating the exposure from all these scans, the data was analyzed statistically. Standard deviation was determined for each scan. By using mean exposure and standard deviation values are presented in pie graph as shown in figure. 2K-01 and is table 2K-02(16-20).

From the experience, we have learnt that many gastroenterologists involved in diagnostic and therapeutic procedures using ionizing radiation do not routinely wear full protective clothing (0.35 mm lead equivalent aprons, thyroid shield, lead glasses) on a regular basis. This is similar to the finding of sociological survey of endoscopes retrograde cholangiopancreatography (ERCP) practices in which only 52% of respondents reported wearing a thyroid shield all of the time. An audit of radiation exposure to personnel performing ERCP found that both patients and staff are exposed to significant radiation exposure. This was equivalent to an estimated additional lifetime fatal cancer risk of between 1 in 3500 and 1 in 7000. These studies highlight the substantial underestimation by medical staff of patient and operator related radiation induced cancer risk.

The National Radiological Protection Board (NRBP) has recently revised the radiation dose for typical *x* ray examinations. For example, an abdominal/pelvic CT scan would typically lead to an effective dose of 10 mSv, which is an equivalent of 4.5 years of natural background radiation.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 4, July 2015

This radiation exposure was estimated to carry a 1:2000 risk of fatal cancer in the 16–69 year old patient population (personal communication from NRPB). For older patients, this may be halved but for younger patients increased up to fivefold. Put another way, this is equal to 250–300 fatal cancers for every 1 million abdominal/pelvic CT scans.

The British Society of Radiology has made specific recommendations to reduce radiation exposure. Adherence to these guidelines may well be an explanation for the comparatively low frequency of diagnostic *x* ray in UK practice. Clinicians should use these recommendations when considering radiological investigations. Protection of operators and nursing staff using recommended protective clothing should also be followed. Change in clinical practice may not be easy to achieve as, for example, endoscopes capacity to reduce the number of alternative radiological investigations, such as barium enemas, is limited. In contrast, barium enemas are often used to reduce the demand on endoscopes services. New technologies and methods may well reduce radiation exposure. Examples in gastroenterology include magnetic resonance cholangiopancreatography or endoscopes ultrasound instead of ERCP and magnetic resonance enteroclysis instead of small bowel enema. Technological advances, in particular low dose helical CT colonography, may reduce radiation exposure by 40–70%. However, availability of these technologies is limited or only slowly increasing and it is therefore unlikely that their use will influence radiation exposure in the near future.

Briefly speaking radiation exposure from all these scans can be reduced by following the radiation protection principles. From radiation protection point of view ALARA is a Program developed in order to keep doses As Low As Reasonably Achievable. Three main ways to keep doses ALARA are Time, Distance, and Shielding. The amount of radiation exposure increases and decreases with the time people spend near the source of radiation or patients. The greater the shielding around a radiation source, the smaller the exposure. By taking care of these three important steps the radiation exposure to the handling staff can be reduced. (21-26).

Radiation reduction methods that decreased radiation exposure to staff were utilized. The most effective included the use of a lead face shield and lead lined storage in the noninvasive imaging area, handling spills by shielding instead of decontamination and to reduce time spent in close proximity to the patient.

IV. Conclusion

It is known that medical applications using ionizing radiation are wide spread and still increasing. Physicians, technicians, nurses and others constitute the largest group of workers occupationally exposed to man-made sources of radiation. Many hospital workers are consequently subjected to routine monitoring of professional radiation exposures. The most obvious applications of ionizing radiation are diagnostic radiology, diagnostic or therapeutic use of radio nuclides in nuclear medicine and external radiation therapy or brachytherapy in radiotherapy departments. Other important applications also include various procedures in interventional radiology (IR), *in vitro* biomedical research and radiopharmaceutical production around cyclotrons. Besides the fact that many of the staff members, involved in these applications, are not measurably exposed, detailed studies were carried out at workplaces where routine dose monitoring encounters difficulties and for some applications where relatively high occupational exposures can be found. Most of the studies are concentrated around nuclear medicine applications and IR. They contain assessments of both effective dose and doses at different parts of the body. The results contribute to better characterization of the different workplaces in a way that critical applications can be identified. Moreover, conclusions point out future needs for practical routine dose monitoring and optimization of radiation protection.

In this study exposure to the technicians was evaluated from Stress MIBI, Rest MIBI, Thyroid scan, Bone scan, Renal scan and Thallium heart scan. For all these scans Stress MIBI gave maximum exposure. Comparison of Stress MIBI with other scans showed that exposure from Stress MIBI scan was not significantly different from Rest MIBI and Bone scan but significantly different from Renal scan, Liver scan, Thyroid scan and Thallium heart scan. Exposure from these scans can be reduced by following radiation protection principles, most importantly shielding.

References

- **Achey B,K. L.Miller, M.Erdman, S.King. 2001.** Some experiences with treating thyroid cancer patients. Health Phys. 80(5):pgs: 62-6.
- **Belleman, M. E.S. Riemann, S. Kapplinge, G. Brix, 2002.** Assesment ofradiation exposure caused by transmission scans in SPECT: an anthropomorphic dosimetry study. Biomed Tech(Berl).2002;47 Supp11 Pt1:pgs: 474-5.
- **Benedetto, A. R. T. W. Dziuk, M.L. Nusynowitz.1989.** Population exposure from nuclear medicine procedures: measurement data. Health Phys. 57(5):pgs725-31
- **Cobral, G. A. Amaral, L. Campos,M. I. Guimaraes, 2002.** Investigation of maximum doses absorbed by people accompanying patients in nuclear medicine departments. Radiat Port Dosimetry 101(1-4): pgs,435-8.
- **Clarke, EA, WH. Thomoson, A. Notghi, LK. Harding. 1992**. Radiation doses from Nuclear Medicine patients to an imaging technologist: relation to ICRP recommendations for pregnant workers. Nucl Med Commun. 13:pgs; 795-798.
- **Colas-Linhart, R.W> Howell.2001**. Modeling radiation dose and effects from internal emitters in nuclear medicine: from the whole body to individual cells: Cell Mol Bio!1(Noisy-el-grand) 47(3): pgs. 535-43.
- **Cheetham,A.M; Naylor,V;.McGhie,,J; Ghiotto,F; Al-Housni,-M-B; Kelion,-A-D. 2006.** Is stress-only imaging practical when a 1-day stress-rest 99mTc-tetrofosmin protocol is used : Nucl-Med-Commun 27(2): pgs: 113-7
- **Garancini, S. l. Bianchi,L. Conte, M. Monciardini, G. Roncari. 1995**. Effective radiation dose to the patients and to the general population from nuclear medicine procedures: variations in the last 20 year period. QJ NUcl Med.39 (2): pgs. 99-104.
- **Harding LK.A Notghi, EA. Clarke, 1997**. Are MIBI /tetrofosmine heart studies a potential radiation hazards to technologist/ Nucl Med Commun. 18(6): pgs;574-7.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 4, July 2015

- **Heller S.L. 1996**. Radiation safety in the central radiopharmacy. Semin Nucl Med. 26(2):pgs.107-18.
- **Husak, V. K. Petrova, Z. Prouza, M.Myslivecek.2000**. Medical radiation exposure of the Czech Repulic paediatrc population due to diagnostic nuclear medicine. Nucl Med Rev Cent East Eur. 3 (2): pgs. 143-7.
- **Jankowski J.J. Olszewski, K. Kluska. 2003**. Distribution of equivalent doses to skin of the hands of nuclear medicine personnel; Radiate Port Dosimetry. 106 (2): pgs. 177-80.
- **Jana,S. Blaufox, M.D.2006.** Nuclear medicine studies of the prostate, testes, and bladder. Semin-Nucl-Med. ; 36(1): pgs 51-72
- **Kim, P,K. Zhu,X. Houseknecht,E. Nickolaus, D. Mahboubi, S.Nance,M. L. 2005.**Effective radiation dose from radiologic studies in pediatric trauma patients. World-J-Surg. 29(12): pgs 1557-62.
- **Kashikura, K. S. Kanaya, A. Kashkura, H. Kobayashi, M.Maki, K.kusakab.. 1996.**Eposure to the tedchnologists from radioactveb patients during nuclear medicine studies. KakuIgaku. 33(5): pgs, 447-83
- **Mountford , P.j, M.J. O'Doherty, N.I.Forge, A. Jeffries, A.J. Coakely. 1991**. Radiation dose rates from adult patients undergoing nuclear medicine investigations. Nucl Med Commun. ;12 (9): pgs, 767-77.
- **Phillips T.L. 2002.** 50 years of radiation research: medicine. Radiate Res 158(4): pgs, 389-417.
- **Regulla D, J. Griebel, D. Nosske, B. Bauer, G. Brix. 2003.** Acquisition and assessment of patient exposuire in diagnostic radiology and nuclear medicine: Med Phys. 13(2): pgs, 127-35.
- **Reiners C. 1993**. Radiation exposure in diagnostic nuclear medicine: risk comparisons on the basis of effective doses, Nuklearmedizine, 32(1): pgs. 47=51.
- **Reiners C, W.Sonneschien. 1994**. Radiation exposure from diagnostic nuclear medicine in Germany 1992(the former Fedral Republc). Nuklearmedizine. 33(6): pgs: 254-62.
- **Shrimpton PC, B.F.Wall, D. Hart. 1999**. Diagnostic medical exposure in the U.K. Apply Radiate Isot. 1999; 50(1): pgs: 261-9.
- **Smart R.2004**. Tasks-specific monitoring of nuclear medicine technologists' radiation exposure. Radiate Port Dosimetry. 109(3): pgs: 201-9.
- **Staniszewska M.A..1987**. Radiation risks to patients from nuclear medicine. Curr Probl Diagn Radiol. 1989 18(1); pgs: 1-37.
- **Steyn,P.F . Uhrig, J. 2005.**The role of protective lead clothing in reducing radiation exposure rates to personnel during equine bone scintigraphy. Vet-Radiol-Ultrasound Nucl-Med-Commun 46(6): pgs 529-32
- **Yenson,T. Larcos,G. Collins, L.T. 2005**. Radiopharmaceutical maladministration in New South Wales 26(11): pgs 1037-41
- **Zeng W. 2001.** Communicating radiation exposure: a saimple approach. J Nucl Med Technol. 2001 29(3): pgs, 156-8.