

How a tertiary medical nuclear medicine department at the Himalayan area in India can be established and function in an exemplary manner. Basic rules revisited

Vandana Kumar Dhingra¹ DNB*,

Sunil Saini² MS,

Sandip Basu³ DNB*

*Diplomate of National Board

1. Department of Nuclear Medicine

2. Department of Surgical Oncology,
Cancer Research Institute, SRHU,
Dehradun, Uttarakhand, India

3. Department of Nuclear Medicine,
Radiation Medicine Centre (BARC),
TMC Annexe, Mumbai, India

Keywords: Nuclear medicine
department, - India, - Hilly area,
- Establishment,
- Cost effectiveness

Correspondence address:

Dr. Vandana Kumar Dhingra,
Department of Nuclear Medicine,
Cancer Research Institute,
Swami Rama Himalayan
University Swami Rama Nagar, P.O.
Doiwala, Distt. Dehradun
248140, Uttarakhand, India.
Tel: 9458121109,
Office: 0135-2471161,
Res. 01334-254363
modisbanu@yahoo.com

Received:

10 October 2015

Accepted revised:

23 November 2015

Abstract

Objective: We describe and discuss the various medical, social and financial aspects of setting up, and optimizing, working conditions of a tertiary Nuclear Medicine Department. This department was established in a North Indian state which comprises 93% of hilly area. During the first three years after establishment we have developed infrastructure, cooperation with other departments, improved radiation safety and cost effectiveness of our work and designed future perspectives. The facility was established in a cancer center of a tertiary care hospital where a medical college infrastructure was developed. National guidelines formulated by the Atomic Energy Regulatory Board (AERB) were followed. Our department served a population area of 10.08 million inhabitants. Over the first three years 2,400 patients underwent diagnostic scans and 106 patients underwent low dose radioiodine treatment for thyrotoxicosis. To optimize resources and at the same time, enhance their effectivity, we procured our ⁹⁹Mo/^{99m}Tc generator every other week and arranged our daily programme accordingly. Fractionation of cold kits allowed us to perform low cost in-vivo procedures on a daily basis and to save the department's running costs by 30%-50%. We run continuing education nuclear medicine programmes for referring physicians, medical students and paramedical workers which were included in routine practice which led to a consistent growth in patients referral. The need for a positron emission tomography/computed tomography (PET/CT) scan and high dose treatment department for thyroid cancer was strongly felt. **Conclusion:** Our nuclear medicine department in a peripheral region of a developing country applied better logistics by procuring new generator every fortnight, fractionating the cold kits and by organizing complete teaching programmes.

Hell J Nucl Med 2015; 18(3): 252-256

Published online: 5 December 2015

Introduction

Commissioning nuclear medicine facility can be challenging for young specialists. We established the first nuclear medicine department amongst the three major tertiary medical colleges in hospitals in the state of Uttarakhand in an area of 53484x10⁶ square meters. We describe various problems we met and our working conditions.

We also describe radiation safety, instrumentation resources, optimization of work, training, research possibilities, the clinical application of our work and future perspectives.

Infrastructure development

Our Institute is a medical college and general hospital with a separate facility of a Cancer Centre in the same campus. Our department of nuclear medicine was planned in the Cancer Centre in 2006 and was included in the master plan as per the Atomic Energy Regulatory Board [AERB] guidelines [1] as Type 4 nuclear medicine facility, without permission for high dose radioiodine (¹³¹I) administration. All civil works followed state guidelines (Figure 1). We applied some minimal changes which were important e.g. the working console was originally planned within the gamma camera room but as we do not have any space constraints we felt that the console could be shifted outside the gamma camera room in view of radiation safety and the as low as reasonably achievable

ALARA principle.



Figure 1. The hot Laboratory

Radiation safety, instrumentation and documentation

Our department was equipped with a single headed gamma camera (E.CAM, Siemens, Germany). We performed quality control and performance tests of the gamma camera at the time of commissioning of which we kept a record. Thereafter a daily and detailed quality control of the gamma camera was done at regular intervals. We kept a record of everyday work and of possible events in our department [2].

All accessories, devices and equipment we used for radiation protection and radiation measurements are listed in Tables 1a and b. All monitoring instruments were calibrated at intervals specified by AERB.

Table1a. Types and numbers of accessories in our department

Accessory (comments)	Number
Lead bricks	100
Dose carriers	2
Multiple syringe holder	1
Foot operated lead lined bins	4
L-benches	2

Detailed records and an inventory of various standard and operating procedures, radiation accidents and radioisotopes used were maintained. Unusual incidents like partial extravasation of the content of injection of diagnostic radiopharmaceuticals (an average of 6 incidents per year), or improper labeling of the radiopharmaceutical (two incidents in 3 years) were also recorded. We audited our work on

weekly basis to improve work practice. A radiation safety committee was created within the Institute and its meetings were held and recorded regularly.

Radioactive waste disposal was done by decay of the solid radioactive waste and by emptying in a delay tank the liquid radioactive waste. The average exposure rate of quarterly disposed solid waste was only 0.002-0.006 rads.

Table1b. Types and numbers of monitoring instruments in our department

Instrument	Range
Portable beta-gamma area monitor Victoreen USA,451B-RYR	0-50R/h
Contamination monitor Fluke Biomedical ASM 993, USA	0-1000mR/hr
Radioisotope calibrator for measurement of dose of radioactivity Capintec CRC-25R, USA	0.1MBq-200GBq ^{99m} Tc
Pocket dosimeter bleeper Sv 05-106	0.1-999.9mR

The generator, iodine-131 (¹³¹I), and cold kits

We ordered every fortnight an 8GBq molybdenum-technetium (⁹⁹Mo/^{99m}Tc) column generator (CIS Bio-International, France).

By ordering the generator every other week we reduced the running cost by 50%. During the first week when ^{99m}Tc radioactivity was high, we examined more patients than during the second week.

During the first week we performed bone scans. We could examine up to two/three bone scans (1000MBq), two/three renograms) and one/two thyroid scans even up to the middle of the second week. We could perform two to three renograms (555MBq) and two to three thyroid scans (150 MBq) on any day up to the end of the second week. An emergency bone scan or a scan for a gastrointestinal hemorrhage could be performed up to two days before the end of the second week. On emergency occasions, renal or thyroid scans were rescheduled. Saturdays were denoted to research and quality control.

We planned patients for low dose ¹³¹I treatment on an "as and when" basis, usually once a month. Cold kits for labeling and compounding radiopharmaceuticals were procured from BRIT (Board of Radioisotope and Technology, India) or other firms.

We have made our phone numbers available to most referring doctors and to all patients who walked in our department. This helped them to seek for an early appointment. We made sure that rescheduled patients were given priority on their appointed day and that their reports were written on priority basis.

Manpower, training and research

Qualified nuclear medicine staff was recruited as per AERB guidelines [2]. During the last 3 years one nuclear medicine physician diplomate of national board (DNB) in nuclear medicine and one qualified technologist MSc. in Nuclear Medicine were appointed in our department. Our staff included also, one nurse and one attendant. During the overall working procedures, these were further trained by our qualified staff. We also had one post graduate student (resident doctor) on rotation basis from the Radiology Department within the Institute.

We observed a general unawareness about nuclear medicine and its applications and a general apprehension about radiation related procedures in most people visiting us or outside our department. Even in our Institute doctors, post-graduate students and medical staff were not aware of our services and did not know what instructions to give to their patients referred for a nuclear medicine tests.

We thus, organized a series of lectures, Continuing Medical Education (CME) lectures and workshops over the first three years. We organized tailor made lectures for various medical specialties [3], including basics of nuclear medicine and medical physics. Lectures included what and how radionuclides are used, benefits and risks, levels of radiation exposure, common scans, their indications and prerequisites. This included a full day programme under the Indian College of Nuclear Medicine (ICNM)-an academic branch of the Society of Nuclear Medicine). By inviting in every teaching programme about a hundred medical practitioners, cardiologists, general surgeons, physicians, surgical gastroenterologists, neurosurgeons and urologists. We communicated with them so that most doctors became aware about the importance of the facility and of the common indications for ordering nuclear medicine procedures. Experts from the nuclear medicine community were invited to present targeted lectures, as simple as possible. We conducted a series of tailor made lectures for about 500 nursing students and staff and about 100 post-graduate medical students. We also conducted a pre- and post- lecture questionnaire which was answered by all attendees in each session. About 90% of these medical workers had no idea about nuclear medicine prior to our sessions and there was an increase in the referral of patients to be examined in our center after the above teaching (Figure 2). Most of our audience had the impression that nuclear medicine procedures were associated with high levels of radiation. We provided regular communication of the attendants with the referring physicians with feedback to them through letters, by telephone and/or e-mails. This communication also gave to us

more experience as to better report our results in the future

Our department is involved in research projects including theses of post graduate students from medical and surgical disciplines on a regular basis e.g thesis work on evaluation of neurological disorders including brain perfusion with single photon emission tomography (SPET) with ^{99m}Tc -ethyl cysteine dimer (ECD) by a post graduate student in medicine or evaluation of thyroid nodules including thyroid scans by a student of ENT surgery.

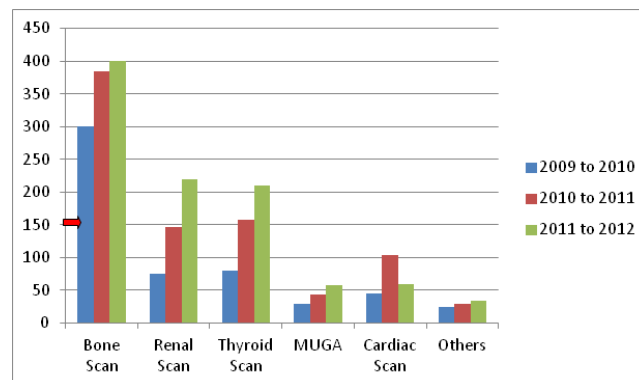


Figure 2. Near consistent rise in referrals of patients to our department (green, purple and blue bars) for two years after the initial year (red bar) with the exception of cardiac scans because of specific unexpected reasons. The red arrow depicts the point of the CME.

Clinical examinations and running of services

A total of 2506 examinations were performed in our department of nuclear medicine during the first three working years: September 2009 to August 2012 (Table 3). The three commonest scans were bone scan, renal scan and thyroid scans. Low dose ^{131}I treatment was administered to 106 patients.

A detailed history was received from all patients asking especially for drug intake which may interfere with the scans. Physical examination was also performed in all patients. [4-7]. We explained, to all patients the procedure of the test in detail and all were given specific instructions for their examination.

Of the 118 patients who were referred to us for treatment of Graves' disease, in 106 (90%) we administered ^{131}I . Most of them were from nearby cities or villages (Figure 3).

After ^{131}I treatment the patients were followed-up at the referring department of medicine or at our Nuclear Medicine Clinic by a joint management policy with mutual understanding between us and the referring physicians. We also communicated regularly by telephone, with patients living afar or at the mountains. This ensured timely detection of possible hypothyroidism.

There were no major untoward radiation side-effects like misadministration, or spillage during the preparation and/or the administration of ^{131}I .

An annual report of the details of the department was sent to the AERB at the end of each calendar year as per regulations [8].



Figure 3. Our Institute (496m above sea level) in relation to Himalayan mountains and nearby

Table 2. Patients' demographics, kind of tests done and referral pattern

Gender and Age	Test type	Referred from	Commonest scans
Total : 2506 Males: 1567	Diagnostic: 2400	Our Institute: 1729	Bone scans: 1084
Median Age: 47yrs	Therapeutic: 106	Outside: 777	Renograms: 448
		Same State: 1693	Thyroid Scans: 441
		Adjacent States: 691	Other: 492
		Distant States: 122	

Future perspective

We are currently referring patients who need a position emission tomography (PET) or PET/computed tomography (CT) scan to another center and communicate with the center by internet or the telephone. We have planned research in collaboration with other Institutes e.g. a PhD programme for our medical physicist.

Discussion

Nuclear Medicine is one of the fastest growing disciplines worldwide. Our country has witnessed a manifold growth in the number of nuclear medicine centers established during the past decade.

Setting up and running of a new nuclear medicine department, like ours, especially by younger specialists can be challenging as many of the facilities they have been trained to use are not available. Our first-hand experience in establishing such a district, isolated department of nuclear medicine in India, as is here presented, may be of value to other younger colleagues.

The Atomic Energy Regulatory Board (AERB) was constituted in India on November 15, 1983 by the President of India by exercising the powers conferred by Section 27 of the Atomic Energy Act, 1962 (33 of 1962) to carry out certain regulatory and safety functions under the Act. The mission of the Board is to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health and the environment.

According to our experience, after civil works were completed and equipment was in use, a department like ours can be commissioned within the next 6 weeks. Nuclear Medicine tests are known to be expensive because of cost of radioisotopes and of cold kits, in addition to the cost of equipment [9]. We decreased the running cost of nuclear medicine tests by 30%-50%.

Communication with other nuclear medicine departments having the same equipment was very useful in order to apply tests like glomerular filtration rate (GFR) where normal values of software based tests was to be compared.

We performed fractionation of all kits, except mebrofenin and sulphur colloid. In the literature the common factor for ensuring stability and proper labeling of the kit fraction is temperature and volume of dilution during fractionation [10-13]. We used a small dilution volume <1.00mL and stored the fractionated kits in the deep freezer section of the refrigerator (-15-20°C). We have analyzed the labeling efficiency indirectly by observing biodistribution of the radiopharmaceutical within the patients' body. However, this procedure needs to be standardized and direct analysis in selected samples is warranted.

Patients who have been treated with radioiodine for Graves' disease may develop hypothyroidism in the long run. They may also need repeated treatment at an optimal time, usually within the next 3-6 months). Nuclear Medicine physicians can be in a better position to manage these conditions at the right time because they are aware of the timing of radiation effects. In our experience, patients' follow-up by both the referring physicians and us was felt to be the best option. Telephonic follow-up has been found to be quite useful in guiding these patients.

Training the nursing staff, to assist our work when necessary was necessary, especially for patients with catheters, pain etc. In our laboratory, physician and technologist trained the nur-

ses during everyday work.

The three commonest procedures performed in our department were bone scan, thyroid scan and renal scan. Recent studies have shown that they are the commonest performed nuclear medicine procedures in most countries [14] (Table 3).

Table 3. Comparing usual examinations in Nuclear Medicine Departments

	Bone scans	Renal scans	Thyroid scans
Developing Countries	25%-28%	16%-18%	15%-25%
Our Department	45.1%	18.6%	18.3%

There is no formal undergraduate nuclear medicine training in our country [15]. From our experience it can be suggested that resident doctors on rotation from related specialties like radiology, internal medicine, cardiology, endocrinology, surgery and radiotherapy could help in routine work while learning basics of nuclear medicine and its applications during their rotation in the department. This could be relevant in departments with no post graduate courses in nuclear medicine. Over a period of time the above courses shall increase awareness of medical workers and make the application of nuclear medicine procedures more effective. Furthermore, knowing that the highest source of exposure for artificial radiation is medical exposure [16], by lectures to medical practitioners, by continuously educating our technicians and giving detailed instructions to our patients we tried to decrease medical radiation exposure of our patients.

In conclusion, our nuclear medicine department established in a peripheral region of developing country as described above, became more cost effective and increased the number of patients studied by procurement of our generator every other week, fractionation of the cold kits as to be used more effectively and by various complete teaching programmes.

Acknowledgment

Special thanks to Kamal, Nisha Bhatia and Rajani Sharma

The authors declare that they have no conflicts of interest

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