Radiation Safety Excellence: Exploring Protocols and Measures at NINMAS

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ABSTRACT

In Bangladesh, the practice of nuclear medicine is expanding daily in both the public and private sectors. For Nuclear Medicine facilities to operate safely and effectively, strict radiation shielding is necessary to lower risks to patients, staff, and the public. This paper describes the radiation safety procedures maintained at the National Institute of Nuclear Medicine and Allied Sciences (NINMAS), including emergency planning, waste management, monitoring systems, occupational health precautions, and shielding techniques.

NINMAS manages radiation exposure using dose-tracking technologies and forefront shielding materials. With notable dose reductions seen, data from thyroid uptake and I-131 therapy procedures highlight the crucial function of shielding. I-131 dosages without shielding reached 80 mSv/h, but shielding reduced this to less than 5 mSv/h. With protective barriers, 18F-FDG doses decreased from 56 uSv/h to less than 10 uSv/h in PET-CT procedures, showing comparable advantages.

To ensure regulatory compliance, NINMAS keeps careful records and complies with waste management standards. This paper highlights the way by which NINMAS has become an influential organization in the Nuclear Medicine community by playing a crucial role in developing safety standards in Bangladesh.

Keywords: Nuclear Medicine, Radiation, Shielding, Dose.

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INTRODUCTION

The journey of nuclear medicine in Bangladesh began over five decades ago with the establishment of the first radioisotope center at Dhaka Medical College Hospital. Starting in a humble tin-shed building, nuclear medicine has since grown into a critical healthcare specialty, with more than 22 centers across the nation, primarily overseen by the Bangladesh Atomic Energy Commission (1-2). The spread of these centers has fostered a significant expansion in the country's diagnostic and therapeutic capabilities of nuclear medicine, with some private institutions now also contributing to this essential field.

Each new center's establishment brings excitement for the advanced care it can provide, coupled with a serious commitment to safety. Reducing the dangers of radiation exposure for patients, employees, and the community is essential to public safety and patient treatment quality. In nuclear medicine, radiation shielding is not just a recommendation; it is a requirement to provide safe, efficient results that benefit patients while lowering the radiation risk for everyone (3). Three forms of exposure are frequently encountered in nuclear medicine: medical, occupational, and public.

Patients getting diagnostic or therapeutic nuclear medicine services, including adults, children, and occasionally study participants, are subject to medical exposure (4). Nuclear medicine professionals and employees who operate in radiation-exposed workplaces, including treatment rooms or radiopharmacy labs, are considered to be exposed at work. Population exposure refers to those in the general population who might be unintentionally exposed because they live close to nuclear medicine operations (5).

Since February 12, 2013, radiation protection and regulatory oversight in Bangladesh have been managed by the Bangladesh Atomic Energy Regulatory Authority (BAERA), established to implement the BAERA Act-2012 and NSRC Rules-1997 (BAERA Rule 12012).

Previously, these responsibilities were under the Nuclear Safety and Radiation Control Division (NSRCD) of BAEC. According to BAERA's regulations, every nuclear medicine department must designate a licensed Radiation Control Officer (RCO), usually a qualified medical physicist. This legislative framework serves as the cornerstone of radiation safety, guiding the secure application of ionizing radiation to protect both the public and professionals (1). The document serves as a thorough guide for recently established nuclear medicine centers in Bangladesh and illustrates the radiation safety procedures put in place at NINMAS. In order to guarantee the safe handling of radioactive materials, it highlights best practices. The approach seeks to harmonize safety protocols throughout the nation.

MATERIALS AND METHODS

Occupational Health and Safety

Ensuring a safe environment for those working with radiation requires strict adherence to protective measures, especially in high-exposure areas like I-131 therapy hot labs, gamma camera scans, and PET-CT scans (3). NINMAS provides various protective garments and equipment to mitigate radiation exposure risks. For instance, employees working in high-radiation environments are equipped with lead aprons and collar bands, typically between 0.35 and 0.5 mm thick, to shield against potential radiation exposure. In addition, protective goggles are used to safeguard the eyes from ionizing radiation, significantly reducing the risk of exposure (IAEA 13).

Figure 1: Lead Aprons

Figure 2: Collar Shield

Figure 3: Lead Googles

Shielding and Containment Facilities

Shielding and containment facilities are paramount to maintaining safety for individuals and the environment, particularly when handling radioactive materials (IAEA 12). NINMAS employs high-density materials such as lead, tungsten, concrete, and steel to effectively shield against radiation. Lead, with its high atomic number, is highly effective in attenuating gamma rays, while concrete is frequently used for neutron shielding. Strategic use of these materials provides a barrier between radiation sources and personnel or patients.

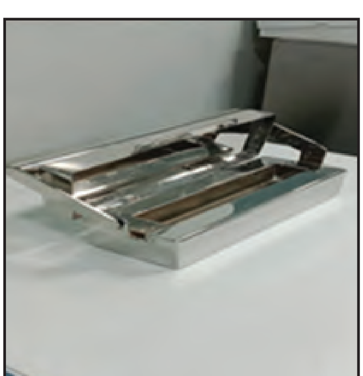

Figure 4: Lead Carrier for Injection

Figure 5: Lead Pot for I-131 toxic Dose Injection

Figure 6: Lead Carrier for FDG Vial Injection

Figure 7: Folded Lead Barrier for I-131 Uptake Injection

Figure 8: Unfolded Lead Barrier for 131I Uptake Machine

Figure 9: Injector Protector at PET-CT

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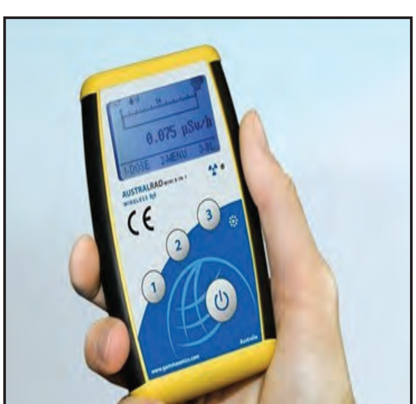

Figure 10: Survey meter

Figure 11: Portable contamination monitor for α- and β-/γ

Figure 12: Hand, Foot monitor

Waste Management Protocols

Proper waste management is vital in nuclear medicine to prevent radioactive contamination and protect public health (6). NINMAS follows an established waste management protocol that aligns with international standards, addressing the handling, storage, and disposal of radioactive waste. Predominantly, nuclear medicine facilities generate liquid radioactive waste, although solid waste-such as syringes, needles, vials, and contaminated gloves-is also common. At NINMAS, waste bins designated for specific isotopes simplify the disposal process. Waste management practices ensure radiation exposure to the public, workers, and the environment remains well within acceptable limits. Additionally, materials contaminated during high-dose treatments, such as clothing and linens from I-131 patients, are handled with special care, reducing the risk of secondary exposure to others (ICRP).

Figure 13: Table top Lead Bin

Figure 14: Lead Waste Bin for I-131

Figure 15: Lead Waste Bin for 99m Tc waste

Figure 16: Lead Waste Bin for 18F waste

Emergency Preparedness

Preparedness for radiation emergencies is a critical aspect of nuclear medicine safety protocols (IAEA 14). NINMAS has established a comprehensive emergency preparedness plan that includes the use of decontamination boxes and procedures for dealing with radiation spills or accidental exposures. Detailed procedures are in place to contain any accidental releases of radioactive materials and to mitigate the potential impact on patients, staff, and the environment. Regular training ensures that all personnel understand their roles in an emergency and are well-prepared to respond effectively.

Figure 17: Decontamination Box

Documentation and Record Keeping

Accurate documentation is a hallmark of effective radiation safety management. NINMAS maintains meticulous records across multiple areas, from patient treatment logs to equipment maintenance records (Ravichandran et al. 95). Specific documents include therapy logbooks, isotope distribution records, safety manuals, and post-therapy discharge records for I-131 patients. These records provide transparency and accountability, supporting continuous improvement and regulatory compliance in managing ionizing radiation.

RESULT

To illustrate the effect of shielding, Table 1 presents radiation dose measurements at a 1-meter distance from a patient undergoing thyroid uptake with and without a shield. The significant dose reduction highlights the protective role of shielding.

Table-1: Thyroid Uptake Patient (dose activity 10 uCi)

No	Dose at 1 meter Distance (without shield) uSv/h	Dose at 1 meter Distance (with shield) uSv/h
1	0.17	0.05
2	0.16	0.04
3	0.18	0.05

For I-131 therapy, NINMAS follows rigorous shielding protocols. Table-2 and Table-3 present dose levels measured with and without shielding for patients administered with I-131. With shielding, dose levels are significantly lower, emphasizing the role of containment measures.

Table-2: Radiation doses for different I131 doses (With Shielding)

No.	Patient Dose of I131 (mCi)	Radiation Dose (With Shield) mSv/h	No.	Patient Dose of I131 (mCi)	Radiation Dose (With Shield) mSv/h
1	15	4	16	14	3.86
2	12	2	17	12	2.2
3	12	2.2	18	14	2.9
4	16	2.7	19	12	4.2
5	12	1.9	20	15	5.3
6	14	3.9	21	12	3
7	15	2.6	22	12	3.5
8	14	1.9	23	15	4.9
9	14	5	24	14	3.84
10	15	4.9	25	15	4.01
11	12	1.7	26	15	1.7
12	16	3	27	12	5.01
13	12	1.9	28	15	3.49
14	12	2.2	29	12	8.21
15	15	3.7	30	12	3.49

Table-3: Radiation doses for different I131 doses (Without Shielding)

No.	Patient Dose of I131 (mCi)	Radiation Dose (Without Shield) mSv/h	No.	Patient Dose of I131 (mCi)	Radiation Dose (Without Shield) mSv/h
1	14	62	16	15	53
2	12	56	17	12	50
3	12	80	18	14	57
4	14	72	19	14	66.04
5	12	39	20	12	48.04
6	12	56	21	12	33.35
7	15	59	22	12	26
8	14	37	23	15	52.06
9	12	24	24	14	47.32
10	14	36	25	15	53.72
11	12	41	26	12	34.6
12	15	68	27	14	42
13	12	30	28	15	67
14	12	32.8	29	12	65
15	15	54	30	12	57

In PET-CT procedures, the introduction of shielding also drastically reduces exposure, as shown in Table-4.

Table-4: Found doses with and without shielding in PET-CT

No	FDG (mCi)	Dose (without shield) uSv/h	Dose (with shield) uSv/h
1	3.4	39	5
2	5.6	45	4
3	6	56	6

Table-5: Name and application of some used equipment at NINMAS

No	Description	Application
01	Lead Aprons	Radiation protection to personnel
02	Collar Shield	Radiation protection to personnel
03	Lead Googles	Radiation protection to personnel
04	Lead Carrier for Injection	Radiation protection to public
05	Lead Carrier for FDG Vial	Radiation protection to public
06	Lead Pot for I131 toxic Dose	Radiation protection to public
07	Lead Barrier for I131 Uptake Machine	Radiation protection to personnel
08	Injector Protector at PET-CT	Radiation protection to personnel
09	Hand, Foot and Cloth Radiation detector	Radiation monitoring
10	Contamination Monitor	Radiation monitoring
11	Survey Meter	Radiation monitoring
12	Table top Lead Bin	Radiation protection to personnel
13	Lead Waste Bin for I131	Radioactive waste management
14	Lead Waste Bin for Tc99m	Radioactive waste management
15	Lead Waste Bin for F18	Radioactive waste management
16	Log Book	Documentation
17	Decontamination Box	Emergency preparedness

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DISCUSSION

The data presented in the tables illustrates the impact of shielding and radiation protection measures at NINMAS. The thyroid uptake measurements in Table 1 show a marked reduction in radiation levels with shielding, underscoring the effectiveness of physical barriers in protecting both staff and patients. In I-131 therapy, Tables-2 and 3 demonstrate the drastic difference between dose rates with and without shielding, reinforcing the importance of containment facilities in high-exposure environments [6]. For instance, without shielding, a patient dose of 12 mCi yields radiation levels up to 80 mSv/h. However, with shielding, the same dose reduces exposure to manageable levels, often below 5 mSv/h.

Table 4 further emphasizes the protective benefits of shielding in PET-CT procedures, where FDG doses without shielding can produce exposure levels as high as 56 uSv/h, which drop significantly to under 10 uSv/h when shielding is used.

Through these tables, NINMAS highlights the direct effect of safety protocols on exposure levels, emphasizing the importance of strict adherence to shielding practices and dose monitoring. Such data-driven insights are invaluable for setting standards and adjusting safety protocols to ensure that radiation exposure remains within safe limits.

CONCLUSION

NINMAS stands out as a leader in radiation protection within Bangladesh, setting an example for other nuclear medicine centers to follow. Its extensive safety measures—including protective equipment, shielding facilities, radiation monitoring systems, and waste management protocols—illustrate a commitment to protecting the well-being of patients, healthcare workers, and the community. Moreover, NINMAS's emphasis on emergency preparedness and meticulous documentation fosters a robust safety culture that promotes continuous improvement and regulatory compliance.

By adhering to these comprehensive safety measures, NINMAS not only enhances patient care quality but also minimizes the potential health impacts of radiation exposure, making it a model institution for nuclear medicine safety in Bangladesh and a respected entity in the global nuclear medicine community.

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