A measuring tool for the necessity for protective environment and behavior against radiation hazard from PET-CT

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Abstract - This paper aims to develop a standardized measuring tool for protective environment and behavior against radiation hazard in order to prepare basic data for finding ways of reducing radiation doses from the use of PET-CT which is a source of high levels of radiation exposures.

The overall explanatory adequacy of items that measure the necessity of protective environment against radiation hazard for items for radiation technologists, patients, radiation technologists and for that which apply commonly was found to be 44.99%, showing that the items satisfactorily measure the degree of necessity of protective environment against radiation hazard. The overall explanatory adequacy for items that measure the necessity of protective behavior against radiation hazard was found to be 50.68%, showing that they satisfactorily measure the degree of necessity of protective behavior against radiation hazard. Therefore it is deemed that if the items devised in this paper are applied at medical facilities that use PET-CT equipment, the environment or behavior against radiation hazard would be relatively objectively measured.

Key Words : Protective environment, Protective behavior, Radiation hazard, PET-CT, Measuring tool

1. Introduction and Objectives

Because of the rapid increase in the use of PET-CT, which is useful for diagnosing cancer, coupled with the high radiation doses from the use, which can lead to radiation poisoning, many potential problems have raised. Therefore research must be conducted to seek various ways to reduce the exposure doses from PET-CT.

Human behavior is understood using a dynamic triangular model in which cognitive or personal factors, behavioral factors, and environmental factors interact with one another to give rise to human behavior. Because of this, when it comes to reducing the exposure doses from the use of PET-CT, both the human behavior aspect and the environmental aspect must be simultaneously considered.

But currently there are not any proper measuring tool that measures the necessity of a protective environment or behavior against radiation hazard with regard to PET-CT. Therefore this paper aims to develop a standardized measuring tool for protective environment and behavior against radiation hazard in order to prepare basic data for finding ways of reducing radiation doses from the use of PET-CT which is a source of high levels of radiation exposures.

2. Methods

The research design and methodology is both qualitative and quantitative. For the factor analysis of each item, a survey was conducted, based on the data provided by the Korean Society of Nuclear Medicine (http://www.ksnm.or.kr), starting August 23, 2010 and lasting for the next 8 consecutive days, targeting about 200 people, or 50% of the sample population drawn from each region according to the proportional stratified sampling, with the population being radiation safety managers and radiation workers working with 109 PET-CT units installed around the country. Among the collected questionnaires, 139 were analyzed.

As for the validity analysis, the principle component analysis was done by grouping the items. To compress the initial information into the least number of factors, the principle component analysis is used in this study. In addition to using the principle component analysis the orthogonal rotation was used, which maintains independence among the factors when they are rotated. There are many specific methods of orthogonal rotation. This study uses the varimax rotation.

3. Results

(1) Factor analysis of the items measuring the necessity of protective environment against radiation hazard

Factor analysis was done for items which measured the necessity of protective environment against radiation hazard. As a result, it was found that for factor 1 on the items relating to protective environment against radiation hazard which applies commonly, the eigenvalue was 6.21 and variance was 20.02%; for factor 2 on the items relating to protective environment against radiation hazard for patients, the eigenvalue was 2.87 and the variance was 9.24%; for factor 3 on the items relating to protective environment against radiation hazard for guardians, the eigenvalue was 2.65 and variance was 8.56%; for factor 4 on the items relating to protective environment against radiation hazard for radiation technologists, the eigenvalue was 2.22 and variance was 7.17%. The overall explanatory adequacy of factors 1, 2, 3, and 4 was 44.99%, showing that the items measure satisfactorily the necessity of protective environment against radiation hazard (see Table 1).

Table 1. Items that measure the necessity of protective environment against radiation hazard

	Description	1	2	3	4
Common	1. There must be an exhaust facility in place in the RI distribution room according to regulations.	**.843**	-.054	.054	-.001

	2. There must be a temporary storage for radioactive waste with lead shielding.	**.821**	.055	.032	.134
	3. There must be radiation warning label attached at the entrance of RI distribution room, resting room, and PET-CT examination room.	**.817**	-.018	.115	.155
	4. There must be shielding for the walls and entrance doors of RI distribution facilities, resting rooms, and PET-CT examination rooms.	**.776**	.168	.200	.104
	5. In the event of radioactive contamination, there must be procedures in place detailing safety procedures.	**.752**	.007	.250	.269
	6. There must be hoods or glove boxes installed in RI distribution rooms.	**.726**	.300	.058	.210
	7. Survey meters that can measure exposure dose and radioactive contamination must be in place in RI distribution facilities, resting rooms, and PET-CT examination rooms.	**.709**	-.041	.083	.410
	8. A ledger must be in place to make records of radiation doses.	**.658**	.018	.127	.393
	9. Decontamination equipment must be in place in RI distribution facilities, resting rooms, and PET-CT examination rooms.	**.592**	.082	.010	-.206
	10. A radiation hazard label must be clearly visible.	**.579**	.354	-.014	-.250
	11. The septic tank of the washroom used by patients must be separated from the general septic tank.	**.568**	.087	.082	-.155
Patients	1. A disclaimer for patients about the PET-CT examination must be clearly displayed in radiation controlled areas.	.113	**.572**	.039	-.030
	2. The resting room must be equipped with facilities for preventing external exposure to other patients.	.101	**.537**	.202	-.276
	3. The resting room must be equipped with a designated washroom.	-.114	**.509**	.282	.215
	4. Surveillance cameras that monitor movements of patients must be installed in resting rooms.	.225	**.479**	.077	.166
	5. The examination preparation room must be equipped with instruments that can measure the height and weight of patients.	.108	**.475**	-.222	-.110
	6. There must be equipment in place that checks blood sugar levels of patients.	-.046	**.474**	.305	.207
	7. There must be an emergency bell installed in resting rooms and washrooms that can summon medical staff.	-.115	**.421**	.080	.269
	8. There must be safety precautions clearly posted in resting rooms.	-.184	**.412**	.235	.230
Guardians	1. Shielding walls and doors must be installed in RI distribution rooms.	.111	.305	**.635**	.180
	2. Proper shielding must be in place in waiting rooms and resting rooms for the protection of guardians.	.156	.192	**.629**	-.128
	3. Protective equipment for guardians must be in place.	.598	-.127	**.610**	.008
	4. A guidebook for guardians must be in place.	-.144	.199	**.593**	-.131
	5. The structure of resting rooms must be so that ordinary people can't easily gain entry.	.162	.040	**.535**	.174

	6. There must be protective measures against radiation with regard to ordinary people going in and out of RI distribution rooms, resting rooms, and PET-CT examination rooms.	.074	.158	**.467**	-.062
	7. Shielding walls and doors must be installed for resting rooms.	.300	.151	**.452**	.342
Radiation technologists	1. An alarm monitor must be installed to sound alarms in case allowable RI contamination levels are exceeded.	.040	-.019	.000	**.583**
	2. A personal dosimeter must be in place for every radiation technologist.	.235	.314	-.233	**.576**
	3. An internal communication device that can communicate with the resting room must be installed.	.154	-.148	.438	**.467**
	4. There must be measures such as switching of duties according to the exposure dose of radiation technologists.	.196	.047	.037	**.458**
	5. The RI distribution room must be equipped with protective equipment (protective gloves, protective glasses, aprons, etc.).	.162	.061	.193	**.431**
Eigenvalue		6.21	2.86	2.65	2.22
Explained variance		20.02	9.24	8.56	7.17
Cumulative variance		20.02	29.25	37.81	44.99

(2) Factor analysis of items measuring the necessity of behavior for protection against radiation hazard

Factor analysis was done for items that measure the necessity for protective behavior against radiation hazard. As a result, it was found that for factor 1 on the items relating to protective behavior against radiation hazard for patients, the eigenvalue was 8.00 and variance was 21.05%; for factor 2 on the items relating to the protective behavior against radiation hazard for radiation technologists, the eigenvalue was 4.08 and variance was 10.73%; for factor 3 on the items relating to protective behavior against radiation hazard that apply commonly, the eigenvalue was 3.67 and variance was 9.67%; for factor 4 on the items relating to protective behavior against radiation hazard for guardians, the eigenvalue was 3.51 and variance was 9.24%. The overall explanatory adequacy of factors 1, 2, 3, and 4 was 50.68%, showing that the items measure satisfactorily the necessity of protective behavior against radiation hazard.

Table 2. Items that measure the necessity of protective behavior against radiation hazard

	Description	1	2	3	4
Patients	1. Precautions while in the RI distribution room and resting room must be explained to patients.	**.837**	.032	.251	.153
	2. Patients must be cautioned to only use the designated washroom after the RI injection.	**.805**	.072	.271	.195
	3. Patients must be cautioned not to move during the examination.	**.773**	.228	.089	.253

	4. The equipment must be checked for any malfunctions and corrected as necessary as part of regular quality management.	**.765**	.184	.063	.414
	5. Beddings in resting rooms that are at risk of being contaminated by patients must be replaced.	**.679**	.226	.139	-.182
	6. When a patient is urinating, they must be cautioned that the urine does not stain their clothes.	**.678**	.212	.132	.043
	7. Before the RI is injected into the patient, their blood sugar level must be checked, as well as that they haven't eaten in the last 12 hours.	**.647**	.123	-.121	.352
	8. After the examination, the patient must be informed of the precautions they need to follow (consumption of water, no contact with pregnant women and children).	**.612**	.187	.216	-.345
	9. The registration number on the medical forms must be checked to make sure it matches the patient.	**.579**	.213	.131	.549
	10. The patient who's got an RI injection should be cautioned against going out of the resting room.	**.547**	.058	.096	.182
	11. The patient needs to be checked for any metal parts on their body, such as keys.	**.500**	.387	-.001	.373
	12. Before examining the patient, it must be confirmed that they have urinated.	**.493**	.224	.027	.394
	13. A physical examination must be performed on the patient (height, weight).	**.458**	.186	.023	.194
	14. The amount and time of RI injection on the patient needs to be measured for before and after.	**.412**	.011	.145	.248
Radiation technologists	1. Protective equipment must be worn when going in and out of the radiation controlled area.	.108	**.662**	.279	-.018
	2. After the RI distribution, the proper open/shut status of the RI storage must be checked.	.273	**.616**	.163	.000
	3. Regular health check-ups for radiation workers must be done according to the regulations.	.268	**.587**	.264	.079
	4. After RI injection, an effort must be made to reduce the time spent with the patient.	.376	**.586**	-.007	.163
	5. Quarterly exposure dose of radiation workers must be found.	.089	**.573**	.565	-.025
	6. Lead cylinder syringe must be used when RI is injected.	.094	**.536**	.463	.018
	7. After the use of RI, radiation workers must be checked for radioactive contamination and decontaminated as necessary.	.093	**.532**	-.054	.141
	8. Personal dosimeters must be worn at all times when working with radiation.	.172	**.507**	.151	.268
	9. Safety management rules and regulations must be followed when working with radiation.	.400	**.482**	.307	-.047
	10. When RI is distributed, protective equipment must be used (protective gloves, vinyl gloves, protective glasses, aprons, lead cylinders, etc.).	.423	**.480**	-.251	.212
	11. When examining, the open/shut status of the examination door must be checked.	.292	**.441**	.305	.174
	12. Regular education and training must be given to radiation workers.	-.129	**.403**	.214	.297

Common	1. To accurately measure RI exposure doses, the equipment must be regularly checked and corrected as necessarily.	.041	-.066	**.648**	-.162
	2. Contamination levels and radiation doses must be measured for equipment used in the radiation work.	.087	.156	**.638**	.132
	3. Records must be made and kept regarding the use, storage, and discarding of RI.	.003	.397	**.631**	.249
	4. The level of contamination in the lead cylinder used for RI injection must be measured with a survey meter.	.051	.198	**.565**	.012
	5. Radioactive waste (vial, syringe, needle, cotton) resulting after the distribution must be disposed according to the regulations.	.362	.021	**.548**	.417
	6. Radiation dose (radioactivity) must be measured for the temporary storage and it must be discarded regularly.	.273	.001	**.529**	.138
	7. After RI is injected on the patient, the syringe must be stored in the temporary storage.	.471	-.103	**.487**	.115
	8. Quality management must be done daily for PET-CT.	.134	.231	**.406**	.279
Guardians	1. There must be distance maintained between guardians and patients.	.132	.061	.250	**.682**
	2. To ensure safety of guardians and ordinary people, the entrance door of the RI distribution room must be closed before RI is distributed.	.172	.286	.006	**.658**
	3. Precautions regarding radiation exposure must be explained to guardians.	.303	-.017	.247	**.592**
	4. If guardians' help is needed for the examination, protective equipment must be provided to them.	.333	.374	-.177	**.521**
Eigenvalue		8.00	4.08	3.67	3.51
Explained variance		21.05	10.73	9.67	9.24
Cumulative variance		21.05	31.78	41.44	50.68

4. Conclusions

There are three major aspects to medical radiation when it comes to its safety: ensuring the safety of the patients; ensuring the safety of radiation workers; and ensuring the safety of ordinary people and the environment. Given the rapidly growing demands for PET-CT diagnosis and the high levels of radiation exposure, various ways to reduce exposure doses for patients, radiation workers, and guardians must be sought out. In this study, a standardized measuring tool that measures the necessity for protective behavior and environment against radiation hazard was developed in order to measure basic data for coming up with a plan for reducing radiation exposure from PET-CT equipment, a source of high levels of radiation exposure.

The overall explanatory adequacy of items that measure the necessity of protective environment against radiation hazard for items for radiation technologists, patients, radiation technologists and for that which apply commonly was found to be 44.99%, showing that the items satisfactorily measure the degree of necessity of protective environment against radiation hazard. The overall explanatory

adequacy for items that measure the necessity of protective behavior against radiation hazard was found to be 50.68%, showing that they satisfactorily measure the degree of necessity of protective behavior against radiation hazard. Therefore it is deemed that if the items devised in this paper are applied at medical facilities that use PET-CT equipment, the environment or behavior against radiation hazard would be relatively objectively measured.

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