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DETERMINING THE CURRENT STATUS AND POTENTIAL OF NUCLEAR MEDICINE IN POLAND

Krzysztof A. Pachocki[1], Agata Sackiewicz-Słaby[2]*

[1]Department of Radiation Hygiene and Radiobiology, National Institute of Public Health – National Institute of Hygiene, Warsaw, Poland
[2]Department of Nuclear Medicine and Endocrine Oncology, Maria Sklodowska-Curie Memorial Cancer Centre and Institute of Oncology, Warsaw, Poland

ABSTRACT

Background. Through its use of ionising radiation, the field of nuclear medicine forms a unique and significant part of medical diagnostics and patient treatment.
Objectives. To assess the operational potential of nuclear medicine in Poland based on existing database/literature sources together with conducting a survey on the relevant healthcare facilities available, staffing, expertise and performance.
Material and Methods. To gather all available literature data on the medical use of ionising radiation in Poland several data bases were used, since currently, there are no single statistical data base devoted to this issue. Data on radiation hygiene were thus collected from the Statistical Bulletin of the Ministry of Health, Annual reports from the National Atomic Energy Agency and Central Statistics Office. Additionally, national and provincial reports were used, as well as those received from the European Society of Nuclear Medicine.
Results. At present, the Public Healthcare system in Poland has 55 nuclear medicine departmental facilities operating and 8 that are private/non-public. These are staffed by 252 doctors, of whom 151 are qualified as nuclear medicine specialists; constituting one specialist per 300,000 inhabitants. In addition, 170 highly qualified staff (biologists, chemists, physicists, electronics engineers and IT specialists) provide indispensable scientific/operational support and are vital for the development of nuclear medicine departments. They are mainly responsible for ensuring that all equipment functions effectively and for developing new diagnostic techniques, together with new radiopharmaceuticals. Furthermore, there are approximately 500 other staff at intermediate-level also involved in nuclear medicine departments, such as technicians, nurses and support workers. The survey demonstrated an average of 22 persons employed per nuclear medicine department. For all institutions, it is estimated that there are 127 gamma cameras, 10 PET/CT scanners and 16 hybrid SPECT/CT systems operating. In 2000, approximately 117,435 diagnostic procedures were performed, compared to 156,214 in 2008 and with the current number of around 170,000; up to 38% were simple thyroid scintigraphies, 25% were bone scans, 11% heart scintigraphies and 10% kidney scans.
Conclusions. The number of diagnostic radioisotopic procedures in Poland are strongly expected to increase by 300% during the next 5-6 years. To meet this rise, additional equipment will thus be necessary, which includes having an extra 100 SPECT/CT gamma cameras.

Key words: *nuclear medicine examinations, radionuclides, statistics*

STRESZCZENIE

Wprowadzenie. Stosując promieniowanie jonizujące medycyna nuklearna stanowi istotną i unikalną gałąź metod diagnostycznych i leczniczych.
Cel badań. Celem podjętych badań było zebranie danych, na bazie dostępnych danych literaturowych oraz przeprowadzonego badania ankietowego i ocena potencjału w zakresie personelu i aparatury itp. jakim dysponuje medycyna nuklearna w Polsce.
Materiał i metoda. W celu zebrania niezbędnych danych, ze względu na brak jednej statystycznej bazy danych dotyczącej medycznych zastosowań promieniowania jonizującego w Polsce, korzystano z kilku istniejących baz danych. Dane dotyczące higieny radiacyjnej pochodziły z Biuletynu Statystycznego Ministerstwa Zdrowia, Rocznych Raportów Państwowej Agencji Energii Atomowej i Głównego Urzędu Statystycznego. Dodatkowo korzystano z krajowych i wojewódzkich raportów oraz danych Europejskiego Towarzystwa Medycyny Nuklearnej.

*** Corresponding author**: Krzysztof A. Pachocki, Department of Radiation Hygiene and Radiobiology, National Institute of Public Health – National Institute of Hygiene, Chocimska Street 24, 00-791 Warsaw, Poland
phone: + 48 22 54 21 224, fax: + 48 22 54 21 309, e-mail: kpachocki@pzh.gov.pl

Wyniki. W Polsce funkcjonuje 55 zakładów medycyny nuklearnej działających w ramach publicznej służby zdrowia oraz 8 ośrodków niepublicznych. Obecnie w obszarze medycyny nuklearnej pracuje ok. 252 lekarzy, w tym ok. 151 posiadających specjalizację z zakresu medycyny nuklearnej. Oznacza to, że jeden lekarz specjalista przypada na 300 000 mieszkańców. W zakładach medycyny nuklearnej zatrudnionych jest także ok. 170 osób z wyższym wykształceniem (m.in. biolodzy, chemicy, fizycy, elektronicy, informatycy). Jest to grupa pracowników ważna dla rozwoju placówek medycyny nuklearnej, zajmująca się sprawnością aparatury, rozwojem nowych technik diagnostycznych oraz rozwojem radiofarmaceutyków. Personel średni (technicy i pielęgniarki) zatrudniony w pracowniach medycyny nuklearnej oraz personel pomocniczy szacuje się na ok. 500 pracowników.
Z przeprowadzonych badań ankietowych wynika, iż średnio w zakładzie medycyny nuklearnej pracują 22 osoby. Szacuje się, że w placówkach tych funkcjonuje 127 gamma kamer, 10 skanerów PET/CT i 16 systemów hybrydowych SPECT/CT. W roku 2000 wykonano około 117 435 badań diagnostycznych, natomiast w roku 2008 liczba ta wzrosła do ok. 156 214 badań, z czego aż 38% stanowiły najprostsze badania scyntygraficzne tarczycy, 25% badania scyntygraficzne kości, 11% badania serca i 10% badania nerek. W Polsce obecnie z zakresu medycyny nuklearnej wykonuje się ok. 170 tys. badań rocznie.
Wnioski. Liczba wykonywanych w Polsce diagnostycznych badań radioizotopowych powinna w ciągu 5-6 lat wzrosnąć o 300%. Konieczny będzie zakup dodatkowego sprzętu i aparatury, m.in. *gamma* kamer typu SPECT/CT w ilości ok. 100 aparatów.

Słowa kluczowe: *badania z zakresu medycyny nuklearnej, radioizotopy, statystyka*

INTRODUCTION

Since many years ago, nuclear medicine has always formed an independent entity within the medical field; its beginnings lying back in the thirties and forties of the 20th century. The official title of 'Nuclear Medicine' was first adopted in 1952 [7]. According to the WHO definition it covers all diagnostic methods and treatments that use radioactive isotopic substances; the latter in a form open to the body, unlike brachytherapy which uses sealed radioactive sources and is part of radiotherapy.

In fact, nuclear medicine is applied in nearly all medical fields, being especially important for oncology, endocrinology, cardiology, nephrology, neurology and orthopaedics. It can be divided into two basic groupings. One is for screening which is highly sensitive, whilst the other is more specific and used in the later stages of making a clinical diagnosis. A group apart, are radioisotope methods that monitor the effectiveness of treatments such as chemo- and radio- therapies so that for instance cancer metastases can become recognised. The fundamental advantage of radioisotope techniques used for diagnosis, is to allow organ function to be assessed through measuring specific operational parameters unrelated to structure; the latter being determined by classical procedures of radiology, X-ray computer tomography, ultrasound or magnetic resonance. Treatment methods which use radioisotopes exploit chemical compounds labelled with radioisotopes which are designed to preferentially accumulate in diseased tissue, thus permitting ionising radiation to destroy these diseased locations. In particular they are used in oncology for treating metastases, e.g. ones from the thyroid or bones, and others. Through its use of ionising radiation, nuclear medicine thereby forms a significant and unique branch of medical diagnosis and treatment. Oncological examination constitute at least 50% of all nuclear medicine testing, excluding those done using PET. According to the European Commission's (EC's) Radiological Protection Section, around 4-14% of patient radiation exposure resulting from all medical examinations is received through nuclear medicine techniques [4]. The actual numbers of examinations performed constitute a smaller corresponding proportion of 2-5%.

The presented study aims to assess the current potential of nuclear medicine facilities that are available in Poland in terms of staffing and equipment.

MATERIAL AND METHODS

In Poland, there is no single statistical data base dedicated just to the medical use of ionising radiation. Furthermore, studies or reports on this subject are intermittent [2, 5, 6]. Data that are available come from different sources and are not always consistent. Basic sources of information were obtained from The Ministry of Health Statistical Bulletin [3], annual reports from the National Atomic Energy Agency [9] and data from the Central Statistics Office on radiation hygiene found in MZ-52 reports [8]. In addition, national and provincial reports were used, as well as those received from the European Society of Nuclear Medicine and the results of the undertaken survey.

The Ministry of Health Statistical Bulletin is annually issued by the Centre for Health Information Systems (within the scope Medical Statistics System) that contains data in various forms collected from *MZ-03* financial reports arising from studies conducted by Central Statistics Office, the Oncology Centre and the Institute of Tuberculosis and Lung Diseases. Data from the Medical Statistics System are gathered according to the Statistical Analysis of the Public Statistics Programme, published annually in the Council of Ministers regulations. This data are only from the remit of the Ministry of Health and not from either the Ministry of Defence nor the Ministry of Internal Affairs and Administration. The bulletin comprises 4 sections in which information can be found on national demographics and health status, on medical personnel and the operation of all healthcare facilities, including resources and finance. Most information is broken down into provincial and district levels.

The main tasks of the National Atomic Energy Agency [9] president are in providing regulation and supervision over radiation exposure activities which are achieved by the following means:

- issuing permits and taking other decisions concerning atomic safety and radiological protection through analysing and evaluating the relevant application documentation submitted by organisational units engaged in radiation exposure activities.
- preparing and carrying out control inspections on all activities that may cause radiation exposure.
- managing all data from radiation monitoring systems.

The number of registered organisational units whose activities (one or more) involve radiation exposure are 2764 and are covered by that part of the Atomic Law Act which establishes their supervision by the President of the National Atomic Energy Agency (31st December 2011). However the numbers of registered activities involving exposure – 4092 [9]. The latter is much bigger than the number of organizational entities since there are a lot of entities which conduct many different activities (some of them even several activities of the same type on the basis of separate licenses). The reports on radiation hygiene *MZ-52* [8] are divided into their provincial sanitary-epidemiological levels and describe those organisational units that use ionising radiation for medical purposes including X-ray units and equipment.

RESULTS AND DISCUSSION

Numbers of institutes

The Polish database reveals that there are 55 medical establishments that provide nuclear medicine facilities serving the public health service and 8 private ones; in all 63 with more gradually being planned. These institutes are however not uniformly distributed throughout the country. In 2011 there were 67 centres that performed isotope diagnosis whilst in 2010 there were 72. The most were in the Lower Silesia province - 10, followed by 8 in Mazovia, 6 in Wielkopolska, 6 in the Lodz region, 6 in Malopolska, however the least (ie. 1) were both in the Swietokrzyskie and Opole provinces (Table 1).

Table 1. The number of medical centres performing radioisotopic diagnostics in Poland [3]

Country/Province	Year	Number of radioisotopic diagnostics centres
Poland	2003	66
	2004	66
	2005	62
	2006	56
	2007	68
	2008	69
	2009	73
	2010	72
Province	2011	67
Lower Silesia	2011	10
Kujavia-Pomerania		4
Lublin Region		5
Lubuskie Region		2
Lodz Region		6
Malopolska		6
Mazovia		8
Opole Region		1
Subcarpathia		3
Podlasia		2
Pomorania		4
Silesia		4
Swietokrzyskie Region		1
Warmia-Mazuria		3
Wielkopolska		6
Western Pomerania		2

It is also worth noting the growth of private centres offering PET which have arisen in Warsaw, Wroclaw, Poznan, Lodz, Krakow and Olsztyn.

The survey showed that the average area of a nuclear medicine facility is 850 m^2 divided into 3 working areas. Usually one of these has a Class II isotope status. Most medical nuclear medicine centres (70%) are part of supervised areas the others being controlled areas.

Departmental / Institutes' equipment

Nuclear medicine centres in Poland are variously equipped, ranging from simple scintillation counters to measuring iodine uptake using a single-headed gamma camera with a small field of view, gamma cameras that are single or double headed providing planar or rotational imaging and up to the SPECT/CT and PET/CT hybrid systems. It is estimated that such centres operate 127 gamma cameras, 10 PET/CT scanners (in 8 centres), 16 SPECT/CT systems, 56 SPECT devices and 8 scintigraphs. The numbers of gamma cameras having risen by 32% within the last 5 years (Table 2).

Europe has a total of 5000 gamma cameras. In its western part there are around 2-4 such cameras per 100,000 inhabitants whereas in Poland the equivalent value is only 0.3 (Table 2). Some of this equipment has

Table 2. Medical devices/equipment – *gamma* cameras [3]

Country/Province	Year	Gamma cameras	
		Numbers	Numbers per 100 000 inhabitants
Poland	2003	87	0.23
	2004	84	0.2
	2005	82	0.2
	2006	86	0.2
	2007	85	0.2
	2008	98	0.3
	2009	104	0.3
	2010	108	0.3
Province	2011	127	0.3
Lower Silesia	2011	10	
Kujavia-Pomerania		11	
Lublin Region		11	
Lubuskie Region		4	
Lodz Region		10	
Malopolska		7	
Mazovia		25	
Opole Region		4	
Subcarpathia		4	
Podlasia		3	
Pomorania		7	
Silesia		14	
Swietokrzyskie Region		2	
Warmia-Mazuria		3	
Wielkopolska		7	
Western Pomerania		5	

been operating for more than 20 years and really needs replacing with up-to-date hybrid types that fulfil the requirements of contemporary diagnostics that guarantee combined isotopic and CT imaging. The average age of gamma cameras used in the European Union (EU) is 5 years, but in Poland this is over 10 years. As an example in Poland, the same eight scintigraphs have still been used for over 16 years since their last manufacture, whose average service age is 27 years, ranging from 19-35 years [7]. Some centres are not equipped with radiopharmaceutical facilities to protect against cells from laminar flow and in measuring radioactivity levels. There also ought to be a systematic supplying of radiological protective equipment such as suitable containers or protective barriers for syringes as well as measures for personal protection and against any accessories remaining that are radioactive.

In 2012 the 'SPECT-CT Network' project was completed in Poland as part of the national campaign programme launched for fighting cancer. As a result Polish nuclear medicine centres became equipped with fully-profiled gamma cameras for undertaking oncological examinations. An important part of furthering the development of nuclear medicine in Poland is the Ministry of Health project entitled 'Positron Emission Tomography (PET) - and radio-pharmaceutical production 18FDG in Poland.

Staff numbers

At present in Poland there are 252 doctors employed in nuclear medicine of which 151 are specialists within this field; constituting one specialist per head of 300,000 of the population; the corresponding average European value being 4-5 times higher.

Nuclear medicine centres also employ around 170 persons that are qualified in higher education (including the subjects of biology, chemistry, physics, electronics and IT). These staff are vital for developing new diagnostic techniques and radio-pharmaceuticals as well as in checking the operating effectiveness of equipment. Middle-ranking personnel, such as technicians, nurses and support staff are around 500 members [11]. Survey results indicate that, on average, 22 staff per centre are employed in nuclear medicine departments.

Recruitment structure

As well as employing doctors in nuclear medicine departments, there a large group of other professionals which include nurses, technicians, radiopharmacists, engineers, medical physicists and support staff. Almost 80% are women. Doctors form 25% of those employed as do technicians whereas medical physicists constitute 6%. Each centre has an radiological protection inspector/officer with the necessary authorisations issued by the President of the National Atomic Energy Agency. The numbers of employees in the aforementioned professional groupings varies within a given department or centre according to its size and the type of isotope diagnostics and/or therapy undertaken. Departments operate in single or double shift systems depending on their size and available facilities/equipment. Those departments that offer isotope treatment therapy provide a 24 hour service to patients. At the moment all employees work for 5 hour stretches. Staff are also obliged to attend and complete introductory and periodic training courses in radiological protection at the end of which an exam needs to be passed resulting in a certificate that also includes radiation dosage controls. Based on both the individual and environmental exposure to ionising radiation dosage, a given staff member from one of the aforementioned groupings is assigned to either Category A or B exposure. According to Atomic Law [12], only a few percent are in fact assigned to Category A.

Doctors specialising in nuclear medicine or those being trained

Using hybrid systems requires that a given doctor be qualified in radiology or is a radiology specialist.

Doctors from nuclear medicine departments manage all diagnostic and treatment procedures, as well their reporting, and in specific cases they actually administer isotope doses themselves by direct application to tumours in certain types of cancer.

Nurses qualified in middling to higher education levels

In nuclear medicine departments, they provide the patient care and administer radiopharmaceuticals as and when necessary. Existing nurse training does not really cover nuclear medicine so it seems that specialist courses need to be organised for about 300 nurses by the Centre for Postgraduate Education of Nurses and Midwives. Such courses should include modules devoted to radiological protection for both staff and patients.

Radiopharmacists qualified in middling to higher education levels

Their duties are to ensure quality control and the preparation of all radiopharmaceuticals given to patients; they are also responsible for controlling the departments' turnover of isotopes. Most are analytical technicians in medicine, chemistry or pharmacy; a few possess higher degrees. Attempts are now being made to launch a radiopharmaceutical specialisation for those qualified at higher degree level that should include training on radiological protection.

Technicians for operating equipment

Current regulations stipulate either technical qualifications or a BSc degree, both in electroradiology. Despite this, at the moment 40% are technically qualified in other areas (e.g. in analytical medicine, nucleonics, electronics, chemistry or nursing). This state of affairs is maintained due to unchanging work practices throughout the smaller centres, that require a rotation of staff duties for different functions e.g. in preparing radiopharmaceuticals, administering doses to patients and in performing tests. The problem is a lack of part-time bridging studies designed for allowing staff with many years experience to be become qualified as electroradiological technicians. Such studies are however now organised by the Polish Society for Nuclear Medicine (under the patronage of the National Consultant for Nuclear Medicine), nevertheless, they are as yet not officially recognised. It is therefore necessary that an appropriate training system be formalised for nuclear medicine technicians or by introducing a system of specialisation based on amended laws. Indeed when starting their new jobs, it is found that both technicians and BSc graduates (who possess appropriate qualifications) demonstrate insufficient knowledge of nuclear medicine and thus a unified educational programme needs to be developed for this field.

Medical physicists

These are qualified staff from higher education but few actually specialise in this field. To obtain authorisation for conducting examinations/testing using such specialist equipment they should, from 2012, possess a certificate issued by the National Centre for Radiological Protection in Health. At present however, most Nuclear Medicine Centres are unable to employ new medical physicists and those already occupying such positions do not have this specialisation. The problem is that there are only limited places in centres that provide training in this area and where those accepted are mainly radiotherapy physicists.

Medical engineers

They also have higher education but in the IT, electronic or mechanical engineering fields. They are responsible for all the equipment and IT systems required for the nuclear medicine departments to operate under. Radiological Protection Inspectors frequently come from this professional group. Medical engineers had also been previously responsible for performing diagnostic tests and instrument calibration prior to the change in the law which now assigns such tasks to the medical physicists.

Support staff

They also need to be taken into account and consist of secretaries, registration-receptionists (responsible for patient documentation), other nursing staff and cleaners. As such, they are required to undertake introductory and periodic training on radiological protection and dosimetric control.

Performing diagnostic radioisotopic testing/examinations

Despite the deficiencies of there being few up-to-date equipment/instruments, the numbers of diagnostic testing is constantly rising. In 2000, there were 117,435 tests performed annually, whereas this number has risen to 156,215 in 2008 (Table 3) [11]. Of these 38% were simple thyroid scintigraphies, 25% were bone scans, 11% heart scintigraphies and 10% kidney scans [5]. At present around 170,000 tests are annually done in nuclear medicine. This can be compared to 7.5 million X-rays performed annually in the Mazovia province alone [1].

The survey demonstrated that the average monthly number of patients that underwent isotopic diagnosis in the centres studied, were around 300, whereas those subjected to isotopic treatment were 24.

In all, 4.3 tests/1000 inhabitants were done in 2008, where in this respect Poland is one of the lowest in Europe; the majority of other countries in the vicinity of Poland being at least 2-3 times higher. Throughout

Table 3. Numbers of radioisotopic diagnostic tests/examinations undertaken in Poland [11]

	Types of diagnostics	Year 2000	Year 2008
1	Brain	2 599	---
2	Thyroid gland	59 772	---
3	Parathyroid glands	528	---
4	Salivary glands	203	---
5	Lungs	4 743	---
6	Heart	11 130	---
7	Liver	3 289	---
8	Intestines and other GI examinations	571	---
9	Kidneys	16 624	---
10	Bones	11 964	---
11	Inflammatory states (Ga, Leucocytes, IgG)	500	---
12	I^{131} – whole body examinations	5 015	---
13	Bone marrow	4	---
14	Lymphoscintigraphy	352	---
15	Adrenal gland	66	---
16	Others	75	---
	Totals	117 435	156,214

*) At present around 170,000 tests are annually done in nuclear medicine.
"---" no data

Europe, 10 million tests are performed per 500 million inhabitants (i.e. 20 tests/1000). In the USA however, 18 million are done per 311 million inhabitants (i.e. 58/1000), and in Australia 560,000 per 21 million inhabitants are done (i.e. 27/1000). The numbers of radioisotopic tests performed globally increases annually by about 10% [13]. The reasons for the low numbers in Poland are varied, but the main one being a poor diagnostic infrastructure and very few qualified specialists. The waiting time for radioisotope testing ranges from 2 to 14 weeks depending on the centre.

Isotope therapy

In 2008 about 18,105 treatments were performed, whilst in 2000 this was 12,379 (Table 4) [11].

Table 4. Radioisotopic therapy – number radioisotopic treatment procedures performed [11].

Radioisotopic therapy	YEAR 2000	YEAR 2008
Thyroid gland; Ablation/metastases	1,424	---
Thyroid gland: Mild disease	10,392	---
Bones; Palliative treatment	475	---
Others	88	---
Totals	12,379	18,105

"---" no data

Table 5. Reference activity levels of commonly used radiopharmaceuticals administered to adult patients with average physique, (weight~ 70 kg, height~ 170 cm) for the most frequently conducted diagnostic examinations/tests [10].

Examination type	Radionuclides and Radiopharmaceuticals	Radioactivity levels used [MBq]
Skeletal imaging	^{99m}Tc phosphates, phosphonates	750
Bone marrow imaging	^{99m}Tc – colloids	400
Brain perfusion	^{99m}Tc – HmPAO ^{99m}Tc – ECD	750 750
Cisternography	^{111}In – DTPA	40
Thyroid imaging	$^{99m}TcO_4$ ^{123}I – iodides ^{131}I – iodides	80 20 4
Searching for thyroid tumour metastases after gland ablation	^{131}I – iodides	240
Imaging of the parathyroids and any arising adenomas	^{99m}Tc MIBI	750
Imaging lung ventilation	^{133}Xe – dissolved gas ^{127}Xe – dissolved gas ^{99m}Tc – DTPA - aerosol	400 200 200
Planar imaging of lung perfusion	^{99m}Tc – microspheres	100
Tomography imaging of lung perfusion	^{99m}Tc – microspheres	400
Liver and spleen imaging	^{99m}Tc – labelled colloids	200
Dynamic imaging of the biliary tract	^{99m}Tc – di-octyl imino derivatives	200
Imaging splenic denatured erythrocytes	^{99m}Tc – denatured erythrocytes	100
Examining the first pass of blood through pulmonary and heart circulation	$^{99m}TcO_4$ – solution ^{99m}Tc DTPA	400 800
Blood pool imaging of the left ventricle and operational dynamics (gating)	^{99m}Tc – erythrocytes (labelled in vivo)	800
Perfusion imaging of the left ventricular cardiac muscle	^{99m}Tc – phosphonates, isonitriles and equivalents ^{201}Tl – chloride	800 100
Imaging Meckel's diverticulum	$^{99m}TcO_4$ – solution	400
Bleeding from the GI tract - localisation	^{99m}Tc – erythrocytes and equivalents	400

Currently, isotopic methods are mainly used for treating mild thyroid disease, thyroid cancer, bone metastases, joint inflammation and lymphomas. New methods for treating endocrine tumours have also been introduced by using isotopically labelled somatostatin analogues (with permission given by the National Health Fund on an individual basis). Three types of radioisotope treatment can be discerned; for thyroid cancer (ablative and treating metastases), for mild thyroid disease and palliative treatment of the skeletal system. In addition isotopic synovectomies are performed together with, amongst others, treatment with monoclonal antibodies. Some treatments require high radiation doses e.g. 3700-5550 MBq for thyroid cancer using the I^{131} labelled meta-iodobenzylguanidine (MIBG). For this, patients need to be hospitalised in isotope therapy departments where appropriate standards of radiological protection are necessary (e.g. having separated drainage systems).

Isotope treatment and radioactivity

Nuclear medicine departments use many radiopharmaceuticals for performing diagnosis and treatment whose reference levels are set down in the Ministry of Health Regulation from 18th February 2011 (Table 5) [10].

Isotopes used, must both have sufficient short half-lives and energy of γ-radiation enabling detection by gamma cameras (e.g. Tc^{99m}, In^{111}), or positron emission in PET diagnosis (e.g. F^{18}, Ga^{68}, C^{11}). Therapies using isotopes chiefly consist of the β- emitting Sr^{89} and Y^{90} as well as α emitters like Ra^{223}. Radionuclides emitting both γ and β- radiation may be used for either treatment, diagnosis or for monitoring the course of therapy, e.g. I^{131}, Sm^{153} (Tables 6 and 7).

CONCLUSIONS

1. The field of nuclear medicine is continually developing.
2. There is an increasing need for more oncological testing, PET-CT and SPECT-CT. It is estimated that the numbers of diagnostic tests using radioisotopes will likely rise by 300% within the next 5-6 years in Poland.
3. Additional equipment/instrumentation will thus be required to meet this need for instance consisting of 100 SPECT-CT gamma cameras. Currently 40% of new equipment purchases comprise of those already

Table 6. Fundamental isotopes used in nuclear medicine departments with maximum activities declared in licenses for using radioactive sources as issued by the National Atomic Energy Agency (estimated average data)

No.	Source type	Isotope	Maximum radioactivity (up to)	Generator isotopes	Used for
1	Open	Ga^{67}	100 GBq	-	Diagnostics
2	Open	Sr^{89}	100 GBq	-	Therapy
3	Open	Tc^{99m}	1 TBq	Generator Mo^{99}-Tc^{99m}	Diagnostics
4	Open	In^{111}	100 GBq	-	Diagnostics
5	Open	I^{123}	100 GBq	-	Diagnostics
6	Open	I^{131}	10 GBq	-	Therapy
7	Open	Sm^{153}	100 GBq	-	Therapy (imaging possible)
8	Open	Y^{90}	100 GBq	-	Therapy
9	Open	Ra^{223}	1 GBq	-	Therapy
10	Open	Lu^{177}	100 GBq	-	Therapy (imaging possible)
11	Open	Re^{188}	10 GBq	Generator W^{188}-Re^{188}	Diagnostics
12	Open	Ga^{68}	1 TBq	Generator Ge^{68}-Ga^{68}	Diagnostics
13	Open	F^{18}	1TBq	-	Diagnostics

Table 7. Fundamental isotopes used for instrument calibration in nuclear medicine departments.

No.	Source type	Isotope	Radioactivity	Remarks
1	Sealed	Co^{57}	370 MBq or 555 MBq	Plane source
2	Sealed	Co^{57}	3,7 MBq	Point source (marker)
3	Sealed	Cs^{137}	3,7 MBq	For meter radioactivity
4	Sealed	Na^{22}	3,7 MBq	For PET/CT scanners
5	Sealed	Na^{22}	2,2 MBq	
6	Sealed	Gd^{153}	22,2 MBq	For SPECT/CT scanners
7	Sealed	Ge^{68}	55 MBq	For PET/CT scanners
8	Free	F^{18}	Uo to 740 MBq	
9	Free	Tc^{99m}	Up to 740 MBq	For gamma cameras

used whereas the 60% are actually new equipment which enlarges the available pool.

4. The data so gathered or obtained, indicate that there must be a change in how diagnostic imaging is structured and conceived in Poland.

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Conflict of interest

The authors declare no conflict of interest.

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