Schweizerische Gesellschaft für Strahlenbiologie und Medizinische Physik
Société Suisse de Radiobiologie et de Physique Médicale
Società Svizzera di Radiobiologia e di Fisica Medica

Schweizerischer Berufsverband für Medizinphysikerinnen und Medizinphysiker
Association professionnelle suisse des physiciens médicaux
Associazione professionale svizzera dei fisici medici

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Medical physicist staffing for nuclear medicine and dose-intensive X-ray procedures

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Contents

1. Introduction 5
2. Role of medical physicists in medicine 6
   2.1 Situation in the United States 7
   2.2 Situation in Europe 7
   2.3 Goal of the present report 8
3. Clinical implementation 8
   3.1 Staffing strategy 8
      3.1.1 “Large” centres 9
      3.1.2 “Small” centres 9
   3.2 Staffing requirement 10
   3.3 Responsibilities of diagnostic medical physicists 10
4. Conclusion 12
5. References 13
6. Members of the working group 14

1. Introduction

The objective of this report is to propose a strategy to comply with Art. 74 introduced in the Swiss Ordinance on radiation protection revised on 1 January 2008 [1]. In Art. 74 it is mentioned that a medical physicist (whose training is recognized by the SSRMP) should be contacted on a regular basis to ensure the radiation protection of nuclear medicine and dose intensive X-ray procedures.

The main task of this working group was to propose a strategy to precise the term “regular basis”. The strategy proposed has been elaborated by members of the SSRMP in close collaboration with members of the Federal Office for Public Health (FOPH). It is important to notice that the activity of the medical physicists required to comply with Art. 74 excludes research activities.

Chapter 2 presents the problem and justifies the need of involving medical physicists where nuclear medicine and dose intensive X-ray procedures are performed. According to Art. 74 alinea 7, dose intensive procedures are radiological examinations that include CT and interventional procedures.

Chapter 3 proposes a way to involve medical physicists taking into account the potential risks associated with the procedures.

2. Role of medical physicists in medicine

The role of medical physicists in radiotherapy is well established and it is clear that they are responsible for all the technical aspects concerning the production and use of ionising radiation to ensure patient and personnel safety. It includes in particular the acceptance and commissioning of the units before their first application on patients. This requires expertise in the field of radiation protection and in the field of physics. Physicians are responsible of the application of ionising radiation to humans and rely on physicists' expertise to make sure that cancer patients receive the prescribed dose of radiation at the correct location. Technologists ensure that the prescribed dose is delivered in the right way by proper positioning and communication with the patients. They also should verify the adequacy of the protocol used and are fully part of the quality assurance chain. They work under the supervision of physicians and medical physicists.

At the moment in Switzerland, the use of ionising radiation in diagnostic radiology and nuclear medicine is performed under the supervision of the physicians who are not only responsible for the clinical tasks but also for all the technical aspects related to the production and optimisation of the use of ionising radiations; tasks that are highly related to physics. If physicians can rely on technologists to manage a part of the technical aspects of radiation protection in nuclear medicine, radiography and CT, the use of fluoroscopy units is in general under the supervision of the physicians alone. This situation is particularly critical since fluoroscopy procedures have a non negligible probability of delivering doses well above the threshold of the deterministic effects exist. Moreover, personnel around the units can receive relatively high doses. In addition the acceptance of the radiological or nuclear medicine units is only under the responsibility of the manufacturer which represents a clear situation with conflict of interest.

If this way of doing could be more or less satisfactory in the past, the technical progresses made during the last two decades imply that some changes have to be introduced now to ensure patient and personnel safety. The units are getting more and more complex and can deliver relatively high doses. At the same time the information to be mastered to establish a diagnosis is continuously increasing. In such a context physicians cannot reasonably take the responsibility for both the clinical and technical aspects of radiation protection. As in radiation therapy a specialized scientist (medical physicist) should takes responsibility for the technical aspects of radiation protection. Even if the individual patient doses associated with diagnostic radiology are far lower than those associated with radiation therapy, two major risks have to be managed in radiology: on the individual basis, a risk of delivering skin doses over the deterministic effect threshold and on a population basis, a risk of increasing the collective dose that might impair the risk benefit balance of radiology in the coming years. In addition there remain major efforts to be made to ensure that the doses received by the staff during fluoroscopy procedures are kept as low as reasonably possible.

Nuclear medicine has also made tremendous progresses and is producing more and more quantitative data that often are used to decide the outcome of patients. These quantitative aspects are highly dependent on the tuning of the imaging unit and its physical properties; aspects that cannot be handled by technologists who have another mission in a nuclear medicine department and who lack expertise in the field of medical physics. Other developments of nuclear medicine concern the use of isotopes that requires special care to assure the safety of patient and personnel. As for diagnostic radiology a medical physicist should take responsibility for the technical parts of the radiation protection aspects of nuclear medicine and help the technologist to provide the best balance between patient and personnel dose esposure and diagnostics information or therapeutic outcomes.

At an international level this increase in sophistication, complexity and high cost of medical imaging equipments has created a growing demand for professionals who can ensure that the investment in these technologies is fully realized. As a consequence in many countries a speciality of medical physics has been developed to train medical physicists specialized in diagnostic radiology or nuclear medicine in order to help to establish a cost-effective and consistent high standard of diagnostic image quality, radiation safety, and patient care.

2.1 Situation in the United States

Already in 1991 the American Association of Physicists in Medicine (AAPM) in its Report 33 stated that departments where diagnostic radiology procedures (including nuclear medicine procedures) were performed required highly educated professionals to provide satisfactory patient care. Individuals who provide such support were referred as “diagnostic radiology physicists” [2]. Among others they should provide professional services for selecting, evaluating, monitoring and ensuring a right balance between the diagnostic information and the associated risk. According to Report 33, devoted to this particular issue, these medical physicists should be directly involved in patient care, radiation safety, teaching, and administrative functions. It is of note that certification of these medical physicists by a specific board was also mentioned [2].

In its present description of the role of medical physicists involved in diagnostic radiology the AAPM states that these professionals should contribute to the effectiveness of radiological imaging procedures, by assuring radiation safety and helping to develop improved imaging modalities (e.g., mammography, CT, MRI, ultrasound imaging). They should also contribute to the development of therapeutic techniques (e.g., prostate implants, stereotactic radiosurgery) and collaborate with radiation oncologists to design treatment plans, and monitor equipment and procedures. It is quite interesting to notice that in the United States, diagnostic medical physicists not only deal with techniques using ionising radiation but also with imaging modalities such as MRI or ultrasound imaging. The present percentages of medical physicists involved in radiation therapy, imaging physics and nuclear medicine are about 75%, 18%, and 3%, respectively [3-4]. According to the most recent AAPM membership directory there are about 15 medical physicists per million inhabitants in the United States.

2.2 Situation in Europe

In Europe, Art. 6 of the Directive 97/43/Euratom concerning “Health protection of individuals against the dangers of ionising radiation in relation to medical exposure …” [5] states that diagnostic procedure should be made with the expertise of a medical physicist to assure an optimal level of safety. This recommendation has been integrated in the Swiss legislation under Art. 74 of the Ordinance on radiation protection. The integration of Art. 6 from EURATOM in the Swiss legislation was strongly supported by the Federal Commission of Radiation Protection (“Eidg. Kommission für Strahlenschutz und Überwachung der Radioaktivität KSR”) in its statement from April 2006. In this document it appears that in Europe the situation concerning the official involvement of medical physicists in diagnostic radiology/nuclear medicine strongly varies (for example from 1.1/0.9 (Yugoslavia) to 7.9/9.3 (Sweden) per million inhabitants in 1998 [6]). According to the Union of Swedish Medical Physicists there are today in Sweden 2 medical physicists per million inhabitants working with MRI, 2.5 medical physicists per million inhabitants working in the field of diagnostic radiology and 5 medical physicists per million inhabitants working in nuclear medicine department [7]. On average in Switzerland it appears that there is slightly more than one medical physicist per million inhabitants involved in diagnostic radiology involving ionizing radiations and nuclear medicine (respectively 0.7/0.6 medical physicists per million inhabitants at the most). Moreover, the duties of these medical physicists are at the moment not clearly defined. They are often considered more as “helper” than real partners that insure radiation safety.

2.3 Goal of the present report

The goal of this report is to propose a strategy to comply with Art. 74 of the Swiss Ordinance on radiation protection to improve the radiation protection of patients and staff in medicine keeping in mind that this article was introduced to comply with the EURATOM requirement. This report will also propose responsibilities that should be devoted to diagnostic medical physicists.

3. Clinical implementation

3.1 Staffing strategy

The working group has studied several approaches to propose an optimal strategy that puts the priority on situations where radiation risks are the highest. The first approach taken attributed a fraction of medical physicist per radiological or nuclear medicine unit within a hospital, clinic or private practice. While this approach would comply with the European Federation of Organisations in Medical Physics (EFOMP) [8] or the AAPM recommendations it would introduce much complexity and require to regularly reassessing the medical physicist requirement when one radiological unit is added or removed in a centre. As an alternative approach it was proposed to separate the centres where medical imaging was performed in three categories according to the FMH classification. That approach was also not satisfying since among a given FMH category it exists a large variation of practices where radiological risks span a wide range of radiological risks. To be pragmatic and ensure an efficient radiation protection strategy the working group proposes to work at two levels. A major effort should be made in centres where complex procedures and sophisticated pieces of equipment are used. These centres will be considered as “large centres” and cover the "Category 1" or "Category 2" centres of the FMH classification. It is in these centres that every effort should be made to enable a staffing level compatible with the international practice. Thus a number of permanent properly training medical physicists should be involved in these centres on a contractual basis.

In smaller centres, the need of expertise in medical physics is certainly important but not on a continuous basis since most of the procedures used are standardized. For these “small” centres the working group proposes to develop a strategy allowing a regular training of the staff together with auditing measures to ensure a good level of radiation protection. This work will also require a collaboration with medical physicists but from the potential risk associated with the use of ionizing radiations in “small” centres, the involvement of medical physicists could be delayed to give full priority to “large” centres.

At the moment, the number of certified medical physicists working in the field of radiotherapy is just sufficient to comply with the legal requirements (minimum one medical physicist per linear accelerator). Thus, a simple extension of certified medical physicists working in the field of radiotherapy into the field of medical imaging or nuclear medicine cannot be introduced without serious concerns about the quality and safety of the radiation therapy treatments.

3.1.1 *"Large" centres*

Large centres are defined in this report as centres where a large number of nuclear medicine and complex dose intensive X-ray procedures are performed.

In order to verify if a hospital, a clinic or a private practice belongs to the "large" centre category the working group proposes to estimate the fraction of medical physicist full time employee (FTE) using Table 1 that was elaborated using data available in ref. [2, 7]. This table gives the fraction of FTE per unit available in a hospital, clinic or private practice. It is proposed to consider that a full time medical physicist is required when the resulting FTE is equal or higher than 0.8 (a result of 1.8 would require the presence of two medical physicists, and so on). Her/his responsibilities will cover all technical aspects of radiation protection, excluding research duties, associated with the use of all CT, fluoroscopy mammography units, gamma camera and SPECT/CT, PET/CT units of the centre. It is of note that the activity of the medical physicist could be split if necessary, between tasks devoted to dose intensive and nuclear medicine examinations.

Table 1. Certified medical physicist requirements

Unit	Medical Physicists fraction of FTE per unit
CT	0.03
Fluoroscopy (I)	0.005
Fluoroscopy (II)	0.03
Mammography	0.01
CR/DR radiography	0.005
Gamma camera unit	0.01
SPECT/CT, PET/CT	0.25
Duty	Medical Physicists fraction of FTE
Involvement in metabolic radiation therapy	0.05
Radiation protection training	0.1

Fluoroscopy (I): no angiography or interventional procedures
Fluoroscopy (II): angiography or interventional procedures (not only in radiology departments)

At the moment there is a drastic lack of medical physicists to comply with the legal requirement introduced by Art. 74. As a transitory measure the working group proposes to accept medical physicists to be involved under the conditions that they are preparing for SSRMP certification. During their training period they should work under the responsibility of a certified medical physicist.

3.1.2 *"Small" centres*

For all other centres the requirements concerning radiation protection could be satisfied by ensuring on the one hand, a continuous education of the staff and in the other hand, periodic auditing/advising visits. In such a case the working group proposes to stratify Switzerland in seven geographical regions:

Lake Geneva region;

Midland space;

Northwest Switzerland;

Zurich;

Eastern Switzerland;

Central Switzerland;

Ticino.

As a first step the working group proposes that for each region at least one senior medical physicist (for example an SSRMP accredited medical physicist with at least five years of experience) will be involved with the use of X-ray units and one senior medical physicist will be involved in centres that perform nuclear medicine examinations.

The advantage of such an approach is that the certified medical physicists involved in all other centres than large ones (according to the definition proposed) could be working in a large hospital and thus exchange experience with his/her colleagues to constitute a centre of expertise where a collaboration with physicians and technologists would offer a radiation protection that is tailored to the needs. The other advantage is that this medical physicist could be administratively attached to a large centre that would have contracts with smaller centres. A contract could be established with each “small” centre to finance the work of the medical physicist administratively being part of a “large” centre.

The main inconvenience of such an approach is that these senior medical physicists would visit the centres without being highly involved in the everyday practice. However, as mentioned previously, in these centres most of the procedures are routine and the main needs are training of the local radiation protection experts, commissioning of new units and performing audits to ensure the best balance between dose and image quality.

3.2 Staffing requirement

According to the international staffing level it appears that a number of 10 to 15 medical physicists per million inhabitants is the standard in western countries. If about 20 % [3] of these medical physicists are involved in diagnostic radiology (X-ray medical imaging and nuclear medicine) we should have in Switzerland between 15 to 23 diagnostic medical physicists. The highest priority concerns the large centres where at least 8 to 12 medical physicists specifically trained in the physics of diagnostic radiology are required and where about 6 to 9 medical physicists specifically trained in the physics of nuclear medicine are required. As a second priority one medical physicist per geographical region should be involved in diagnostic medical physics.

3.3 Responsibilities of diagnostic medical physicists

According to IAEA [9] the duties and responsibilities of diagnostic medical physicists in large centres should be the following:

Radiation safety

- The radiation safety officer should be a trained medical physicist.

Specification, acceptance testing and quality control of the instrumentation

- The medical physicist should be directly involved in equipment procurement and should take responsibility for acceptance testing and establishment of routine quality control; technologists should perform routine quality control under the supervision of a medical physicist.

Development and validation of clinical studies

- The medical physicist should work closely with the medical staff to provide technical advice relevant to the execution of the studies.

Teaching

- The medical physicist should be involved in teaching other professionals particularly in the fields of radiation safety and instrument principles.

More specifically:

Diagnostic radiology/cardiology/gastroenterology/urology

- Support the local expert in radiation protection concerning general topics in radiation safety (Shielding, operational, optimization....);
- Organisation of the continuous education of the staff;
- Commissioning of new units;
- Quality control supervision;
- Inspection of the technical adjustments and calculations of the manufacturers;
- Verify the compliance of standard acquisition protocols with DRLs (Dose Reference Levels);
- Mentoring of technologists and physicians to insure the safe use of the unit;
- Performing scatter measurements and look for solutions to allow the lowest exposure to personnel
- Collect patient dose data on a regular basis to allow an adaptation of the DRLs;
- Patient dose estimation;
- Check the outcomes of stability tests made on the unit;
- Discussion of the results with on-site experts.

Nuclear medicine

- Support the local expert in radiation protection concerning general topics in radiation safety (Shielding, operational, optimization....);
- Organisation of the continuous education of the staff;
- Commissioning of new units;
- Quality control supervision;
- Inspection of the technical adjustments and calculations of the manufacturers;
- Ensuring the quantitative aspects of the measurements;
- Verify the compliance of standard acquisition protocols with DRLs;
- Mentoring of technologists and physicians to insure the safe use of the unit;
- Performing scatter measurements and look for solutions to allow the lowest exposure to personnel;
- Collect patient dose data on a regular basis to allow an adaptation of the DRLs;

- Patient dose estimation;
- Check for image fusion (multi-modality)
- Check the outcomes of stability tests made on the unit;
- Discussion of the results with on-site experts;
- Radiation protection when dealing with metabolic therapy.

The duties and responsibilities of diagnostic medical physicists in small centres could focus on training and auditing tasks.

4. Conclusion

This report summarizes the international practices concerning the management of the technical aspects of radiation protection in medicine outside the radiotherapy departments. The options proposed here for Switzerland concentrate on the situations where major improvements are required to ensure the radiological safety of the patients. Until training of newly certified medical physicists, including the aspects of diagnostic radiology and nuclear medicine in sufficient depth, is established in a comprehensive schedule, it is suggested to give additional training to already certified medical physicists. This could be organised e.g. in the format of a two week summer school.

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6. Members of the working group

Sébastien Baechler	CHUV-IRA, Lausanne
Michela Chianello	Clinique La Source, Lausanne
Frédéric Corminboeuf	Inselspital Bern
Roberto Mini	Inselspital Bern
Regina Mueller	PSI, Villigen
Samuel Peters	Kantonsspital St. Gallen
Nicolas Stritt	FOPH, Bern
Stefano Presilla	Kantonsspital Luzern
Hans Roser	Universitätsspital Basel
Jakob Roth	Arisdorf
Wolf Seelentag	Kantonsspital St. Gallen
Philipp Trueb	FOPH, Bern
Francis R. Verdun (chair)	CHUV-IRA, Lausanne