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Review paper

The International Atomic Energy Agency action plan on radiation protection of patients and staff in interventional procedures: Achieving change in practice

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ABSTRACT

Introduction: The International Atomic Energy Agency (IAEA) organized the 3rd international conference on radiation protection (RP) of patients in December 2017. This paper presents the conclusions on the interventional procedures (IP) session.
Material and methods: The IAEA conference was conducted as a series of plenary sessions followed by various thematic sessions. “Radiation protection of patients and staff in interventional procedures” session keynote speakers presented information on: 1) Risk management of skin injuries, 2) Occupational radiation risks and 3) RP for paediatric patients. Then, a summary of the session-related papers was presented by a rapporteur, followed by an open question-and-answer discussion.
Results: Sixty-seven percent (67%) of papers came from Europe. Forty-four percent (44%) were patient studies, 44% were occupational and 12% were combined studies. Occupational studies were mostly on eye lens dosimetry. The rest were on scattered radiation measurements and dose tracking. The majority of patient studies related to patient exposure with only one study on paediatric patients. Automatic patient dose reporting is considered as a first step for dose optimization. Despite efforts, paediatric IP radiation dose data are still scarce. The keynote speakers outlined recent achievements but also challenges in the field. Forecasting technology, task-specific targeted education from educators familiar with the clinical situation, more accurate estimation of lens doses and improved identification of high-risk professional groups are some of the areas they focused on.
Conclusions: Manufacturers play an important role in making patients safer. Low dose technologies are still expensive and manufacturers should make these affordable in less resourced countries. Automatic patient dose reporting and real-time skin dose map are important for dose optimization. Clinical audit and better QA processes together with more studies on the impact of lens opacities in clinical practice and on paediatric patients are needed.

1. Introduction

Physicians in many medical specialties perform minimally invasive interventional procedures (IP) using fluoroscopic guidance. For patients, these procedures usually pose less risk, typically cause less pain and provide a shorter recovery time compared with open surgery [1–4]. Efforts to monitor and optimize radiation protection in IP both for patient and staff have been conducted for many years [5–15]. The continuous evolution of fluoroscopy systems is rapidly transforming the landscape leading to higher utilization, potential for better

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management of radiation dose or even reductions in dose and a greater likelihood of a successful clinical outcome [16–18]. High performance digital X-ray detectors, coupled with sophisticated, dedicated software and advances in computing and low dose technology have boosted patient throughput, facilitated the growth of interventional applications and patient dose optimization [19]. The use of fluoroscopy, however, still poses a certain risk for both patients and staff [20,21]. Patient characteristics (e.g. size, clinical condition, co-morbidities) and operator skills are key determinants of radiation use [22]. Technical evolution of fluoroscopic equipment, other medical devices and international standards for the safety and effective performance of these devices play important additional roles in making patients safer [23,24].

The International Atomic Energy Agency (IAEA) organized an international conference on radiation protection (RP) of patients in March 2001 in Malaga, Spain. This conference resulted in an international action plan on the radiation protection of patients. The IAEA held a second conference on RP in medicine, in Bonn, Germany in 2012. The result of the Bonn conference was the "Bonn Call for Action" [25]. Since then, a substantial number of national, regional and international actions have been initiated, either by professional or by scientific societies or organizations related to radiation protection campaigns. At the same time, the medical industry introduced a number of technological developments with the potential to reduce radiation doses to patients, staff and the public. These initiatives, together with the increased interest of many professional groups in RP, indicated a need for a third conference, where improvements in RP since the Bonn conference could be highlighted, discussed, and placed in perspective. A 3rd conference on RP in medicine was held at IAEA headquarters in Vienna in December 2017 [26]. The conference was organized by the IAEA and cosponsored by the World Health Organization (WHO) and the Pan American Health Organization (PAHO). The objectives of the conference were to gather all international, regional, national or local work done on this topic, to investigate change in practice and provide a toolkit that consolidates information available from cooperating organizations as the way forward.

This paper presents information and conclusions from the conference session that focused on patient and staff exposure in IP. The objectives of the session were to: 1) show possible advances, challenges and opportunities, 2) assess the impact of the international action plan, 3) identify tools for improving RP in IP and 4) develop new international recommendations, if deemed appropriate, in interventional fluoroscopy.

2. Materials and methods

The conference was conducted as a series of plenary sessions followed by various thematic sessions. Session number 6 focused on "Radiation protection of patients and staff in interventional procedures". Keynote speakers presented information on: 1) Risk management of skin injuries, 2) Occupational radiation risks and 3) RP for paediatric patients.

The topic of each session was introduced by a chairperson, followed by three keynote speakers, a summary of the session-related accepted papers presented by a rapporteur, and an open question-and-answer discussion session lead by a chairperson. Authors were given the opportunity to present their work in the form of posters at the conference exhibition area.

3. Results and discussion

3.1. Submitted papers

Eighteen papers were accepted in the "RP of patients and staff in IP" session as shown in Table 1. Table 1 provides data on the number of submitted papers in interventional field related to each of the ten Bonn Actions. The accepted papers originated from twelve countries and one multi-national research study. Sixty-seven percent (67%) of papers came from Europe. Forty-four percent (44%) were patient studies, 44% were occupational studies and 12% were combined patient and staff studies. Fifty percent (50%) were dedicated to interventional cardiology (IC), 39% to interventional radiology (IR) and the remaining 13% to combined subfields. Occupational studies were mostly on eye lens dosimetry (60%). The remaining studies were on scattered radiation measurements (20%, European studies) and combined patient and staff exposure tracking (20%, European studies). Eye lens research work was largely from Europe (5 papers, 83%); there was only one study from Asia (17%) and none from Africa, the Middle East, Australia, or the Americas. The majority of patient studies related to patient exposure (75%, 2 African, 1 Asian and 3 European papers). One paper reported a skin injury (12.5%, Asian study) and one paper focused on paediatric doses (12.5%, Latin American paper). Paediatric research work accounted only for 5.5% of all studies in the interventional procedures section.

Selected observations from the occupational studies, as available at [27] are:

1) A pilot individual monitoring assessment is one of the best approaches to identify workers in IP, who require eye lens monitoring, and to decide on the best dosimetry system.
2) Online occupational dosimetry systems can have a positive effect on the behavior of IP personnel.
3) There is need for guidance on occupational IP dosimetry with emphasis on pulsed fields and eye lens dosimetry.
4) Eye doses in endoscopic retrograde cholangiopancreatography (ERCP), an IP performed usually by gastroenterologists, can be significant for over couch X-ray machines.
5) Use of a conversion factor to derive eye lens dose from patient radiation dose measured in terms of kerma-area product (P_{KA}) is not recommended if limitations are not established.
6) Eye lens dosimeters should be calibrated to take into account the spectrum energy range of 20–35 keV.

Selected observations from the patient studies were [27]:

1) Patient dose recording (mainly automatic patient dose reporting) could be considered as a first step for dose optimization in IC and IR (this is reported in five patient studies).
2) There is a need to establish and reinforce national diagnostic reference levels (DRLs) in IP, especially in paediatric procedures.
3) Public awareness and safety culture in IP must be improved.
4) Paediatric radiation dose studies are scarce and must be increased.

3.2. Invited presentations

3.2.1. Risk management of skin injuries in interventional procedures

The clinical benefits of IP are generally much higher than the radiation risk for patients [4]. Radiation risk should be explicitly included in overall pre-procedure justification for: Extremely large patients, certain complex pathologies, or repeated procedures in the same patient [4,22,28]. The frequency of major radiation injuries is estimated to be between 1:10000 and 1:100000 procedures (based on 10 injuries reported every year in the United States from nearly 10 million interventions, using a rounded figure), but the true risk is not known, mainly because these injuries are not reported around the world [22]. Several factors can contribute to tissue reactions such as skin effects or skin injuries [29]. These include a complex clinical problem, the type of procedure, operator experience, X-ray equipment that is not optimal for the procedure, long fluoroscopy times, large number of images, or operating with non-optimized technical parameters (beam rotation, position of X-ray tube and image detector, magnification, fluoroscopy mode, use of filter, etc) [30–34]. Medical physics evaluation of