Corresponding author:

email: virginia@otenet.gr

Medical Physics: Forming and testing solutions to clinical problems

Virginia Tsapaki [1], Richard Bayford [2]

Abstract

The enormous evolution in medical technology and the vast growth in the use of highly sophisticated equipment and techniques in the medical field proliferate the demands for patient safety and quality. Medical Physicists are the best suited medical scientists which can contribute towards optimal patient safety and paramount clinical treatment. The latest developments related to this increasingly significant medical specialty were presented during the 8th European Conference of Medical Physics 2014 which was held in Athens, 11-13 September 2014 and hosted by the Hellenic Association of Medical Physicists (HAMP) in collaboration with the EFOMP and are summarized in this issue.

Keywords: Medical physicist, radiology, nuclear medicine, radiotherapy

Introduction

The development of medical technology has achieved a remarkable boost in the last few decades for both patient therapy and medical diagnosis [1]. There is also a considerable array of sophisticated medical equipment produced as a result of competition between vendors. This has resulted in patient data becoming more accessible than 10 or 20 years ago; technological evolution resulted in moving from soft copy to CD-ROM and recently i-cloud technology that it is often questionable how diagnosis and treatment worked 5 or 10 years ago. New tracking technologies help to facilitate the process of clinical diagnosis and overall treatment of the patient, providing real-time information on clinical examinations and other notifications that are crucial to their treatment [2].

All this has resulted in a manifest increase in the number of procedures and the creation of new medical specialties [3]. Within this context, it is very important to use medical radiation technology with prodigious care. As defined by the European Federation of Organizations for Medical Physics (EFOMP), Medical Physics is the application of physics to healthcare; using physics for patient imaging, measurement and treatment [4]. Medical physicists are graduate scientists, normally holding post-graduate qualifications, who work in many different areas of healthcare managing and delivering services and carrying out research and development [4]. The imperative role of the medical physicists in all areas that cover medical technology and is uses for clinical outcome is evident [5-9]. A number of organizations have underlined the role of medical physics profession. The International Atomic Energy Agency (IAEA) has taken a number of initiatives to facilitate this process [10-12].

This issue follows the successful works of the 8th European Conference of Medical Physics 2014 (ECMP 2014) which was held in Athens, 11-13 September 2014 and hosted by the Hellenic Association of Medical Physicists (HAMP) in collaboration with the. A total of 560 participants and 60 invited speakers participated in the conference. The largest number of scientists was from Greece (53 %) and rest of Europe in general (37 %). However, a substantial number of people travelled from USA, South America, Asia, Australia and Middle East. Ninety two percent (92 %) of invited speakers and session chairs came from Europe (largest percentage came from Greece: 46 %), with a small number coming from USA, Middle East and Australia.

The main scope of the conference was to present all recent research and technological advances in radiation oncology, including proton therapy, computer hardware and software, robotics as well as technological advances in astronautics and military technology which are applied in modern radiotherapy, to report on new diagnostic methods and techniques in the fields of Radiology and Nuclear Medicine, such as multi slice CT, PET-CT, PET-MRI and other hybrid systems, as well as modern therapeutic radiopharmaceutical and show the recent guidelines on radiation protection for patients and hospital staff regarding X-rays, electromagnetic fields, radiation from mobile phones, etc. The program included 38 scientific sessions, symposia and poster Sessions in 2.5 days. It was run in two parallel sessions and covered Radiation Therapy, Medical Imaging, Medical Informatics, Radiation Protection, Legislation and Standards, and Education and Training. In addition there was a workshop on Biomedical Instrumentation and Related Engineering and Physical Sciences, a hands-on training course on QA and safety in MRI, and a satellite symposium on safety standards for non-ionizing radiation. Three hundred and twenty abstracts were received from countries ranging USA to Australia and Europe and Middle East to Asia. Accepted abstracts were published on a special issue of European Journal of Medical Physics (Volume 30, Issue S1, September 2014, ISSN 1120-1797). The majority of the invited lectures were uploaded on the conference web site (http://www.efomp-2014.gr/index.php/invited-lectures-are-uploaded-on-ecmp-website).

All major Scientific and Regulatory Organizations contributed to the Conference apart from EFOMP. The Middle East Federation of Organizations of Medical Physics (MEFOMP), which is the regional organization member of the International Organization for Medical Physics (IOMP) for Middle East, the International Atomic

Energy Agency (IAEA), the International Committee of Radiation Protection (ICRP), the American Association of Medical Physicists (AAPM) and last but not least the European Commission (EC). The Conference's works have been supported by the Greek National Tourism Organization, IAEA, the Technological Educational Institution (T.E.I.) of Athens and finally the European Society of Magnetic Resonance in Medicine and Biology (ESMRMB). Furthermore, a total of 18 major vendors in the Medical field and Medical Physics area participated in the technical exhibition. Apart from the exhibition booths, a number the vendors organized satellite symposia during which participants had the opportunity to follow the current technological and commercial trends. There was an electronic poster exhibition. A certain number of abstracts were chosen by the scientific committee to be presented as a presentation using only one slide taking 2 min, the 3rd day of the conference. Finally all authors were invited to prepare peer-reviewed papers for inclusion in this issue of European Journal of Medical Physics. The manuscripts were put through a process of careful review before selection. A total of 20 were accepted covering an important range of topics.

More specifically, the International Council on Radiation Protection committee 3 representatives presented an overview of the work in recent years and current work in progress such as radiation protection work on Ion Beam Therapy, Occupational Protection in Brachytherapy, Justification in Imaging, Beam Therapy, Occupational Protection in Brachytherapy, Justification in Imaging, RP in Cone Beam CT, Doses to Patients and Staff from Radiopharmaceuticals (update), Occupational Protection in Interventional Radiology, and Diagnostic Reference Levels for Diagnostic and Interventional Imaging. The Committee is also involved in preparation of a document on effective dose (and its use medicine) [13].

The IAEA's comprehensive clinical audits by the Quality Assurance Team for Radiation Oncology (QUATRO) were presented in a special conference session. QUATRO assesses overall practices in radiotherapy centres including the infrastructure, patient and equipment procedures, quality assurance programmes, radiation protection, staffing levels and professional training of the local radiotherapy staff. It has conducted over 70 audits on request, in radiotherapy centres of Central and Eastern Europe, Asia, Africa, and Latin America contributing to the improvement at the audited centres [14].

The European Commission representative underlined the fact that experts with highly qualified nuclear and radiation safety culture competences will be needed over a long time period to deal with radiation protection issues in modern diagnosis and treatment [15]. In this context, the main stakeholders of Euratom programmes have developed a common approach regarding needs, vision and implementation instruments. Furthermore lifelong learning and cross-border mobility will be one of the main objectives of the Education, Youth and Culture policy of the European Union.

AAPM European affairs representative reported on the intentions of the Association to increase international activity due to the globalisation of the medical physics profession [16]. Close collaboration of EFOMP with AAPM is one of the first objectives and first steps to this direction include: 1) free flow of information between EFOMP and AAPM,2) links between organizations websites, 3) organization of joint sessions at each other's society meetings and 4) interaction between EFOMP and AAPM Working Groups.

Furthermore, the progress of various national, European and International research programs was presented during the conference such as the microbeam radiation therapy (MRT) project [17], the Geant4-DNA project [18], the METROMRT project [19], the CONCERT project [20], the MPE project [21], the EUTEMPE-RX project [22] and finally the Paediatric Diagnostic Reference Levels project [23].

Below, a summary of the selected papers selected for publication are presented.

Non ionizing radiation

The importance of non ionizing radiation is highlighted in the recent European Electromagnetic Fields (EMF) occupational exposure Directive [24] which includes minimum health and safety requirements regarding the exposure of workers to the possible risks from EMF and provides exposure limit values for the current density induced in the body by EMF and action values for the strength of EMF outside the body. Magnetic Resonance Imaging (MRI) systems are associated with the exposure of personnel to EMF putting forward questions on occupational safety issues. Despite the fact that MRI systems are today excluded from the application of the exposure limits values Gourzoulidis et al, 2015 decided to investigate these systems in terms of [25]. The preliminary results of the study showed that Action Levels (ALs) set by the new EMF Directive were not exceeded. This will require investigation in the near future as to whether these exposures pose a risk to occupational workers. Another study on EMF was presented, Kottou S et al [26]. Their study investigated the fluctuation of Greek indoor EMF intensity values and identifies peaks that might occur concluding that the observed indoor EMF intensity values remained well below domestic and European established limits.

The scientific interest in non-ionizing radiation techniques did not include only occupational exposure but optimization of imaging. One of these studies which is also published in this issue is that of Tsiapa et al [27]. The study quantitatively and qualitatively compared various sequences in High-Resolution Magnetic Resonance Imaging (HR-MRI) of the eye utilizing a 1.5T whole body imaging system (the eye is the ideal tissue for HR-MRI because of its wide variation in water content particularly and specially due to the need for high spatial resolution in extremely small field of view).

Radiotherapy

External beam radiation therapy has evolved immensely in the recent years which resulted in a rather focused radiation dose to the tumour without irradiation of healthy organs or tissues. Intensity-Modulated Radiation Therapy (IMRT), Volumetric Modulated Arc Therapy (VMAT), Tomotherapy, Image-Guided Radiation Therapy (IGRT) and other modern techniques allow operators to achieve this tissue sparing. Sdrolia A, et al 2015 [28] focused on VMAT and critically evaluated the effectiveness of patient specific quality assurance tolerances for prostate VAMT plans, in an effort to ensure that it is sensitive enough to catch outliers and specific enough to correctly identify deliverable plans were identified. Spirou S et al 2015 [29] investigated whether the dose-scoring process of Monte Carlo (MC) simulations of Gold nanoparticles in radiation therapy affects the results. They concluded that, for a given volume, the dose curves are not affected by the size of the dose-scoring voxels. However, the voxel size may hide or reveal the finer structure of the dose curves and/or may result in misleading curves.

Occupational

The study of Zagorska et al [30] compared radiation doses to eye lens of medical staff during Endoscopic retrograde cholangiopancreatography (ERCP) procedures with the new annual limit of 20 mSv per year and concluded that if eye protection is not used, annual doses to the eye lens of the gastroenterologist performing the procedure as well as the anesthesiologist can exceed the dose limit.

Diagnostic and Interventional Radiology

Tzamicha E et al [31], investigated dual-energy contrast-enhanced digital mammography and estimated glandular breast dose using a Monte Carlo code and a voxel phantom. The dose contribution analysis of each projection for all voxel phantom thicknesses and breast compositions ,from 1% to 100% glandular, indicated that low dose part mammography was the main contributor to total glandular breast dose. Hernandez-Giron I et al [32], investigated low contrast detectability (LCD) performance of model observers based on Computed Tomography (CT) phantom images. As a result, an automated method to investigate LCD in CT based on two different model observers was developed. The authors concluded that the models can be useful tools to predict human performance in CT low contrast detection tasks in a standard phantom.

Conclusions

The conference and the papers published in the particular issue provided up to date information on the latest research in the field medical physics and related medical applications with a focus on radiotherapy, diagnostic and interventional radiology as well occupational dosimetry. The uninterrupted evolution of medical technology within different medical areas will even more broaden the horizon for Medical Physics. Medical physicists have managed to metamorphose little experimental work to clinical solutions very successfully until today. What comes next one shall have to wait to witness during the next European conference of medical physics.

References

1) United Nations Scientific Committee on the Effects of Atomic Radiation Sources and effects of ionizing radiation: UNSCEAR 2008 report to the General Assembly with scientific annexes, vol. 1. New York, NY: United Nations, 2010.
2) O'Malley AS, Reschovsky JD, Saiontz-Martinez C. Interspecialty communication Phys Med. Challenges in radiation protection of patients for the 21st century. AJR Am J Roentgenol 2013 Apr; 200(4): 762-4.
3) www.efomp.org.
4) Christofides S, Sharp P. The European federation of organisations for medical physics policy statement no. 15: Recommended guidelines on the role of the medical physicist within the hospital governance board. Phys Med 2015; 1 (3): 201–3.
5) Tsapaki V. Education and training of medical physicists in Europe. Phys Med 2014; 30: e7.
6) Noel A. A parallel between the technological evolution and the medical physicist occupation. Phys Med 2012; 28: S15.
7) Webb S. Combatting cancer in the third millennium–The contribution of medical physics. Phys Med 2008; 24 (2); 42–8.
8) Malicki J. Medical physics in radiotherapy: The importance of preserving clinical responsibilities and expanding the profession's role in research, education, and quality control. Rep Pract Oncol Radiother 2015 May-Jun; 20(3): 161-9.
9) Halvorsen PH. The next decade for clinical medical physics. J Appl Clin Med Phys. 2014 Nov 8; 15(6): 5334.
10) Meghzifene A1, Sgouros G. IAEA support to medical physics in nuclear medicine. Semin Nucl Med. 2013 May; 43(3):181-7.

11) Meghzifene A. A call for recognition of the medical physics profession. Lancet 2012 Apr 21; 379(9825): 1464-5.

12) Roles and Responsibilities and Education and Training Requirements for Clinically Qualified Medical Physicists. IAEA Human Health Series 25 2013; ISBN:978-92-0-142010-7.

13) Vano E et al. ICRP Committee 3 overview (protection in medicine). Phys Med 2014; 30: e13.

14) J. Izewska et al. IAEA quality audits in radiotherapy. Phys Med 2014; 30: e13.

15) Van Goethem G. Synergy between nuclear research, innovation and education in Euratom programmes, with emphasis on safety culture. Phys Med 2014; V 30: e12.

16) Lief G. involvement of AAPM in Europe. Phys Med 2014; 30: e12.

17) Brauer-Krisch E. Medical physics challenges within the microbeam radiation therapy (MRT) project. Phys Med 2014; 30: e5.

18) Sebastien Incerti S. the Geant4-DNA project: overview and status. Phys Med 2014; 30: e8.

19) Smyth V et al. Standards for MRT dosimetry: the METROMRT project. Phys Med 2014; 30: e9.

20) Damilakis J. An overview of the CONCERT project. Phys Med 2014; 30: e10.

21) Caruana C. Final results of the European 'guidelines on MPE project. Phys Med 2014; 30: e11.

22) Bosmans H, Bliznakova K, Padovani R, Christofides S, Van Peteghem N, Tsapaki V et al. EUTEMPE-RX: A new EC supported course for medical physics experts in radiology. Phys Med 2014; 30: e11.

23) Damilakis J. The European diagnostic reference levels for paediatric imaging' PROJECT. Phys Med 2014; 30: e12.

24) Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields), Official Journal of the European Union L 179/1.

25) Gourzoulidis G, Karabetsos E, Skamnakis N, Xrtistodoulou A, Kappas C, Theodorou K et al. Occupational electromagnetic fields exposure in magnetic resonance imaging systems. Preliminary results for the RF harmonic content. Phys Med 2015; 31 (DOI: 10.1016/j.ejmp.2015.03.006).

26) Kottou S et al. EJMP-D-14-00334R3. Preliminary background indoor EMF measurements in Greece.

27) Tsiapa I, Tsilimbaris MK, Papadaki E, Bouziotis P, Pallikaris IG, Karantanas AH et al. High Resolution MR eye protocol optimization: comparison between 3D-CISS, 3D-PSIF and 3DVIBE sequences. Phys Med 2015; 31 (DOI: 10.1016/j.ejmp.2015.03.0090.

28) Sdrolia A, Brownsword KM, Marsden JE, Alty KT, Moore CS, Beavis AW. Retrospective Review of Locally Set Tolerances for VMAT Prostate Patient Specific QA using the COMPASS® System. Phys Med 2015; 31 (DOI: 10.1016/j.ejmp.2015.03.017).

29) Spirou S. EJMP-D-15-00007R2. Does the setup of Monte Carlo simulations influence the calculated properties and effect of Gold Nanoparticles in Radiation Therapy?

30) Zagorska A, Romanova K, Hristova-Popova J, Vassileva J, Katzarov K. Eye lens exposure to medical staff during Endoscopic Retrograde Cholangiopancreatography. Phys Med 2015; 31 (DOI: 10.1016/j.ejmp.2015.03.011).

31) Tzamicha E, Yakoumakis E, Tsalafoutas IA, Dimitriadis A, Georgiou E, Tsapaki V et al. Dual-energy contrast-enhanced digital mammography: glandular dose estimation using monte carlo code and voxel phantom. Phys Med 2015; 31 (DOI: 10.1016/j.ejmp.2015.03.013).

32) Hernandez-Giron I, Calzado A, Geleijns J, Joemai R.M.S., Veldkamp W.J.H. Model observers low contrast detectability performance at different kV levels in CT phantom images. Phys Med 2015; 31 (DOI: 10.1016/j.ejmp.2015.04.012).