Acta Oncologica, 2009; 48: 165–168

informa
healthcare

EDITORIAL

Medical physics in the Nordic countries: The past, the present and the future

LUDVIG PAUL MUREN[1,2,3], JØRGEN B. PETERSEN[1], JOLANTA HANSEN[1] & RUNE HAFSLUND[3]

[1]*Department of Medical Physics, Aarhus University Hospital, Aarhus, Denmark,* [2]*Department of Oncology, Aarhus University Hospital, Aarhus, Denmark and* [3]*Department of Oncology and Medical Physics, Haukeland University Hospital, Bergen, Norway*

Medical physics as a separate profession developed from both theoretical and experimental physics. In the current understanding of the scope of the medical physics domain, the field is usually considered to be born with Röntgen's discovery of x-rays in 1895. However, physical laws and relationships are also underpinning other biomedical applications and techniques that have a longer history, such as hyperthermia. The majority of medical physicists today still work in the fields of radiotherapy, medical imaging and nuclear medicine, in which use of high-energy ionising radiation is the common component. Röntgen's x-rays, Marie and Pierre Curie's gamma rays and the other radiation modalities that have followed represent the essence of the medical physics profession's existence.

As mentioned by Steve Webb in his combined historic and futuristic outlook paper published in this issue, most of the early achievements within the field of medical physics were performed by physicists and engineers that did not consider themselves as being *medical* physicists [1]. This was also the case for the Nordic scientists who earned a place in the medical physics history books for their scientific achievements in the early part of last century. Gustaf Ising, Rolf Sievert and Lars Leksell from Sweden as well as Rolf Widerøe from Norway are among those mentioned in Webb's overview in this issue. Readers are referred to Webb's paper for further details of the achievement of these early Nordic scientists from which our profession has developed.

The first Nordic medical physics meeting was held in 1962 (in Örebro, Sweden) while the Nordic Association of Clinical Physics (NACP) was formally founded in 1965, only a few years later than e.g. the American Association of Physicists in Medicine (AAPM) that has celebrated its 50th anniversary
in 2008. This reflects the strong dedication and professionalism of the scientists involved in these early days of Nordic medical physics. Already in 1965–1966, NACP had formed eight different working groups, within the topics dosimetry, radiation protection, treatment planning data, education, betatron dosimetry, simulation techniques, isotope techniques and electronic data management/treatment planning. At this time, NACP had 81 regular members (41 from Sweden, 21 from Denmark, 11 from Finland and 8 from Norway) in addition to its first honorary member, Rolf Sievert. The NACP meeting in 1966 (in Hangö, Finland) attracted more than 100 participants, the majority from outside of the Nordic countries; proceedings from this meeting were also published. It is also interesting to note that NACP was formed before several of the Nordic national societies that it now acts as an umbrella organisation for, i.e., the Norwegian Society for Medical Physics was formed in 1976, the Danish Society for Medical Physics in 1981 while the Icelandic Society for Biomedical Engineering and Medical Physics was formed in 2000. In Finland, the hospital physicist branch of the Finnish Society for Mathematicians and Physicists was founded in the

Correspondence: Ludvig Paul Muren, Department of Medical Physics, Aarhus University Hospital, Nørrebrogade 44, Building 5, DK-8000 Aarhus C, Denmark. Tel: +45 8949 4450. E-mail: muren@as.aaa.dk

(Received 10 October 2008; accepted 16 October 2008)

ISSN 0284-186X print/ISSN 1651-226X online
DOI: 10.1080/02841860802558946

same year as NACP (in 1965), and was re-organised into the Finnish Association of Hospital Physicists in 1986. A Swedish society for medical physics had been founded before NACP and was separated in 1961 into a scientific organisation, the Swedish Society for Radiation Physics, and a professional organisation, the Swedish Hospital Physicist Association.

As evident already in the above list of early NACP working groups, computer-aided radiotherapy planning has been an important research area during the last decades of front-line activities within Nordic medical physics. IMRT and inverse planning was invented in the Nordic countries, with the key scientist being Anders Brahme, although with contributions from e.g. Ingmar Lax and Niels Ulsø [2–4]. Several inverse planning algorithms for IMRT have been developed with the basis in Nordic research groups and companies, today these are actually dominating this field, being implemented in several major commercial treatment planning systems. Besides, the development of treatment planning algorithms for photons and electrons, represented primarily by the activities within the former company Helax AB (Uppsala, Sweden), now part of Nucletron [5], is also a direct consequence of the same focus on computer-based treatment planning documented as early as in the 1965 report of NACP.

Throughout the following decades, NACP's activity level and membership base grew steadily. Meetings were held, serving the role as the main forum for scientific exchange for Nordic medical physicists. Major achievements were the development of a NACP dosimetry protocol [6,7] as well as a protocol for target volume definitions and dose prescription [8], which both gained considerable interest and were widely adopted. The ideas of the latter were later on implemented in the ICRU 62 report [9].

After the 14th NACP meeting held in 1992 (in Reykjavik, Iceland), NACP entered a quiescent period that lasted until its re-vitalisation in 2004, when a new constitution was approved at a meeting in Bergen, Norway. The main modification was the change from individual membership in NACP to the current situation where the five national Nordic societies are the members of NACP. Since 2004, NACP has been supporting the activities in the member organisations by forming new working groups, e.g. in education, and by offering various travel grants to Nordic medical physicist. Following discussions in the NACP council during 2006–2007, it was decided to organise an NACP meeting in June 2008, in Aarhus, Denmark. This NACP 2008 symposium attracted almost 200 participants, mostly from the five Nordic countries. Both the Norwegian and the Danish medical physics societies held their annual general assemblies during NACP 2008, medical physicists from these two countries therefore constituted the majority of participants. The scientific program of the NACP2008 symposium consisted of invited talks by outstanding scientists as well as oral and poster presentations based on submitted abstracts. The topics of the invited talks ranged from a new principle for particle acceleration [10] and normal tissue complication probability modelling [11] in radiotherapy, to new possibilities in diagnostic radiology with dark field imaging [12], magnetic resonance [13] and image analysis [14], to pitfalls and possibilities in nuclear medicine when using PET/CT and immunotherapy [15,16]. The quality and quantity of the submitted abstracts gave a clear indication of the current activity level of Nordic medical physicists. It is difficult to point out a specific focus on current medical physics research in the Nordic countries; on the contrary, most of the main medical physics areas were covered. In the field of radiotherapy, there were presentations within dosimetry and quality assurance [17–21], treatment planning and optimisation [22–27] and treatment verification [23–30]. In diagnostic imaging and nuclear medicine, the presentations covered image analysis and management as well as radiation protection [31–36]. Besides, it should also be mentioned that a broad spectrum of activities of Nordic radiotherapy physicists were presented at the co-localised IGRT2008 meeting [37–39], covering medical physics issues within biological/functional imaging [40–44], anatomical imaging [45–55] and image management [56]. For a more detailed summary of the scientific sessions at NACP2008, readers are referred to the comprehensive report written by Fynbo, Hysing and Østerås, available at www.nacp2008.dk as well as at the home page of NACP (www.nacp-nordisk.org).

The NACP 2008 meeting ended with a session that aimed to look into the future of medical physics. In the key presentation in this session, Robert Jeraj foresaw a future for medical physics where we in addition to exploring new research fields also need to fortify the cross-disciplinary nature of our profession, strengthening existing and establishing new relations with other disciplines in the biomedical field [57]. These changes will have important implications for medical physics education and training programmes. Physicists have a unique approach to problem-solving that is likely to be useful in fields of biomedicine few of us today are familiar with. In principle, medical physicists should therefore be well equipped to approach these areas. Our common, future challenge will be to find the right balance in our education and training to

secure that we also maintain our competence within the key areas of our profession.

The present issue of Acta Oncologica is dedicated to papers presented at the NACP 2008 meeting. In addition to papers from world-leading scientists invited to the plenary sessions of the meeting, the majority of papers in this issue originate from the Nordic countries, representing a sample of the scientific activities in Nordic medical physics. With this merge of international and Nordic science that is also the hallmark of Acta Oncologica, the selection of this journal for the papers from NACP 2008 was felt as highly suitable. We certainly believe that the compilation of this issue has been one of the success factors for the NACP 2008 meeting, and we hope such a process will be repeated at future NACP meetings.

References

[1] Webb S. The contribution, history, impact and future of physics in medicine. Acta Oncol (current issue).

[2] Brahme A, Roos JE, Lax I. Solution of an integral equation encountered in rotation therapy. Phys Med Biol 1982;27: 1221–9.

[3] Lax I, Brahme A. Rotation therapy using a novel high-gradient filter. Radiology 1982;145:473–8.

[4] Ulsø N, Brahme A. Computer-aided irradiation technique optimization. Proceedings from a joint US-Scandinavian symposium on computer-aided radiotherapy (San Antonio, TX, 1988); Sponsored by AAPM/NCI. NCI, Bethesda. p 1–33.

[5] Ahnesjö A, Aspradakis MM. Dose calculations for external photon beams in radiotherapy. Phys Med Biol 1999;44: R99–R155.

[6] Procedures in external radiation therapy dosimetry with electron and photon beams with maximum energies between 1 and 50 MeV. Recommendations by the Nordic Association of Clinical Physics (NACP). Acta Radiol Oncol 1980;19: 55–79.

[7] Electron beams with mean energies at the phantom surface below 15 MeV. Supplement to the recommendations by the Nordic Association of Clinical Physics (NACP) 1980. Acta Radiol Oncol 1981;20:401–15.

[8] Aaltonen P, Brahme A, Lax I, Levernes S, Näslund I, Reitan JB, et al. Specification of dose delivery in radiation therapy. Recommendation by the Nordic Association of Clinical Physics (NACP). Acta Oncol 1997;36(Suppl 10):1–32.

[9] ICRU. Prescribing, recording and reporting photon beam therapy (Supplement to ICRU Report 50). ICRU Report 62, 1999.

[10] Caporaso GJ, Mackie TR, Sampayan S, Chen YJ, Blackfield D, Harris J, et al. A compact linac for intensity modulated proton therapy based on a dielectric wall accelerator. Phys Med 2008;24:98–101.

[11] Gagliardi G, Lax I, Rutqvist LE. Partial irradiation of the heart. Semin Radiat Oncol 2001;11:224–33.

[12] Pfeiffer F, Bech M, Bunk O, Kraft P, Eikenberry E, Brönnimann C, et al. Hard-X-ray dark-field imaging using a grating interferometer. Nat Mater 2008;7:134–7.

[13] Gjesdal KI, Smith HJ. Magnetic tomography–new imaging techniques and future perspectives. Tidsskr Nor Laegeforen 2000;120:1562–6.

[14] Sjöstrand K, Rostrup E, Ryberg C, Larsen R, Studholme C, Baezner H, et al. Sparse decomposition and modeling of anatomical shape variation. IEEE Trans Med Imaging 2007; 26:1625–35.

[15] von Schulthess GK, Hany TF. Imaging and PET-PET/CT imaging. J Radiol 2008;89:438–47.

[16] Gleisner KS, Nickel M, Lindén O, Erlandsson K, Wingårdh K, Strand SE. Parametric images of antibody pharmacokinetics based on serial quantitative whole-body imaging and blood sampling. J Nucl Med 2007;48:1369–78.

[17] Korreman S, Medin J, Kjær-Kristoffersen F. Dosimetric verification of RapidArc treatment delivery. Acta Oncol (current issue).

[18] Sjøstrøm D, Bjelkengren U, Ottoson W, Behrense CF. A beam-matching concept for medical linear accelerators. Acta Oncol (current issue).

[19] Hoffmann L. Implementation and experimental validation of the high dose rate stereotactic treatment mode at Varian accelerators. Acta Oncol (current issue).

[20] Rønde HS, Hoffmann L. Validation of Varian's AAA algorithm with focus on lung treatments. Acta Oncol (current issue).

[21] Helt-Hansen J, Rosendal F, Kofoed IM, Andersen CE. Medical reference dosimetry using EPR measurements of alanine: Development of an improved method for clinical dose levels. Acta Oncol (current issue).

[22] Bassler N, Holzscheiter MH. Calculated LET-spectrum of secondary antiprotons. Acta Oncol (current issue).

[23] Kjær-Kristoffersen F, Ohlhues L, Medin J, Korreman S. Treatment planning for RapidArc beam delivery. Acta Oncol (current issue).

[24] Ottoson RO, Engstrøm PE, Sjøstrøm D, Behrens CF, Karlsson A, Knöös T, et al. The feasibility of using Pareto fronts for comparison of treatment planning systems and delivery techniques. Acta Oncol (current issue).

[25] Søndergaard J, Høyer M, Petersen JB, Wright P, Grau C, Muren LP. The normal tissue sparing obtained with simultaneous treatment of pelvic lymph nodes and bladder using intensity-modulated radiotherapy. Acta Oncol (current issue).

[26] Zimmerman J, Korreman S, Persson G, Cattell H, Svatos M, Sawant A, et al. DMLC motion tracking of moving targets for intensity modulated arc therapy treatment – a feasibility study. Acta Oncol (current issue).

[27] Thomsen MS, Nørrevang O. A model for managing patient booking in radiotherapy departments with differentiated waiting times. Acta Oncol (current issue).

[28] Bertelsen A, Nielsen M, Westberg J, Jensen HR, Brink C. The representativeness of patient position at the first three radiotherapy sessions. Acta Oncol (current issue).

[29] Riis HL, Zimmermann SJ. Elekta Precise Table characteristics of IGRT remote table positioning. Acta Oncol (current issue).

[30] Nielsen M, Bertelsen A, Westberg J, Jensen HR, Brink C. Cone beam CT evaluation of patient set-up accuracy as a QA tool. Acta Oncol (current issue).

[31] Kvinnsland Y, Brekke N, Taxt TM, Gruner R. Multispectral analysis of multimodal images. Acta Oncol (current issue).

[32] Källman HE, Halsius E, Olsson M, Stenstrøm M. DICOM Metadata repository for technical information in digital medical images. Acta Oncol (current issue).

[33] Hetland PO, Friberg EG, Øvrebø KM, Bjerke HH. Calibration of reference KAP-meters at SSDL and cross calibration of clinical KAP-meters. Acta Oncol (current issue).

[34] Hansen J, Jurik AG. The analysis of current practice of multislice CT examinations. Acta Oncol (current issue).

[35] Jurik AG, Hansen J. Survival and radiation risk in patients obtaining more than six CT examinations during one year. Acta Oncol (current issue).
[36] Jødal L. Beta emitters and radiation protection. Acta Oncol (current issue).
[37] Grau C, Muren LP, Hoyer M, Lindegaard C, Overgaard J. Image-guided adaptive radiotherapy – integration of biology and technology to improve clinical outcome. Acta Oncol 2008;47:1182–5.
[38] van Herk M. Will IGRT live up to its promise? Acta Oncol 2008;47:1186–7.
[39] Baumann M, Hölscher T, Zips D. The future of IGRT – Cost Benefit Analysis. Acta Oncol 2008;47:1188–92.
[40] Dasu A. Treatment planning optimisation based on imaging tumour proliferation and cell density. Acta Oncol 2008;47: 1221–8.
[41] Søvik Å, Skogmo HK, Bruland OS, Olsen DR, Malinen E. DCEMRI monitoring of canine tumors during fractionated radiotherapy. Acta Oncol 2008;47:1249–56.
[42] Røe K, Muren LP, Rørvik J, Olsen DR, Dahl O, Bakke A, et al. Dynamic contrast enhanced magnetic resonance imaging of bladder cancer and implications for biological image-adapted radiotherapy. Acta Oncol 2008;47:1257–64.
[43] Nielsen T, Mouridsen K, Maxwell RJ, Stødkilde-Jørgensen H, Østergaard L, Horsman MR. Segmentation of dynamic contrast enhanced magnetic resonance imaging data. Acta Oncol 2008;47:1265–70.
[44] Eilertsen K, Nilsen L, Vestad TA, Geier O, Skretting A. A simulation of MRI based dose calculations on the basis of radiotherapy planning CT images. Acta Oncol 2008;47: 1294–302.
[45] Assenholt MS, Petersen JB, Nielsen SK, Lindegaard JC, Tanderup K. A dose planning study on applicator guided stereotactic IMRT boost in combination with 3D MRI based brachytherapy in locally advanced cervical cancer. Acta Oncol 2008;47:1337–43.
[46] Haskå TM, Honore H, Muren LP, Høyer M, Poulsen PR. Intrafraction changes of prostate position and geometrical errors studied by continuous electronic portal imaging. Acta Oncol 2008;47:1351–7.
[47] Carl J, Nielsen J, Holmberg M, Larsen EH, Fabrin K, Fisker RV. A new fiducial marker for image-guided radiotherapy of prostate cancer: Clinical experience. Acta Oncol 2008;47: 1358–66.
[48] Redpath AT, Wright P, Muren LP. The contribution of on-line correction for rotational organ motion in image-guided radiotherapy of the bladder and prostate. Acta Oncol 2008; 47:1367–72.
[49] Arnesen MR, Eilertsen K, Malinen E. Optimal treatment margins for radiotherapy of prostate cancer based on interfraction imaging. Acta Oncol 2008;47:1373–81.
[50] Wright P, Redpath AT, Høyer M, Grau C, Muren LP. The normal tissue sparing potential of adaptive strategies in radiotherapy of bladder cancer. Acta Oncol 2008;47:1382–9.
[51] Korreman SS, Juhler-Nøttrup T, Persson GF, Pedersen AN, Enmark M, Nystrøm H, et al. The role of image guidance in respiratory gated radiotherapy. Acta Oncol 2008;47:1390–6.
[52] Persson GF, Nygaard DE, Olsen M, Juhler-Nøttrup T, Pedersen AN, Specht L, et al. Can audio coached 4D CT emulate free breathing during the treatment course? Acta Oncol 2008;47:1397–405.
[53] Juhler-Nøttrup T, Korreman SS, Pedersen AN, Persson GF, Arup LR, Nystrøm H, et al. Interfractional changes in tumour volume and position during entire radiotherapy courses for lung cancer with respiratory gating and image guidance. Acta Oncol 2008;47:1406–13.
[54] Jensen HR, Hansen O, Hjelm-Hansen M, Brink C. Inter- and intrafractional movement of the tumour in extracranial stereotactic radiotherapy of NSCLC. Acta Oncol 2008;47: 1432–7.
[55] Johansen J, Bertelsen A, Hansen CR, Westberg J, Hansen O, Brink C. Set-up errors in patients undergoing image guided radiation treatment. Relationship to body mass index and weight loss. Acta Oncol 2008;47:1454–8.
[56] Noe KØ, De Senneville BD, Elstrøm UV, Tanderup K, Sørensen TS. Acceleration and validation of optical flow based deformable registration for image-guided radiotherapy. Acta Oncol 2008;47:1286–93.
[57] Jeraj R. Future of physics in medicine and biology. Acta Oncol (current issue).