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Review

The future of Radiation Oncology: Considerations of Young Medical Doctor

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ABSTRACT

Radiation therapy plays an increasingly important role in the management of cancer. Currently, more than 50% of all cancer patients can expect to receive radiotherapy during the course of their disease, either in a primary management (radical or adjuvant radiotherapy) or for symptom control (palliative radiotherapy).

Radiation oncology is a very unique branch of medicine connected with clinical knowledge and also with medical physics. In recent years, this approach has become increasingly absorbed with technological advances. This increasing emphasis on technology, together with other important changes in the health-care economic environment, now place the specialty of radiation oncology in a precarious position. New treatment technologies are evolving at a rate unprecedented in radiation therapy, paralleled by improvements in computer hardware and software. These techniques allow assessment of changes in the tumour volume and its location during the course of therapy (interfraction motion) so that re-planning can adjust for such changes in an adaptive radiotherapy process.

If radiation oncologists become simply the guardians of a single therapeutic modality they may find that time marches by and, while the techniques will live on, the specialty may not. This article discusses these threats to the field and examines strategies by which we may evolve, diversify, and thrive.

1. Background

As a young resident in radiation oncology, working in the Greater Poland Cancer Centre I feel proud to have an opportunity to write an article about new perspectives and challenges in radiation oncology. The purpose to write this manuscript was to have a look at the situation of young radiation oncologists. I would like to discuss the position of radiation oncology in the field of oncology and to describe the Greater Poland Cancer Centre as a place where I work.

In this manuscript, I would like to raise a very important issue of new technologies in modern radiotherapy, its advantage and potential pitfalls. I will prove that there is no valuable treatment without very precise imaging.

I think that the very essential subject like system of education should be also included into this paper. At the end, I will provide a discussion on future pathways of development in radiation oncology.

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1.1. Personal opinion

I am specially interested in radiation therapy in gynaecological malignancies (both tele- and brachytherapy) including multidisciplinary treatment of the diseases. Currently, I am developing a doctoral thesis on the subject of intraoperative radiotherapy (IORT) in early breast cancer patients. By participating in clinical trials, I increase my skills and knowledge in the field of oncology.

2. Aim

Working in Gynaecological Radiotherapy Ward, I have encountered many difficult clinical situations and because of the multidisciplinary character of our team it is much easier to resolve them all. Every cervical patient with an intent of radical treatment is given PET/CT scan and MRI to prepare an optimum RT plan.

2.1. Multidisciplinary team (MDT)

Multidisciplinary meetings (MDMs) have increasingly become an important decision-making forum in oncology. These meetings bring together medical, radiation, and surgical oncologists, pathologists, physicians, radiologists, and allied health practitioners with the aim of combining the expertise from each field to generate a comprehensive and coordinated care plan for patients. Patients who are managed through such group meetings have better survival outcomes, shorter waiting times, and the benefit of more robust treatment decision-making processes than those managed without formal multidisciplinary discussions. MDMs are used extensively in my hospital in the specialties of breast, head and neck, gynaecological, and gastrointestinal cancers. Every tumour board meet once a week and discuss every difficult clinical case.

I think that the development of MDTs in cancer care has been promoted in the expectation that improved treatment decisions, coordination of cancer care, and outcomes will eventuate. The establishment of MDMs at Greater Poland Cancer Centre is a valuable educational opportunity for medical students, oncology trainees, and other health professionals, while attendance at MDMs counterbalances the unidisciplinary focus of most postgraduate oncology curricula.

3. History of the hospital

The Greater Poland Cancer Centre (WCO), established in 1953, is one of the biggest oncology centres in Poland and Europe. Its basic task is to provide specialist health care to people afflicted with cancer diseases. The centre provides medical service in the field of oncological surgery, head and neck cancer surgery, radiotherapy, chemotherapy, gynaecological oncology, anaesthesiology and intensive care, brachytherapy and diagnostics. Each year, the centre hospitalises 18,000 patients, performs 5600 operations and 8000 ambulatory procedures. Annually, over 5500 patients undergo radiotherapy treatment (along with brachytherapy), 4400 patients, system treatment (chemotherapy), and almost 11,000 patients. Ambulatory chemotherapy treatment. We receive over 160,000 annual outpatient visits annually.

Following the West European model, the centre features interdisciplinary teams providing holistic care for patients with particular types of cancers, e.g. a team providing care for patients with gynaecological malignancies, breast cancers, cancers of the upper part of the digestive tract, larynx cancers. These teams include first of all physicians of different specialities, psychologists, physical therapists, nurses, and supporting workers, e.g. social worker or dietician. Team meetings are held at least once a week.

The WCO centre has two radiotherapy departments and is famous for its use of radiotherapy and brachytherapy involving the application of modern ionizing radiation technologies for medical purposes. Currently, the centre uses 7 state-of-the-art irradiation accelerators, including Poland's first machine for tomotherapy. Additionally, the centre was the first in Poland to start treatment of prostate gland cancer by means of brachytherapy, with the use of permanent seed implants (LDR permanent implants).[24]

To the benefit of its patients, staff and students, the WCO has established its Teaching and Conference Centre. Numerous classes for students of the Poznań University of Medical Sciences and other universities are organized at the hospital. The Department of Electroradiology was founded by Prof. Julian Malicki in 2005 to improve qualifications of future RTTs (radiotherapy technologists).

Currently, in my hospital there are over 20 residents in radiation oncology. During five years of education, we have to receive training in several different areas of oncology, for example: radiotherapy grouping by sites of disease, radiobiology, imaging, medical oncology, pathology. As a group of young medical doctors, we have an opportunity to attend many conferences, courses, international exchanges between hospitals, clinical trials and scientific research projects. I have to mention at this point the Young Scientists' Forum which is dedicated to the promotion of scientific research and projects of young (under 35 years of age) radiation oncologists, medical physicists and radiobiologists in Poland.

4. Modern radiotherapy

Radiation therapy plays an increasingly important role in the management of cancer. Currently, more than 50% of all cancer patients can expect to receive radiotherapy during the course of their disease, either in the primary management (radical or adjuvant radiotherapy) or for symptom control (palliative radiotherapy). This has led to a doubling of the need for radiotherapy during the last 10 years, and a consequent expansion of radiotherapy services needed. In many countries, training of the staff involved in radiotherapy has proved to be bottleneck for the expansion. Planning and delivering radiation therapy is a complex process, based on high-tech software and hardware, and involving a wide range of staff, e.g. physicians, physicists, radiographers and radiation therapists/nurses (RTTs).

Planning of radiotherapy consists of several steps:

1. Imaging: starts with a CT scan of the patient; immobilized in the treatment position on a flatbed couch.

2. Delineation: the gross tumour volume, clinical target volumes and organs at risk are then outlined on each CT slice, with the aid of multimodality imaging (MRI/PET/SPECT).[10] Margins for uncertainties (biological, organ motion, patient positioning) are added.
3. Plan optimization: a fully segmented CT scanning forms the basis for computer-aided dose-planning. Chosen are beam orientations delivering high doses to the tumour while sparing as much critical tissue as possible. The resulting accumulated radiation dose distribution is calculated, and one or more plans are produced.
4. Evaluation of treatment plans: at the planning review conference involves cautious assessment of doses received in the target volumes as well as in the structures of organs at risk. A visual inspection of the dose distributions superimposed on CT slices is done, ensuring an accurate presentation of spatial relationships in the patient anatomy. The best treatment plan is chosen.
5. Plan test: since the gantry of a linear accelerator can rotate 360 degrees around the patient, there is a risk of collision of the gantry with the treatment couch or the patient. Any plan should be tested for collision danger before the first treatment of the patient.
6. Patient placing: when the dose plan is evaluated, accepted and quality checked, the patient is brought to the linear accelerator and placed on the treatment couch, assisted by RTTs. The position of the patient relative to the isocentre of the machine is guided by laser beams in the room. In recent years, setup using external laser guided markers has been gradually replaced by image-guided setup: imaging devices on the accelerator are used for online daily imaging and matching of internal markers (bony anatomy, gold markers) or even soft tissue (cone-beam CT).

5. Modern brachytherapy

The subject of brachytherapy highlighted recent advances in this modality of radiation therapy.[39] In the past, brachytherapy was carried out mostly with Radium (226Ra) sources. Currently, the use of artificially produced radionuclides such as 137Cs, 192Ir, 60Co, 198Au, 125I, and 103Pd has rapidly increased.[15,19,20] Brachytherapy is an essential component of the curative treatment of cervical cancer and cannot be replaced by other modalities in this setting. High dose-rate (HDR) brachytherapy is preferable to low dose-rate (LDR) for departments with limited resources that treat a large number of patients with cervical cancer. New systems using a miniaturised 60Co source are becoming very popular. This is due to the fact that 60Co based HDR systems require source replacement approximately every 5 years while 192Ir requires replacement every 3–4 months. This represents a significant advantage in terms of resource sparing, import of radioactive sources into countries, regulatory requirements and additional workload. Over the last decade, developments in imaging, computer processing and brachytherapy systems and applicators have made it possible to implement three-dimensional treatment planning based on cross sectional imaging with the applicators in place using CT or MRI.[6,35] This has been successfully developed for the brachytherapy of cervical cancer.[21–23] Individual departments in low-middle income countries should carefully weigh the advantages and disadvantages of adopting this system, which implies expenses related to applicators and requires readily available MRI services dedicated to the brachytherapy unit or department.[37]

5.1. *Workflow in brachytherapy for cervical cancer*

1. Imaging: mostly CT scans for every patient.
2. Delineation: external contours of the sigmoid, rectum, and bladder are made. The window and level settings of the images are manipulated to decrease the scatter artifact from the applicator. Physician contour the sigmoid from the rectosigmoid junction to the level where the sigmoid crosses anteriorly to the pubic symphysis. Rectal contrast helps define the rectosigmoid junction and distinguish the large bowel from the small bowel.
3. Plan optimization: using diffrent systems Advantage Sim (GE Medical Systems) Virtual Simulation Software and Plato (brachytherapy planning v14.2.6 Nucletron Systems, Veenendaal, the Netherlands).
4. Plan verification and evaluation: the post-implant dose-volume histograms (DVHs) of the sigmoid, rectum, and bladder generated for the D0.1cc and D2cc volumes.
5. Dose delivery: using after-loading HDR unit.

6. Implementation of new technology

I feel that we must reconsider the use of advanced technologies in radiation therapy discussing the assumption that improved dose distribution leads to improvement in clinical outcomes. New treatment technologies are evolving at a rate unprecedented in radiation therapy, paralleled by improvements in computer hardware and software. The challenging use of highly precise collimators in the IMRT setting, small fields, robotics, stereotactic delivery, volumetric arc therapy and image guidance have brought new challenges for commissioning and QA.[38] These techniques allow assessment of changes in the tumour volume and its location during the course of therapy (interfraction motion) so that re-planning can adjust for such changes in an adaptive radiotherapy process. Some target volumes move during treatment due to respiration (intrafraction motion), especially those in the lung, liver and pancreas. Advanced techniques for compensating for such motion are already commercially available and include respiratory gating, active breathing control and target tracking.

The new technology should be implemented with caution.[26,27] If the identification of target tissues is uncertain when margins around target volumes are tight, the likelihood of geographic misses or under-dosing of the target increases. Movement of the target with respiration or for any reason during treatment increases the risk of missing or under-dosing the target. Since in some instances IMRT uses more treatment fields from different directions, its use may increase the volume of normal tissue receiving low doses which might lead to a higher risk of secondary cancers. With the introduction of any advanced technology, such as IMRT and IGRT, data should be collected prospectively to allow a thorough evaluation of cost effectiveness and cost-benefit.[8,14,28–31,40] It is remarkable that the implementation of advanced radiotherapy technologies tends to distance the physician from the patient, a trend that needs to be consciously counterbalanced by a more personal and holistic approach. In addition, it makes it more and more difficult to intuitively understand the relationship between the radiation fields and the patient's anatomy. Whereas with 3D conformal radiation therapy, the physician can rely on port films to assess the irradiated volume, with IMRT the physician must rely on tools such as computer simulations and dose-volume histograms (DVH).[3,7] Users of advanced technologies should be cautioned not to allow themselves to become too dependent upon the technology alone. It is also recommended that advanced technologies such as IMRT and IGRT should not be acquired until physicians and hospital staff are fully experienced with advanced treatment planning techniques in 3D conformal therapy. Modern 3D approaches, including IMRT, introduce new requirements in terms of the understanding of axial imaging and tumour/organs delineation.[4] Recent literature points to an uncertainty level at this stage known as "interobserver variations". Efforts continue to harmonize the criteria with which tumours, organs and anatomical structures are contoured and how volumes are defined.[32]

Advanced technologies provide an opportunity for the acceleration of treatment without excessive risk to normal tissue.[1,2] Hypofractionated treatments are more convenient to patients and caregivers.[12,13] But convenience is not enough to make hypofractionation a mainstay treatment. Much of this subject is still surrounded by ongoing controversy. The avoidance of dreaded late effects of hypofractionation obviously cannot be confirmed without long and careful follow-up.[11] In curative and palliative treatment, several trials of hypofractionation in common cancers have shown comparable clinical outcomes to conventional fractionation. These schedules vary for different diseases with fractions > 2 Gy given daily to once weekly. Common cancers, such as breast cancers, can be successfully treated in three weeks rather than in five weeks. Advanced technology radiation therapy (3D CRT and IMRT) may provide an opportunity for the study of tissue tolerance as high doses per fraction can be delivered to small tumour volumes while normal tissues receive conventional fractionated radiation.[5,33,34]

6.1. *Situation of radiation oncology*

Firstly, I would like to discuss the position of radiation oncology in the field of oncology.

Although in some countries our specialty is disease oriented and organized as clinical oncology, in many countries it is a monomodality specialty. Radiotherapy is a discipline specialised in the use of ionizing rays. And, as such, we are recognized within the European system (Union Européenne des Médecins Specialists, UEMS).

In some countries, the radiation oncologists feel that they are members of a "Cinderella" specialty. The position of the medical oncologists becomes stronger and they are now recognized as independent specialty in Europe. Maybe we have to reconsider the position of our specialty in the field of oncology. Apart from political aspects, we can look at this from a professional point of view. The options are the following:

- We keep it as it is now.
- We reintegrate with radiology and nuclear medicine towards an imaging and image guided radiotherapy department.
- We integrate with medical oncology to clinical oncology as is already the case in some countries.

Keeping it as it is now does not seem to be the best option. The second and third options are, therefore, worth discussing. Radiology and nuclear medicine representatives wrote a white paper in 2007 in which they discussed a possible merge of the two specialties, because of the introduction of multimodality imaging (PET/CT, SPECT/CT and PET/MR). We also see that many radiation oncology departments have intensified their collaboration with radiologists. Larger departments sometimes have appointed dedicated radiologists to help with target volume delineation and an MRI based or a PET based linear accelerator is being developed. So, these developments might be the reasons to reintegrate with radiology and nuclear medicine.

If we believe that this is the direction to go, we could consider thinking of a multi modality (molecular) imaging specialist, bringing together anatomical and molecular information, as well as oncological skills for staging, tailor-made image guided interventions and therapy monitoring. The other direction is the integration of medical oncology and radiation oncology. Many colleagues want radiation oncologists to also play a role in combined modality treatment. Tumours for which no combined modality, either with cytostatic drugs or targeted therapy, is used hardly exist anymore. This development could lead to a disease oriented clinical oncologist with expertise in radiation oncology and systemic treatment. If this clinical oncologist is also experienced in prescribing systemic treatment in an (neo)adjuvant setting and in metastatic disease, this could be very beneficial for both the patient and the doctor, because it will reduce the necessary transfer from one specialty to another and improve the continuity of the doctor–patient relationship.

And what about the subspecialisations? I think that it might be the right direction to follow and even if we do not change the orientation of our specialty, subspecialization is already a fact of life. The general (radiation) oncologist is disappearing, as is the general surgeon or internist. There is no way to keep up with the literature and treatment techniques of all tumour sites. This subspecialization has consequences for:

– The number of multidisciplinary meetings.
– The size of the staff.
– The size of a center.
– The organization of oncology in a country.

General multidisciplinary meetings are gradually being replaced by disease (tumour) oriented multidisciplinary meetings. Also, the character of multidisciplinary meetings changes from an advice about radiotherapy towards a triage for the best multimodality therapeutic approach. This shift towards multidisciplinary meetings increases the burden for the staff and, together with the need for a subspecialized tumour site oriented radiation oncologist or clinical oncologist, will result in the need for a minimum size of staff (not only doctors but also physicists and technologists) and, consequently, a minimum size of a center.[25–27] Sufficient patients are needed to guarantee the quality of care delivered by subspecialist doctors.

The digital world, the creation of satellites in networks and teleconsulting might help to find the best solution for concentrating knowledge and skills to improve quality and experience.

I know that we should be strong as young radiation oncologists and therefore we must create some kind of a European network. Working together we will achieve much more goals than individually (clinical trials, articles, research).

The next, but not the last question to ask is what the future for radiation oncology will be? I am sure that it is effective education, and in this context I would like to thank the ESTRO organization for a wide range of courses for different RT professionals based on established teaching methods and good educational practice. These are supported by experienced ESTRO staff who ensure the efficient organization of all courses leading to a truly valuable and memorable experience for participants.

7. Conclusions and final reflexion

At the end, I would like to make some final discussion and conclusions. As radiation oncologists, we perceive ourselves to have a holistic clinical outlook seeing patients at every stage of their disease from curative to the most palliative. We see ourselves as discriminating users of our modality, selectively picking the arrows from our quivers and artfully manipulating dose, dose rate, and fractionation to improve outcome. This skill-set would appear to make us unique and secure in our field, but this is a concept that needs close examination. As the therapeutic options increase (and radiation is just one of several), as others feel empowered to select treatment for us, and as technology becomes increasingly automated, our input becomes progressively less relevant. Others could do this job and indeed they do. If there is less and less need for specialized human input, there is less and less need for a specialist.[18,36]

I think that the specialty is unlikely to survive by sinking deeper into the technical aspects of a single, although multifaceted, therapy. The radiation oncologist must remain a credible clinician within a multidisciplinary group, acting as an articulate spokesman in the selection of therapy, managing their own morbidity, and following their own patients. More than this, the radiation oncologist must overcome his/her current aversion to any form of medical therapy and rapidly embrace and co-own the new biological strategies that enhance the action of radiation. This means diversifying the portfolio.

Conflict of interest

None declared.

REFERENCES

1. Vikram B, Coleman CN, Deye JA. Current status and future potential of advanced technologies in radiation oncology. Part 1: Challenges and resources. *Oncology* 2009;**23**(279):83.
2. Vikram B, Coleman CN, Deye JA. Current status and future potential of advanced technologies in radiation oncology. Part 2: State of the science by anatomic site. *Oncology* 2009;**23**:380–5.
3. Veldeman L, Madani I, Hulstaert F, De Meerleer G, Mareel M, De Neve W. Evidence behind use of intensity-modulated radiotherapy: a systematic review of comparative clinical studies. *Lancet Oncol* 2008;**9**:367–75.
4. Rothschild S, Studer G, Seifert B, et al. PET/CT with intensity modulated radiotherapy (IMRT) improves treatment outcome of locally advanced pharyngeal carcinoma: a matched-pair analysis. *Radiat Oncol* 2007;**2**:22.
5. Pignol J, Olivotto I, Rakovitch E, et al. Phase III randomized study of intensity modulated radiation therapy versus standard wedging technique for adjuvant breast radiotherapy. *Int J Radiat Oncol Biol Phys* 2006;**66**(3 (Suppl. 1)):S1.
6. Donovan E, Beakley N, Denholm E, et al. Randomised trial of standard 2D radiotherapy versus intensity modulated radiation therapy (IMRT) in patients prescribed breast radiotherapy. *Radiother Oncol* 2007;**82**:254–64.
7. Mell LK, Mehrotra AK, Mundt AJ. Intensity-modulated radiation therapy use in the U.S. *Cancer* 2005;**104**:1296–303, 2004.
8. Van Herk M. Different styles of image-guided radiotherapy. *Semin Radiat Oncol* 2007;**17**(4):258–67.
10. Shortt K, Davidson L, Hendry J, Dondi M, Andreo P. International perspectives on quality assurance and new techniques in radiation medicine: outcome of an IAEA conference. *Int J Radiat Oncol Biol Phys* 2008;**71**(Suppl. 1): S80–4.
11. Timmerman RD. An overview of hypofractionation and introduction to this issue of Seminars in Radiation Oncology. *Semin Radiat Oncol* 2008;**18**:215–22.
12. Dewar JA, Haviland JS, Agrawal RK, et al. Hypofractionation for early breast cancer: first results of the UK standardisation of breast radiotherapy (START) trials. *J Clin Oncol* 2007;**25**:LBA518 [abstract].
13. Whelan TJ, Kim DH, Sussman J. Clinical experience using hypofractionated radiation schedules in breast cancer. *Semin Radiat Oncol* 2008;**18**:257–64.
14. International Conference on Advances in Radiation Oncology (ICARO): Outcomes of an IAEA Meeting.
15. Baltas D, Lymperopoulou G, Zamboglou M. On the use of HDR cobalt-60 source with the Mammosite radiation therapy system. *Med Phys* 2008;**35**:5263–8.
18. The future development of radiation oncology in Europe: a personal view Jan Willem H. Leer.
19. Richter J, Baier K, Flentje M. The use of Co-60 sources for after loading alternate to Ir-192 sources. In: *IFMBE proceedings. World Congress on medical physics and biomedical engineering Seoul Korea*. 2006. p. 1726–30.
20. Ntekim A, Adenipekun A, Akinlade B, Campbell O. High dose rate brachytherapy in the treatment of cervical cancer: preliminary experience with cobalt 60 radionuclide source – a prospective study. *Clin Med Insights Oncol* 2010;**4**:89–94.
21. Haie-Meder C, Pötter R, Van Limbergen E, et al. Recommendations from gynecologal GEC-ESTRO working-group (I): concepts and terms in 3D image based 3D treatment planning in cervix cancer brachytherapy with emphasis on MRI assessment of GTV and CTV. *Radiother Oncol* 2005;**74**:235–45.

22. Pötter R, Haie-Meder C, Van-Limbergen E, et al. Recommendations from gynaecological GEC-ESTRO working group (II): concepts and terms in 3D image-based treatment planning in cervix cancer brachytherapy – 3D dose-volume parameters and aspects of 3D image-based anatomy, radiation physics, radiobiology. *Radiother Oncol* 2006;**78**:67–77.
23. Viswanathan AN, Erickson BA. Three-dimensional imaging in gynecologic brachytherapy: a survey of the American Brachytherapy Society. *Int J Radiat Oncol Biol Phys* 2010;**76**(1):104–9.
24. www.wco.pl.
25. Virtual reality in radiation therapy training Annette Boejen*, Cai Grau.
26. Staff requirements for a radiotherapy programme: setting up a radiotherapy programme: clinical, medical physics, radiation protection and safety aspects. International Atomic Energy Agency, Vienna; 2008. p. 17–31.
27. IAEA. Human Health: Resources and learning for health professionals. http://nucleus.iaea.org/HHW/RadiationOncology/Makingthecaseforradiotherapyinyourcountry/Roleofradiotherapyincancercare/Radiotherapyisacosteffectivesystemwhichneedsabalance/index.html
28. Hayman JA, Hillner BE, Harris JR, Weeks JC. Cost-effectiveness of routine radiation therapy following conservative surgery for early-stage breast cancer. *J Clin Oncol* 1998;**16**:1022–9.
29. Prieto L, Sacristan JA. Problems and solutions in calculating quality adjusted life years (QUALYs). Health Qual Life Outcomes 2003;1:80. http://www.hqlo.com/content/1/1/80
30. Bleichrodt H, Quiggin J. Life-cycle preferences over consumption and health: when is cost-effectiveness analysis equivalent to cost–benefit analysis? *J Health Econ* 1999;**18**(6):681–708.
31. IAEA. Progrramme of Action for Cancer Therapy: cutting cancer treatmentcosts to save more lives: http://cancer.iaea.org/newsstory.asp?id=76
32. International Conference on Advances in Radiation Oncology (ICARO). Outcomes of an IAEA Meeting.
33. Joseph B, Supe S, Ramachandra A. Cyberknife: a double edged sword? *Rep Pract Oncol Radiother* 2010;**15**(4):93–7.
34. Ceylan C, Kucuk N, Bas Ayata H, Guden M, Engin K. Dosimetric and physical comparison of IMRT and cyberknife plans in the treatment of localized prostate cancer. *Rep Pract Oncol Radiother* 2010;**15**(6):181–9.
35. Chicheł A, Skowronek J, Kanikowski M. Thermal boost combined with interstitial brachytherapy in breast conserving therapy – assessment of early toxicity. *Rep Pract Oncol Radiother* 2011;**16**(3):87–94.
36. Janaszczyk A, Bogusz-Czerniewicz M. Comparison of curricula in radiation technology in the field of radiotherapy in selected European Union countries. *Rep Pract Oncol Radiother* 2011;**16**(5):189–97.
37. Guedea F. Recent developments in brachytherapy. *Rep Pract Oncol Radiother* 2011;**16**(6):203–6.
38. Malicki J. The importance of accurate treatment planning, delivery, and dose verification. *Rep Pract Oncol Radiother* 2012;**17**(2):63–5.
39. Potters L, Morgenstern C, Calugaru E, et al. 12-year outcomes following permanent prostate brachytherapy in patients with clinically localized prostate cancer. *J Urol* 2005;**173**:1562–6.
40. Konski A, Speier W, Hanlon A. Is proton therapy cost-effective in the treatment of adenocarcinoma of the prostate? *J Clin Oncol* 2007;**25**:3603–8.