By Dragica Bosnjak,
DELO

Ervin B. Podgoršak, Recipient of the Coolidge Award from the American Association of Physicists in Medicine

"I would like to conclude my presentation with a Slovenian proverb that says: A healthy man has a thousand wishes, a sick man has only one. Most of the work of medical physicists is indirectly related to people who have only one wish. We must not forget that, despite our scientific and technical training, our strongest guiding attributes must be compassion for patients and discipline toward our work." With these words Ervin Podgorsak, PhD concluded his Coolidge Award acceptance speech in the awards ceremony during the 48th annual meeting of the American Association of Physicists in Medicine (AAPM) held in Orlando, Florida July 30 – August 4, 2006.

The Coolidge Award is the AAPM's highest honor, presented during the annual AAPM meeting to a medical physicist who has exhibited a distinguished career in medical physics in three areas: research, teaching and service, and who has exerted a significant impact on the practice of medical physics. The award is named in honor of William D. Coolidge, American physicist and inventor, educated at the Massachusetts Institute of Technology (MIT) and the University of Leipzig. During his 40-year career at General Electric, Coolidge became known as a prolific inventor and was awarded 83 patents. He is best known for the invention of ductile tungsten in the early years of his career. In 1913 he introduced ductile tungsten into x-ray tubes and revolutionized x-ray tube design with the use of the hot filament cathode as the source of electrons. Hot cathodes emit electrons through thermionic emission and are still in use today in x-ray tubes, now called Coolidge tubes, and in the electron guns of linear accelerators. In 1972 Dr Coolidge was the first recipient of the AAPM Award named after him.

Dr Podgorsak is Professor and Director of Medical Physics at McGill University in Montreal, Canada. He was born to Slovenian parents in Vienna, Austria and grew up in Ljubljana, Slovenia. Four universities shaped his scientific, pedagogic and clinical careers, and he never forgets to stress that the first of these was the University of Ljubljana.

The two sides of the Coolidge medal.

As stated in the recent Canadian Medical Physics Newsletter (July 2006), your 80-page curriculum vitae and the web-based information on the AAPM web site kept the authors of your profile quite busy. If we skip the years of your growing up in Ljubljana and your studies of technical physics at the University of Ljubljana, how did you make the transition from technical to medical physics?

The University of Ljubljana gave me excellent training in undergraduate physics, the University of Wisconsin gave me graduate physics training and introduced me to medical physics, the University of Toronto trained me in clinical physics, and McGill University allowed me to devote my professional life to academic and clinical medical physics. Medical physics is a very rewarding profession, combining one's love of physics with compassion for patients. There are about 15,000 practicing medical physicists around the World, of these about 6000 in North America. The AAPM was formed in 1958 and currently has almost 6000 members, 350 of whom practice their profession in Canada.

You state that your mother, who was widowed when you were 10 years old, instilled in you the understanding that the only way to succeed in life is through hard work and education. How did you use this view in your studies and professional advancement, and how did you deal with responsibilities in your own family?

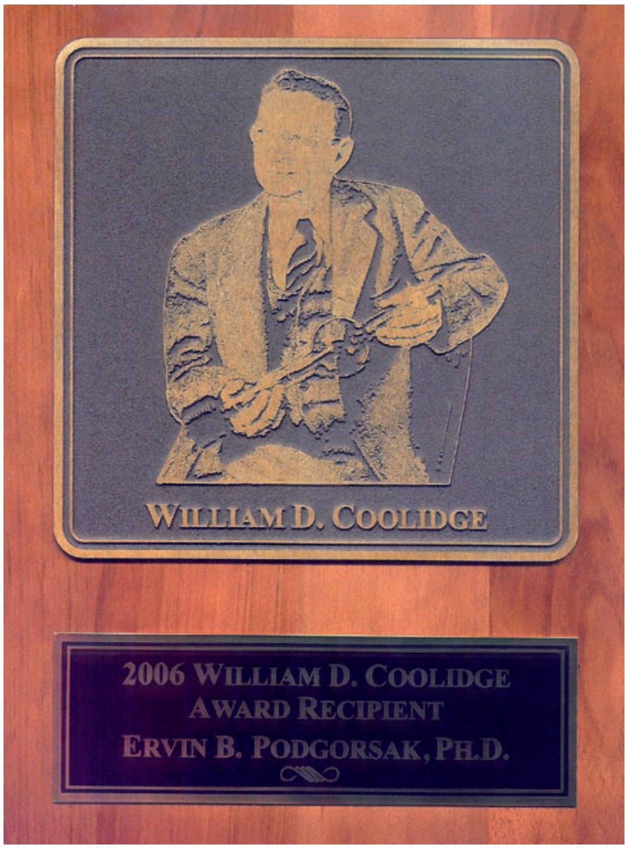
I believe that this advice still holds true for everybody, and especially for young people. If they do not heed this truism, they may miss many opportunities for improving their quality of life and their position in society. I was lucky in my marriage, and my wife Mariana, with unequivocal support and an assumption of the lion's share in the upbringing of our two sons, made a large contribution to my academic and professional successes. One of our sons, Matthew, is also a medical physicist. He received his PhD degree in Medical Physics from the University of Wisconsin and works in Buffalo, New York. The second son, Gregor, received his BSc degree in Environmental Science from McGill University and works in Montreal.

My entry into the world of science and clinical work was precipitated by an invitation from Dr Harold E. Johns to join his medical physics laboratory at the University of Toronto as a post-doctoral Fellow. At first I was involved in applied physics research, studying targets and flattening filters of high-energy linear accelerators used in cancer therapy, and later on I joined Dr John R. Cunningham's group at the Ontario Cancer Institute in Toronto to gain experience in clinical physics. Dr Johns received the Coolidge Award in 1976 and Dr Cunningham in 1988; thus, of the 35 Coolidge Awards given since 1972, three came to Canada and 32 were given to American medical physicists.

How is healthcare organized under the auspices of the renowned McGill University in Montreal where you have been working as director of the medical physics department in the McGill University Health Centre (MUHC) since 1979, as well as director of the Medical Physics Unit at McGill University since 1991?

The MUHC incorporates five McGill University teaching hospitals under one management organization and employs close to 10,000 people. The MUHC Medical Physics department provides clinical physics services to the hospital-based Radiation Oncology department, and the Medical Physics Unit is an academic entity at McGill University offering M Sc and Ph D degrees in Medical Physics.

Our clinical and academic medical physics services are integrated well, and the research carried out by staff and graduate students is of an applied nature. Often the research results are rapidly translated into clinical service that directly benefits patients. Our department is well known for the excellent collaboration between physicists and clinicians that resulted in many new cancer treatment techniques. Stereotactic radiosurgery is a good example. McGill University and Harvard University were the first North American institutions using radiosurgery based on clinical linear accelerators. Harvard used the so-called multiple converging arcs technique introduced a few years before in Buenos Aires, Vicenza and Heidelberg; McGill developed its own unique technique and called it dynamic stereotactic radiosurgery. We also introduced other techniques in radiotherapy treatment and radiation dosimetry, and this placed us on the forefront of medical physics in Canada as well as in North America in general.



The Coolidge plaque showing William D. Coolidge holding an x-ray tube based on his hot cathode design.

Ervin B. Podgorsak

You lectured on radiosurgery in Slovenia several years ago. What are the new developments in this accurate method for irradiation of brain tumors and vascular malformations located in critical brain areas not accessible by classical neurosurgery?

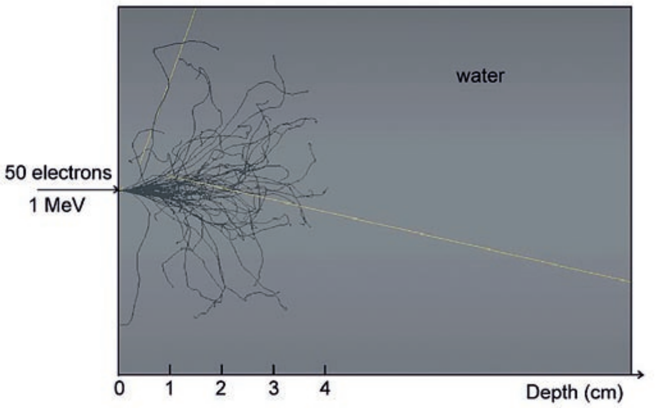
Radiosurgery combined with stereotaxy was developed in Sweden by neurosurgeon Lars Leksell in the early 1950s. Since then, three different types of beams were used for this purpose: protons from cyclotrons, gamma rays from so-called GammaKnives, and high-energy x rays from isocentric linacs. Proton radiosurgery started in the 1950s but proved costly and was practiced only in a few specialized centers around the world. It was supplanted first by the GammaKnife in the late 1960s and then by linac-based radiosurgery in the 1980s. We must note, however, that proton beams and even heavy charged particle beams are currently making a come back with several cyclotrons and synchrotrons being installed in major radiotherapy centers around the world for use in general radiotherapy, despite the relatively high installation and operating costs involved.

The GammaKnife incorporates 201 cobalt-60 sources producing 201 narrow gamma ray beams aimed at the machine isocenter. The machine is quite sophisticated technologically, but since it is dedicated solely to stereotactic radiosurgery, its purchase by standard radiotherapy or neurosurgery departments is difficult to justify. Nonetheless, the machine is commercially available and is installed in over 100 institutions around the world.

Over 20 years ago, it became apparent that the use of stereotactic frames and a few simple modifications to clinical isocentric linacs make linacs suitable for delivery of relatively inexpensive radiosurgical irradiation. Initially, the modifications consisted of special collimators that produced circular 1 cm to 4 cm diameter x-ray beams; subsequently specially designed miniature multileaf collimators (MLCs) were introduced. These developments made stereotactic radiosurgery widely available, and the technique is now considered a routine technique available in most major radiotherapy departments around the world. In comparison with the GammaKnife, the miniature MLC offers a simpler approach for accurate dose delivery to irregular targets within the brain as well as an option for intensity modulation, which is a recently introduced, exciting, linac-based radiotherapeutic technique.

Schematic diagram of the cobalt machine pictured on a Canadian stamp issued in 1988 by Canada Post in honour of Dr Harold E. Johns (1915–1997). (Photograph: Courtesy of the Canada Post Corporation. Reproduced with permission).

Dr Johns was a renowned Canadian medical physicist credited with the invention of the cobalt-60 teletherapy machine used for cancer therapy since the 1950s. Despite being eclipsed by the linear accelerator (linac) in the developed world, the cobalt machine is still the most important radiotherapy machine in developing countries due to its significantly lower capital, installation and operating costs as well as simpler operation in comparison with linacs.



An electron pencil beam consisting of 50 electrons with a kinetic energy of 1 MeV penetrates into a water phantom. The distribution of electrons is calculated with the EGS-nrc Monte Carlo code that traces the trajectories of individual incident electrons through their various Coulomb interactions with the orbital electrons and nuclei of the water molecules. Interactions of incident electrons with orbital electrons result in collision (ionization) losses of the incident electrons; interactions with nuclei result in scattering (change in direction of motion) and may also result in radiative (bremsstrahlung) losses. The jagged paths in the figure represent incident electron tracks in the water; the two straight traces represent two bremsstrahlung photons, both escaping the phantom. A careful observer will also be able to discern the tracks of secondary electrons (delta electrons) that are liberated in the water by the primary electrons and given sufficient kinetic energies to be able to ionize matter in their own right.

(Photograph: Courtesy of Jan P. Seuntjens, PhD, McGill University, Montréal. Reproduced with permission).

Monte Carlo simulations played an important role during the recent AAPM meeting in Orlando with many presentations devoted fully or partially to this subject. What is the relationship between the Monte Carlo method and radiotherapy physics?

Monte Carlo calculation is a statistical process, and its accuracy depends on the number of events included in the calculation. The larger the number, the better the accuracy of the calculation and, of course, the longer the calculation time. With the ever-increasing power and speed of computers, Monte Carlo techniques are becoming of practical importance in radiation dosimetry and in calculations of dose distributions in patients treated with x-rays, gamma rays or particle beams. While the current treatment planning techniques are based on a set of measurements carried out in water phantoms, practical Monte Carlo-based treatment planning algorithms that are currently under development in many research centers will base the calculations directly on data for a particular patient, thereby, in principle, significantly improving the accuracy of dose distribution calculations. Patient-specific Monte Carlo-based treatment planning systems are already commercially available; however, their routine implementation in radiotherapy clinics still hinges on many factors, such as: (1) adequate modeling of radiation sources; (2) solving several experimental problems involving tissue inhomogeneities; (3) answering many important clinical questions; (4) updating the dose calculation algorithms; and (5) improving the computing hardware. It is expected that in the near future incorporation of predictive biological models for tumor control and normal tissue complication into Monte Carlo-based dose calculation engines will form the standard approach to radiotherapy treatment planning.

In addition to the GammaKnife and isocentric linac-based radiosurgery, we should also mention two other linac-based techniques that can be used for radiosurgery: the CyberKnife and the TomoTherapy machine. Both are based on a miniature 6 MV linac waveguide, mounted on a robotic arm in the CyberKnife and in a CT-type gantry in the TomoTherapy machine. The two machines deliver accurate treatment without the use of a stereotactic frame and can be used for treatment of intracranial as well as extracranial lesions.

Medical physicists play an important role in the team of professionals delivering radiation to cancer patients. Would you briefly explain what medical physics is and what a medical physicist does?

Medical physics is a branch of phys-

Montréal General Hospital, the largest of the McGill teaching hospitals which form the McGill University Health Centre (MUHC). The hospital is located in downtown Montréal at the foot of Mont Royal, the mountain that gives Montréal its name.

ics concerned with the application of physics to medicine. It deals mainly, but not exclusively, with the use of ionizing radiation in diagnosis and treatment of human disease. In diagnostic procedures relatively low energy x-rays (diagnostic radiology) and gamma rays (nuclear medicine) are used; in therapeutic procedures most commonly high energy (megavoltage) x-rays and gamma rays or megavoltage electrons are used (radiation therapy also called radiation oncology or therapeutic radiology). During the past two decades medical physics has undergone a tremendous evolution, progressing from a branch of applied science on the fringes of physics into an important mainstream discipline that can now be placed on an equal footing with other more traditional branches of physics.

The study and use of ionizing radiation in medicine started with three important discoveries: x-rays by Wilhelm Roentgen in 1895, natural radioactivity by Henri Becquerel in 1896, and radium by Pierre and Marie Curie in 1898. Since then, ionizing radiation has played an important role in atomic and nuclear physics, and has provided the impetus for the development of radiology and radiotherapy as medical specialties and medical physics as a specialty of physics. The discovery of natural radioactivity triggered subsequent discoveries of artificial radioactivity by Frédéric and Irène Joliot in 1934 and nuclear fission by Otto Hahn, Fritz Strassmann, Lise Meitner, and Otto Frisch in 1939.

The potential benefit of x-ray use in medicine for imaging and treatment of cancer was recognized within a few weeks of Roentgen's discovery of x-rays. New medical specialties using radiology and radiotherapy evolved rapidly, both relying heavily on physicists for routine use of radiation as well as for development of new techniques and equipment. However, while radiology and radiotherapy have been recognized as medical professions since the early 1900s, medical physics achieved professional status only in the second half of the last century.

Initially most technological advances in the medical use of ionizing radiation were related to improvements in efficient x-ray beam delivery, development of analog imaging techniques, optimization of image quality with concurrent minimization of delivered dose, and an increase in beam energies for radiotherapy. During the past two decades, on the other hand, most developments in radiation medicine were related to the integration of computers in imaging, development of digital diagnostic imaging techniques, and incorporation of computers into therapeutic dose delivery with high-energy linear accelerators. Radiation dosimetry and treatment planning have also undergone tremendous advances in recent years: from development of new absolute and relative dosimetry techniques to improved theoretical understanding of basic radiation interactions with human tissue, and to introduction of Monte Carlo techniques in dose distribution calculations.

How does a medical physicist fit into the radiotherapy team and how is the team organized to gain the optimal treatment outcome for the patient?

It is well known that radiotherapy uses ionizing radiation to destroy cancerous cells. Essentially all malignant tumors can be eradicated with a large enough radiation dose; however, the problem associated with tumor dose delivery is in accessing tumors deep inside the body – a significant amount of radiation may be delivered to healthy tissues surrounding the tumor and this may result in acute or chronic complications and morbidity for the patient. The essence of radiotherapy, therefore, is to balance the tumor dose with the dose to healthy tissues, concurrently maximizing the tumor dose and minimizing the normal tissue dose. The higher the tumor dose, the higher the probability of tumor control; the lower the dose to surrounding healthy tissues, the lower the probability of normal tissue complications.

Accurate dose delivery to the tumor, of course, implies accurate imaging and target localization in three dimensions (3-D), as well as sophisticated treatment planning in 3-D in support

Isocentric linear accelerator (Varian, Trilogy) with an on-board imaging system for cone-beam CT. (Courtesy of Varian, Inc.)

TomoTherapy HiArt machine combining on-board imaging, patient positioning, 3-D treatment planning and dose delivery in a single system. (Courtesy of TomoTherapy, Inc.)

CyberKnife incorporating a miniature linac waveguide mounted on an industrial robotic arm for dose delivery and two orthogonal planar x-ray imaging systems for determination of target location. (Courtesy of Accuray, Inc.)

of the essential maxim of radiotherapy: "If you cannot see it, you cannot hit it; if you cannot hit it, you cannot cure it". To fulfill this basic principle effectively, the modern radiotherapy team consists of at least three professionals: radiation oncologist, medical physicist and radiotherapy technologist. The radiation oncologist determines the target volume, critical organs surrounding the tumor, and prescribes the total target dose and fractionation. The medical physicist is responsible for calibration of the radiotherapy equipment and calculation of the dose distribution in 3-D, as well as for ensuring that the radiation equipment is safe for the patient and staff. The radiotherapy technologist delivers the dose to the patient following the prescribed treatment plan, total dose and fractionation.

In addition to radiotherapy, medical physicists are also involved with medical imaging for general diagnosis of disease or specifically for target determination in radiotherapy. This imaging is carried out with: (1) relatively low-energy x-rays used in radiography, fluo-

TomoTherapy and CyberKnife sound like machines of the future, yet they are already commercially available. Could you briefly discuss these two futuristic machines and compare them to the standard linac?

The TomoTherapy machine was invented by Dr T. Rock Mackie and colleagues at the University of Wisconsin and uses a miniature 6 MV linac waveguide mounted on a CT-type gantry ring, allowing the linac waveguide to rotate around the patient. Beam collimation is accomplished with a computer-controlled multileaf collimator (MLC), also mounted on the rotating gantry. The MLC has two sets of interlaced leaves that rapidly move in and out of the beam to constantly modulate the intensity of the radiation beam as the waveguide rotates around the patient. During treatment, the table advances the patient through the gantry bore so that the radiation dose is delivered in a helical geometry covering the full target volume. The system is designed to obtain a megavoltage CT scan of the patient's anatomy at any time before, during or after treatment. The CT data are used for calculating the intensity of beam modulation that will result in an optimized dose distribution inside and outside the target volume and also provide an option for image guidance of the actual treatment. This image guidance allows fine adjustment of the patient's position at every treatment fraction to ensure that the dose distribution is delivered to the target volume precisely as planned.

The CyberKnife was developed as an innovative tool for frameless intracranial stereotactic radiosurgery, but its use has recently been expanded to treatment of extracranial targets. The machine delivers the dose with a miniature linac mounted on an industrial robotic arm, a combination that offers excellent spatial accuracy in dose delivery and allows a great deal of flexibility in directing the beam toward the target. Owing to its on-line planar target imaging and automatic adjustment of the radiation beam direction to compensate for target motion, the CyberKnife provides a frameless alternative to conventional radiosurgical procedures. The location of the target is pre-determined through a family of axial CT images that serve as a base for the determination of a set of digitally reconstructed radiograph images. During treatment, a set of paired orthogonal x-ray imagers determines the location of the lesion in the treatment room coordinate system and communicates these coordinates to the robotic arm, which adjusts the pointing of the linac beam to maintain alignment with the target and provides veritable image-guided dose delivery to the patient.

The TomoTherapy and CyberKnife machines are very sophisticated and cannot be used to replace standard teletherapy machines in routine treatments. They are, however, very suitable for treating certain types of tumors and complement well the standard armamentarium available in larger radiotherapy centers.

roscopy and computed tomography (CT) scanning; (2) ultrasound; (3) nuclear magnetic resonance in magnetic resonance imaging (MRI); (4) gamma rays in gamma cameras and single photon emission computed tomography (SPECT); and (5) positron annihilation in positron emission tomography (PET). The majority of medical physicists currently work in radiotherapy; however, many newly graduated medical physicists now enter positions related to work with modern diagnostic imaging equipment such as CT, MRI, and PET.

How does one protect the patient and staff from the hazards posed by ionizing radiation?

Soon after the discovery of x-rays and natural radioactivity it became apparent that ionizing radiation was not only useful for the diagnosis and treatment of disease but also harmful to human tissue. Two scientific disciplines evolved from the study of the effects of ionizing radiation on biological tissues: radiobiology combining radiation physics and biology and health physics concentrating on the study of radiation hazards and radiation protection.

When biological cells are exposed to ionizing radiation, the standard physical effects between radiation and the atoms and molecules of the cells occur first and the possible biological damage follows later. The biological effects of radiation result mainly from damage to the DNA, which is the most critical target within the cell; however, there are also other cites in the cell that, when damaged, may lead to cell death.

The effects of radiation on the human population can be classified as either somatic or genetic. Somatic effects are harm that exposed individuals suffer during their lifetime, such as radiation- induced cancers (carcinogenesis), sterility, opacification of the eye (cataract) and life shortening. Genetic effects manifest themselves as radiation-induced mutations to an individual's genes and DNA that can contribute to the birth of defective offspring.

The harmful effects of radiation are also classified into two general categories: stochastic and deterministic. A stochastic effect is one in which the probability of occurrence increases with increasing doses, but the severity in affected individuals does not depend on the dose (carcinogenesis and genetic effects). There is no threshold dose for stochastic effects because these effects arise in single cells and it is assumed that there is always some small probability of the event occurring even at very small doses. A deterministic effect is one that increases in severity with increasing doses, usually above a threshold dose, in affected individuals (organ dysfunction, cataract formation).

From left: son Gregor, grandson Anthony, grandson Alex, wife Mariana, granddaughter Kimberly, Ervin, son Matjaz and his wife Kristine.

It is obvious that ionizing radiation, despite its proven beneficial use in the diagnosis and treatment of human disease, must be used diligently and with care because of its potential for causing deleterious effects even at very low doses. Before any diagnostic or therapeutic procedure involving ionizing radiation is used on a patient, it must be established that the potential diagnostic and therapeutic gains outweigh the small, but not negligible, radiation risk associated with the procedure. As far as staff is concerned, strict national and international rules must be followed when installing, operating or servicing radiation emitting devices to ensure that staff exposure does not exceed prescribed limits.

What are the most notable recent developments in radiotherapy?

There is no doubt that the introduction of the CT-simulator and virtual simulation into radiotherapy services over a decade ago has triggered a greatly improved method for target definition and acquisition of patient data. This enabled reliable 3-D dose distribution calculations, a decrease of target margins and concurrent escalation of prescribed doses, all of which improved the outcome of cancer treatment with ionizing radiation. New treatment techniques, such as intensity-modulated radiotherapy (IMRT), have been developed on isocentric linacs equipped with multileaf collimators, and new machines, such as the CyberKnife and TomoTherapy, were introduced to allow unconventional dose delivery.

The IMRT technique is an advanced form of conformal radiotherapy with the objective of conforming the dose distribution to the shape of the target volume and resulting in increased tumor control probability and decreased normal tissue complication probability. The accuracy of dose delivery with the new techniques has been limited by uncertainty in target localization at the time of treatment. Interfraction as well as intrafraction target movement relative to reference landmarks coupled with set-up errors and other inaccuracies add to this uncertainty. The standard approach has been to add margins to the target volume, but this is done at the expense of most of the potential benefits of the more precise delivery techniques.

It has recently become possible to image patient anatomy just before delivery of a fraction of radiotherapy, thus gaining precise knowledge of the location of the target volume on a daily basis. This incorporation of imaging with dose delivery to the patient is known as image-guided radiotherapy (IGRT) and has the potential of ensuring that the relative positions of the target volume and the reference point for each treatment fraction are the same as in the treatment plan. IGRT thus allows reduced treatment margins, fewer treatment complications, dose escalation and the avoidance of geographical treatment misses.

Several IGRT systems are currently commercially available, all of them allowing pre-treatment imaging immediately after a patient is positioned on the linac treatment table for radiotherapy. Most notable of these are: (1) a kilovoltage or megavoltage imaging system integrated with an isocentric linac, referred to as cone-beam CT, (2) megavoltage CT with the TomoTherapy machine, and (3) on-line imaging with paired orthogonal planar imagers used in conjunction with the CyberKnife.

The next step in the full implementation of the IGRT is the concept of adaptive radiotherapy (ART) to correct for: (1) the interfraction changes in target volumes to account for tumor shrinkage, patient's loss of weight or increased hypoxia occurring during the course of fractionated treatment, as well as (2) the intrafraction motion of the target to compensate for the effects of respiratory motion during the treatment. To account for organ motion during treatment, 4-D imaging technology is required, allowing the viewing of volumetric CT images changing over the fourth dimension, time.

With your own example, you presented the education and training required for entering the medical physics profession and you also alluded to the shortage of medical physicists. What would be of general interest in this regard from your Canadian and American experience?

Today's sophistication of modern medical physics and the complexity of the technologies applied to diagnosis and treatment of human disease by radiation demand a stringent approach to becoming a member of the medical physics profession. Currently, the most common path to a career in medical physics is an academic progression through a BSc degree in one of the physical sciences, but preferably in physics, to a MSc degree in medical physics and then to a PhD degree in medical physics from an accredited program in medical physics. The minimum academic requirement for a practicing medical physicist is a MSc degree in medical physics, and this level is adequate for physicists who are mainly interested in clinical and service responsibilities. However, medical physicists working in academic environments should possess a PhD degree in medical physics.

Academic training alone does not make a medical physicist. In addition to academic training, practical experience with medical problems and equipment is essential, and this may be acquired through on-the-job clinical training or, preferably, through a structured two-year traineeship, also referred to as an internship or residency program in a hospital, after graduation with a MSc or PhD degree in medical physics.

Many graduate programs are now available to an aspiring medical physicist, and progression through the three educational steps (undergraduate BSc degree in physics, graduate degree in medical physics and residency in medical physics) is feasible, albeit still somewhat difficult to follow in practice because of the relatively small number of accredited academic and residency programs in medical physics. The number of these programs is growing, however. We are now in a transition period, and within a decade, progression through the three steps will become mandatory for physicists entering the medical physics profession. The sooner broad-based didactic and clinical training through accredited educational programs in medical physics becomes the norm, the better it will be for the medical physics profession and for the patients the profession serves. In North America there is currently a shortage of newly trained medical physicists. The current output of accredited medical physics academic programs meets about 75% of the actual needs, while the accredited residency programs fare much worse, meeting only about 20% of the needs.

In connection with the education and training of medical physicists, I am pleased to see that the Physics Department of the University of Ljubljana is seriously planning to introduce an MSc program in medical physics. The general conditions for introducing this option are favorable, because the Physics Department, in collaboration with the Jozef Stefan Institute of Ljubljana and the Institute of Oncology of Ljubljana, has excellent equipment and qualified staff to allow the setting up of a world-class graduate program in medical physics. Of course, if the program aspires to attract foreign students, the lectures will have to be conducted in English. I have already seen the preliminary program, and I believe that within a few years the program should be able to acquire accreditation and a ranking among the leading medical physics programs around the world. Božo Casar and Vlado Robar, medical physicists from the Oncology Institute of Ljubljana, have already spent some time in our center in Montreal and Mr Robar received his MSc degree in medical physics from McGill University. In relation to contacts with Slovenian colleagues, I should add that a young Slovenian medical physicist, Dr Robert Jeraj, has a position as Assistant Professor at the University of Wisconsin in Madison. It would make a lot of sense to attract him back to Slovenia, since he could play a very important role in the nascent academic medical physics program to be introduced at the University of Ljubljana.

President of the AAPM Dr Russell Ritenour (left) and Ervin Podgoršak.

From your description of the medical physics profession I note that medical physicists are employed either by hospitals or medical schools, or hold joint appointments on the clinical as well as academic staff. This implies that the medical physics profession is influenced strongly by the healthcare model applied in a given country. How is healthcare organized in Canada and the U.S.?

The professional life of medical physicists is intimately related to the vagaries of healthcare management by governments and private organizations. Canadian and American healthcare standards are well respected around the world, yet in recent years it is becoming apparent that North American healthcare systems are not immune to the ills plaguing the healthcare systems of other developed countries.

There are three basic indicators upon which any healthcare system is evaluated: quality, accessibility and cost. In terms of quality and standards, it is safe to say that the healthcare systems in Canada and the U.S. are among the best in the world; however, in terms of accessibility and cost, the healthcare systems of both countries are in serious trouble. Actually, in comparison with the OECD healthcare indicators, Canada and the U.S. are below average on a number of specific and important indicators.

You mentioned the OECD. What role does the OECD play in healthcare?

OECD is an acronym for the Organization of Economic Cooperation and Development, an international organization of 30 countries that subscribe to the principles of market economy, pluralist democracy and respect for human rights. Its head office is in Paris, France, and its main contribution to modern societies is in providing a forum for comparing developmental indicators of individual member states and in coordinating, in a non-binding manner, domestic and international policies. The OECD group consists of countries from Western and Far Eastern democracies, as well as Turkey and several former Soviet bloc countries. Slovenia clearly meets all membership criteria, applied for membership in 1996, and is likely to be admitted in 2007. The OECD plays an important role in healthcare by issuing comparative statistics on the health status of member states' populations as well as on healthcare indicators for all member states.

It is surprising to hear that North American healthcare systems are in serious trouble. Why is this so?

The main problems with the Canadian and American healthcare systems are in their accessibility and sustainability. The two countries have similar social and economic systems, similar living standards and similar healthcare standards, but they differ significantly in the organization and funding of healthcare. Both countries use a mixture of private and public funding for medical services; however, the public share in Canada is at 70%, while in the U.S. it is only at 45%, allowing us to describe the Canadian healthcare system as publicly administered and the U.S. system as private medicine. Healthcare systems in both countries are relatively expensive: Canada spends 10% of its gross national product (GNP) on healthcare, compared to an 8.6% average for the OECD countries; however, several other countries, at 11% of GNP, rank above Canada, and the U.S. is in a league of its own at 15%.

The U.S. clearly leads Canada in availability of high-technology equipment and in timely access to healthcare, at least for the 85% of the U.S. population that subscribes to private medical insurance offered through employment or is ensured publicly through special programs for the aged or poor. On the other hand, in the U.S. some 45 million people (15% of the total population) have no health insurance and thus their access to healthcare is curtailed significantly. In contrast, all legal residents of Canada are covered through the nationalized healthcare system financed by the Federal and Provincial governments through general tax revenues. In comparison to the U.S., the Canadian public administration of healthcare delivery is more socially just and equitable as well as less expensive to administer; the administrative cost of the U.S. healthcare system stands at 25% of the total healthcare cost, compared to 12% in Canada. On the other hand, public administration in Canada is marred by chronic budgetary deficits, resulting in staff and equipment shortages, decreased productivity and waiting lists for non-emergency medical procedures.

Are there any useful lessons learned from the North American experience that can be translated to Slovenia?

In comparison to healthcare systems of economic powerhouses such as the United States and Canada, the Slovenian healthcare system is in reasonably good shape. On several healthcare indicators, such as the infant mortality rate, obesity rate and relative number of physicians, Slovenia is actually doing better than North America, and on most indicators it is close to the OECD average. Similarly to Canada, Slovenia is below the OECD average in availability of high-technology equipment, but this is to a degree understandable, since per capita expenditures for healthcare in Slovenia are only about 40% of those in Canada, and yet the price of high-technology equipment for Slovenian institutions is the same as that for an American or Canadian institution. Healthcare in Slovenia is financed through a payroll tax rate of 13.5% that covers 78% of total healthcare costs. Co-payments for many items in the mandatory package and voluntary supplementary insurance cover the private component of 22%.

Many interest groups and governments promote privatization as a solution to problems with healthcare costs and accessibility, yet it is not logical to surmise that a healthcare system run with a profit motive will be cheaper than an efficiently run public system. The U.S. private healthcare model clearly shows that privatization leads to inequity and high administrative costs. On the other hand, the basic principles of the Canadian healthcare system, enunciated in the Canada Health Act, can serve as a good role model for a nationalized healthcare system, since Canadian federal law prohibits co-payments as well as private coverage of publicly funded services. Unfortunately, during the past few years difficulties with public funding resulted in "creeping privatization" in Canada and the governments' reluctance to rigorously uphold the Canada Health Act.

Slovenia, with its small and socially conscious population, has an opportunity to develop its own healthcare system without the pitfalls of privatization. Health should not be treated as an ordinary commodity; like education, universal and timely access to good quality healthcare, regardless of citizens' ability to pay, should be a basic right of citizenship. This can only be achieved through an adequately funded, publicly administered and efficiently run nationalized healthcare system.

TABLE: A comparison of the Canadian, American and Slovenian healthcare systems with the OECD average. Data are from OECD: "Health at a Glance" and from "National Report on Health Care and Long-term Care in the Republic of Slovenia", June 2005.

	Canada	United States	Slovenia	OECD average
Health care cost as % of GNP	10	15	8.6	8.6
Health care cost per capita (USD)	3003	5635	1370	2307
Public share of total cost (%)	70	45	78	72
Physicians per 1000 population	2.1	2.3	2.5	2.9
Life expectancy at birth (years)	79.7	77.2	76.7	78.2
Infant mortality per 1000 live births	5.4	7.0	3.8	4.8
Population aged 65 years and over (%)	12.5	12.5	15	14