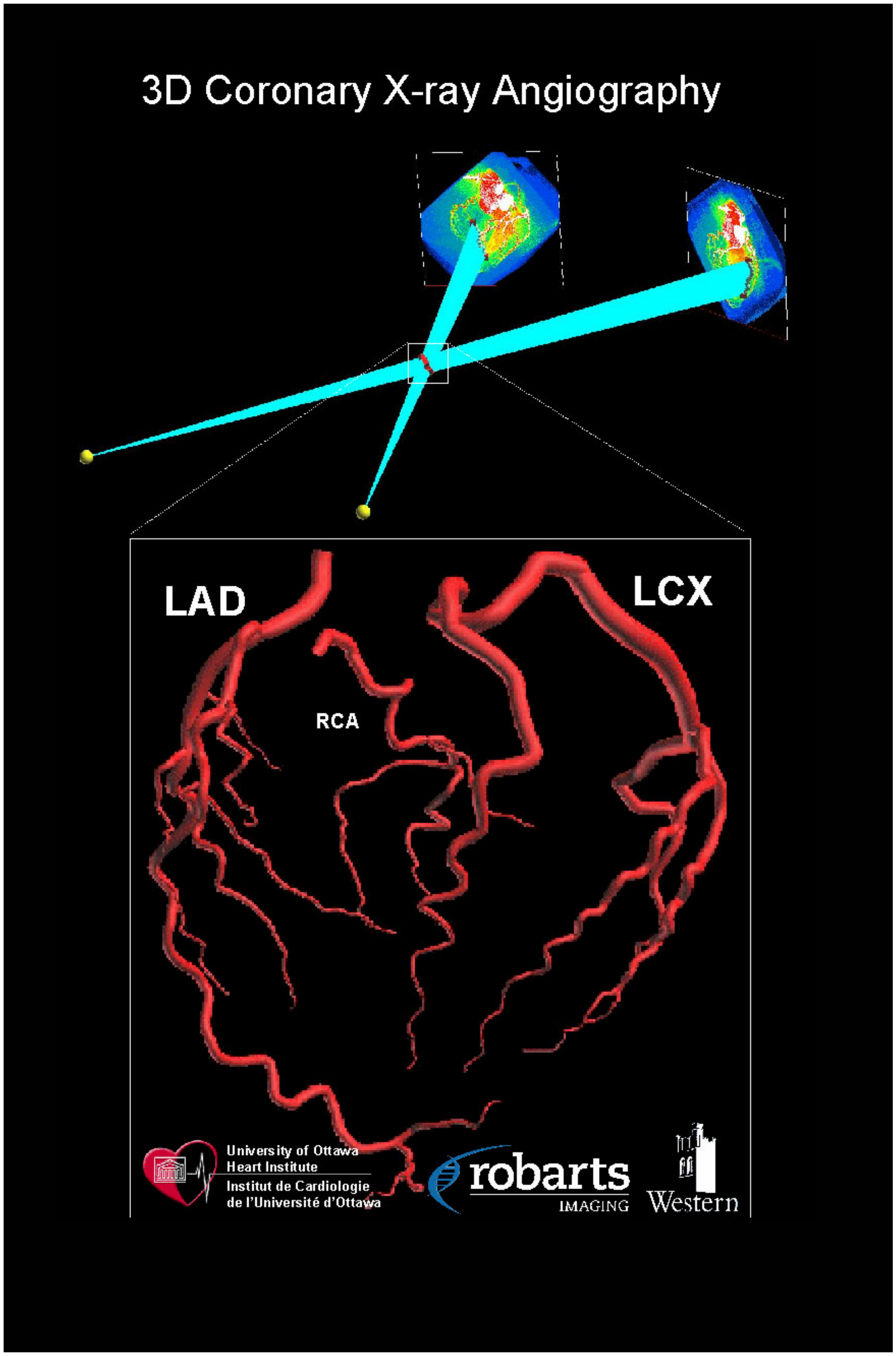
InterACTIONS

CANADIAN MEDICAL PHYSICS NEWSLETTER
Le BULLETIN CANADIEN de PHYSIQUE MÉDICALE



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CANADIAN COLLEGE OF PHYSICISTS IN MEDICINE
LE COLLÈGE CANADIEN DES PHYSICIENS EN MÉDECINE

49 (2) avril/April 2003

About our Cover

Three-dimensional coronary arteries (top) reconstructed from arbitrary single-plane angiograms (bottom). The three main arteries and distal branches are visualized in this heart with 'left-dominant' coronary circulation: left anterior descending (LAD), left circumflex (LCA) and right coronary artery (RCA). This 3D coronary tree was reconstructed using software developed through the University of Ottawa Heart Institute, and is based on simulated angiograms using a CRA cardiac image volume from the Robarts Research Institute. These developments are part of a multi-site research project entitled *Fusion of 3D Coronary Anatomy with Myocardial Imaging*, sponsored by the **Ontario Consortium for Cardiac Imaging**. The project is a collaboration between the University of Ottawa Heart Institute (Robert deKemp, Terry Ruddy, Kevin Sprague), the Robarts Research Institute (Maria Drangova, Terry Peters, Glen Lehmann), and the University of Western Ontario (Piotr Slomka, Usaf Aladl).

Images provided by Rob deKemp

The Canadian Medical Physics Newsletter, which is a publication of the Canadian Organization of Medical Physicists (COMP) and the Canadian College of Physicists in Medicine (CCPM) is published four times per year on 1 Jan., 1 April, 1 July, and 1 Oct. The deadline for submissions is one month before the publication date. Enquiries, story ideas, article submissions can be made to:

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Please submit stories in Publisher 98, Word 6.0, Word 97, or ASCII text format. Hardcopy submissions will be scanned to generate an electronic document for inclusion in the Newsletter. Images in Tiff format at 300 dpi resolution are preferred. Advertising and corporate enquiries can be made to:

Michael Henry
Email: henry@abellshenry.com
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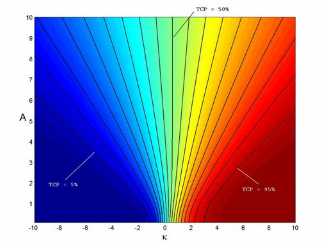

Inside this issue:

Message from the COMP Chair:

We are still looking for individuals who want to get involved with the organization. Replacements for the Chairs of the Communications Committee and the Professional Affairs Committee are presently being sought.

When you read this message, most of the planning for our Annual Scientific Meeting will be completed. Our new abstract submission process got its first real test. Except for a few difficulties with the file conversion of certain documents, everything went well. This service was provided by the AAPM and we were able to use all of the features that had been developed for the 2000 World Congress in Chicago to streamline the development of the scientific program for the meeting. These features will reduce considerably the amount of work required by the Conference Committee. Many people worked hard to set up these features for the February 3 deadline. I would like to thank the Conference Committee and, especially Sherry Connors and Michael Kolios, for all their help. Also, our thanks to the AAPM IT Director, Michael Woodward, and his staff for completing the setup of the system on time. Our Annual Meeting is promising to be a stimulating and informative meeting. We have several interesting sessions planned. Not surprisingly, tomotherapy will be an important topic during the meeting. The new installations of CBIAR (Centre for Biological Imaging and Adaptive Radiotherapy) will also be at the forefront. A tour of the facility will be organised. For those planning to attend, a reminder that the deadline for early registration is May 1, 2003. Registration information is available on our website. I hope many of you will be able to join us in Edmonton. Now, let's just hope that Mother Nature does her bit to make this a successful meeting!

As was done for the 2001 Meeting, we will be applying to CAMPEP for Continuing Education Credits for our meeting. This process should be made simpler this year since this is the second time we apply. I remind the attendees that the forms must be filled out in order for you to receive your credits. They will be available at the meeting and must be filled out for each session you attend. A reminder that CAMPEP points can be used when applying for CCPM recertification.

One item we could not get ready for this year's meeting was the online payment of the registration fees. Our new Treasurer, Horacio Patrocinio, is working on a solution to this problem that he will present to the Executive at our June Meeting. I am confident that we can have a working system in place in the near future.

On January 21, I had the pleasure of meeting with Ms. Claudette Bradshaw, Minister of Labour, to discuss various issues facing our profession such as licensure, professional recruitment and training, research funding and capital investments. Ms. Bradshaw

showed vivid interest in our issues and recommended that we continue raising the profile of our profession. I would like to thank Michael Henry, our Executive Director, for preparing briefing notes for the meeting. As you can imagine, when meeting with politicians, the more prepared you can be the better your points will get across. Our next step is to try to coordinate a meeting with the Minister of Health.

Following our last InterActions, David Wilkins, Chair of the Professional Affairs Committee, has sent to all members information on liability insurance and the arrangement he was able to negotiate with Aon Reed Stenhouse Inc.. Every day, medical physicists place themselves in a position of potential liability should an error in treatment occur. Although we have reasonable expectation of being shielded from liability by our employers, it is important for us to know to what extend we would be covered if a liability issue were to arise. However, the proposal from Aon would guaranty coverage in all situations. For those of us who act as private consultants, liability coverage should be considered seriously.

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Message from the CCPM President:

At last year's AGM, the members present requested the CCPM Board to construct a cohesive vision for both Membership and Fellowship. In this edition of InterACTIONS, you will find two pages of proposed ***Bylaw changes*** for consideration and voting at the AGM in Edmonton. These proposals are being made after careful consideration

of the substantial number of responses to two membership polls on the subject last fall and, if passed, would, in the opinion of the Board, contribute to strengthening the profession of Medical Physics in Canada. As these proposals address three separate issues, commensurate changes to the Appendices were found to be too complex to address prior to the vote on the Bylaws. In focusing only on the Bylaws for the Edmonton meeting, our aim is to optimise clarity and ensure that the vote is taken on the concepts.

The focus of the CCPM at this time of year is the ***Membership examination***, undoubtedly the most important function of our organisation. This year 27 candidates will have sat the examination by the time you read this, a relatively high number in an organisation with a total membership of 179 and clearly indicative of the high esteem with which this certification is held. The Board of the CCPM constantly strives to ensure that the certification process is transparent, credible and responsive to the changing needs of the profession. For those of you unfamiliar with the process, I will give an outline of the work done by the various members who volunteer to participate.

After the application deadline is reached, the Registrar and two other Fellows (together called a Credentials Committee) review the material submitted by each applicant to determine whether or not the applicant meets the eligibility criteria. All relevant material must be sent to the members of the committee and the review completed within a 2 week period so that the candidates can be notified that their application to sit the examination has been approved. This year 30 candidates were assessed, representing a large body of work to be done in a short time by a few volunteers. The Examination Committee, led by the Chief Examiner, is another group of volunteers who review and update the examination booklet on an annual basis, and help to set and mark the completed papers. This group must include the appropriate expertise in all sub-specialties where there are candidates. A third group of volunteers is available for an independent evaluation of any marginal papers. Yet another group of volunteers must also be identified to invigilate the examination on the nominated Saturday. Clearly this examination represents considerable effort on the part of ***many volunteers***, the majority of whom are anonymous, and all of whom have demanding day jobs to contend with at the same time. I would like to take this opportunity to recognise their efforts and thank them. If you are called upon to help by an officer of the CCPM, please be assured that your efforts are highly valued.

In focusing only on the Bylaws for the Edmonton meeting, our aim is to optimise clarity and ensure that the vote is taken on the concepts.

We are also looking to rationalise our work with the adoption of some electronic cost-cutting measures. The applications are currently submitted by surface mail and there were some difficulties this year due to a single digit error in the postal code of the Registrar quoted on the application form. Maybe we can require the applications to be submitted electronically in the future. The examination booklets are sent out to the invigilators by courier. All completed papers are first copied to provide insurance against loss, and then couriered back to the Chief Examiner who sends the reshuffled material out for marking. It has been suggested that we consider moving to an ***electronic format for our written examination*** as many comparable organisations have already done. Although an electronic format would be helpful to those candidates who find writing difficult, it may be a challenge to those with slower computer skills. Also, it is still difficult to imagine a process for

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Message from the Executive Director of COMP/CCPM

The proposed National Post-Secondary Education Act would establish a set of national principles for post-secondary education and provide some predictability of federal funding ...

Medical Physicists in Canada work in both academic and clinical settings. Academic freedom and the resources to conduct research, to develop new technology, to enhance best practices, to train more medical physicists, as well as to develop new clinical techniques are fundamental to the practice.

A significant amount of medical physics research in Canada is conducted in public institutions – in our hospitals, universities, and research centres. Increasingly, the private sector is playing a complementary leadership role in research and development.

The 2003 Federal Budget brought good news for researchers. In addition to $34.8 billion increase in health care contributions from the federal government to the provinces over the next five years, the budget allocated $1.5 billion for new medical equipment. It is likely that this funding will be leveraged with contributions from the provinces. As medical physicists well know, capital development and replacement are essential to the continued provision of high quality health services.

Medical Physics relies largely on research granting agency support, coupled with academic institutional support for research dollars. The federal government plays a role in fostering research and innovation, but is a secondary to the provinces as a player in post-secondary education and research. Education, like health, is under provincial jurisdiction, although the federal government provides significant funding for both.

The federal government's involvement in health is carried out under the framework of the Canada Health Act. The Act re-inforces provincial jurisdiction over the provision of health services sets the conditions for federal government involvement. It also provides the federal government with the power to provide funding to the provinces for carrying out its responsibilities and with conditions for receiving funding. The Act provides the federal government with remedies if, in its view, a province does not adhere to the terms of the Act.

When it comes to the federal government's involvement in post-secondary education and research, the framework is less clear. While education is a provincial responsibility, the federal government has played a significant role, both in providing transfers of funds to the provinces and for direct intervention through granting agencies such as NSERC and the CIHR. However, this involvement has been growing in the absence of an overall legislative framework.

The Canadian Association of University

Teachers (CAUT) has long advocated for a "National Post-Secondary Education Act" and in recent years has intensified efforts to convince the federal government to enact such legislation. The Act would establish a set of national principles for post-secondary education and provide some predictability of federal funding and assurance that the provinces follow a set of common standards and principles when accepting federal government dollars.

The Act would provide a framework for a new funding arrangement to replace the Canada Health and Social Transfer (since the 2003 budget, known as the Canada Health transfer and the Canada Social Transfer).

There is solid rationale supporting the CAUT's proposed Act. It would provide a national framework and common standards for the use of federal dollars in post-secondary education. A long term federal commitment to the research granting agencies in this context would be a logical next step.

If you would like more information about the proposed National Post-Secondary Education Act, visit the CAUT website at http://

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49th Annual Scientific Meeting of COMP and CCPM Symposium

June 5-7, 2003

Edmonton, Alberta

The Canadian Organization of Medical Physicists and the Canadian College of Physicists in Medicine are pleased to invite you to Edmonton, AB for our 49th Annual Scientific Meeting. Our Local Arrangements Committee is hard at work and has planned a wonderful nightout. Details are available on the COMP website (www.medphys.ca).

Early-registration:

The Early-registration began on February 3, 2003 and ends on May 1, 2003. Information and instructions on how to register will be posted on the COMP website.

Please visit the COMP website for all details on registration and abstract submission.

IMPORTANT DATES:

May 1, 2003	- End of Early-registration
June 5-7, 2003	- COMP Meeting

HAROLD JOHNS TRAVEL AWARD

The Board of the Canadian College of Physicists in Medicine is pleased to honour the Founding President of the College by means of the Harold Johns Travel Award for Young Investigators. This award, which is in the amount of $1500, is made to a College member under the age of 35 who became a member within the previous three years. The award is intended to assist the individual to extend his or her knowledge by traveling to another centre or institution with the intent of gaining further experience in his or her chosen field, or, alternately, to embark on a new field of endeavour in medical physics.

Further information can be obtained from:

BOURSE de VOYAGE HAROLD JOHNS

Le Conseil du Collège Canadien des Physiciens en Médecine est heureux d'honorer son président fondateur en offrant aux jeunes chercheurs la bourse Harold Johns. Cette bourse, d'une valeur de $1500, est éligible aux membres du Collège agés de moins de 35 ans at qui sont membres depuis moins de trois an. La bourse a pour but d'aider le récipiendaire à parfaire ses connaissances dans son domaine ou à démarrer dans un nouveau champ d'activités reliées à la physique médicale, en lui permettant de voyager vers un autre centre spécialisé.

Les demandes seront addressées à:

Dr. Christopher Thompson
The Registrar / Le Resistraire
CCPM
c/o Montreal Neurological Institute
McGill University
3801 University, WB3
Montreal, Quebec, H3A 2B4

The deadline for applications for the next award is **May 1, 2003**. The award will be announced at the 2003 CCPM Annual General Meeting in Edmonton.

La date limite pour les demandes du prochain concours est le **1er mai 2003**. Le récipiendaire de la bourse sera annoncé à la rencontre annuelle de 2003 du CCPM à Edmonton

Past recipients:

Récipiendaire anterieur:

1990 Dr. L. John Schreiner, Montreal
1991 Ms. Moira Lumley, Kingston
1992 Dr. Donald Robinson, Edmonton
1993 Dr. Yunping Zhu, Toronto
1994 Dr. Brendan McClean, Edmonton
1995 Dr. George Mawko, Halifax
1996 M. Alain Gauvin, Montreal
1997 Dr. Katherina Sixel, Toronto
1998 Mr. Horacio Patrocinio, Montreal
1999 Mr. Craig Beckett, Regina
2000 No recipient
2001 No recipient
2002 No recipient

Members of the COMP and/or CCPM can make a donation to the fund by volunteering to increase their 2003 membership dues.

Les membres du COMP et\ou OCPM peuvent faire un don à la cotisation de 2003 un montant additionel de leur choix.

CADRE DES FONCTIONS DES PHYSICIENS MÉDICAUX QUALIFIÉS DANS LES CENTRES CANADIENS DE RADIOTHÉRAPIE

CADRE DES FONCTIONS DES PHYSICIENS MÉDICAUX QUALIFIÉS DANS LES CENTRES CANADIENS DE RADIOTHÉRAPIE

Ce document a été préparé par le Comité des affaires professionnelles de l'Organisation canadienne des physiciens médicaux (OCPM) et du Collège canadien des physiciens en médecine (CCPM).

30 novembre 2002

I. INTRODUCTION

Les physiciens médicaux sont des professionnels des soins de santé ayant reçu une formation spécialisée dans l'application médicale de la physique. Leur travail requiert l'utilisation d'agents physiques, dont les rayons X, les matières radioactives, les ultrasons, les champs magnétiques et électriques, les rayons infrarouges et ultraviolets, ainsi que les rayons calorifiques et laser, pour l'établissement de diagnostics et l'administration d'une thérapie. La plupart des physiciens médicaux travaillent dans des centres de traitement du cancer, dans des services hospitaliers de visualisation diagnostique ou dans des établissements de recherche en milieu hospitalier. Les autres œuvrent au sein d'universités, du gouvernement et de l'industrie.

Le présent document décrit le cadre des fonctions des physiciens médicaux qualifiés à l'œuvre dans les centres canadiens de radiothérapie (autrement appelés physiciens en radiothérapie). L'Organisation canadienne des physiciens médicaux (OCPM) a émis un énoncé sur ce qui constitue comme tel un physicien médical qualifié.

« L'Organisation canadienne des physiciens médicaux considère que l'accréditation par l'une ou plusieurs des organisations suivantes constitue la preuve d'une compétence avérée en physique médicale :

a) le Collège canadien des physiciens en médecine,
b) l'American Board of Radiology et
c) l'American Board of Medical Physics.

*Une accréditation dans une sous-spécialité de la physique médicale ne signifie pas qu'il y ait compétence dans d'autres sous-spécialités. On s'attend à ce que les physiciens médicaux respectent le code de déontologie du COMP et du CCPM. » (*www.medphys.ca/info/reports/ethics.cfm).

II. DESCRIPTION GÉNÉRALE DE LA PHYSIQUE MÉDICALE EN RADIOTHÉRAPIE

A. Service clinique

Les physiciens médicaux sont principalement responsables de l'exactitude du traitement de radiothérapie administré. Les fonctions du physicien en radiothérapie comprennent la planification des traitements et la conception de l'équipement de radiothérapie, la caractérisation, l'acceptation, la mise à l'essai, l'étalonnage et le dépannage (voir aussi « The Role and Function of Medical Physicists in Canadian Cancer Therapy Centres », *Interactions* **44**(4) : 133, oct. 1998).

B. Sécurité en matière de rayonnements

Les physiciens médicaux sont compétents en matière de sécurité contre les rayonnements. La réglementation canadienne reconnaît les physiciens médicaux qui sont accrédités par le Collège canadien des physiciens en médecine à titre d'officiers de la radioprotection dans les installations médicales qui utilisent des appareils émetteurs de rayonnements et des matières radioactives.

C. Recherche et développement

Au Canada, les physiciens en radiothérapie jouent un rôle central dans des domaines tels que la conception et la construction d'équipements de traitement de radiothérapie, l'utilisation des rayons calorifiques et laser pour le traitement du cancer, la théorie de l'absorption de rayonnements, ainsi que le calcul des doses et la radiobiologie. Les laboratoires canadiens sont les chefs de file aux chapitres de la tomographie par émission de positrons, de l'imagerie par résonance magnétique, des ultrasons, de l'imagerie radiologique et radio-isotopique, et de la cartographie biomagnétique, entre autres domaines.

D. Enseignement

La plupart des physiciens médicaux canadiens ont une affiliation à une université. Plusieurs d'entre eux enseignent la physique médicale et œuvrent au sein de programmes de physique à tous les cycles universitaires. Ils enseignement également la radiologie et la radio-oncologie aux médecins résidents, aux étudiants en médecine ainsi qu'aux technologues en radiologie, en radiothérapie et en médecine nucléaire.

E. Statut professionnel

Au Canada, la majorité des physiciens médicaux sont membres de l'Organisation canadienne des physiciens médicaux (OCPM, www.medphys.ca). L'OCPM promeut l'application de la physique à la médecine par le biais de rencontres entre scientifiques, de publications techniques, de programmes

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éducatifs et par l'élaboration de normes professionnelles. L'OCPM a établi des liens avec des organismes de physique médicale d'autres pays par l'entremise de l'International Organization of Medical Physics. L'OCPM comptait quelque 400 membres en 2002.

La plupart des physiciens médicaux cliniciens sont aussi accrédités par le Collège canadien des physiciens en médecine (CCPM), qui a été créé en 1979 afin de reconnaître une compétence avérée en physique appliquée à la médecine. Les candidats qui possèdent un niveau de scolarité et une expérience satisfaisants deviennent membres du Collège en subissant avec succès un examen écrit. Le CCPM comptait 87 membres et 107 membres associés en 2002. L'accréditation du CCPM devient largement acceptée au Canada, dans d'autres pays et dans plusieurs provinces, où elle constitue soit une exigence d'emploi, soit une possibilité d'avancement professionnel. Chaque année, le CCPM soutient l'enseignement supérieur professionnel en parrainant des colloques sur des sujets spécialisés, en plus d'offrir une bourse de séjour à l'étranger à l'un de ses jeunes membres, en mémoire d'Harold E. Johns.

F. Emploi des physiciens médicaux au Canada

Approximativement 75 p. cent des physiciens médicaux canadiens travaillent dans des centres de traitement du cancer, des hôpitaux et des centres de recherche en milieu hospitalier, 7 p. cent pour le gouvernement, 8 p. cent pour l'industrie et 10 p. cent au sein de facultés universitaires qui ne sont pas situées en milieu hospitalier. Le nombre de postes en physique médicale augmente généralement de 5 à 10 p. cent par année.

Même si la physique médicale est un champ diversifié, la plupart des physiciens médicaux au Canada travaillent au sein du service clinique de l'un des 37 centres canadiens de radiothérapie. Le présent document porte essentiellement sur le cadre des fonctions des physiciens qualifiés en radiothérapie.

III. FORMATION DES PHYSICIENS MÉDICAUX

Au Canada, tous les physiciens en radiothérapie détiennent au moins un diplôme de second cycle en physique médicale, en physique ou dans une discipline connexe, les deux tiers étant titulaires d'un diplôme de doctorat. Ces études sont suivies d'une période d'environ deux ans de résidence clinique ou de formation en cours d'emploi dans un centre de radiothérapie. Dans certaines provinces, la fin de la résidence est marquée par une récapitulation officielle et un examen oral. Après deux années de pratique clinique, le physicien médical est admissible à une demande d'adhésion au CCPM, après avoir réussi deux examens, oral et écrit. Le mandat principal du CCPM est d'accréditer ses membres en tant que physiciens médicaux compétents.

Les physiciens médicaux accrédités sont tenus de participer à un programme d'éducation continue et de démontrer le maintien permanent de leur compétence tous les cinq ans, par le biais du processus de renouvellement d'accréditation du CCPM. Un système de notation fondé sur la participation du physicien médical accrédité à des conférences, à des cours, à des activités de recherche et d'enseignement, et au perfectionnement de techniques cliniques garantit que ce dernier se tient au courant de l'évolution rapide de la profession.

La profession de physicien médical possède un mécanisme d'accréditation des programmes d'enseignement supérieur et de résidence en physique médicale qu'il soumet au programme de vérification de la Commission on Accreditation of Medical Physics Education Programs (www.campep.org). Le milieu canadien de la physique médicale appuie ce processus d'accréditation, le CCPM étant une organisation qui parraine officiellement la CAMPEP (avec l'American Association of Physicists in Medicine, l'American College of Medical Physics et l'American College of Radiology). Deux membres du CCPM font partie du conseil d'administration de la CAMPEP.

IV. COMPÉTENCE ET EXPERTISE DES PHYSICIENS MÉDICAUX

Les physiciens médicaux disposent, plus que toute autre professionnel, de connaissances très précises sur tous les aspects du processus de la préparation et de l'administration d'un traitement de radiothérapie, dont l'imagerie médicale, la planification des traitements, le calcul des doses, l'immobilisation des patients, les mécanismes d'exploitation des appareils de traitement, les interactions entre les radiations et la matière, ainsi que la réaction biologique des cellules et des tissus aux rayonnements ionisants. La nature complexe de la radiothérapie moderne exige que le processus soit supervisé par un professionnel qui saisit bien à la fois la situation dans son ensemble et les détails techniques. Parce qu'ils ont reçu un enseignement qui met l'accent sur une compréhension fondamentale de la science de base et sur la résolution de problèmes, les physiciens médicaux sont particulièrement bien formés pour jouer ce double rôle.

Lorsque des difficultés surviennent en radiothérapie, que ce soit en raison de la complexité d'un cas, d'un fonctionnement défectueux ou d'un bris d'équipement, de problèmes de communications informatiques, d'anomalies touchant les logiciels ou encore d'erreurs humaines, les physiciens médicaux sont mis à contribution pour mettre en pratique leur savoir-faire et leurs capacités de résolution de problèmes afin de corriger la situation. Les physiciens médicaux sont les personnes-ressources qui,

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dans un programme de radiothérapie, font autorité sur les plans technique et scientifique.

La physique médicale étant un champ en évolution, les domaines de compétence particuliers se transformeront avec les nouveaux développements touchant la science fondamentale et la technologie de la radiothérapie. En même temps, les physiciens médicaux en radiothérapie ont une expertise, entre autres dans les domaines suivants :

A. Sélection de l'équipement

Le physicien médical doit avoir une connaissance active des développements récents des équipements de radiothérapie, fournir une évaluation critique des prétentions du fabricant, recommander la sélection du meilleur équipement de façon à satisfaire aux exigences des programmes en tenant compte des ressources disponibles, négocier certains détails techniques avec les fabricants et préciser le rendement souhaité de l'équipement dans les documents d'achat.

B. Conception et protection des installations

Les équipements de radiothérapie modernes ont des exigences complexes ayant trait aux infrastructures et à la sécurité. Lors de l'installation d'un nouvel équipement, le physicien médical doit voir à ce que l'alimentation électrique, la ventilation, la régulation climatique, la surveillance et la protection radiologiques soient appropriées de façon à protéger le personnel et le public en général, et veiller à la mise en place de verrouillages de sécurité et de systèmes de surveillance audio et vidéo des patients, etc. Des plans doivent être soumis aux organismes de réglementation appropriés pour approbation, et des mesures de rayonnement détaillées doivent être prises par le physicien médical en vue de vérifier la conception et la construction des blindages.

C. Essai de réception

À la suite de l'installation d'un nouvel équipement de radiothérapie, le physicien médical a la responsabilité d'effectuer une série de tests et de mesures pour vérifier si le rendement de cet équipement satisfait aux exigences de l'achat.

D. Mise en service

Les physiciens médicaux effectuent des mesures précises visant à caractériser complètement l'exploitation de l'équipement de radiothérapie. Les données sont traitées et compilées de manière appropriée pour permettre l'utilisation clinique courante de l'équipement.

E. Systèmes de planification des traitements

Des systèmes informatiques de pointe sont utilisés pour modéliser l'administration de traitements de radiothérapie, afin de prévoir avec exactitude la dose administrée au cours du traitement et d'aider à optimiser le traitement prévu. Il incombe au physicien médical de comprendre les algorithmes utilisés par les systèmes de planification des traitements, d'enquêter sur leurs lacunes et de les documenter, d'alimenter les logiciels en données valides, de vérifier l'exactitude des calculs, de former et de superviser le personnel technique utilisant des systèmes de planification de traitements, d'exécuter les fonctions d'administration des systèmes et d'intégrer les systèmes informatisés de planification aux autres systèmes utilisés en radiothérapie, tels les systèmes d'imagerie et les systèmes d'enregistrement et de verification des traitements.

F. Imagerie

La radiothérapie dépend fortement de l'information provenant de la formation d'images à des fins médicales, pour poser des diagnostics sur les affections cancéreuses, les classifier par stade et planifier des traitements. Le tomodensitomètre (TDM), l'imagerie par résonance magnétique (IRM), la fluoroscopie, la radioscopie sur film et digitale, la médecine nucléaire, l'angiographie par soustraction digitale, la tomographie par émission de positrons (TEP) et d'autres modes d'imagerie sont couramment utilisés. Les physiciens médicaux possèdent des compétences particulières en physique et dans la technologie associée à ces techniques de formation d'images, de façon à en faire un usage optimal et approprié en radiothérapie.

G. Systèmes informatiques et réseautique

La radiothérapie moderne mise sur le transfert de grandes quantités d'information entre un assortiment de logiciels commerciaux fonctionnant sur une variété de plateformes matérielles, tels les systèmes de planification, d'enregistrement et de vérification des traitements, les systèmes de stockage, de transport et d'affichage d'images dans l'hôpital (PACS) et les logiciels personnalisés écrits à la demande d'un établissement, par des physiciens et des programmeurs. Les physiciens médicaux, qui travaillent souvent avec des employés de soutien des systèmes informatiques, agissent à titre d'administrateurs de ces mêmes systèmes, veillant au transfert exact des données entre les plateformes et à l'utilisation précise des appareils de traitement sous contrôle programmé.

H. Dosimétrie absolue

L'étalonnage des équipements de radiothérapie et des sources radioactives est effectué par des physiciens

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médicaux à l'aide d'appareils de mesure précis, dont l'étalonnage peut être retrouvé aux laboratoires nationaux de normes de mesure. Les physiciens médicaux ont une expertise dans la mesure des rayonnements ionisants et une connaissance courante des derniers protocoles de mesure recommandés par les laboratoires de normes et les organismes nationaux du secteur de la physique médicale.

I. Assurance de la qualité

Les physiciens médicaux établissent et maintiennent des programmes permanents d'assurance de la qualité touchant tous les aspects de la planification en radiothérapie, de l'administration du traitement et du rendement de l'équipement. Avant le début d'un traitement, un physicien médical exécute ordinairement un examen d'assurance de la qualité (ou une « vérification du dossier ») du traitement prévu, afin de s'assurer que le traitement proposé est sûr, approprié et optimal pour le patient.

J. Planification de traitement

Les aspects techniques de la planification de traitements sont sous la supervision des physiciens médicaux. Les radio-oncologues, les dosimétristes et les technologues consultent quotidiennement les physiciens médicaux sur les stratégies de traitement et les détails s'y rapportant. En outre, le traitement des cas inhabituels ou complexes est souvent planifié par les physiciens médicaux.

K. Sécurité en matière de rayonnements

Les physiciens médicaux sont tenus d'assurer la sécurité du personnel et des patients contre les rayonnements. Dans la plupart des centres de traitement du cancer, c'est un physicien médical qualifié qui agit en tant qu'officier de radioprotection de l'établissement. Les programmes de radioprotection comprennent la demande de délivrance de tous les permis touchant les installations de radiothérapie et leur surveillance, l'établissement et la supervision d'un programme de dosimétrie à l'intention du personnel, la surveillance des niveaux de radiation à l'aide de relevés et d'essais de contamination par frottis, la conception des installations de radiothérapie (blindage, stockage des isotopes, etc.), la formation du personnel en radioprotection, la surveillance de l'inventaire des matières radioactives, l'acquisition et l'élimination des sources, l'évaluation de tous les incidents radiologiques et la communication de ces incidents aux organismes de réglementation appropriés, ainsi que le respect des exigences relatives aux permis.

L. Mise au point de techniques

Les méthodes de radiothérapie évoluent continuellement en raison des nouvelles capacités techniques et d'une meilleure compréhension du traitement du cancer. La mise au point, l'évaluation et la mise en œuvre clinique des nouvelles techniques de radiothérapie font partie du travail courant des physiciens médicaux.

M. Radiobiologie

Les modèles décrivant la réaction des tumeurs et des tissus normaux à la radiothérapie reposent sur des calculs mathématiques compliqués, et ils sont mieux compris par les physiciens ayant reçu une formation sur les effets biologiques des rayonnements ainsi qu'en statistique et en modélisation. Les physiciens médicaux sont mis fréquemment à contribution pour effectuer des calculs fondés sur ces modèles afin d'évaluer des éléments tels que l'équivalence des doses des divers schémas de fractionnement de radiothérapie et la meilleure façon de compenser les interruptions de traitements en radiothérapie.

N. Enseignement et recherche

Il est courant que les physiciens médicaux enseignent aux étudiants de tous les cycles en physique et en physique médicale, aux médecins résidents en radio-oncologie et aux technologues en radiothérapie. Plusieurs physiciens sont nommés à des postes universitaires, gèrent des bourses de recherche, présentent les résultats de leur recherche dans le cadre de conférences scientifiques ou médicales ou bien les publient dans des revues scientifiques approuvées par des collègues.

V. OBLIGATION DE RENDRE COMPTE DES PHYSICIENS MÉDICAUX

Le physicien médical est avant tout responsable devant le patient, et cette responsabilité consiste à lui fournir le meilleur traitement possible avec la technologie et les ressources disponibles, et avec l'expertise de l'équipe de radiothérapie. Les doses thérapeutiques de rayonnements ionisants peuvent être prescrites uniquement par un médecin disposant d'une formation et d'une expérience appropriées. Il incombe au physicien médical de veiller à ce que la radiothérapie soit administrée avec exactitude et de manière sûre et efficace. En assumant cette responsabilité, le physicien médical répond devant le patient, le médecin qui a prescrit le traitement et les autres membres de l'équipe de radiothérapie, le public et les organismes de réglementation, telle la Commission canadienne de sûreté nucléaire, qui ont le mandat légiféré de protéger le public et l'environnement des effets délétères des rayonnements ionisants. De plus, le physicien médical accrédité répond devant le CCPM, qui, en vertu de ses règlements internes, dispose d'un mécanisme permettant de révoquer une adhésion au Collège pour manquement à respecter le code déontologique du COMP et du CCPM (www.medphys.ca/info/reports/ethics.cfm).

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Le service de physique médicale d'un centre de traitement du cancer d'un hôpital relève normalement du programme de radiothérapie, et les physiciens médicaux doivent d'ordinaire rendre compte devant le chef du service de physique, lui-même un physicien médical. Au sein d'une structure organisationnelle courante, le chef du service rend compte devant le chef du programme de radiothérapie pour les questions relatives au service clinique, devant le directeur général du centre de traitement du cancer pour les questions touchant la radioprotection et devant le directeur du département universitaire affilié ou le directeur général du centre de traitement du cancer pour les questions relatives au programme médical universitaire.

VI. ENGAGEMENT À L'ÉGARD DE L'ASSURANCE DE LA QUALITÉ

L'assurance de la qualité est extrêmement importante en radiothérapie. La seule façon de veiller à ce que le traitement de radiothérapie soit réellement administré tel que prescrit consiste à établir un programme routinier et complet de mesures physiques détaillées. Les physiciens médicaux sont responsables de l'élaboration, de la mise en place et du maintien des programmes d'assurance de la qualité visant à s'assurer que la radiothérapie est administrée de façon sûre et efficace. Les critères de ces programmes d'AQ ont été définis par des physiciens médicaux. par l'entremise d'organismes telles que l'Organisation canadienne des physiciens médicaux, l'American Association of Physicists in Medicine, la Commission canadienne de sûreté nucléaire et la Commission de protection contre les rayons X de l'Ontario. Il incombe aux physiciens médicaux de connaître et de comprendre les exigences et la raison d'être des programmes d'AQ recommandés ou autorisés par ces organismes, de mettre en œuvre et de maintenir ces programmes afin d'assurer l'administration exacte d'une radiothérapie, qui soit sûre pour le patient, le personnel et le public.

VII. LES PHYSICIENS MÉDICAUX ATTÉNUENT LE RISQUE POTENTIEL

Les risques potentiels pour la santé découlant d'une exposition aux rayonnements ionisants ont été bien documentés et comprennent les dommages aux tissus, la carcinogenèse et la mutagenèse. Les bienfaits attendus de l'administration thérapeutique des rayonnements ionisants doivent l'emporter sur le risque potentiel qu'ils représentent pour le patient, et il est de la responsabilité commune du physicien médical et du radio-oncologue que le rapport entre les avantages et les risques puisse justifier la thérapie.

En plus des risques associés aux rayonnements, les équipements de radiothérapie modernes constituent des risques potentiels pour le patient et le personnel, en raison des systèmes électriques à voltage élevé, du mouvement automatique de l'équipement, des émissions électromagnétiques et d'une possible exposition à des matières dangereuses. Il incombe au physicien médical de veiller à ce que ces risques soient évalués et gérés, et à ce que les programmes d'assurance de la qualité soient en place afin de vérifier le fonctionnement exact et sûr des appareils de radiothérapie.

L'utilisation de rayonnements ionisants à des fins thérapeutiques pose aussi des risques éventuels pour le personnel des établissements de soins de santé et pour le public en général. Les physiciens médicaux sont spécialement formés et accrédités en radioprotection et sont responsables de la gestion du programme de radioprotection. Ce programme est mandaté par la Commission canadienne de la sûreté nucléaire et comprend la conception et la vérification du blindage des installations, la surveillance des doses reçues par le personnel, les essais de contamination par frottis et la vérification de l'inventaire des sources radioactives ainsi que l'éducation du personnel.

VIII. LA PHYSIQUE MÉDICALE EST FONDÉE SUR LES RÉSULTATS CLINIQUES ET SCIENTIFIQUES

Les physiciens médicaux sont titulaires de diplômes d'enseignement supérieur décernés par des universités reconnues et sont formés à la méthodologie de la recherche scientifique. Le champ de la physique médicale a évolué grâce à un siècle de recherche et de développement scientifiques pour atteindre un niveau de connaissance tel que la radiothérapie peut être administrée avec une exactitude impressionante. Une culture de la recherche rigoureuse en physique médicale, un souci rigoureux du détail, une communication ouverte des résultats de recherche dans le cadre de conférences scientifiques et de revues approuvées par les pairs, et une participation active aux activités des associations nationales et internationales ont contribué à maintenir la radiothérapie sur des fondements scientifiques solides et basés sur des résultats.

Les avancées survenant dans le domaine de la physique médicale sont publiées dans des revues scientifiques approuvées par les pairs, telles la *Medical Physics* et la *Physics in Medicine and Biology* (les revues scientifiques officielles de l'OCPM et du CCPM), l'*International Journal of Radiation Oncology, Biology and Physics* (la revue scientifique officielle de l'American Society of Therapeutic Radiation Oncology (ASTRO) et le *Journal of Applied Clinical Medical Physics* (la revue scientifique officielle de l'American College of Medical Physics). En outre, l'OCPM publie un bulletin trimestriel intitulé *Interactions* (ISSN 1488-6839) qui s'adresse au milieu canadien de la physique médicale. Ces publications, de

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même que certaines conférences telles les rencontres scientifiques annuelles de l'OCPM, de l'AAPM et de l'ASTRO, et d'autres rencontres régionales comme le WESCAN et l'Atlantic Medical Physics Group, sont les principales tribunes où sont communiqués les résultats et les développements des recherches, de même que les nouvelles pratiques de la physique en radiothérapie.

IX. LE MILIEU DE TRAVAIL ET LA CULTURE DES PHYSICIENS MÉDICAUX

Les physiciens en radiothérapie sont employés dans l'un des quelque 37 centres de radiothérapie établis un peu partout au pays pour les patients externes. Dans la plupart des provinces, ces centres font partie d'un organisme provincial de lutte contre le cancer et sont rattachés à un hôpital hôte, qui est habituellement un hôpital d'enseignement de soins tertiaires. Les services de physique médicale emploient d'un à 15 physiciens médicaux (les normes de dotation en personnel recommandent l'embauche d'environ un physicien médical par 300 séries de radiothérapie dispensées annuellement), en plus de dosimétristes, de technologues de l'électronique, d'assistants en physique, de technologues mécaniciens, du personnel de soutien en informatique, de secrétaires, d'étudiants et de titulaires de bourses de recherche postdoctorale. Un ou plus d'un physicien médical remplit la fonction de chef de service, en plus d'autres rôles liés à l'administration, à la supervision et à la direction. Les physiciens médicaux travaillent avec les membres de leur service ainsi qu'avec les radio-oncologues, les radiologistes et autres spécialistes médicaux, les technologues en radiothérapie et les infirmiers ou infirmières, en vue d'assurer la meilleure thérapie possible aux patients.

Les physiciens médicaux contribuent au programme de radiothérapie clinique en assumant la responsabilité générale des aspects techniques des traitements et de l'exactitude des doses de rayonnements administrées. La mise au point et l'application de nouvelles techniques de radiothérapie constituent une part importante du rôle du physicien médical, et, en conséquence, la plupart d'entre eux participent à des programmes de recherche et/ou de développement. Il est courant que les physiciens médicaux soient titulaires d'un poste universitaire, soit à une faculté de médecine, où ils enseignent aux médecins résidents en radio oncologie, ou au département de physique, où ils dispensent des cours à des étudiants en physique de tous les cycles et supervisent les étudiants de deuxième et de troisième cycle. Au nombre des autres tâches universitaires, mentionnons l'enseignement aux étudiants en technologie de la radiothérapie et la supervision des projets de recherche de ces derniers, ainsi que la supervision des étudiants qui occupent un emploi d'été ou participant à un programme d'alternance travail-études, l'enseignement aux médecins résidents en radio-oncologie ou aux résidents en physique médicale, en plus de dispenser un enseignement en service aux autres membres de l'équipe de radiothérapie. L'importance de la composante universitaire des fonctions du physicien médical varie d'un établissement à l'autre, mais elle est fortement encouragée par le biais du processus de renouvellement d'accréditation du CCPM, qui accorde des points pour la rédaction d'articles dans des revues approuvées par les pairs, pour l'enseignement et pour la présence à des conférences. La participation à des conférences scientifiques est largement reconnue comme un moyen exceptionnel de communiquer les résultats de recherche et de se tenir au courant des récents développements en ce domaine.

Les physiciens médicaux travaillent dans un environnement fondé sur le savoir, au sein d'une équipe dont l'objectif est l'administration de soins de qualité aux patients. La nature hautement technologique et en évolution rapide de la radiothérapie moderne exige une intégration des connaissances dans divers domaines tels que la médecine, la physiologie, l'anatomie, la physique des rayonnements, les soins aux malades, les mathématiques, les statistiques, l'électronique, la programmation informatique et la réseautique, la mécanique, la biologie des rayonnements, l'imagerie médicale et la radioprotection. Alors que les membres de l'équipe de radiothérapie sont des experts dans des domaines différents, c'est le physicien médical qui comble le fossé entre ces divers secteurs et qui fournit une continuité sous la forme d'une compréhension scientifique fondamentale du processus radiothérapeutique, d'une approche systématique du dépannage et d'une résolution créative de problèmes.

X. RESPONSABILITÉ LÉGALE ET ASSURANCES EN PHYSIQUE MÉDICALE

En dépit du contrôle rigoureux de la qualité et de multiples vérifications indépendantes, et étant donné la nature complexe de la radiothérapie moderne, il se peut que l'administration d'un traitement soit erronée. En acceptant la responsabilité de l'exactitude des doses de rayonnement administrées, les physiciens médicaux se placent dans une situation d'obligation potentielle si jamais une erreur survenait au cours du traitement. En tant qu'employés de centres de traitement du cancer, les physiciens médicaux qui pratiquent dans le cadre de leur emploi et agissent au mieux des intérêts de leurs employeurs s'attendent raisonnablement à être protégés de cette responsabilité par ces derniers. Tout physicien médical agissant en tant qu'expert-conseil privé ou qui est

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travailleur autonome doit avoir une assurance responsabilité pour se prémunir contre le risque, peu probable, que l'administration erronée d'un traitement fasse qu'une action en justice soit introduite contre lui. Un régime d'assurance erreurs et omissions est offert aux physiciens médicaux par le biais de l'Organisation canadienne des physiciens médicaux.

XI. RÉGLEMENTATION DES PHYSICIENS MÉDICAUX

Actuellement, la physique médicale n'est pas une profession réglementée au Canada, au sens où aucune législation fédérale ou provinciale ne définit le terme « physicien médical » ou ne restreint son usage à des personnes dotées de compétences particulières. Les physiciens médicaux ne sont visés par la loi réglementant les professions médicales d'aucune province et ne sont pas non plus cités en tant que tels ni dans la Loi sur la sûreté et la réglementation nucléaires du gouvernement fédéral ni dans ses règlements. Les efforts déployés par le milieu canadien de la physique médicale en vue d'obtenir un statut réglementaire et une reconnaissance ont échoué en raison du faible nombre de physiciens médicaux pratiquant au Canada. Aux États-Unis, les États de New York, de Floride et du Texas sont en voie de promulguer un droit exclusif d'exercice, ou l'ont déjà fait, à l'intention des physiciens médicaux. La législation de ces États définit la pratique de la physique médicale, restreint cette pratique aux physiciens autorisés et établit les compétences nécessaires à l'obtention d'un permis. Au cours des prochaines années, les physiciens médicaux canadiens ont l'intention de demander qu'on légifère sur un semblable permis d'exercer.

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Finally, with the Scope of Practice for Medical Physicists in Radiation Therapy Centres now completed, the Professional Affairs Committee will be looking for individuals who would be interested in writing an equivalent document for Diagnostic Physics. These types of documents are important in establishing our responsibilities with respect to other professions. Any diagnostic physicist interested in participating in drafting such a scope of practice can contact me, or the Chair of the PAC, for more information.

We are still looking for individuals who want to get involved with the organization. Replacements for the Chairs of the Communications Committee and the Professional Affairs Committee are presently being sought. Information on these positions can be obtained from any member of the Executive. Please feel free to contact us if you are interested or if you would like more information.

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drawing graphs and diagrams electronically, so the questions would have to be restructured to address the issues adequately in an electronic format. Please give us your feedback on this issue if you have some thoughts or suggestions.

The Board has recently published a document describing the standards used in the Membership and Fellowship examinations. The aim of this document, which is available from the web site, is to increase awareness within the community of the criteria used by the examination committee to construct and assess applicants. It has recently been suggested that we also publish a ***list of competencies*** to be obtained, a suggestion which will be considered at a future Board meeting. Clearly compiling such a comprehensive list for each of the sub-specialties would require considerable effort. If you feel that this would be useful, please let us know.

Other topics, we are seeking a ***volunteer*** to represent us on the ***General Assembly of Accreditation Sponsors*** of the ***Canadian Medical Association***. We have several physicists who have participated in accreditation reviews under the auspices of the CMA and found the experience to be rewarding. I think we all agree that participation in this activity is vital. We have one representative on the General Assembly and ***Michael Evans*** has done sterling service for the past 6 years. Although he has enjoyed the experience, he would be happy to pass on this responsibility. Please contact him if you are interested for more information.

Brenda Clark

Executive Director of COMP/CCPM (Continued from page 46)

www.caut.ca/english/issues/funding/
I will keep COMP and CCPM members posted on developments with this proposal.

This June, we will meet in Edmonton for the Annual Meeting. Sherry Connors and the LAC in Edmonton have been hard at work preparing for the meetings. Many thanks to Sherry and her committee for their continued hard work.

I look forward to seeing you in Edmonton!

Michael Henry
Executive Director
COMP/CCPM

Clinical radiobiology, early and late responding tissues, and hypofractionation for prostate cancer

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Introduction

The manner by which dose prescription and fractionation in radiotherapy are determined has evolved considerably since the first uses of ionizing radiation in the treatment of cancer. Today, total doses and fractionation schemes have been tweaked continuously for the better part of the last century and the results are fairly uniform protocols of dose delivery that have been adapted by most radiotherapy centers. In external beam teletherapy, most curable cancers are treated with a series of small fractions, typically about 2 Gy, up to the prescription dose, which is specifically chosen for each disease. Brachytherapy, on the other hand, has traditionally been given in single fractions, but at a greatly reduced dose rate than would be used in teletherapy. Conventional wisdom dictates that administering the dose in small fractions, or low dose rate, can give the same biological effect on the tumor, which is to kill all its cells, while minimizing undesirable side effects to the healthy tissue. Why then do small fraction sizes or low dose rates have this effect? Is there a biophysical reasoning, and if so are current fractionation methods the best way to treat all cancers?

From a physical viewpoint, identical cure rates and complications should occur whether treating a patient with a single fraction of dose or with multiple fractions whose sum is equal. The physical dose from individual fractions is additive, and there is no reason that the multiple fractions would be any different than a single fraction. From a biological viewpoint, however, there can be a world of difference. Using ionizing radiation, cells are killed, not by an overbearing force that attacks the entire cell, but rather by small, strategic lesions that attack highly sensitive "targets" within the cell. It is widely believed that chromosomal aberrations are the leading cause of cell death due to ionizing radiation. If the ionizing radiation can cause damage to molecular DNA that is important enough to lead to a chromosomal aberration, when the cell attempts to replicate at division (mitosis), the division will fail, and the cell dies. The way dose is delivered in time is important because lesion formation and the cell's response to the lesions are dynamic processes.

The linear quadratic model

The linear quadratic model is the most widely used model of cell survival. This success is largely due to the differentiation of two processes that lead to cell death: death by non-repairable lesions, and death by repairable lesions. The essence of the linear quadratic model is that to a first order approximation, these two processes can be described using two fixed proportionality constants, which are the well-known α and β parameters. The amount of non-repairable damage should be proportional to the number of lesions formed, which in turn should be proportional to the dose. The contribution of cell death that is due to repairable lesions is more complicated since some time dynamics are involved. If we first consider the maximum number of lesion interactions that are possible, then this will be proportional to the number of repairable lesions formed raised to the power of 2, since there is a probability that each repairable lesion can interact with each other. The maximum number of repairable lesion exchanges (as they are called) is thus proportional to the dose squared, which we write βD^2. However, these lesions are repairable by definition, so if the dose rate is low, such that there is enough time for these minor lesions, or sub-lethal lesions, to repair themselves before another lesion is formed, the amount of cell killing that is due to the repairable lesions will be reduced. In the complete linear quadratic model a factor is introduced which is called the Lea-Catcheside dose protraction factor, and denoted *G*. It depends on the time of irradiation, and the repair constant of the irradiated cells. This factor can be thought of as the ratio of repairable exchanges that would occur in the presence and absence of repair, and so it is constrained to be between zero and unity. The linear quadratic model says that, to a first order approximation, the number of lethal lesions that will be induced in the cell as a function of dose will be $\alpha D + G(\mu, T)\beta D^2$, where μ is the rate constant for exponential repair and T is the time of irradiation. To transform this to a cell survival probability, we assume that this is a stochastic process; that the number of targets in the cell is large; and that the probability a target site will be transformed into a lesion is small. With these assumptions, the resulting distribution of lesions should follow Poisson statistics, and the probability that the cell survives, which happens only if there are no lethal lesions induced, is:

$$S = exp[-\alpha D - G(\mu, T)\beta D^2] \qquad (1)$$

The linear quadratic model uses only two concepts, or mechanisms of cell death: lesions that directly lead to cell death regardless of repair, and exchange of repairable lesions that also leads to cell death. Critics of the linear quadratic model contend that this is too simple a view of a considerably complicated process. In physics, however, good theories are ones that minimize the complexity of the approach while maximizing the predictive ability of the method. The most important concept of the linear quadratic model is that of the relative importance of the two processes that lead to cell death. Ignoring the G function, the relative number of lethal lesions to lethal exchanges is $\alpha/\beta D$, if we multiply this dimensionless quantity by the dose administered, the resulting quantity, the α/β ratio represents the dose where the two processes that lead to cell death have equal importance.

Tissues that have a high α/β ratio are tissues where the exchange of repairable lesions plays a low role in cell death, most cell death is due to the non-repairable, α-type lesions. For tissues with a low α/β ratio, repair plays a more important role at lower dose, and so the dose per fraction is important since larger fraction doses increase the number of lethal exchanges

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quadratically. Mathematically, this can be seen if we re-write the survival equation in a more useful form. For fractionated exposure to cells, with the dose per fraction equal to *d*, and the total dose equal to *D*, the survival is:

$$S = \exp\left(-\alpha D\left[1+\frac{d}{\alpha/\beta}\right]\right) \qquad (2)$$

In this form, it is clear how the dose per fraction and the α/β ratio relate with one another. When the α/β ratio is large as compared to *d*, the term in the square brackets of Eq. 2 will be close to one, and the survival will depend much more strongly on the total dose than on the dose per fraction. However, if the dose per fraction is of the same order as the α/β ratio, then the survival will depend not only on the total dose D, but also on the fraction size, *d*.

The linear quadratic model, using only two key concepts, that of repairable and unrepairable lesion formation, can be used predict how different tissues should respond to different fractionation schemes. Normally this would not be of great interest if it were not for a biological effect that is still poorly understood: *the α/β ratio seems to be proportional to the time required for cells to divide and cycle.*

Tissues that have a short cell cycle are those that replicate quickly; for instance skin, mucosa, and most tumors, and these tissues typically have an α/β ratio of 10 Gy. Tissues that have a long cell cycle are tissues that are not readily dividing; for instance brain tissue, spinal cord, lung, and kidney, and these tissues typically have an α/β ratio of 3 Gy. This leads to common phrases in radiobiology: "early responding tissues" and "late responding tissues". There is a cell cycle time dependence of the interval between irradiation and observable cellular response, such as the ability to form colonies in a petrie dish, or by some clinically observable change, such as reddening or moist desquamation of the skin, reduced lung capacity, or paralysis. Cells that cycle quickly show the damage "early", while cells that are slowly cycling show their effect "late", as the effect manifests itself when the cell attempts to divide. Tissues that cycle quickly tend to have a high α/β ratio; in radiotherapy the most important tissue of this type is the tumor. Tissues that cycle slowly are typically the tissues that we want to protect in radiotherapy: the spinal cord, the lungs, kidneys, and these all tend to have a low α/β ratio.

Prostate Cancer

Prostate cancer is atypical of many cancers since this disease evolves more slowly than many other types of cancer. A study of PSA at Toronto-Sunnybrook showed that for low risk patients, the mean PSA doubling time for 134 patients was 5.1 years, with one-third of the patients having a PSA doubling time of greater than 10 years[1]. The PSA doubling time is not equal to the tumor doubling time, but it is thought to be proportional. The best estimates of prostate cancer cell doubling times put this figure between 16 to 61 days[2]. Following the discussion of early and late responding tissue, and knowing that prostate cancer is less aggressive than most cancers, several authors have recently suggested that the α/β ratio for prostate cancer may be significantly lower than the typical value of 10 Gy that is often used to characterize tumors[3,4,2]. The important idea in this suggestion is not that the α/β value for prostate cancer may be atypical of other cancers, it is that the difference between the fraction size dependence of prostate cancer and that of late responding normal tissues may be less than it is for other cancers. Prostate cancer is treated in 2 Gy fractions, not due to specific experience with prostate cancer itself, but as a result of all experiences in radiotherapy, where the large differential in fraction size dependence between the tumor and the normal tissue has lead radiation oncologists to use small dose per fractions to preferentially spare late responding normal tissue. If the α/β ratio for prostate cancer is closer to that of the normal tissue we want to protect, then the biological justification for small fraction sizes disappears, which suggests larger fraction sizes may be used. This would have an obvious economic advantage since larger dose per fraction would lead to a reduced workload for prostate cancer.

Methods to determine the α/β value for prostate cancer

Accurate determination of the prostate a/b ratio is crucial if hypofractionation is to be considered seriously for prostate cancer. The value of 1.5 Gy was first suggested by Brenner[3], and has been corroborated by King[5], and Fowler[6], and again by Brenner[7]. The value is somewhat surprising, because it suggests that prostate cancer has an α/β ratio even lower than most late responding normal tissues. Traditionally, the α/β value has been determined by means of a cell survival experiment. These measurements on prostate cancer cell lines have not yielded conclusive results with different labs reporting values that range from 1.2 to 22.3 Gy[8,9,10]. A possible reason for this is that prostate cancer cell lines are difficult to grow in culture. The ones that can be grown in culture may not be typical of cells found in the population. Because of the inconclusiveness of this method, Brenner has suggested in a series of publications that we can use clinical results to estimate these radiobiological parameters. This is an appealing suggestion that directly uses the *in vivo* observations, without the need to correlate *in vitro* to *in vivo* results.

Preliminary results using this method were obtained by analyzing the fairly large diversity of protocols that have been reported on in the literature to treat prostate cancer. In England, two groups have reported clinical results using hypofractionation. Lloyd-Davies[11] has reported, in a mostly qualitative manner, the results of 22 years experience with a truly unique protocol for prostate cancer: 6 fractions of 6 Gy, with fractions delivered twice per week over three weeks. Logue has twice published, although not yet in a refereed paper, clinical results of treatment using 50 Gy delivered in 16 fractions (3.125 Gy/fraction)[12,13]. Both of these protocols can be used to estimate the α/β ratio using a method known as isoeffect analysis, whereby we assume that equivalent radiobiological outcomes (equivalent tumor control in this case) is due to an equivalent surviving fraction of tumor cells. The method is formulated mathematically by equating the exponent of Eq. 2 for different fractionation protocols (value of *d*). In the case where equivalent outcomes are obtained using an external

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beam therapy and a low dose rate brachytherapy, this method gives the important formula:

$$\frac{\alpha}{\beta} = \frac{d\,D_e}{\left(D_b - D_e\right)} \qquad (3)$$

where D_e is the dose from external beam therapy, and D_b is the low dose rate brachytherapy dose that yields equivalent tumor control as the external beam therapy. Using this type of analysis, and comparing the results of Lloyd-Davies and Logue to the standard 74 Gy in 2 Gy per fraction for prostate cancer gives an α /β ratio that is in the 1 – 2 Gy range. Experience with low dose rate permanent seed brachytherapy offers another dose point for comparison. For treatments with ^{125}I, doses of 145 Gy are known to give clinical cure rates comparable to the standard external beam regimen of 37 x 2 Gy. Using these parameters Eq. 3 yields an α/β value in the 1–2 Gy range[5].

A second method to estimate radiobiological parameters is to model treatment outcome using a tumor control model that uses the linear quadratic model to calculate the number of surviving tumor cells. A tumor control probability is estimated by relating the number of surviving tumor cells to the probability that all have been removed. The usual form of the model is expressed mathematically:

$$k_S = k \exp\left(-\alpha D\left(1 + \frac{d}{\alpha / \beta}\right)\right) \qquad (4)$$

$$TCP = exp(-k_s) \qquad (5)$$

k is the initial number of tumor stem cells, and k_S is the mean number of surviving stem cells in a population of tumors. The surviving number of stem cells is then converted to tumor control probability by assuming that the cell killing process is stochastic, and follows binomial statistics. If there are a large number of stem cells, and the survival probability is small, the binomial distribution can be approximated by a Poisson distribution. The tumor control probability becomes the Poisson probability that a given tumor has zero remaining stem cells given the expected mean number of surviving cells, which results in Eq. 5. To implement this method, dose escalation results are needed to fit a TCP model to the sigmoid dose response curve seen clinically. Several high quality dose response studies for different protocols of prostate cancer treatment have been published that involve conventional external beam teletherapy[6,14,15], low dose rate brachytherapy[16], and high dose rate brachytherapy boosts to a first plan of teletherapy[17]. Parameter estimation using tumor control modeling has also yielded low estimates for the α/β ratio: 1.2 Gy[7] and 1.5 Gy[4,6].

This preceding evidence has led Fowler to write an editorial that appeared in January, 2002 in the International Journal of Radiation Oncology*Biology*Physics that declared enough proof for a low α/β value for prostate cancer exists, and that clinical efforts should now be directed towards determining an optimal fractionation protocol for this disease, based on hypofractionation[18]. His editorial correctly points out that in order to determine an optimal fractionation protocol for prostate cancer, more work needs to be done on the radiobiology of the normal tissue, to properly determine its parameters. The optimal fractionation protocol can be determined only when the difference between α/β ratios of the tumor and normal tissue is known.

Does enough evidence exist to correctly state that prostate α/β is low? One of the principal problems that can be addressed with the analyses we discuss, especially those using tumor control models, are that these models use averaged clinical results of many patients. However, the model assumes homogeneity: it assumes (1) the tumor cells have uniform radiosensitivity; (2) all patients in the studies have equal radiosensitivity; and (3) the dose to the tumor is homogenous. The problem with assuming homogeneity of patient radiosensitivity is that parameter estimates are biased towards the radioresistant end of the radiosensitivity spectrum that is known to exist in the population[19]. This is because the slope of the dose response curve depends on the radiosensitivity used in the TCP calculation, with the slope increasing with decreasing radiosensitivity[20]. The slope of the population averaged dose response curve that is clinically observed is low, so parameter estimates tend toward radioresistant values. Thus, the estimates of the number of tumor stem cells, k in Eq. 5, have all been very low: 138 for Brenner[7], 294 for Fowler[6], and 15 for Brenner[3,21,22], with corresponding low values for α, the radiosensitivity parameter. Brenner and Fowler have argued that while the method of tumor control modeling may not give accurate estimates of individual parameters, i.e. α, β and k, the number of tumor stem cells, the important parameter, the α/β ratio, should be insensitive to parameter bias due to the shallow slope of clinically observed tumor control curves[21,6]. This idea is supported by discussions from Dubray[23] and Fenwick[24].

Our own modeling done at the Ottawa Regional Cancer Center does not support the view that the ratio of parameters is independent of the radiosensitivity heterogeneity. We have found that unique parameter estimates are not obtained by applying a tumor control model that allows the radiosensitivity of individual patients to vary in the population. For instance the most common form of the heterogeneous tumor control model is expressed mathematically:

$$TCP \equiv P = \frac{1}{\sqrt{2\pi}\,\sigma}\int_{-\infty}^{\infty} e^{-ke^{-aD}}\, e^{-\frac{(a-\alpha)^2}{2\sigma^2}}\, da \qquad (6)$$

The α and β parameters are from the linear quadratic model and have been incorporated into a single parameter which we also call α, but represents the combined quantity α + βd, which is a constant for constant dose per fraction therapy (d, the dose per fraction, is constant). Eq. 6 represents the tumor control probability of an individual with radiosensitivity a averaged over a population with a Gaussian distribution of radiosensitivity centered at α with standard deviation σ. Parameter estimates obtained by fitting Eq. 6 to clinical data show a linear relationship between the α and $ln(k)$ parameters, as well as between the σ and α parameters. For example, our fit results to

(Continued on page 59)

clinical data for low dose rate permanent seed ^{125}I implants are shown in Fig. 1, where it can be seen that there are a family of α and *ln(k)* combinations that fit the clinical data equally well. Several other investigators have also reported this correlation of parameters (Webb[25], Fenwick[24] and Levegrün[26]). We have been able to explain this correlation of parameter estimates by reformulating Eq. 6 using more fundamental parameters, κ=αD-*ln(k)*, A=σ*D,* and the integration variable x = aD-*ln(k)*. Using these variables, Eq. 6 is rewritten:

$$P = \frac{1}{\sqrt{2\pi}\ A} \int_{-\infty}^{\infty} e^{-e^{-x} - \frac{(x-\kappa)^2}{2A^2}} \, dx \qquad (7)$$

Eq. 7 has many properties that have important effects on tumor control modeling. Since the integration variable disappears upon integrating, the tumor control probability, P, depends on the two fundamental parameters αD-*ln(k)* and σ*D*. A plot of Eq. 7 as a function of these parameters is shown in Fig. 2. From this figure, it can be seen why non-unique parameter estimates are obtained when fitting to Eq. 5: The linear relationship that is observed between α and *ln(k)* is because this relationship is actually estimating a more fundamental quantity, which we have called κ, and represents the logarithm of the number of tumor stem cells that remain after radiotherapy. It turns out that for most clinical data, this value is in the range zero to one, and Fig. 2 shows that in this region the function P is independent of the quantity σD. Thus, the parameter estimation procedure yields a linear relation between α and *ln(k)* with all parameter combinations fitting the clinical data equally well. By considering the slope of the dose response curve, it can also be shown that the parameter σ/α is also of fundamental importance, and the fitting procedure also estimates this quantity, thus the linear relation between α and *ln(k)* is accompanied by a linear relation between σ and *ln(k)*.

A last and striking property of Fig. 2 is that over most of the parameter space, iso lines of TCP, or P as we have relabeled it in Fig. 2, are linear in α*D-ln(k)* and σ*D*. Making the assumption that over the clinically interesting range, this linear relation holds, we have derived an expression for the α/β ratio using *heterogeneous* isoeffect analysis:

$$\frac{\alpha}{\beta} = \frac{d\,D_e}{(D_b - D_e) - \frac{1}{m}\frac{\sigma_\alpha}{\alpha}\left(D_b - \sqrt{1 + d^2\left(\frac{\sigma_b}{\sigma_\alpha}\right)^2}\, D_e\right)} \qquad (8)$$

Eq. 8 was derived assuming that a brachytherapy treatment given to dose D_b, and external beam therapy, given to dose D_e, yield equal TCP. The variables σ_α and σ_β represent standard deviation in the α and β parameters in the population, and *m* is the slope of the isoeffect line of Fig. 2. Eq. 8 bears a striking resemblance to Eq. 3 and it shows that the α/β ratio explicitly depends on heterogeneity, which is the quantity that proponents of low α/β ratio for prostate cancer have ignored. We have yet to determine the magnitude of this effect; our modeling indicates that the α/β ratio estimated using this method could be biased by the survival level where the clinical data was measured, and we have not yet determined what characteristics are required of the clinical data to obtain an unbiased estimate of the α/β ratio.

The prostate hypofractionation debate

Based on the arguments that we have presented here, we believe that it is too soon to tell exactly what the best strategy for radiotherapy of the prostate should be. There are good biological reasons to believe that the prostate α/β should be lower than most tumors, however, to change clinical protocols, more concrete proof is needed. The principal proponent from hypo-fractionation for prostate is Fowler, and his arguments do have considerable merit, however, it is troubling that the idea of an α/β value for prostate cancer that is on the order of 1 to 2 Gy is consistent with dose escalation studies only for a very low number of tumor stem cells, on the order of hundreds. If this were true, it would add an extra complexity to prostate cancer treatment by radiotherapy. For instance, it is inherently forgiving to use many fractions (up to 37) in prostate cancer management since geographic misses due to target motion and set-up errors tend to average out. However, treating a potentially very low number of target stem cells with fewer fractions could significantly reduce TCP with an inaccurate treatment[27].

A further troubling aspect to the current results of this debate is the reliance of tumor control models to derive information that we use to predict outcomes from untested protocols. It has long been known that tumor control models are not predictive in nature. Rather, tumor control modeling has been used to derive clinical insights and understanding, but they are not yet sophisticated and reliable enough to predict untested protocols. Proponents of hypo-fractionation argue that experience with iso-effect analysis offers compelling evidence for a low α/β value for prostate. A concern here, however, is that our experience with iso-effect analysis deals mostly with normal tissue complications. The method of iso-effect depends on the assumption of equivalent survival, which is equal to assuming the initial number of cells is the same for different iso-effects. It is much simpler to establish this for normal tissue than for tumors, which are more diverse in size and intra-tumor radiosensitivity, than normal tissue is.

To highlight the potential for error that can occur when using tumor control models to predict outcome from untested treatment protocols, we have performed a study in which we used the parameters estimates obtained from a particular treatment protocol to predict the outcome from a different protocol whose clinical results are known. Prostate cancer is one of the only disease sites where this is possible since it has been treated using several fractionation approaches. The results are that the tumor control models, in virtually every case, failed to predict outcomes from other protocols at the 95% significance level[28]. We believe this failure can be attributed to the model itself. The basic premise of the tumor control model is that radiosensitivity alone is used to describe the reduction of tumor stem cells. In radiobiology, four key areas have been identified which are known to contribute significantly to outcomes in radiotherapy. These are known as the four R's of radiotherapy: **R**epair, **R**e-oxygenation, cell cycle **R**e-distribution, and

Regrowth. Repair and regrowth have been considered at length in the prostate α/β debate, but there has been very limited discussion of the other two, re-oxygenation, and redistribution. Both of these are known to be affected by fractionation, and will likely have dynamic effects on the overall radiosensitivity of the prostate tumor cells during the course of radiotherapy. The net result is that the effective α and β parameters are likely changing during the course of radiotherapy treatments. Our current understanding of tumor radiobiology as it can be applied clinically is simply not at the level required to tackle this problem.

Daily doses of approximately 2 Gy/day have become ingrained in radiotherapy, so the suggestion that some cancers can be treated using different fractionation protocols may be confusing to some. It is our hope that this article will make this idea more accessible to radiotherapy physicists, since in clinics that may have an interest in prostate hypofractionation, the physicist can, and should, play an important role in designing new treatment strategies. It is highly likely that the standard 2 Gy fractions that are currently used for virtually all tumor types is not the most optimum approach for all cancers. In evaluating the literature on new treatment strategies, the most important concept to remember is that there is still a great amount of uncertainty regarding most aspects of this debate.

Reference List

1. Choo, R., DeBoer, G., Klotz, L., Danjoux, C., Morton, G.C., Rakovitch, E., Fleshner, N., Bunting, P., Kapusta, L., and Hruby, G. "PSA doubling time of prostate carcinoma managed with watchful observation alone," Int. J. Radiat. Oncol. Biol. Phys. **50**, 615-620 (2001).
2. Duchesne, G.M. and Peters, L.J. "What is the alpha/beta ratio for prostate cancer? Rationale for hypofractionated high-dose-rate brachytherapy," Int. J. Radiat. Oncol. Biol. Phys. **44**, 747-748 (1999).
3. Brenner, D.J. and Hall, E.J. "Fractionation and protraction for radiotherapy of prostate carcinoma," Int. J. Radiat. Oncol. Biol. Phys. **43**, 1095-1101 (1999).
4. Brenner, D.J. "Toward optimal external-beam fractionation for prostate cancer," Int. J. Radiat. Oncol. Biol. Phys. **48**, 315-316 (2000).
5. King, C.R. and Fowler, J.F. "A simple analytic derivation suggests that prostate cancer alpha/beta ratio is low," Int. J. Radiat. Oncol. Biol. Phys. **51**, 213-214 (2001).
6. Fowler, J., Chappell, R., and Ritter, M. "Is alpha/beta for prostate tumors really low?," Int. J. Radiat. Oncol. Biol. Phys. **50**, 1021-1031 (2001).
7. Brenner, D.J., Martinez, A.A., Edmundson, G.K., Mitchell, C., Thames, H.D., and Armour, E.P. "Direct evidence that prostate tumors show high sensitivity to fractionation (low alpha/beta ratio), similar to late-responding normal tissue," Int. J. Radiat. Oncol. Biol. Phys. **52**, 6-13 (2002).
8. Algan, O., Stobbe, C.C., Helt, A.M., Hanks, G.E., and Chapman, J.D. "Radiation inactivation of human prostate cancer cells: the role of apoptosis," Radiat. Res. **146**, 267-275 (1996).
9. Leith, J.T., Quaranto, L., Padfield, G., Michelson, S., and Hercbergs, A. "Radiobiological studies of PC-3 and DU-145 human prostate cancer cells: x-ray sensitivity in vitro and hypoxic fractions of xenografted tumors in vivo," Int. J. Radiat. Oncol. Biol. Phys. **25**, 283-287 (1993).
10. DeWeese, T.L., Shipman, J.M., Dillehay, L.E., and Nelson, W.G. "Sensitivity of human prostatic carcinoma cell lines to low dose rate radiation exposure," J. Urol. **159**, 591-598 (1998).
11. Lloyd-Davies, R.W., Collins, C.D., and Swan, A.V. "Carcinoma of prostate treated by radical external beam radiotherapy using hypofractionation. Twenty-two years' experience (1962-1984)," Urology **36**, 107-111 (1990).
12. Logue, J.P., Cowan, R.A., and Hendry, J.H. "Hypofractionation for prostate cancer," Int. J. Radiat. Oncol. Biol. Phys. **49**, 1522-1523 (2001).
13. Logue, J.P., Livsey, J.E., Cowan, R.A., Wylie, J.P., Swindell, R., Read, G., and Khoo, V.S. "Hypofractionated Conformal Radiotherapy in Carcinoma of the Prostate: 5 year Outcome Analysis 44th Annual Meeting of the American Society for Therapeutic Radiology and Oncology October 2002 New Orleans Abstract no. 1052," (2002).
14. Hanks, G.E., Schultheiss, T.E., Hanlon, A.L., Hunt, M., Lee, W.R., Epstein, B.E., and Coia, L.R. "Optimization of conformal radiation treatment of prostate cancer: report of a dose escalation study," Int. J. Radiat. Oncol. Biol. Phys. **37**, 543-550 (1997).
15. Pinover, W.H., Hanlon, A.L., Horwitz, E.M., and Hanks, G.E. "Defining the appropriate radiation dose for pretreatment PSA < or = 10 ng/mL prostate cancer," Int. J. Radiat. Oncol. Biol. Phys. **47**, 649-654 (2000).
16. Stock, R.G., Stone, N.N., Tabert, A., Iannuzzi, C., and DeWyngaert, J.K. "A dose-response study for I-125 prostate implants," Int. J. Radiat. Oncol. Biol. Phys. **41**, 101-108 (1998).
17. Martinez, A.A., Kestin, L.L., Stromberg, J.S., Gonzalez, J.A., Wallace, M., Gustafson, G.S., Edmundson, G.K., Spencer, W., and Vicini, F.A. "Interim report of image-guided conformal high-dose-rate brachytherapy for patients with unfavorable prostate cancer: the William Beaumont phase II dose-escalating trial," Int. J. Radiat. Oncol. Biol. Phys. **47**, 343-352 (2000).
18. Fowler, J.F., Chappell, R.J., and Ritter, M.A. "The prospects for new treatments for prostate cancer," Int. J. Radiat. Oncol. Biol. Phys. **52**, 3-5 (2002).
19. Buffa, F.M., Davidson, S.E., Hunter, R.D., Nahum, A.E., and West, C.M. "Incorporating biologic measurements (SF (2), CFE) into a tumor control probability model increases their prognostic significance: a study in cervical carcinoma treated with radiation therapy," Int. J. Radiat. Oncol. Biol. Phys. **50**, 1113-1122 (2001).
20. Yaes, R.J. "The slope of the sigmoid dose response curve for tumor control," Int. J. Radiat. Oncol. Biol. Phys. **44**, 470-471 (1999).

21. Brenner, D.J. and Hall, E.J. "Low alpha/beta values for prostate cancer appear to be independant of modeling details," Int. J. Radiat. Oncol. Biol. Phys. **47**, 538-539 (2000).

22. King, C.R. and Mayo, C.S. "Is the prostrate alpha/beta ratio of 1.5 from Brenner & Hall a modeling artifact," Int. J. Radiat. Oncol. Biol. Phys. **47**, 536-539 (2000).

23. Dubray, B.M. and Thames, H.D. "The clinical significance of ratios of radiobiological parameters," Int. J. Radiat. Oncol. Biol. Phys. **35**, 1099-1111 (1996).

24. Fenwick, J.D. "Predicting the radiation control probability of heterogeneous tumour ensembles: data analysis and parameter estimation using a closed-form expression," Phys. Med. Biol. **43**, 2159-2178 (1998).

25. Webb, S. "Optimum parameters in a model for tumor control probability including interpatient heterogeneity," Phys. Med. Biol. **39**, 1895-1914 (1994).

26. Levegrun, S., Jackson, A., Zelefsky, M.J., Skwarchuk, M.W., Venkatraman, E.S., Schlegel, W., Fuks, Z., Leibel, S.A., and Ling, C.C. "Fitting tumor control probability models to biopsy outcome after three- dimensional conformal radiation therapy of prostate cancer: pitfalls in deducing radiobiologic parameters for tumors from clinical data," Int. J. Radiat. Oncol. Biol. Phys. **51**, 1064-1080 (2001).

27. Craig, T., Moiseenko, V., Battista, J., and Van Dyk, J. "An examination of the impact of geometric uncertainty in hypofractionated external beam therapy for prostate cancer 44th annual meeting of the AAPM July 2002 Montreal Med.Phys. Vol. 29 No. 6 p1293," (2002).

28. Carlone, M.C., Wilkins, D., and Raaphorst, G.P. "Radiobiological parameter estimation for a predictive tumor control model for early stage prostate carcinoma 44th annual meeting of the AAPM July 2002 Montreal Med.Phys. Vol. 29 No. 6 p1294," (2002).

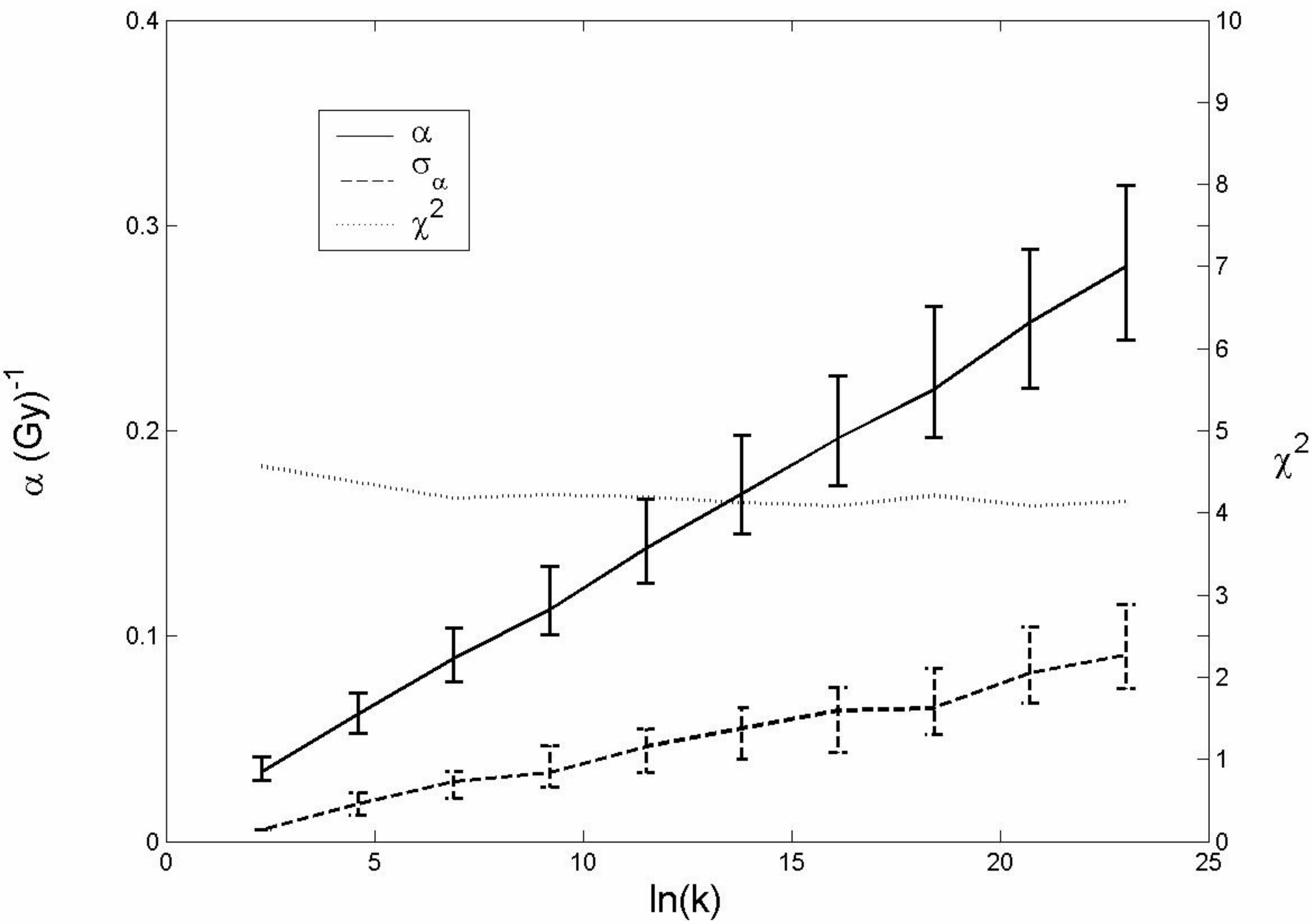

Fig. 1. Fit results for a ^{125}I brachytherapy prostate implant dose escalation study by Stock (IJROBP, 1998, vol 41, pp 101-108) to Eq. 6. No best parameter estimates are found, however, there is a linear correlation between α and *ln(k)* estimates that produce equivalent fit statistics. The fit statistic (χ^2) is plotted with the short dashed line, and the scale is on the right axis. Also observed is a linear relation between the standard deviation σ of the corresponding α estimate, and ln(k). The lower, dashed line, shows this linear relation.

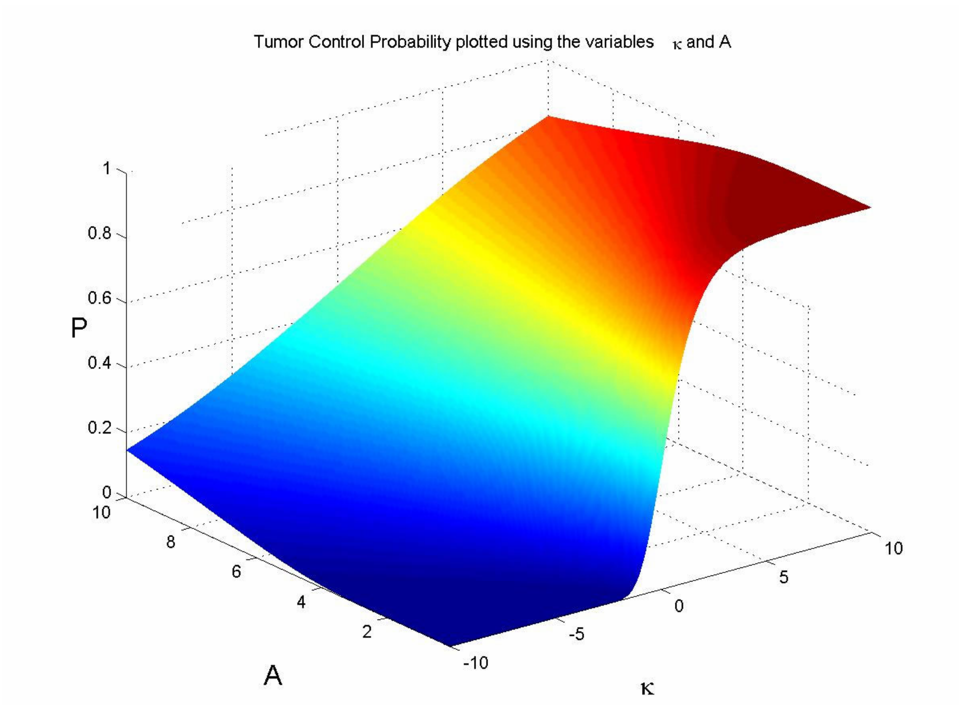

Fig. 2a. Tumor control probability, P, plotted as a function of the two fundamental variables: $\kappa=\alpha D-ln(k)$, and $A=\sigma D$. (Eq. 7.) For A fixed, the result is the familiar sigmoid dose response curve, and the slope of this curve decreases with increasing A. The tumor control probability, P, is independent of A when P ≈ 50%. This is easier shown using a contour plot, which is shown in Fig. 2b.

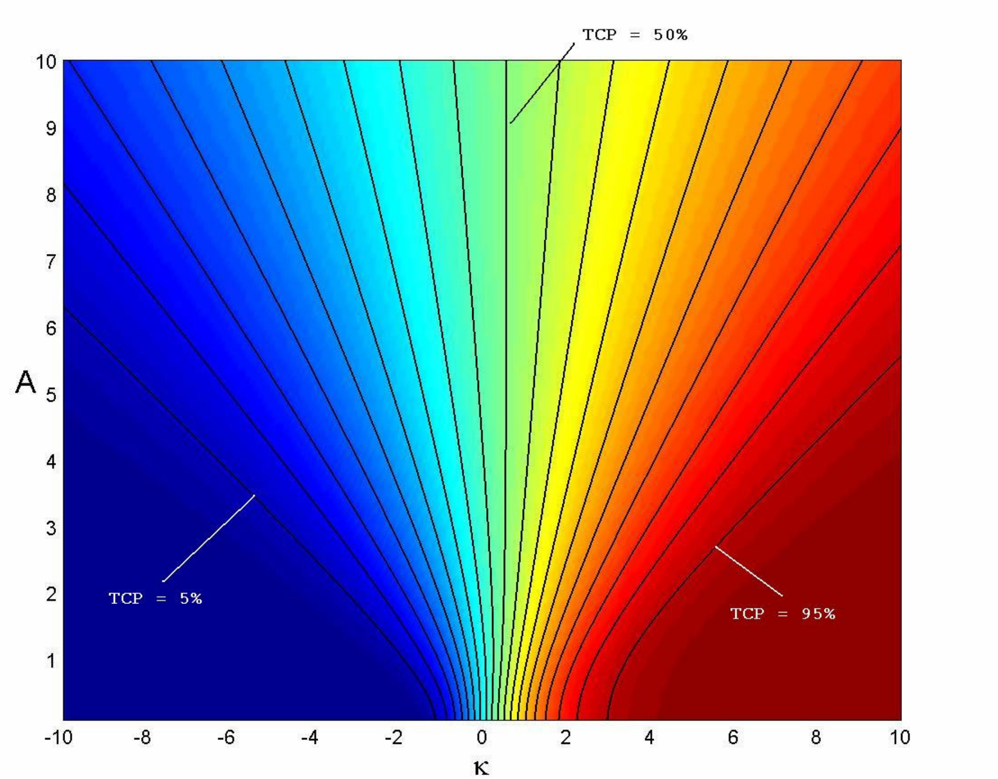

Fig. 2b. Isoplot of Fig. 2a, and Eq. 7. The iso-TCP lines are remarkably linear for A > 1. The asymptotic limit of these lines all cross the common point A=0 and $\kappa\approx0.58$. When TCP = 50%, Eq. 7 is independent of A. This is intuitive, since it is not difficult to show that for TCP = 50%, Eq. 6 is independent of σ. The independence of TCP from A is effectively when κ is in the range 0 to 1. This has important consequences since this is the range of κ that is most often found in practical tumor control modeling.

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CANADIAN COLLEGE OF PHYSICISTS IN MEDICINE

LE COLLÈGE CANADIEN DES PHYSICIENS EN MÉDECINE

Proposed Bylaw Amendments - 2003

The Board of the CCPM hereby gives notice that we will be seeking ratification of the following Bylaw amendments at the Annual General Meeting in June 2003 in Edmonton, Alberta. The proposed changes are in bold, italic and underlined. Commensurate changes to the Appendices will also be discussed at the AGM.

1 **RADIATION SAFETY COMPETENCE** The proposal is to add a separate section to the written examination addressing radiation safety issues. Applicants from the three ionising radiation specialties will write the same examination, a different examination will be supplied for the magnetic resonance imaging specialty. This change is being proposed to satisfy the requirement that the CCPM has a transparent method of assessment of the appropriate safety expertise such that certified medical physicists are not excluded from acting as radiation safety/protection officers within their designated specialty.

ARTICLE III: MEMBERSHIP CATEGORIES AND CONDITIONS FOR ADMISSION

Add the following paragraph after the listing of sub-specialties and before the paragraph beginning "From time to time…."

Members will also be recognized to have competence in Radiation Safety. Those certified in the three ionizing radiation sub-specialties are recognized to have competence in radiation safety, while Members certified in Magnetic Resonance Imaging are recognized to have competence in magnetic and electromagnetic field safety.

2 **MEMBERSHIP ORAL EXAMINATION** The proposal is to add an oral examination to the Membership examination process to be held immediately prior to the annual COMP meeting. The rationale for this change is to ensure that clinical competency is adequately assessed by the examination process.

ARTICLE III: MEMBERSHIP CATEGORIES AND CONDITIONS FOR ADMISSION

Add the words "and oral" to the second sentence in the first paragraph and section 1 (c) Eligibility for Membership.

Members are certified by written ***and oral*** examination to be competent in physics as applied to medicine.

(1) Eligibility for Membership

(c) Applicants must also satisfy the Board that they meet the standards deemed desirable in a Member and must pass written ***and oral*** examinations.

3 **CLARIFICATION OF FELLOWSHIP** - As a result of extensive consultation with the membership, the proposal is to remove the issue of clinical competency from the assessment at the Fellowship level. All applicants are required to have current certification of clinical competency by other means. This would allow the CCPM to consider applications for Fellowship from Medical Physicists working in Canada who have obtained clinical competency certification from another appropriate organisation. Eligibility would be clearly defined, Fellowship would be granted once only for clearly defined accomplishments in the field. The rationale is to clarify the current status and continue the CCPM tradition of providing a higher level certification for some clinical medical physicists to attain during their career.

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ARTICLE II: OBJECTIVES

Add a part 1b) to the objectives to read:

(1b) To identify individuals demonstrating excellence in the practice of medical physics.

ARTICLE III: MEMBERSHIP CATEGORIES AND CONDITIONS FOR ADMISSION

Remove "Members with advanced certification demonstrating excellence in physics as applied to medicine" and ***add*** "certified to have demonstrated excellence in the practice of medical physics" to give:

Fellows are certified to have demonstrated excellence in the practice of medical physics.

Remove "***and Fellows***" from "Members ~~***and Fellows***~~ will be recognized to have competence in up to two of the following sub-specialties of medical physics:

Remove "***Only***" from and add the following part (b) to the Eligibility for Fellowship:

(2) Eligibility for Fellowship

(a) ~~***Only***~~ Those who have successfully fulfilled the requirements for Membership are eligible to become Fellows of the College.

(b) Medical physicists working in Canada and certified as competent by an appropriate organisation in another country may be eligible for Fellowship at the discretion of the Board.

Clarification of the paragraph (3) Re-certification

Retention of ~~***the status of Member or Fellow of***~~ ***clinical competency certification (Membership)*** in the Canadian College of Physicists in Medicine shall require re-certification every five years.

4 GENERAL CLARIFICATION - The Bylaws have been changed in small increments over many years and these word changes are proposed to improve clarity.

ARTICLE I: Name

Remove from the definition of the name "and members of the College shall be known as "Members" or "Fellows".

ARTICLE II: Objectives

Add the phrase "to protect the public by" to the objectives and modify the verb to read:

The objective of the College shall be ***to protect the public by***:

(1a) Identify***ing*** competent persons who are responsible for applications of the physical sciences in the medical field.

*(1b) Identify**ing** individuals demonstrating excellence in the practice of medical physics.*

(2) Promot***ing*** knowledge and disseminat***ing*** information relating to developments of the physical sciences in the medical field.

Radiation Safety and Technical Standards Advisory Committee

By: Peter Dunscombe

Last year at our Annual Meeting in Montreal the reigns of the Joint Radiation Regulations Committee were handed over to this author. This article is the first in a series of occasional updates on the work of the committee.

- At the 2002 midwinter meeting of the Joint COMP/CCPM Executive the title of the Radiation Regulations Committee was changed to the Radiation Safety and Technical Standards (RSTS) Committee to better reflect the role of the group. The following Terms of Reference were also approved:

1. *The Radiation Safety and Technical Standards Advisory Committee reports to the combined COMP Executive and CCPM Board.*

2. *The mandate of the RSTSAC is*

   (1) To review and comment on existing and proposed regulations in the areas of radiation safety and technical standards on behalf of the COMP/CCPM membership.
   (2) To be proactive in the development and review of radiation safety and quality assurance protocols for use by the COMP/CCPM membership.
   (3) To provide advice to COMP/CCPM on matters relating to radiation safety, technical standards, quality assurance and associated training and continuing education issues.
   (4) To act as a resource to the COMP/CCPM membership in radiation safety training.
   (5) To act as a repository of federal and provincial regulations relating to radiation safety and technical standards.

3. *The chair of the RSTSAC or designate shall liaise with the Canadian Radiation Protection Association in areas of mutual interest.*

4. *The chair of the RSTSAC is appointed by the joint COMP/ CCPM Executive to a 3 year renewable term. Committee members are appointed by the Executive in consultation with the chair of the committee to 3 year renewable terms.*

- The Canadian Radiation Protection Association is a national organization with interests which overlap those of the medical physics community. In particular the CRPA is in the process of establishing a certification program for Radiation Safety Officers. The RSTS Committee has already established informal links with the CRPA and one of the potentially fruitful areas of collaboration is in such a certification program. It is, of course, up to the regulators which certifications they recognise and which they do not. However, there is no suggestion of exclusivity here and some sharing of knowledge and consistency of standards can only be beneficial to those to whom we are providing radiation safety services.

- The major project underway at this time is the review of proposed national quality control protocols associated with the document "Standards for Quality Assurance at Canadian Radiation Treatment Centres" produced by the Canadian Association of Provincial Cancer Agencies. Currently nine such protocols exist. The RSTS Committee, with considerable assistance from additional reviewers, is providing an independent assessment of these documents on behalf of the Canadian medical physics community. We hope to complete this task at the annual meeting in Edmonton this year.

- In addition, we are involved in a variety of other projects including intravascular brachytherapy (qc and standards) and generating an inventory of training materials.

So there you have it. If you have any comments or suggestions for the Committee please let us know. We'll keep you updated on the progress the Committee makes.

Peter Dunscombe
26th February 2003

- for the RSTS Committee: John Aldrich, Francine Dinelle, Cheryl Duzenli, Harry Johnson and George Mawko.

Federal Provincial Territorial Radiation Protection Committee (FPTRPC) Meeting

Ottawa, Ontario - October 20 - 26, 2002

By P. J. Wall
Nova Scotia Department of the Environment & Labour

What a difference a year makes. This time last year, when I reported on these meetings, I was still on a high from the effects of the opulent surroundings of the National Arts Center, where we were sequestered for two fruitful days as a result of September 11, 2001. As a poor boy growing up in rural Newfoundland; the National Arts Center didn't exist; Ottawa was a distant place in another country and in my capitol, St. John's, a fellow by the name of Joey was trying to convince everyone to join that faraway country called Canada. It happened in1949. Not a drop of blood was shed and together we all began a long journey toward harmonization.

Although elusive, harmonization remains a goal especially in a world getting smaller as a result of global travel and communications. Not referred to as such, but initiatives like the International Standards Organization (ISO) accreditation, the North American Free Trade Agreement (NAFTA) and the ICRP are all attempts at global harmonization. We, here in Canada, have the FPTRPC which, as the name implies, is our country's attempt to garner consensus from 13 little countries toward harmonizing the field of radiation protection from coast to coast to coast. A large step in that direction was taken at this year's meeting when the committee hosted a one and a half day workshop on the possible harmonization of pregnant worker dose limits. It was sponsored by the Canadian Nuclear Safety Commission (CNSC) and the Department of National Defense (DND). The workshop began with evening presentations by Dr. E.Waller and Ms. Michele Legare-Vezina. Both speakers provided some background and summarized the situation across the country focusing on the complexities associated with the current limits. The following day all seventy one participants, of which twenty nine were female, were divided into 5 working groups that excluded regulators. Their task was to discuss and develop options that were to be presented to a plenary session on the afternoon of the day long deliberations. All groups were given two questions for direction in their discussions. First, given that a pregnancy has been declared, what dose limit should apply to the balance of the pregnancy? The second was a two part question. What problems or obstacles would you foresee in implementing a new limit and how would you recommend they be addressed?

Each group did arrive at a consensus regarding a dose limit; consensus was defined as 60% agreement of the group membership. Two of the five recommended a limit of four mSv and two recommended five mSv. One group recommended that one limit to be applied to all workers pregnant or not. They selected 20 mSv as the dose limit with a one mSv dose to the conceptus as a target. The basis of their thoughts was to use the ALARA principle to bring doses as low as possible taking social and economic factors into consideration. The working groups identified several obstacles and presented potential solutions for implementing a new limit. The overall conclusion of the workshop was unanimous agreement to harmonize the pregnant worker dose limit to ionizing radiation. Several suggestions were made but perhaps the most important was that, once a harmonized balance of pregnancy dose limit is agreed upon, a clear concise document should be written for educators, health professionals and regulators. This document should delineate: the dose limits; why they are at a certain value; how to properly communicate them and their potential risks to the pregnant worker. The results of this workshop are now in the hands of the FPTRPC membership who will be providing a report for its next meeting.

Following the workshop, a laser training day was presented by experts from the DND. Laser applications new to committee members were covered and protective equipment demonstrated. The information provided was well received and appreciated by all members and our hats are off to the DND for their considerable efforts in organizing and sponsoring these events. During the course of this workshop many committee members expressed their concerns that Canada does not have its own laser regulations.

Provincial chairman Wayne Tiefenbach of Saskatchewan opened the official meetings of the committee on Wednesday, October 23, 2002 at the offices of the CNSC. This day is set aside for provincial, DND and territorial representatives to share information about radiation topics encountered in their jurisdictions during the past year. In addition, reports from the various sub-committees and working groups, of which the FPTRPC is comprised, are tabled for discussion and further action. These action items are assigned to the appropriate individual or group following deliberations with CNSC and Health Canada during the next two days. Perhaps a highlight of this year's reports was a business plan tabled by Brian Phillips of British Columbia. This well constructed report provides a background on the committee, outlines it's major accomplishments and, most importantly, sets out a route map for the committee's work over the next three years. The reports of the remaining groups will be highlighted in the section under working groups and sub-committees later in this document.

The second day's agenda is devoted to items where the provinces and territories interact, primarily, with the CNSC. This year's meeting, co-chaired by Mr. Rod Utting and Mr.Kevin Bundy, began with a presentation by Mr. Ken Pereira, vice-president of the Operations Branch. Mr Pereira outlined CNSC's new structure and gave an overview of it's future initiatives. He stressed that the organization is planning to give risk management a wider scope through ranking activities by weighting factors, no play on words here, and directing its efforts based on an assessment of these factors. Security, he emphasized, has become a major issue at the CNSC and he

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FPTRPC Meeting *(Continued from page 67)*

pointed to a number of significant security related changes. Some committees that FPTPRC members were familiar with, like the Advisory Committee on Radiation Protection, will no longer exist but will be replaced with advisory groups. He had attended the presentations on harmonization of the pregnant worker dose limits and wished the group well in reaching a consensus. Mr. Pereira recognized the work and benefits of the FPTRPC and indicated that the CNSC is committed to working with and remaining a strong supporter of the committee. Wayne Tiefenbach thanked Mr. Pereira for his informative presentation and commitment of support. Following Wayne's address, Rod Utting, took the reins and skillfully steered the group through the 17 item agenda.

Health Canada hosted the committee at the Radiation Protection Bureau (RPB) on day three. The morning's agenda was led by Jack Cornett and Robert Bradley took the helm in the afternoon. Pat Wall opened the morning session with an overview of natural occurring radionuclides in the drinking water of some Nova Scotian Schools. Lead-210 is the most common radionuclide found above the Canadian guidelines in 17 of the 184 schools tested to date. This presentation was followed by Dr. Dorothy Meyerhof who outlined Health Canada's work in progress on the Guidelines for Canadian Drinking Water Qualtiy (GCDWQ). Following this, an exchange took place on Radon Guidelines for Canadian Homeowners. This was precipitated by notification of a new synthesis of radon-lung cancer studies, to be published soon, that apparently shows excess risk from residential radon exposure. Discussion focused on the fact that Canada's guideline is one to the highest in the world and whether it should be changed. An action was placed on all members to review the current Health Canada/ Central Mortgage and Housing radon guideline document to ensure that contact information provided therein is accurate. Further discussion on the issue was deferred to Saturday's agenda where a working group will be considered to address the situation.

J.P.Auclair, Director of the Federal Nuclear Emergency Plan (FNEP) gave an overview of new initiatives in this area. He indicated that the plan has been updated, promulgated by the Federal Minister of Health, and sent to participating federal departments for endorsement. Additionally, two exercises have taken place since 2001 and a full exercise plan for 2003 has been developed. A new and revised nuclear emergency preparedness and response website is in progress, as are guidelines to assist federal and provincial emergency response authorities with the introduction of countermeasures for public protection.

A number of other information items were presented beginning with the refurbishment of the National Dose Registry (NDR). Changes being made to the 18 year old system are gargantuan and will eventually place 30 years of data and 14 million dose records on-line with 24/7 internet access. Target date for completion of the entire project is fall 2003. Clients of the NDR will experience a significant improvement in the service they receive.

The DND representatives raised the issue of radio-frequency safety regulations and requested that representatives provide a list of the regulations they use in their jurisdictions. While DND and military personnel fall under Safety Code 6, civilian contractors under the employ of DND come under provincial jurisdictions, even while working on DND property. They felt this list would help them enhance DND's radio frequency safety program.

Health Canada staff, led by Bob Bradley, provided an overview of the progress on a strategic plan to review and update the various safety codes. Presently, safety code 20A and 20B are being upgraded and harmonized to ensure consistency in their approach to small facilities. In future, a more rigorous definition will be applied to the documents as to whether they are "guidelines"or "safety codes." It was also noted that the Dental X-Ray Equipment Regulation amendments have been prepared and distributed for comment with a plan to go to Gazette1 by spring, 2003.

The day's agenda was completed following a discussion on the need to review options to harmonize X-Ray and Nuclear substance dose limits. Committee members agreed to form a working group to perform this task.

Saturday, the final day of the yearly meetings, is strategically set aside to review the deliberations that took place in the previous three days and allocate action items to the appropriate working group or sub-committee. As usual, there were numerous items to be addressed and Wayne Tiefenbach, had everyone on deck early to start the proceedings with:

The Radiation Standards Working Group.

The main item to be addressed by this group in the coming year is harmonization of the pregnant worker dose limit. The approach to this item will include: whether to accept the report of the Consultative Workshop on Dose Limits for Pregnant Worker Exposure to Ionizing Radiation; the selection of a dose limit; the rationale for accepting that limit; suggested text for regulations; and an action plan for implementation of this limit. Following this item, a discussion on "who should be monitored" took place and agreement was reached to accept the rationale in the CNSC document G-91, titled: "Ascertaining and Recording Doses to Individuals."

Industrial Radiography Regulation Harmonization Working Group.

This is a new four member body formed to review the regulations regarding industrial radiography.

Provincial Radiation Dosimetry Review Working Group.

A long standing group, whose mandate is to review dosimetry provider applications and monitor those providing services in Canadian jurisdictions, is currently investigating a deficiency in one provider's service. A new application to provide service is also being reviewed.

Survey Instrument Working Group.

On going collection of data on survey instruments from all jurisdictions is being encouraged by this group with a plan to

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find convenient, consistent and cost effective calibration services.

Medical X-Ray Utilization Working Group.

A letter, prepared by this group, will be sent to the National and Provincial Colleges of Physicians and Surgeons outlining the need for radiation safety training for specialists utilizing radiation in their work. A copy of ICRP 85 will be attached. The group will also investigate the possible dose increases from the use of digital x-ray devices and report to the next meeting.

Naturally Occurring Radioactivity Material (NORM) Working Group.

Two initiatives will be undertaken by this group for the coming period. They will address the need to harmonize the Western Canadian Guidelines with the Canadian Guidelines for the management of NORM and, in consultation with the CNSC, update the transport section of the latter.

Business Plan Working Group.

The three year plan presented, for approval, to the committee on Wednesday was discussed with general agreement that the document be accepted. An additional short comment period was suggested with final comments to be sent to the group's chairman by December 3, 2002. Some comments presented were: the role of the FPTRPC with respect to nuclear emergency response needs to be clarified and added to the business plan. Also, the terms of reference need to be modified to show that each jurisdiction receives only one vote on the committee. Once the plan is finalized it will be converted to a (PDF) file and posted to the website.

Communications Working Group.

Extensive discussion on the communication needs of the committee took place, primarily, focused on the requirement of a separate FPTRPC website. During both this discussion, and the previous one on Wednesday that had input from both HC's and CNSC's web management, there was general agreement that a separate site was needed. Both federal jurisdictions felt they could work together, harmonization in progress, to develop this site with Health Canada taking the lead. Members were asked to review the websites of organizations with similar functions and forward their suggestions as to what the FPTRPC's website should contain, and how it should look, to the chairman, Pat Wall.

C-260 Document Working Group.

No progress was made on this document and, following discussion, an agreement was reached to merge both this group and the one working on C-266. The mandate of this new "Joint Document Working Group" will be to prioritize the production of documents for presentation to the FPTRPC. It will also develop it's terms of reference prior to the next meeting.

ELF Working Group.

During the course of the year this group will determine whether there is a need for a 60 Hz standard and, in addition, have the committee's position paper on ELF translated.

Mammography Working Group.

The committee was informed by this group that the Canadian Mammography Quality Guidelines had been published and are available from Health Canada. Officials at Health Canada have indicated that an action plan for the future on this federal initiative is under way.

Once the working group business was complete exchanges on other issues got underway. They began with changes to the GCDWQ and Radon in homes. On Friday, Dr. Meyerhof had requested help from the committee with respect to changes regarding radionuclides in drinking water and in reviewing new data regarding radon. Three representatives, one each, from British Columbia, Nova Scotia and Ontario were selected to represent the FPTRPC in discussions with Health Canada on radionuclides in drinking water. A new working group was formed to work with Health Canada, who would take the lead role, in assessing the new information and providing direction on radon.

An exchange of views took place with respect to the absence of representation on the part of some jurisdictions. Representatives from New Brunswick; Ontario Health and Long-Term Care; the NWT; Nunavut and the Yukon have not been present for a number of years. Committee members are concerned that the absentees do not have the benefit of providing input to National decisions on radiation protection that could significantly affect their areas. All agreed that a letter from the committee's provincial chairman be sent to the ministers of these jurisdictions regarding their participation on the FPTRPC.

During the week, concern was raised by several members about the safety of new radiation technology entering the country. Quite often many jurisdictions are unaware that this technology is available. To keep abreast of this situation all members were requested to forward information they receive to officials at Health Canada's Consumer and Clinical Radiation Protection Branch who would then advise jurisdictions and the committee.

The last item of the day's agenda, and perhaps the most important, was the election of the provincial chairman. Having agreed to have his name stand for another two year term, Wayne Tiefenbach of Saskatchewan was unanimously approved. Little wonder, considering the amount and quality of service he has provided during his past two terms. From all of us, Wayne, thank you and congratulations.

International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry

By: Ken R. Shortt
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Division of Human Health
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Background

1. The International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry was organized by the Agency in Vienna from 25 to 28 November 2002 to foster exchange of information and highlight recent advances in research in this field. Over 250 scientists from 62 Member States attended the Symposium, at which 140 presentations were delivered covering a broad range of topics in medical radiation dosimetry.
2. A key issue addressed by the Symposium was knowledge of the accuracy of radiation doses delivered to patients, which is essential for the safe and effective diagnosis and treatment of disease. Such accuracy in dose measurement is an integral part of a comprehensive quality assurance programme to ensure that the technology is used properly and has the intended effect on patients.

Co-sponsoring and collaborating organizations

3. The co-sponsoring organizations of the Symposium were the European Commission, the European Society for Therapeutic Radiology and Oncology, the International Organization for Medical Physics and the Pan American Health Organization.
4. The collaborating organizations were the American Association of Physicists in Medicine, the European Federation of Organisations for Medical Physics, the International Society for Radiation Oncology, the International Commission on Radiation Units and Measurements and the World Health Organization. Ten companies participated in a scientific exhibition of equipment relevant to medical radiation dosimetry and the treatment of cancer. One of these companies arranged for the display of a cobalt therapy machine, which was located in the rotunda of the Vienna International Centre during the Symposium.

Special plenary session on cancer management

5. A special plenary session entitled “Meeting the Needs” focused attention on the impending crisis in cancer management. A speaker from the International Agency for Research on Cancer indicated that cancer incidence within developing countries is expected to increase by 50% within the next decade, primarily due to population ageing. In the discussion following this special session, representatives of the manufacturers participating in the equipment exhibition, as well as speakers and delegates tried to identify appropriate and affordable technologies and to define possible roles for the Agency to help in transferring equipment and developing local expertise required to meet the needs arising out of this crisis.

Findings and Recommendations

6. Recommendations from the Symposium sessions were presented for discussion and approval by participants in the final session. Although many of these recommendations concern the scientific community, some are directed to governments and industry as these affect the practical application of nuclear technology in the healthcare sector in both developing and developed countries. Several themes appear consistently throughout the various recommendations, which are in accord with the recommendations of the International Conference on the Radiological Protection of Patients in Diagnostic and Interventional Radiology, Nuclear Medicine and Radiotherapy organized by the Agency and held in Málaga, Spain, from 26 to 30 March 2001. As emphasized at Málaga, the education and training required for healthcare workers to diagnose and treat patients safely and effectively is of utmost importance. In addition, The Symposium recognized that:
   - appropriate and affordable equipment is required to meet the needs of developing countries in particular, with manufacturers as partners in the process of technology transfer;
   - it is essential for treatment methodologies to be supported by infrastructural services in medical physics and diagnostic radiology; and
   - programmes in quality control and assurance should provide the necessary auditing tools to demonstrate the safe and effective application of nuclear technology for patients.

7. Explicitly within the field of medical radiation dosimetry, the Symposium made recommendations:
   - for the further development of physical standards; and
   - for performance comparisons, and participation in audits by end-users and primary and secondary standards dosimetry laboratories in the sub-fields of nuclear medicine, brachytherapy, proton therapy and clinical dosimetry.

8. There are recommendations for primary and secondary standards dosimetry laboratories:
   - to develop further their absorbed dose to water standards and air kerma standards;
   - to refine the assessment of the uncertainties on the physical standards; and
   - to participate in comparison exercises in order to build confidence in their measurement capabilities.

9. A recommendation was made to enhance the application of the Agency’s dosimetry code of practice for external beam therapy and to complete the development of a new code for diagnostic radiology.

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International Dosimetry Symposium *(Continued from page 70)*

Response of the secretariat

10. Work is under way to complete the process of refereeing and editing the proceedings of the Symposium, which will comprise about 85 papers and include the recommendations.

11. The Secretariat intends to convene a Technical Meeting in 2003 to prepare an action plan in response to the recommendations of the Symposium. It will additionally take into account the recommendations of the Málaga conference and a Technical Meeting to formulate an International Action Plan on the Radiological Protection of Patients held at Agency Headquarters in January 2002. Implementation of the action plan by the Agency will be subject to approval of the Board of Governors in due course.

In Brief

"Physicists Hit the Road"

|Five physicists on the East Coast are often packing their bags as they make longer commutes to work in week-long rotations at the Prince Edward Island Cancer Treatment Centre in Charlottetown. The extra effort is as a result of a agreement between Cancer Care Nova Scotia and the Oncology services administration in the neighbouring province. Under the leadership of Dr. John Andrew, Drs. Mike Hale, Jim Meng and Mammo Yewondwassen from Halifax and John Grant from Sydney are sharing the coverage for Judy Hale, while she is on maternity leave.

|The physicists find their service there to be a pleasant change of scenery however the pattern of longer days of service is about to take an interesting up-turn. As construction efforts on the site of a new oncology department at the Queen Elizabeth Hospital intensify toward obtaining the all-important occupancy permit, this group will receive a Clinac 2100EX at the end of April. Upon commissioning, this treatment unit will provide state-of-the-art treatment services to patients living in Canada's smallest province.

All physicists report that it is a pleasure to work with the dedicated staff at the Charlottetown clinic, including Grant MacNevin, a physics assistant who joined the department in the summer of 2002.

"Its a Boy"

Colleagues of Judy Hale, the medical physicist at the Prince Edward Island Cancer Treatment Centre, are pleased to share the news that Judy delivered a healthy baby boy, named Simon, on November 28, 2002. In her cheerful and very efficient way, one shouldn't be surprised to learn that Judy worked a full day before driving herself to the hospital to deliver at 3am. Simon is a most welcome addition to Judy and Stephen's family including big sister, Sophie (age 4).

- John Grant

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Radiation Oncology Physicist

LOCATION: Fox Chase Cancer Center
Philadelphia, Pennsylvania

The Department of Radiation Oncology at Fox Chase Cancer Center (FCCC) is presently recruiting radiation oncology physicists. Qualifications include a M.S. for a clinical appointment or a doctoral degree or equivalent in medical physics or a closely related field for a faculty appointment, a minimum of three years of clinical experience in radiation therapy physics and certification or eligibility for certification by the American Board of Radiology or the American Board of Medical Physics.

Primary responsibilities are divided between clinical services, research, teaching and other associated activities depending on the appointment. Excellent communication, interpersonal, organizational and computer skills are required. Successful candidates are expected to provide clinical services for external beam radiotherapy, stereotactic radiosurgery/therapy and brachytherapy, to implement new technologies, to initiate and participate in research programs, and for a faculty member, to work both individually and with other faculty members to obtain extramural funding.

The department is located in a new pavilion and includes 4 Siemens linear accelerators and 2 Varian linear accelerators (to be installed), a dedicated HDR brachytherapy suite, three commercial 3D treatment planning systems, two IMRT treatment planning systems, one conventional simulator, a spiral CT simulator, and an open MRI unit. A CT/PET and a CT-on-rails have been/to be installed. Current research includes 3D conformal therapy and delivery methods, photon IMRT and modulated electron radiotherapy, laser accelerated proton beams, target localization, organ motion compensation, MRI based treatment planning, Monte Carlo dose calculation, and analysis of biological effects of radiation.

FCCC is located in a residential area of Northeast Philadelphia. Salary will be commensurate with experience and qualifications. FCCC has an excellent fringe benefits package and is an equal opportunity employer.

The applicant should submit a curriculum vitae, and the names, addresses and telephone numbers of At least three references to:

C-M Charlie Ma, Ph.D.,
Director, Radiation Physics
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Laurentian University • Université Laurentienne

Biomedical Physics Faculty Position
Department of Physics and Astronomy

The Department of Physics and Astronomy at Laurentian University invites applications for a tenure-track appointment at the Assistant Professor level, effective July 1, 2003.

Applicants should have a Ph.D. in a medical physics area or in a closely related discipline. The successful candidate will coordinate the department's new B.Sc. program in Radiation Therapy and prepare and teach courses in medical physics or biophysics for the program. A background and research experience in radiation therapy or biomedical imaging is preferred. The candidate is expected to contribute to the research program of the department, which includes collaboration with colleagues at the nearby Northeastern Ontario Regional Cancer Centre and at the Northern Ontario Medical School in which Laurentian is a partner.

The Department has an M.Sc. graduate program and a biomedical physics undergraduate program in addition to general and honours physics degree programs. Other research activities include neutrino astrophysics and trace radioisotope research at the Sudbury Neutrino Observatory and theoretical condensed matter and nuclear physics. For further information, visit the web site of the department at www.laurentian.ca/physics/ .

Bilingual (English/French) ability is an asset, and a capability of passive bilingualism (English /French) is a condition for the awarding of tenure.

Applications will be accepted until the position is filled. Candidates should send their curriculum vitae, and arrange to have three letters of reference sent to:

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FAX (705) 675-4868
e-mail: physics_chair@laurentian.ca

Laurentian University is committed to equity in employment and encourages applications from all qualified persons, including women, aboriginal peoples, members of visible minorities and persons with disabilities. In accordance with Canadian immigration requirements, all qualified candidates are encouraged to apply, however Canadians and permanent residents will be given priority. The position is subject to budget approval.

cancer care ontario | action cancer ontario

London Regional Cancer Centre

POSITION: **RADIATION ONCOLOGY PHYSICIST**

LOCATION: London Regional Cancer Centre
London, Ontario, Canada

The London Regional Cancer Centre is committed to providing leadership in cancer treatment, research, and education. Current treatment resources include 8 megavoltage therapy machines, several with MLC and portal imaging, 2 simulators, a CT-simulator, HDR and LDR units, and specialty programs in IMRT, prostate brachytherapy with 3-D ultrasound, stereotactic radiosurgery, and photodynamic therapy. A prototype helical tomotherapy system is being installed and will be a major focus for R&D activity. Related research is underway in IMRT, gated tomotherapy, 3-D gel dosimetry, optical CT, dose optimization, radiobiological modeling, treatment uncertainty propagation and the use of imaging in oncology. The successful candidate will join one of Canada's top Medical Physics teams and will participate in clinical service, research, teaching, and graduate student supervision.

Minimum qualifications include a Ph.D. with several years of related clinical experience, and Canadian certification (CCPM) or equivalent. The successful candidate must be eligible for an appointment at the University of Western Ontario with productivity in research or education.

London, Ontario is a pleasant and affordable university and health care city of 350,000 people nestled in south-western Ontario within a short drive to Toronto, Windsor (Detroit), and Niagara Falls (Buffalo). Proximity to Canada's Great Lakes region offers a wide range of recreational activities during all seasons.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. Cancer Care Ontario is an equal opportunity employer. We thank all those who apply; however, only candidates chosen for interview will be contacted.

CONTACT: Jake Van Dyk
London Regional Cancer Centre
790 Commissioners Road East
London, Ontario, Canada, N6A 4L6
Phone: 519-685-8607 Fax: 519-685-8658
E-mail: jake.vandyk@lrcc.on.ca Website: http://www.lrcc.on.ca/

UNIVERSITY OF CALGARY

Medical Physicist

Creating the future of health.

The **Department of Oncology** and the **Alberta Cancer Board (Tom Baker Cancer Centre)** invite applications for a full-time academic position as a Medical Physicist at the Assistant Professor level or higher. Duties include education and training of graduate students and residents as well as research.

The Division of Medical Physics is one of 10 Divisions within the Department of Oncology at the University of Calgary. Physicists within the Division are funded by the Alberta Cancer Board and provide clinical physics services at the Tom Baker Cancer Centre (TBCC). Approximately 2,500 patients per year receive radiotherapy on one of the nine megavoltage units at the TBCC. Eight of these units are Varian linear accelerators, all of which are equipped with multileaf collimators and three of which have aSi EPIDs. Treatment preparation takes place on one of two CT simulators or a conventional simulator with plans generated by the Pinnacle treatment planning system. HDR/LDR brachytherapy and stereotactic radiosurgery programs are in place and expected to expand significantly in the next year. There are currently eight faculty physicist positions at the TBCC within a total Physics Department staff of 45.

The Department of Oncology is part of the rapidly growing Faculty of Medicine which is in the process of building a major new research facility. Calgary is a vibrant, multicultural city (population ~1,000,000) near the Rocky Mountains, Banff National Park and Lake Louise.

Qualifications include a PhD in Medical Physics or Physics, membership or fellowship in the Canadian College of Physicists in Medicine and a record of effective teaching and productive research. A strong commitment to the highest clinical standards and highly developed interpersonal, teamwork, organizational and leadership skills are also required.

Please submit a curriculum vitae and a statement of career goals together with the names of three referees by **June 1, 2003**, to:

Dr. Peter Dunscombe
Director
Medical Physics Division
Tom Baker Cancer Centre
1331 – 29 Street N.W.
Calgary, Alberta T2N 4N2

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

The University of Calgary respects, appreciates and encourages diversity.

www.ucalgary.ca

MOUNT ALLISON UNIVERSITY

POSTDOCTORAL POSITION

Medical Physics

A position is available, beginning July 1, 2003 for a postdoctoral research fellow in medical physics, in the laboratory of Dr. David E.B. Fleming at Mount Allison University. The successful applicant will have a Ph.D. in a relevant discipline and research experience or interests in radiation physics and X-ray fluorescence. A strong background in computer programming is preferred. An opportunity to gain experience in university teaching may be made available, through a single semester undergraduate course assignment. This position is grant funded and the appointment will be for one year, renewable for an additional year. A comprehensive benefits package is included. Interested candidates should submit a statement of research interests and career goals, a curriculum vita, and the names of three references, to:

Dr. David E.B. Fleming
Canada Research Chair
Department of Physics
Mount Allison University
67 York Street
Sackville, New Brunswick, Canada
E4L 1E6
Telephone: 506-364-2584
Fax: 506-364-2583
e-mail: dfleming@mta.ca
http://www.mta.ca/~dfleming

There is no restriction on this position with regards to nationality or residence.

HEAD, MEDICAL PHYSICS RESEARCH

Toronto Sunnybrook Regional Cancer Centre
Toronto, Ontario

Our cancer centre is seeking a successful researcher to implement a structured program in medical physics research as applied to radiation oncology. This is a leadership position in the Radiation Program and the successful candidate will recruit staff and allocate resources to further the research program goals. The position will report to the Head of the Radiation Program at TSRCC.

The TSRCC is a comprehensive cancer centre and is a part of the Sunnybrook and Women's College Health Sciences Centre in north central Toronto. The radiation program has a complete complement of treatment and planning resources and treats over 5500 new radiation cases each year with conventional and advanced techniques. Physicists and radiation oncologists have appointments in the departments of medical biophysics and/or radiation oncology at the University of Toronto. Together with the imaging research group at the Sunnybrook and Women's we have active research programs to explore the role of functional PET imaging in radiation therapy planning and to develop imaging tools for treatment guidance and verification. The Head of Medical Physics Research will mentor existing staff in the program and will establish an independent, externally funded research program which will complement existing research activity and expand the collaborations between imaging and radiation therapy physics.

The successful candidate must have a Ph.D. and a proven academic record. Salary and benefits are consistent with the senior level of this position.

Contact: Human Resources Dept.
Toronto Sunnybrook Regional Cancer Centre
2075 Bayview Avenue- T Wing
Toronto, Ontario
CANADA
Phone: 416-480-4876
FAX : 416-217-1323
E:mail: michael.rowan@tsrcc.on.ca

RADIATION ONCOLOGY PHYSICS RESIDENT

UNIVERSITY OF CALIFORNIA, IRVINE

A 2-year residency training position is available in the Division of Medical Physics, Department of Radiation Oncology starting July 01, 2003. The position is suitable for an individual with a recent (within the last two years) doctoral degree in Medical Physics/Physics and a demonstrated interest in, and aptitude for, clinical radiotherapy physics.

The program outline follows AAPM report no. 36 for medical physics residencies. It includes all aspects of clinical radiotherapy physics such as treatment planning, quality assurance, radiation dosimetry and brachytherapy. The resident is also expected to attend didactic lectures in radiation therapy physics, radiation biology and clinical radiation oncology. Satisfactory progress in the program is contingent upon successful completion of periodic evaluations and presentation of several seminars throughout the training period. There is also an opportunity to participate in ongoing clinical physics projects. Upon completion of the program, the candidate is expected to be ready to take the certification board examinations offered by the American Board of Radiology in Therapeutic Radiological Physics.

Graduates of this program have been successful in their board scores and in securing positions at academic institutions. We hope to apply for CAMPEP accreditation during the term of the incoming resident.

The Department offers a comprehensive program of clinical radiotherapy services including IMRT and brachytherapy. Imaging facilities (CT and MRI) for treatment planning are available in the adjacent Radiology Department of the Medical Center. Ultrasound guided permanent seed implant for prostatic carcinoma and intravascular brachytherapy programs are in place. Treatment planning facilities available are 3D (with virtual simulation and image fusion capabilities), inverse and brachytherapy planning systems. A full set of physics equipment is available.

Interested candidates are invited to submit a curriculum vitae and the names and addresses of three referees to the contact stated below. Applications are accepted until the position is filled.

Dr. M. Al-Ghazi
Director of Medical Physics
Department of Radiation Oncology
University of California, Irvine
101 The City Drive
Orange, CA 92868

The University of California, Irvine is an equal opportunity employer committed to excellence through diversity.

US Oncology

Clinical Physicists in Radiation Oncology

Location: Various Cities & States, USA

Contact: Charlotte Carnagey
Senior Recruiter
US Oncology
16825 Northchase Drive, Suite 1300
Houston, Texas 77060
Phone: 800-381-2637 or Fax: 832-601-6861
e-mail: charlotte.carnagey@usoncology.com

Position: Clinical Medical Physicists in Radiation Oncology

US Oncology is America's largest integrated healthcare network dedicated exclusively to cancer treatment and research and a pioneer in community-based cancer care. Our network delivers care to more than half a million cancer patients each year including over 15 percent of all newly diagnosed cancer cases in the United States. The US Oncology network includes some 500 sites in 29 states all across the country. Our facilities provide a full range of Radiation and Medical Oncology services. These facilities are typically equipped with Varian Accelerators with MLC, CT/PET Imaging, Computer Simulation, 3D Inverse Treatment Planning Systems, IVB Systems and HDR units.

We are seeking experienced candidates for Clinical Physicists positions currently available in the following locations: Southwestern Radiation Oncology Tucson, Arizona, Cancer Centers of the Carolinas Greenville, South Carolina, Texas Oncology Fort Worth/Arlington, Texas, Indiana Cancer Center Indianapolis, Indiana, Southwest Cancer Center Las Vegas, Nevada, South Tulsa Cancer Center Tulsa New York Oncology Hematology PC, Albany/Amsterdam/Hudson/Rexford, New York, , Oklahoma, Texas Oncology P.A. Abilene, Texas, North Texas Regional Cancer Center Plano, Texas, Cancer Care Northwest Spokane, Washington, Texoma Cancer Center Wichita Falls, Texas

Minimum qualifications include a Master's degree in Medical Physics or a Master's degree in Physics with 3 or more years of clinical experience in radiation oncology. PhD and board certification are preferred. Only candidates eligible for TN Visa can be considered. Responsibilities include all aspects of clinical radiation oncology physics, quality assurance, treatment planning, radiation safety and research. Special procedures include Prostate Seed Implants, Implants, Intravascular Brachytherapy, BrainLab Radiosurgery, HDR and IMRT.

US Oncology is an equal opportunity employer and offers excellent benefits and competitive compensation based on experience and credentials. For more information, please visit our website at www.usoncology.com.

MEDICAL PHYSICIST AND RADIATION SAFETY OFFICER

Join a Group of 15 Physicists providing clinical physics services to radiotherapy.

BC Cancer Agency, Vancouver Centre

The British Columbia Cancer Agency is a multi-disciplinary diagnostic, treatment and research centre dedicated to cancer care of the highest quality.

The Vancouver Centre treats 6600 new patients annually and has 7 linacs, some with multileaf collimation and portal imaging, a cobalt unit, CT simulators, LDR and HDR afterloading units, well equipped machine and electronic shops and a Cadplan treatment planning system. In addition, physicists at VCC participate in the Screening Mammography Program and have responsibility for Canada's only proton therapy facility at TRIUMF. Stereotactic radiosurgery and prostate brachytherapy are also offered. The entire physics group is housed in a newly constructed facility and has an active academic program affiliated with UBC.

Half of your time will be devoted to radiation safety activities including:
* administering the various licences issued to the institution by the Canadian Nuclear Safety Commission ,
* overseeing and co-ordinating all aspects of radiation safety within the institution ,
* collaborating with the RSOs at other Agency centres.

In addition, activities may include some corporate responsibilities.

For the remainder of the time you will be called upon to participate in such clinical service activities as:
* treatment planning,
* selecting, acceptance testing, commissioning and calibrating of high-energy radiotherapy equipment.

You will also be offered research opportunities allowing you to participate in:
* new radiotherapy techniques development,
* treatment planning algorithm innovations,
* the proton therapy program at TRIUMF.

Qualified candidates can obtain an academic appointment at the University of British Columbia and supervise graduate students. Teaching opportunities also exist in the Residency Training Program and School of Radiation Therapy Technology.

The successful candidate should have a PhD or MSc degree in Medical Physics. Preference will be given to those with experience in radiotherapy physics and certification by the Canadian College of Physicists in Medicine.

An attractive salary and benefits package is offered. Please forward a resume by February 28, 2003 to:

Human Resources
BC Cancer Agency
Vancouver Center
400-555 West 12th Avenue, East Tower
Vancouver, BC, V5Z 3X7
Fax: 604 708-2015
Email: HROpportunities@bccancer.bc.ca

We would like to thank all applicants and regret that only those invited for an interview will be acknowledged.