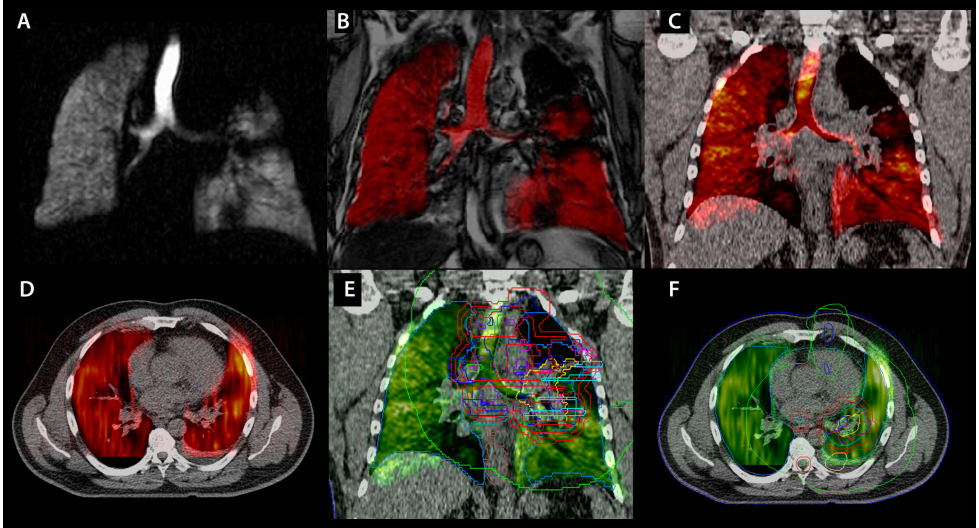
InterACTIONS

CANADIAN MEDICAL PHYSICS NEWSLETTER
Le BULLETIN CANADIEN de PHYSIQUE MÉDICALE

Detection of Lung Remodelling following Radiation Therapy using Hyperpolarized ^{3}He Magnetic Resonance Imaging



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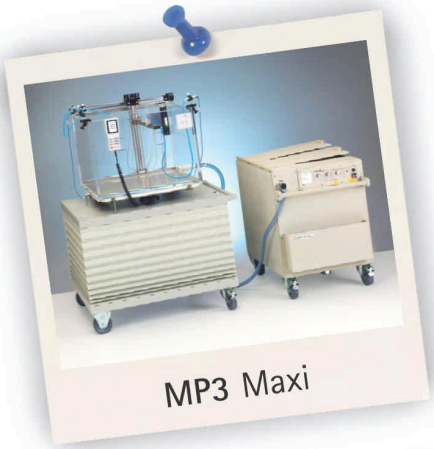
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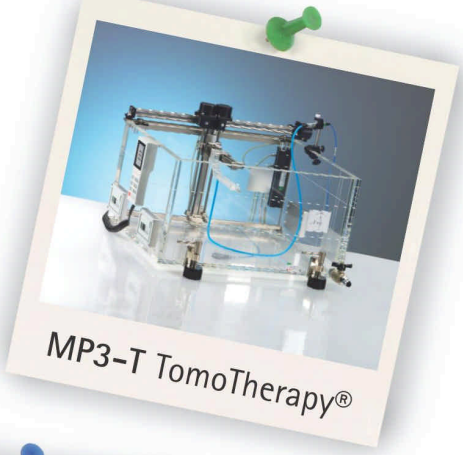
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InterACTIONS

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Cover Image

Hyperpolarized helium-3 magnetic resonance imaging (MRI) methods are being developed in a handful of respiratory and MR centres to provide a quantitative method for the measurement of lung function and tissue microstructure by exploiting the diffusion properties of ^{3}He. Feature article on page 77 presents longitudinal results in a small group of patients with clinically diagnosed RILI.. The figure illustrates ^{3}He MRI images registered with ^{1}H images and CT.

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Message from the COMP President

Welcome to this, my inaugural message as COMP President. As I write I am discovering my very first challenge: the most significant annual event in the COMP calendar, the Annual Scientific Meeting (ASM), will commence in a week or two and this article will not be published until a week or two following. While I have thoughts of encouraging you to attend the Annual General Meeting, to diligently review the background material to motions that will be brought forward, and to be prepared to bring forward your own ideas (which I do hope is indeed what has transpired), such thoughts can only be considered very early encouragement for 2011. Malcolm McEwen and the Ottawa Local Arrangements Committee (LAC) look to have put together an outstanding program and, while I look forward to an exciting and stimulating meeting, I hope that those of you who have attended found it to be so.

As my first opportunity to open what I hope will be an ongoing dialogue, one initial theme that I do want to take a moment to highlight, and one that is certainly not new, is that the Membership is the lifeblood of COMP: COMP only functions because of the voluntary efforts invested by its Members. I have been involved with COMP for much longer than I am willing to admit, my first role with the Executive (now Board) being appointment as Councillor for Professional Affairs in 2003. As a result, I have been witness to a number of profound changes in how COMP operates that have significantly enhanced the ability of the organization to serve its Members. One of the most strategically prudent and effective moves was the creation of the position of Executive Director. We have been extremely fortunate to have Nancy Barrett in this role as she has truly been an invaluable asset in advancing the ability of COMP to fulfill its six principal objectives. The Executive Director and her supports have become the backbone of the organization, providing dedicated time and continuity that did not previously exist. The fact that Nancy became so indispensible so rapidly makes me appreciate even more the accomplishments and the dedication of those who contributed their time and efforts to first establish and then, prior to her arrival, nurture COMP into a robust professional organization.

Now to the point: COMP cannot exist or function without the active participation of its Members. While the Executive Director certainly facilitates and enables, the Members are the content specialists and must be engaged. Moreover, Medical Physicists constitute a particularly small community. As a consequence, relative to sister organizations, a disproportionate effort is needed from all Members in order to optimally engage the professional challenges that we face. We need to engender a culture where being a Member of COMP is more than paying fees and participating in the occasional ASM. Far too often Board appointments are essentially made by acclamation. We have quite detailed bylaws regarding how to conduct an election, and I cannot recall the last time they were actually exercised. Would the organization not benefit from hearing two or more individuals speak as to why they would like a particular position, to offer different visions of the direction in which they would like to see COMP evolve? Case in point, I wonder how many of you have any idea why I would want to be the incoming President. (It's ok though, looks like you will have no choice but to find out.) I am not at all sure what the prospects are but, by the end of my term, I do hope that COMP has grown sufficiently that Members are willing to not only stand but also to challenge for Board positions. So, how do we get there? I would very much like to hear from you. And I do hope that this is at least a bit provocative…listening to crickets chirping is for the most part pleasant, but tends to not be terribly productive.

With that out of the way, much of the business of COMP will be addressed at the ASM so, aside from a few highlights, a more detailed update will be deferred to the next issue of InterACTIONS. Having had such a success with the first Winter School, Marco Carlone and the Science and Education Committee (SEC) are stridently working towards achieving the same in 2011. If not already being disseminated, details can be anticipated to be forthcoming in short order. Marco is also approaching the Board to determine whether the format of the ASM can be modified to increase the time available for continuing education. Please weigh into this consideration if you have an opinion. By now Joe Hayward and the Professional Affairs Committee should be reporting glowingly about how you *ALL* completed the Professional Survey, and they would also like to continue to encourage those with interest to get involved with the Bone Mineral Densitometry accreditation process being sponsored by the Canadian Association of Radiologists. And Bill Zeigler, our prudent and conscientious Treasurer, asked me to relay a reassurance that COMP is indeed financially sound. (For my first message, I thought that this was a particularly positive point to include.) He will, of course, be providing a full report once the budget is approved. I would also like to echo Jason Schella's appreciation for the efforts of Stephen Pistorius, Past President, and Patrick Rapley, Secretary, both of whom will have stepped down from the Board. And as for Jason himself, while I am certainly appreciative of his efforts and contributions as well, I would mostly like to remind everyone that he is not off the hook yet as he is now Past President. I look forward to working with him and rest of the dedicated, motivated, and exceptionally capable individuals that comprise your Board. More will be said on the

(Continued on page 75)

Dr. Peter McGhee
COMP President

Message from the CCPM President

The Canadian College of Physicists in Medicine has completed its membership certification process for 2010. Thirty new members are welcomed this year, which represents a 10% increase in the membership of the College.

The overall pass rate was 79% this year, which is comparable to past years. One new member in the MRI subspecialty, and one in the Diagnostic Radiologic Physics subspecialty, joins the College this year. Three candidates wrote the exam and did the oral exam in French this year. The written question bank is still available in English only (we are working on addressing this), but candidates can provide their written answers in French.

Chief Examiner Robert Corns was responsible for coordinating the entire exam process, and he deserves a large thank you for the enormous amount of work involved. Many others helped set the exam, mark it, conduct oral exams, and coordinate logistics. By my count, 29 CCPM members and fellows were involved, representing almost ten percent of the College.

It is a testament to the success of the College and its certification process that we are able to get 10% of the membership to volunteer their time to help run the examination process. Of course, this process is at the core of the mission of the College and is essential to the future of our profession.

What is the mission of the CCPM? The Bylaws state the Objectives as:

The objective of the College shall be to protect the public by:
(1a) Identifying competent persons who are responsible for applications of the physical sciences in the medical field.
(1b) Identifying individuals demonstrating excellence in the practice of medical physics.
(2) Promoting knowledge and disseminating information relating to developments of the physical sciences in the medical field.

The second objective refers to the Fellowship examination process. The third objective is quite broad -- the only specific mechanism by which CCPM promotes knowledge and disseminates information in our field is through the CCPM symposium at the COMP Annual Scientific Meeting. Apart from that, this objective is accomplished through the certification process itself, and by support of COMP initiatives such as InterACTIONS, the ASM, and the Winter School.

The first objective is the important one, and it is worth noting how it is stated: The objective of the College is to protect the public by identifying competent persons in our field. The College does not exist to serve its membership, but to protect the public. Initiatives to serve the interests of the medical physics community in Canada are the domain of COMP, which it does through such things as this newsletter, job postings, meetings and conferences, promotion of the profession, salary and manpower surveys, technical standards, lobbying on behalf of the profession, etc. These activities are not the included in the mission of the College.

Like any professional college, CCPM is engaged in four main activities by which it protects the public:

- Running an examination process to identify individuals who are competent to practice clinical medical physics;
- Maintaining a publically accessible registry of competent individuals;
- Running a maintenance of competency process (recertification);
- Having a disciplinary mechanism by which incompetent individuals or those acting unethically can have their certification revoked.

The fact that so many are seeking CCPM certification (10% growth in the College this year) is an indication that those practicing clinical medical physics recognize the importance of the first objective.

Dr. David Wilkins

However, certification of individuals is only one component in protecting the public and ensuring that those practicing medical physics are competent. There is increasing recognition in health care of the importance of accreditation of the education programs which prepare individuals who present themselves for certification. This is the basis of the recently adopted policy that anyone applying for CCPM certification after 1 Jan 2016 must have graduated from either a graduate or residency program accredited by CAMPEP.

It is a reasonable expectation, recently articulated by advocates of patients harmed in the US by the medical use of radiation and experts testifying before Congress, that medical physicists, like any health care providers, should be trained in accredited education programs for the tasks they are expected to perform and should have their competency certified by nationally respected institutions.

Anyone interested in helping the Canadian medical physics profession meet the challenges discussed above, should consider getting involved in the work of CCPM or COMP. To volunteer for CCPM, contact the chair of the nominations committee (Brenda Clark), myself, or any Board member.

Message from the Executive Director of COMP/CCPM

.2010 ASM

By the time you read this issue of InterACTIONS, the 2010 ASM will be behind us. It was truly a pleasure working with Malcolm McEwen and the Ottawa LAC on this event. A special thank you to our corporate sponsors: Varian, Elekta, CNSC, Philips and Tomotherapy - your generous support makes a great deal of difference to the quality of the meeting.

Thank you to all participants for providing feedback via our evaluation survey. Your support helps us in the planning of future meetings. On that note, the 2011 meeting will be a joint meeting with the AAPM in Vancouver. Mark your calendars for July 31st to August 4th!

2010 Professional Survey

All full members of COMP were invited to participate in the 2010 Professional Survey. This survey is conducted every second year and is developed by the Professional Affairs committee(PAC) in an effort to provide you with the best and most up-to-date professional information on Canadian medical physicist salaries and benefits. The results of the survey will be published in an upcoming issue of InterACTIONS.

Winter School 2011

Building on the success of the inaugural school that took place in Banff in January 2010, plans are well underway for the **2011 Winter School** which will be taking in beautiful Mont Tremblant from **January 30, 2011 to February 3, 2011**. Don't miss this opportunity for continuing education and networking.

The COMP Student Council

A Student Council was established at the 2008 meeting in Quebec City and has grown both in numbers and enthusiasm. A special section of the COMP website has been established with information that is pertinent to students and the group also connects via a Facebook group. Thank you to Alejandra Rangel and Nadia Octave for their leadership and energy for this important initiative.

Physics Associates

Through the PAC and particularly Joe Hayward, COMP has been providing support to those working in the medical physics profession as Physics Associates. The group has met in both Victoria and Ottawa and is also conducting its own professional survey with the support of the COMP office.

Connecting with Adjacent Communities

As part of the Board meeting that took place in Ottawa before the 2010 ASM, representatives from CARO, CAR, CAMRT, CAP and CMBES were invited to participate in a roundtable discussion. The purpose of the session was to facilitate information-sharing and networking between the various organizations.

As always, please feel free to contact me at nancy@medphys.ca or Gisele Kite at admin@medphys.ca at any time with your feedback and suggestions.

(Continued from page 73)

topic of Board members in the next issue.

With that, so ends my first challenge. Although it would be nice, I doubt it will be the last. I hope that this column will not be a one way street and that the Board and I do hear from you. When an issue is important to you, please take the time to let us know, including any suggestions as to how we could make such communication easier. COMP is your organization.

Oh, and by the way, for those who may have forgotten, the six principal objectives are:

- To promote scientific knowledge;
- To further the exchange and publication of scientific or technical information;
- To promote educational opportunities;
- To develop and protect professional standards;
- To promote and encourage certification by the Canadian College of Physicists in Medicine; and

To link to activities of other organizations with similar objectives.

Just let me know if you believe we are not making the grade.

Looking forward to having seen you in Ottawa.

Ms. Nancy Barrett

Did You Know?

Inter***ACTIONS*** is published four times a year

January , April, July, October

Next deadline for the October issue is **September 1!**

Get your material in early!

CNSC Feedback Forum

Submission of Annual Compliance Reports

Kavita Murthy, Director
Class II Nuclear Facilities and Equipment Division
Canadian Nuclear Safety Commission

The CNSC recently launched a project called ACR-Online which will allow licensees to complete and submit their Annual Compliance Reports (ACRs) using a web interface. This interface will be similar to the one that the CNSC has had in place for the purposes of Sealed Source Tracking. It is expected that this online submission capability will make the process of ACR submission faster and much simpler for licensees.

Annual compliance report is submitted for each licence every year (!) by the licence holder and contains information about the licensed activities necessary to reassure the CNSC that the activities conducted under that licence were in compliance with the regulations and the licence conditions. A desktop review of the ACR is one of three tools that the CNSC uses to ensure a licensee's ongoing compliance with regulatory requirements. The other two methods are Type I and Type II inspections, both of which involve a site visit by CNSC staff.

In addition to administrative information, there are some key performance related questions in all ACRs such as sealed source inventory management, facility workload, dose summaries for monitored staff, etc. Information gathered via ACRs is used by CNSC staff when preparing for inspections, trending licensee performance against previous years as well as against other similar licensees.

If you hold a CNSC licence, you will have submitted an ACR to the CNSC every year. ACR-Online will allow you, the licensee, to access your ACR using a secure web interface to fill it out online, or download it to your local computer and then complete it at your leisure. In both cases, once it is complete you can then submit it to the CNSC using the web interface. It will allow you to upload complex inventories, and when submitted, provide instant confirmation that the ACR has been received. You will be able to view the status of previously submitted ACRS, and view and download read-only copies of submitted ACRs. Based on information that is available to the CNSC on your licensed activities, the system will also make data entry into the various mandatory fields much simpler and more accurate by providing drop-down lists of equipment and source details, location details, etc. It is expected that later versions of the project will have much of the information pre-filled. Additionally, we plan to automate the process of receipt and notification of when an ACR is submitted, and automatically generate flags when information provided in the ACR does not match our records, thus making the process of assessment more efficient. It will allow us to collect a more complete inventory of sealed sources, and make it possible to trend and track the information we collect much more effectively.

In order to ensure secure data collection, you will be required to obtain authorization codes from the CNSC to allow you access your ACR online. The user authentication process will ensure that the correct information is released to the right person so neither your identity nor your information is compromised. The system we are building will meet the Government of Canada's strict guidelines about gathering and storing this type of information.

The ACR-online project is expected to be rolled out in several phases, each phase incorporating features that allow for increasing automation for both the submitter and the CNSC. The roll-out plan will make ACR-online available to different licence types gradually so everyone will be able to ease into the new way of doing business. The first roll-out is expected to take place in January 2011, with the licensees who have medical linear accelerators. The CNSC will contact you when the system is ready for launch, but in the meantime, you can look for information on our website: www.nuclearsafety.gc.ca

Class II regulations now require RSO certification

On the recommendation from Treasury Board Ministers, the Governor General brought into force the Regulations Amending the Class II Nuclear Facilities and Prescribed Equipment Regulations.

The regulations come into effect on May 13, 2010, the day they were registered, and were published in the Canada Gazette, Part II on May 26, 2010.

For English go to:

http://www.gazette.gc.ca/rp-pr/p2/2010/2010-05-26/html/sor-dors107-eng.html
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If you have any questions about this article or any other published in this series, contact me at Kavita.Murthy@cnsc-ccsn.gc.ca

Feature Article

Detection of Lung Remodelling following Radiation Therapy using Hyperpolarized ^{3}He Magnetic Resonance Imaging

L. Mathew*[1,2], S. Gaede[2-4], A. Wheatley[1], R. Etemad-Rezai[5], G. Rodrigues[3,4] and G. Parraga[1,2,3,5]

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Editor's note: This article is the recipient of the 3rd place in the J.R. Cunningham Young Investigators Award 2009.

INTRODUCTION

The lung is an extremely radiosensitive organ highly susceptible to radiation induced injury. Despite the fact that radiation treatment dose to thoracic tumours is limited in order to decrease the incidence of this injury, radiation induced lung injury (RILI) still occurs in as many as 34% of thoracic cancer cases involving radiation treatment. Symptoms of RILI are a result of structural changes in the lung including capillary obstruction and septal thickening in the pneumonitis phase of the injury, and further septal thickening with obliteration of the alveolar space in the fibrotic phase, all of which result in the functional impairment of the lung. Functional impairment can be observed using spirometry, which shows an immediate and rapid functional decline, with a steady decline continuing after two year. Although pulmonary function measures are good indicators of global lung response, the ***regional functional impact*** of inflammation and fibrosis in the lung over time remain relatively unclear.

Hyperpolarized helium-3 magnetic resonance imaging (MRI) methods are being developed in a handful of respiratory and MR centers to provide a quantitative method for the measurement of lung function and tissue microstructure by exploiting the diffusion properties of ^{3}He. Although ^{3}He MRI has been applied as a research tool in a number of respiratory diseases and explored as a potential radiation treatment planning tool, it has not to our knowledge been developed to monitor RILI progression. Here we present longitudinal results in a small group of patients with clinically diagnosed RILI.

MATERIALS AND METHODS

Study Subjects

Subjects (n=7) were recruited from the London Regional Cancer Program based on a clinical diagnosis of RILI, and four subjects returned for a follow up visit 22.0 ± 0.8 weeks later. All subjects provided written informed consent to the study protocol approved by The University of Western Ontario Health Research Ethics Board and Health Canada

Study Visits

Pulmonary function testing was performed prior to imaging and included spirometry and plethysmography. Scanning was performed at 3.0T using an Excite 12.0 MRI system (GEHC, Milwaukee, WI). Hyperpolarized ^{3}He with 30% polarization was provided through a spin exchange optical pumping system (Helispin, GEHC, Durham, NC) at a dosage of 5 mL/kg and mixed with medical N_2 to 1.0L. Three sets of images were acquired during a 15 second breathhold; a spin density image, a proton image and a diffusion weighted image.

Image and Statistical Analysis

^{3}He and ^{1}H images were manually segmented on a slice-by-slice basis to acquire a ventilation volume (VV) and thoracic cavity volume (TCV). Percent ventilated volume (PVV) was calculated as a ratio of the ventilated volume (^{3}He) to thoracic volume (^{1}H). All volumes were calculated for the ipsilateral lung (radiation target determined by cancer location), the contralateral lung, and total lung. Apparent diffusion coefficients were calculated from diffusion weighted images using b=1.6s/cm^2 for each lung independently and combined. The paired t-test was used to assess differences between the ipsilateral and contralateral lungs, as well baseline and follow up parameters.

Image Registration

Feasibility of single point image registration of ^{3}He-^{1}H, ^{3}He-CT and ^{3}He-radiation planning images was assessed, and resultant registered images were evaluated using a modified overlap coefficient

$$\Omega = 100 \text{ x } \frac{A_{MRI} \bigcap A_{CT}}{A_{MRI}}$$

The mean ADC and ADC standard deviation were calculated for the 5 center slices. The mean ventilated, thoracic and percent ventilated volume and standard deviation were calculated from repeated measures for the ipsilateral lung, contralateral lung and combined lung volume. The difference between baseline and follow up MRI measurements were calculated for the four subjects returning for a second visit, and a mean difference is reported. Differences between ipsilateral and contralateral lung ^{3}He MRI measurements were assessed using a paired t-test. The paired t-test was also used to evaluate differences between parameters measured at both baseline and follow up. Correlations between imaging, radiation treatment and pulmonary function parameters were assessed using Pearson's product moment correlation coefficient.

RESULTS

Seven subjects were enrolled following a diagnosis of RILI based on symptomatic presentation, six following radiation treatment for lung cancer and one following breast cancer treatment. The mean period of time between the start of radiation and the first visit was 35.1 ± 12.2 weeks, with the first visit being 9.1 ± 5.1 weeks following the initial report of RILI symptoms. Four subjects returned for a follow up visit 22.0 ± 0.8 weeks later. The remaining three subjects were deceased or otherwise unable to return for follow up. Subjects were treated with a mean dose of 58 ± 7 Gy, and the six subjects treated for lung cancer received a V_{20}Gy 32% ± 3%.

Representative center slice functional images and corresponding ADC maps are shown for subjects with RILI following radiation treatment for a right hilar mass (Figure 1a), a left upper lobe mass (Figure 1b) and a left hilar mass (Figure 1c). All mean ^{3}He MRI ADC and ventilation measurements are reported in table 1 for the ipsilateral lung, contralateral lung and total for both baseline and follow up visits. For the baseline scan a difference in the mean ADC of 0.03 cm^2/s between lungs was observed, although this failed to show significance (p=0.053). Ventilation images showed

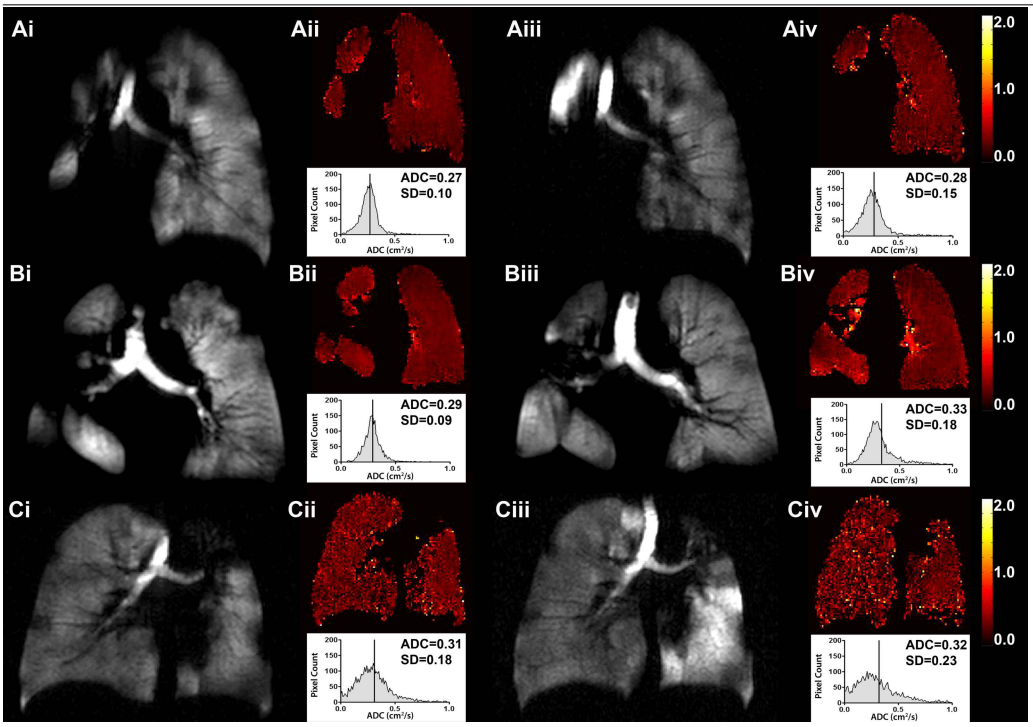

Figure 1. Representative Baseline and Follow up Ventilation Images, ADC Maps and ADC Histograms

A, B and C show representative subjects at baseline (i and ii) and follow up (iii and iv). i and iii show ventilation images at baseline and follow up respectively, while ii and iv show an ADC Map and Histogram for the same subjects at baseline and follow up respectively

a significant difference in ventilated volumes between ipsilateral and contralateral lungs (p=0.014), as did thoracic cavity volumes (p=0.027). Percent ventilated volumes were significantly different (p=0.025), and 33% lower in the ipsilateral lung as compared to the contralateral lung.

At follow up total mean ADC values were significantly higher than baseline (p=0.016). When measured independently ipsilateral mean ADC was not significantly different between baseline and follow up (p=0.053), while contralateral mean ADC at follow up was significantly higher as compared to baseline (p=0.003). The contralateral lung also showed a significant increase in percent ventilated volume at follow up (p=0.012), while no other ventilation parameters showed a statistically significant change.

Baseline ipsilateral mean ADC and the radiation parameter V_{20Gy} were significantly correlated (R= -0.961, p=0.009), while the contralateral ventilated volume at baseline was significantly correlated with the mean lung dose (R=0.94, p=0.016). The only baseline pulmonary function value showing a correlation with imaging measurements was D_{Lco}, which correlated with the ipsilateral ventilated volume (R=0.83, 0.041). Total dose was also correlated with the follow up ipsilateral ventilated volume and percent ventilated volume (R= -0.98, p=0.024 and R= -0.98, p=0.015 respectively).

Image registration results are provided in Figure 3 for a representative subject, with (a) showing the ^{3}He MRI image, (b) image registration of ^{3}He MR and ^{1}H images where ^{3}He signal is shown scaled from red and the ^{1}H image is provided in grayscale. For the same representative subject who underwent intensity modulated radiation therapy (IMRT) registration with CT, and radiation structural plans are shown in the axial and coronal planes in Figures 3 c, d, e and f respectively. ^{1}H – ^{3}He registration was assessed for the baseline visit in all seven subjects, and a mean overlap coefficient of 93.6 ± 4.6% was reported. ^{3}He MR – CT registration was assessed for four subjects, with a mean overlap coefficient of 75.3 ± 10.5%.

DISCUSSION

In this first longitudinal application of hyperpolarized ^{3}He MRI in subjects after presenting with RILI we observed a significant difference in the baseline thoracic cavity volume of the ipsilateral and contralateral lungs indicitave of thoracic remodelling following radiation injury. Importantly, we noted a significant difference in the percentage of the thorax ventilated, as measured by PVV, which was higher in the contralateral lung, suggesting that the functional capacity of the contralateral lung remains high following structural remodelling of the lungs. The lower PVV reported in the ipsilateral lung can likely be attributed to inflammation and scarring due to the targeted radiation dose or the presence of cancer (either original tumour or re-growth), causing the narrowing or closure of the airways. The finding of a high percent ventilated volume in the contralateral lung of all subjects shows that despite receiving radiation dose, the contralateral lung remains highly functional; not otherwise evident through pulmonary function testing or radiography.

For the small number of patients who were scanned at follow up, there was a significant change in both ^{3}He ADC (contralateral and combined) and PVV between baseline and follow up visits which suggests that ^{3}He MRI can sensitively detect lung structural and functional changes as RILI progresses. In this small number of subjects there was a significant increase in ADC (which typically reflects a worsening of airspace disease or emphysema) observed over a period of 20 weeks was greater than the rate previously established as due to either aging or due to COPD progression. Based on the timeline of our imaging the reported increase in ADC

Table 1. Baseline and Follow up ^{3}He MRI ADC and Ventilation Measurements

	Baseline			5 month Follow up		
	Ipsilateral	Contralateral	Total	Ipsilateral	Contralateral	Total
WL ADC (SD) cm^2/s*	0.33 (0.06)	0.30 (0.06)	0.31 (0.05)	0.35 (0.04)	0.32 (0.04)	0.32 (0.04)
WL ADC SD (SD) cm^2/s*	0.12 (0.07)	0.11 (0.07)	0.11 (0.08)	0.24 (0.02)	0.19 (0.05)	0.20 (0.04)
WL VV (SD) L	0.9 (0.5)	2.1 (0.6)	3.0 (0.7)	1.0 (0.7)	2.5 (0.7)	3.5 (0.6)
WL TCV (SD) L	1.6 (0.3)	2.3 (0.7)	3.9 (0.8)	1.4 (0.2)	2.4 (0.7)	3.8 (0.5)
WL PVV (SD) %	55 (29)	88 (5)	76 (12)	68 (45)	103 (5)	92 (15)

in the contralateral lung reflect a decrease or resolution in radiation induced inflammation over time following radiation, while no change in the ipsilateral ADC was reported due to the likely occurrence of irreversible fibrosis. In addition, at follow up, while the volume of the thoracic cavity showed no significant change, PVV increased possibly due to a similar decrease in inflammation in the airways of the contralateral lung. The increase in PVV of the contralateral lung over this short period of time perhaps also suggests that functional remodelling occurs in response to loss of function, fibrosis and volume loss observed in the ipsilateral lung as evidenced in the low ipsilateral PVV observed in the majority of subjects.

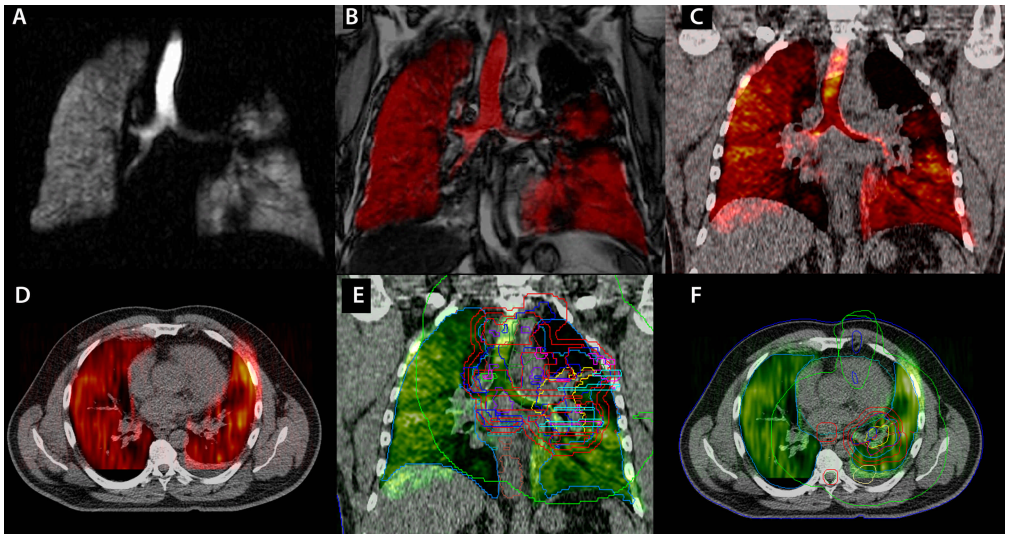

Figure 3. ^{1}H – ^{3}He and ^{3}He – CT Image Registration
A) ^{3}He MR image B) ^{1}H – ^{3}He MR image registration C) coronal ^{3}He – CT image registration D) axial ^{3}He – CT image registration E) coronal ^{3}He – CT with structural contours image registration F) axial ^{3}He – CT with structural contours image registration

We showed that ^{3}He MR registration was feasible with both ^{1}H MRI, CT and radiation dosimetry treatment plans. Despite the fact that for some subjects with RILI there was significant thoracic remodelling; ^{1}H / ^{3}He registration was implemented successfully likely due to the fact that the elapsed time between scans was on the order of minutes, and the subject was not moved between scans. Furthermore, registration of ^{3}He ventilation images with CT and radiation dosimetry plans were also found to be feasible. The feasibility of this registration will be important for future studies aiming to assess functional information that ^{3}He MR yields in conjunction with structural data from CT.

CONCLUSIONS

In this small pilot study of seven patients with RILI, we show the potential for ^{3}He MRI to provide structural and functional information about target and non-target lung regions. Furthermore, we observed that radiation induced functional effects were largely restricted to the ipsilateral lung and remained constant, while lung function as measured using ^{3}He PVV increased in the contralateral lung over time.

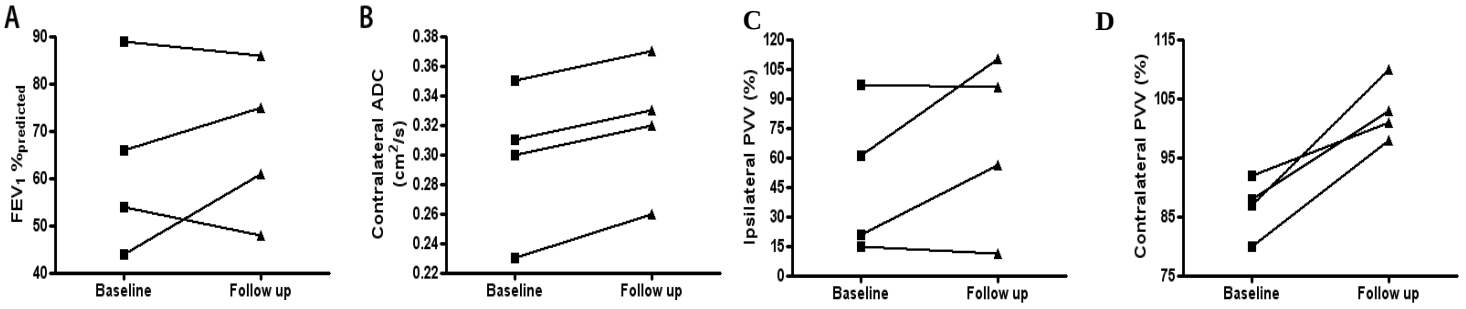

Figure 2. Plot of Longitudinal Differences in 3He MRI derived measurements
Differences between baseline and follow up data for subjects returning for a second visit (n=4) are observed for A) FEV1 %pred, B) contralateral ADC, C) ipsilateral PVV and D) contralateral PVV.

Coeff6 – A Tool for Radiation Physics

Jack Cunningham, Ph.D.

Coeff6 is a program, written in Visual Basic 6.0, for the purpose of creating and manipulating tables of electron stopping powers and photon interaction coefficients for elements and composite materials. The origin of this project was a series of FORTRAN programs that were written by the author to put together much of the tabular material that appears in the Appendix of "The Physics of Radiology". At the time of writing that book, stopping powers for electrons for some of the materials that were used for constructing dosimeters and phantoms were not readily available. Such materials were particularly relevant for measuring dose from the spectra of photon beams produced by the, then new, generation of linear accelerators. There was thus a felt need to calculate the required, and missing, stopping power data. The Bethe-Bloch equation for energy loss by electrons was solved along with the Sternheimer calculation for the effect of the density of the material.

(Continued on page 80)

Book Review: Clinical Dosimetry Measurements in Radiotherapy By D.W.O. Rogers, Joanna E. Cygler, Editors, Proceedings of the AAPM Summer School 2009

Alasdair Syme, PhD
Cross Cancer Institute, Edmonton AB

This hardcover publication is the monograph of the 2009 AAPM summer school. It is a lengthy volume (over 1100 pages) that covers a wide range of topics under the general umbrella of clinical dosimetry. It is presented in 32 chapters and 2 appendices. The print is high quality and easy to read, however the figures in the document range in quality from excellent to quite poor (usually due to the fact that they are reproductions from earlier publications). Each chapter contains an extensive reference list and a series of problems for which answers are provided in one of the appendices. The text and figures are conveniently available electronically on the accompanying CD and the lectures from the summer school are also available on the AAPM's website.

The work begins with a historical overview of dosimetric measurements and calibrations and is followed by two chapters covering basic physical interactions of radiation, quantities relevant to dosimetry and cavity theory. Subsequent chapters build on this foundation to describe the physics of TG-51 and its clinical implementation. Three chapters are devoted to brachytherapy dosimetry (calculations and measurements). Eleven chapters cover a wide range of radiation detection instrumentation (ionization chambers, radiochromic and radiographic film, TLDs and OSLs, diamond detectors, diodes, MOSFETs, gel and chemical dosimeters and plastic scintillators). The remaining chapters cover an array of topics including kilovoltage x-ray dosimetry, electron dosimetry, primary standards of measurement, instrument calibration, quality assurance in clinical dosimetry, IMRT dosimetry, small field dosimetry, hadron dosimetry and uncertainties in dosimetric measurements.

One of the highlights of the work is the description of the physics of TG-51 and its clinical implementation. As Dave Rogers states, this "is a long-overdue effort to document and explain, in a single place, as much of the physics and computational details behind TG-51 as reasonable". This collection of chapters (including the underlying cavity theory) is extremely informative and well written. It goes into significantly more detail than a number of standard textbooks. The medical physics community will benefit greatly from the effort put into compiling this information.

The chapters on radiation detectors also provide a wealth of information on the principles of operation, applications and limitations of each detector, as well as correction factors the user must be aware of. The volume of information presented can appear daunting, however the text is well segmented which allows the reader to locate appropriate subsections with ease.

A few chapters make for challenging reading either because they do not stray far from previously-published material (i.e. kilovoltage dosimetry) or because they provide a level of detail that is likely to interest mainly those with an active research interest in the field (i.e. reference -quality brachytherapy dosimetry). Nonetheless, the book benefits from the inclusion of these chapters.

This book will serve as an excellent reference for any practicing radiation oncology medical physicist. The variety of topics covered and the quality of writing make it a valuable resource. The level of detail offered in many areas, and particularly in the TG-51 physics sections, likely exceeds that found in most didactic graduate courses. As such, medical physics residents in this field who take the time to digest this work will benefit from a very strong theoretical foundation in the area of clinical dosimetry. These individuals will certainly also value this text as they prepare for their certification exams! In summary, this book deserves the status of "must have" within the field of radiation oncology medical physics.

(Continued from page 79)

Photon interaction data had kindly been made available, via magnetic tape, from what is now NIST. We thus had a useful collection of basic data. The next step in the project was the creation of programs that would calculate ratios of averaged stopping powers for various combinations of materials and spectra representing a wide range of commonly used radiotherapy machines. In a similar way, programs were written to calculate ratios of mass energy absorption coefficients for these materials and spectra.

With the availability of programming tools such as Visual Basic, the author realized that it would be practical to rework these old Fortran programs and to bring them together to produce a tool that might find useful application in the practice of radiation physics and in the teaching of that subject. This program, called ***Coeff6***, is the result. It is so named because the component modules are written in Visual Basic 6.0.

Program ***Coeff6*** is acompanied by an extensive library of electron stopping power and photon interaction coefficient data, and information concerning the composition of a number of composite materials that are useful in radiation physics. It also includes routines for creating new tables of these data. There is also a collection of both photon and electron spectra and of routines for creating and manipulating them. The spectra can be used to calculate various quantities averaged over the spectra and are useful for demonstrations. **Coeff6** includes procedures and other demonstrations that may be generally useful in the teaching, learning or practice of radiation physics.

The modern source of the data in the ***Coeff6*** library are websites hosted by NIST.

Coeff6, in executable form, along with the library of data files and a detailed manual, which includes the relevant physics, may be freely obtained on CD from the author. Instructions and the source code are included.

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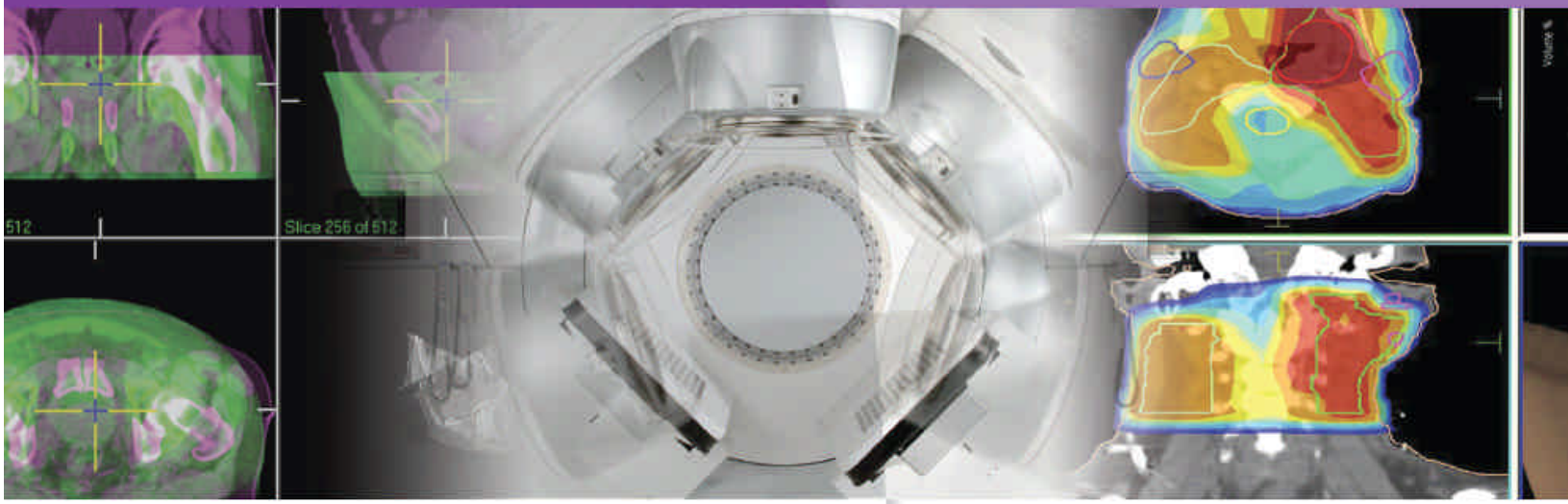
Beyond technology there are intelligent solutions



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Report of the 2009 Harold E. Johns Travel Award Visit

Hyperpolarized Gas Magnetic Resonance Lung Imaging at the Robarts Research Institute in London, Ontario

Dr. Atiyah Yahya
Cross Cancer Institute, Edmonton, Alberta

I was supported by the Harold E. Johns travel award to visit the respiratory imaging group at the Robarts Research Institute in London, Ontario, for a week during March 2010. I was kindly hosted by Dr. Giles Santyr who arranged for me to observe some hyperpolarized gas lung MRI (magnetic resonance imaging) experiments. In addition, he organized meetings for me with other academic staff, post-doctoral fellows, and graduate students. I also had the opportunity to present a seminar on some of my research to the laboratory. The following article provides details of my visit and the valuable information that I learnt from it.

MRI research scanners at the Robarts Research Institute:

The Robarts Research Institute hosts an impressive number of MRI research scanners. Hyperpolarized gas MRI experiments are conducted with two scanners, a 3 T whole-body scanner (Figure 1), and a home-built 0.075 T low-field small animal scanner (Figure 2). The centre also has a home-built animal insert equipped with gradient coils that can provide gradient strengths up to 500 mT/m (Figure 3). The animal insert was designed such that it can easily be slid into the bore of the 3 T magnet. In this manner, the 3 T machine can be used for human studies or for high resolution animal experiments. In addition to the mentioned scanners there are three more MRI systems at the Robarts Institute at the Centre for Functional and Metabolic Mapping (CFMM), namely, a whole body 3 T scanner, a 7 T brain imaging scanner, and a 9.4 T animal system. I had the pleasure of being toured around the CFMM by Dr. Ravi Menon who also spoke to me about the challenges associated with high-field MRI.

Hyperpolarized gas lung MRI at the Robarts Research Institute:

Introduction:

Conventional proton (^{1}H) MRI of lungs is challenging due to the low proton density of lungs as well as the numerous air-tissue interfaces, which result in large susceptibility gradients causing the MRI signal to rapidly decay. During the last decade, advancements in lung MRI have been made by exploiting hyperpolarized ^{3}He or ^{129}Xe gas as a contrast agent and detecting signal from the ^{3}He or ^{129}Xe nuclei. Hyperpolarization of the gases is done by spin exchange optical pumping, and it enhances the signal producing magnetization by approximately five orders of magnitude, thereby compensating for the low density of the gases. After the gas is hyperpolarized it is collected and the patient inhales it while in the scanner. An MRI image of the gas is obtained while the patient undergoes a breath hold. Signal is only visible in lung regions which contain the gas. Dark areas indicate poor ventilation implying an abnormality. Hyperpolarized ^{3}He gas lung MRI has been used to study a number of respiratory diseases at the Robarts Research Institute including asthma, cystic fibrosis, and chronic obstructive pulmonary disease (COPD). Figure 5 shows ^{3}He lung MRI images obtained from the studies. Regions of poor ventilation are clearly observable. Hyperpolarized gas MRI

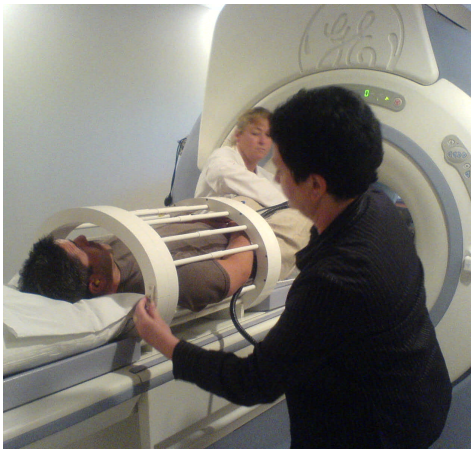


Figure 1: Volunteer being scanned for a hyperpolarized ^{3}He study on the 3 T. The RF coil around the volunteer transmits and receives at the ^{3}He Larmor frequency (97.3 MHz at 3 T).

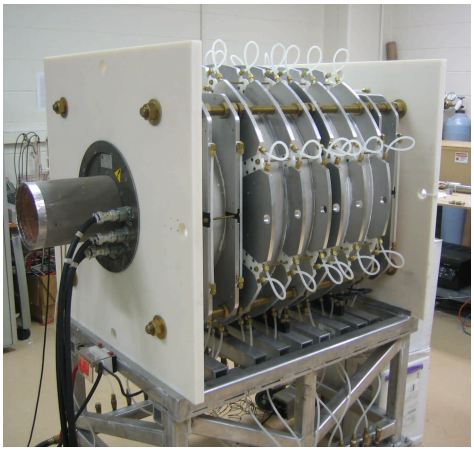


Figure 2: Low field 0.075 T animal scanner designed and constructed at Robarts for hyperpolarized gas MRI of rodent lungs.

Dr. Giles Santyr (right) and Dr. Atiyah

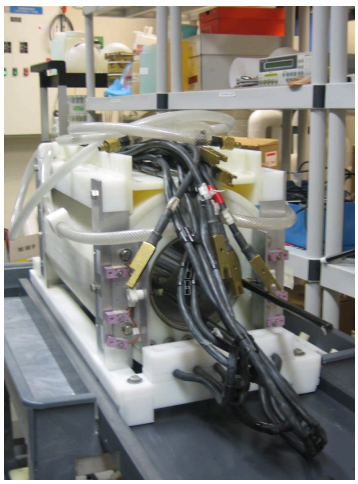


Figure 3: Animal gradient insert designed to slide into the 3 T scanner.

Figure 4: Home-built ^{3}He RF coil for rat imaging with the 0.075 T scanner. The outer coil is for uniform RF transmission, while the smaller, inner coil is for sensitive RF reception.

experiments of rat lungs are also being carried out to investigate rat models of disease.

Human ^{3}He MRI scan at 3 T:

I had the opportunity to observe the procedure for a ^{3}He MRI scan on an asthmatic patient volunteer. The first step was to hyperpolarize the ^{3}He. This was accomplished with a spin exchange optical pumping unit, shown in Figure 7, which hyperpolarizes the ^{3}He by spin exchange with optically pumped Rb vapour. Approximately one litre of ^{3}He is placed in a glass cell which contains small amounts of pure Rb and N_2 (N_2 allows for more efficient optical pumping). The cell is in a magnetic field of approximately 15 G and is at a pressure of a few atmospheres. It is heated to about 150 °C, causing the Rb to vaporize. A circularly polarized laser light, tuned to the desired electron resonance of Rb (795 nm), is applied to the cell, and the result is a high electronic polarization for the Rb gas. Polarization is transferred to the ^{3}He nuclei through collisional exchange. The optical pumping is conducted for several hours (12 – 20 hours) after which the ^{3}He is 40 – 45 % polarized. The gas is cooled to room temperature, which causes the Rb to condense on the walls of the cell. The ^{3}He is dispensed and used immediately or stored in a magnetic field until the patient is in the scanner and ready to be scanned. The patient was positioned supine on the patient bed with a ^{3}He RF coil placed around his chest (as shown with the volunteer in Figure 1), and was entered feet first into the magnet. Some ^{1}H images were acquired by the MRI technologist for comparison with the ^{3}He images. During this time the hyperpolarized ^{3}He was dispensed from the polarizer. The amount of ^{3}He required was calculated as 5 mL per kg of the patient's body weight. The ^{3}He was added to N_2 gas in a large syringe to form a litre mixture of gas. This mixture was placed in a 1 L bag, previously vacuumed to minimize the presence of O_2, which if present would cause rapid depolarization of the ^{3}He, and was quickly taken to the patient. A member of staff instructed the patient how to inhale the gas and once it was all consumed the patient held his breath, a signal was given to the MRI technologist, and the ^{3}He scan was acquired in a few seconds using a 2D fast gradient echo sequence. It is essential that the image be acquired rapidly because once in the lungs the ^{3}He loses most of its polarization in about 20 s.

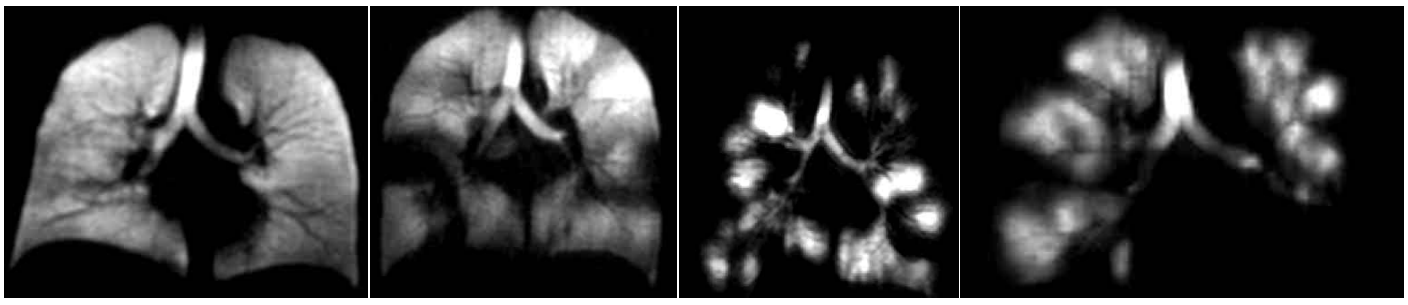
Rat ^{3}He MRI scan at 0.075 T:

In addition to the human scan, I also had the chance to watch a rat imaging session at the low-field scanner. Prior to the scan the rat was anesthetized, and intubated. An air-tight seal was ensured between the trachea and intubation so that the rat's breathing could be controlled by a ventilator. The rat was positioned supine within the ^{3}He RF coil displayed in Figure 4 in the centre of the magnet. The ventilator system delivered the hyperpolarized ^{3}He to the rat through mechanical ventilation.

Hyperpolarized ^{129}Xe lung studies:

Unlike ^{3}He, ^{129}Xe can be absorbed into the blood or tissue after being inhaled. This property renders it advantageous despite its lower sensitivity. ^{129}Xe can

Figure 5: ^{3}He lung MRI images acquired at 3 T



Healthy volunteer

Asthma patient
Wheatley et al. SPIE proceedings. 2007

Cystic fibrosis patient
Ahmed et al. RSNA 2009

COPD patient
Mathew et al. Acad Radiol. 2008

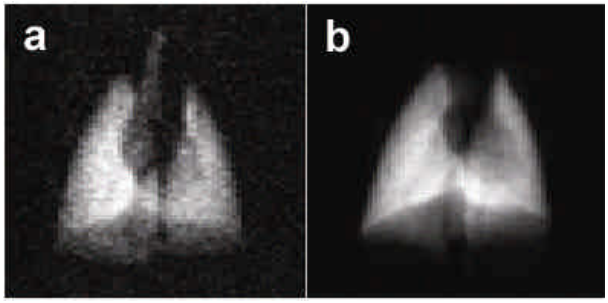


Figure 6: a) ^{129}Xe and b) ^{3}He MRI images of normal rat lungs acquired with the low-field animal scanner. The lower signal to noise ratio (SNR) of the ^{129}Xe image stems from the lower gyromagnetic ratio of ^{129}Xe and the fact that the ^{129}Xe may not have been hyperpolarized to the same degree as the ^{3}He. Images are courtesy of William Dominguez Viqueira.

Figure 7: Spin exchange optical pumping system. The labelled parts are:
1) Helmholtz coil pair that provides the magnetic field.
2) The optical cell.
3) Circularly polarized laser light source.
4) Gas outlet.
5) Monitor that displays amount of polarization.

also be hyperpolarized by optical pumping; however, this is done in a continuous flow fashion without storage in the optical pumping cell. Instead, the hyperpolarized ^{129}Xe flows out of the cell and is collected in liquid N_2. The ^{129}Xe freezes and its polarization is maintained by placing it in a magnetic field. To convert it back to a gas state, it is rapidly heated in boiling water situated in a magnetic field in order to sublimate the gas and collect in a bag for delivery. Figure 8 displays the home-built ^{129}Xe optical pumping system at the Robarts Research Institute.

Research projects:

From my meetings with the post-doctoral fellows and the graduate students I received an overview of the variety of hyperpolarized ^{3}He and ^{129}Xe MRI research projects taking place at the Robarts Research Institute. The projects include measuring ^{3}He ventilation maps in healthy elderly volunteers, asthma, COPD, cystic fibrosis, and lung cancer patients. ^{3}He ventilation maps are also being used to study the effect of exercise in asthma patients, and radiation induced pneumonitis in lung cancer patients. Moreover, ^{3}He apparent diffusion coefficients (ADCs) are being employed to investigate emphysema in COPD patients as well as in emphysema rat models. In addition to ^{3}He experiments, the solubility of ^{129}Xe in blood is being exploited to study gas exchange with blood, which can become degraded in pulmonary diseases and in radiation induced lung injury. The exchange can be determined by magnetic resonance spectroscopy techniques because ^{129}Xe in blood yields a peak that is separated in chemical shift from gaseous ^{129}Xe by ≈ 200 ppm. Both hyperpolarized ^{3}He and ^{129}Xe magnetic resonance techniques require pulse sequences that enable efficient use of the enhanced spin magnetization prior to its depolarization in addition to tailored RF coils tuned to the appropriate Larmor frequencies. Therefore, pulse sequence and RF coil design form a significant component of the research at the respiratory MRI laboratory.

Hyperpolarized ^{13}C NMR at the Robarts Research Institute:

The Robarts Research Institute also hosts a ^{13}C DNP (dynamic nuclear polarization) polarizer that hyperpolarizes ^{13}C nuclei. It is being used to hyperpolarize 99%-$^{13}C_1$ pyruvate for animal experiments. Within a minute after pyruvate injection into the subject signal can be collected from pyruvate and its metabolic products, namely, lactate, alanine, and bicarbonate. The technique is promising in the study of cancer where lactate levels are associated with tumour progression. While I was at the Robarts Institute I observed the DNP process of ^{13}C hyperpolarization which differs somewhat from the optical pumping method used for ^{3}He and ^{129}Xe. 350 – 400 mg of ^{13}C enriched pyruvate is mixed with 6 – 7 mg of trityl radical and a small amount of Gd^{3+}, which has been found to increase the amount of polarization. The solution is placed in a 3.35 T magnetic field and is frozen in liquid helium (about 1.4 K). The magnetic field and the low temperature significantly polarizes the trityl free electrons. Subjecting the mixture to ≈ 94 GHz microwave irradiation transfers some of the polarization to the ^{13}C nuclei. ^{13}C polarizations of about 10 – 20% can be attained in approximately two hours. To transform the sample into an injectable solution without much loss of polarization it is dissolved and rapidly melted with a hot buffer.

Visit to the London Regional Cancer Program (LRCP):

On one of the days Dr. Santyr arranged an afternoon visit for us to the London Regional Cancer Program, a hospital in London that provides treatment and support services to cancer patients and their families as well as being a research and teaching hospital. At the LRCP we were given a tour by Dr. Kevin Jordan and Dr. Jerry Battista. We were introduced to the fascinating research being done in the areas of photodynamic therapy and optical CT measurements of three dimensional dose distributions in radiochromic gels. A number of graduate students also presented overviews of their valuable research in the field of adaptive radiotherapy.

Concluding remarks:

My visit to the Robarts Research Institute was enjoyable and benefited me greatly. The opportunity to speak with researchers in the field and to watch experiments being conducted provided me with valuable insight as to what is required to initiate hyperpolarized gas lung MRI studies at my institute, where the methodology should have useful application in lung cancer studies and in lung radiotherapy treatment planning.

Acknowledgments:

First of all, I must thank the CCPM for awarding me the 2009 Harold E. Johns travel award, which made my trip to the Robarts Research Institute possible. I am also indebted to Dr. Giles Santyr for hosting and organizing my visit while making me feel more than welcome. In addition, I thank all the staff, post-doctoral fellows and students who spent time with me discussing their work, namely, Dr. Timothy Scholl, Dr. Alexei Ouriadov, Dr. Lanette

Laptops for Kenya

Marija Popovic
The Ottawa Cancer Centre

In a town of Embu, Kenya, about 12,000 km from here, there is a group of 199 energetic youngsters, aged 13 to 19, attending the Rukira Day Secondary School. These kids consider themselves to be very privileged because their families are able to afford to pay the annual tuition, amounting to 325 kg of maize and 360 kg of beans, a school uniform, and the valuable time that could be used instead to help their families work the fields in this agricultural region of the country. Many of these students will be fortunate enough to overcome the challenges related to poverty, malnutrition, direct and indirect effects of HIV/AIDS, and numerous infectious and potentially lethal childhood diseases foreign to the developed countries such as Canada. They will go on to complete high school. Some will even obtain a college diploma or a university degree and grow up to be outstanding members of the society willing to give back to their community. These kids have plenty of role models, and Mr. Peter Ndwigah is just one such example. Mr. Ndwigah works at the Institute of Nuclear Science and Technology at the University of Nairobi and devotes much of his time to ensuring that the road to success for these children is at least a bit less bumpy than it was for him.

Locally, Mr. Ndwigah is working incessantly to provide a satisfactory learning environment to the children of his birthplace. He has hosted Dr. Fiona McNeill, the Associate Vice-President, Research, at McMaster University and I in Nairobi in January 2009, and has asked us to help with the effort. Dr. McNeill has recruited a number of ambitious McMaster University students who will spend several weeks in Embu in an effort to widen the horizons of these youngsters and motivate them to demand the most out of life. *I would like to ask you kindly to consider donating your used* ***laptops*** *for this cause.* The local school board is many years away from being able to afford any type of computer education for students. Even a single laptop that is many, many years old would give these children a chance to learn some basic computer skills. With some luck, this may be an important step in helping these youngsters achieve great things in life!

Please share this message with anyone who may be able to assist us with this project. I would be more than happy to answer any questions you may have. My email is mpopovic@toh.on.ca.

(Continued from page 87)

Figure 8: Home-built ^{129}Xe optical pumping system. The solenoid provides the magnetic field. Two lasers, which are at the other end of the box and not shown, produce the circularly polarized laser light.

Friesen Waldner, Adam Farag, Shayna McKay, Sandra Halko, Mathieu Boudreau, Marcus Couch, Matthew Fox, Miranda Kirby, Lindsay Mathew, Julie Tanguay, Kundan Thind, and the students who presented at the LRCP. Special thanks to the following: Dr. William Dominguez Viqueira for acting as my guide for the week and teaching me about the low-field system, Dr. Ravi Menon for touring me around the CFMM, Dr. Jerry Battista and Dr. Kevin Jordan for touring me around the LRCP.

NSERC opening up for Medical Physics

David W O Rogers[a)] and William Whelan[b)]

a) Carleton Laboratory for Radiotherapy Physics, Carleton University, Ottawa

b) Department of Physics, University of Prince Edward Island

The Natural Sciences and Engineering Research Council of Canada (NSERC) provides almost $1B of funding per year for academic research programs in Canada. NSERC Discovery Grants (DG) can provide stable 5 year funding to support individual researchers and their research programs. NSERC Research Tools and Instruments (RTI) grants support research equipment purchases typically costing from $7,000 to $150,000. Requests for larger equipment grants are typically directed to the Canada Foundation for Innovation (CFI). We strongly encourage Canadian medical physicists to investigate these programs for possible research funding related to natural sciences or engineering advances in medical physics as opposed to clinical/patient based research which is funded by the Canadian Institutes of Health Research (CIHR). NSERC has recently changed its procedures for reviewing their baseline grant programs, (i.e. DGs and RTIs). The purpose of this article is to briefly outline the DG and RTI programs and to provide some tips on grant writing. We do this as two members of the Physics Evaluation Group (EG) which reviewed all of the physics DG and RTI grant applications for 2010 (with the exception of subatomic physics).

Perhaps the most important piece of news is that Medical Physics is now a recognized "Research Topic" within the NSERC Physics EG review structure (identified as PHYS08), and it is separate from Biological Physics (identified as PHYS09). In conjunction with that, in the 2010 competition there were 6 medical physicists on the Physics EG (out of 40 members). This means that when a medical physics grant application was being reviewed, up to 5 of the members participating in the discussion (see below) had some medical physics background, which is much better than in previous years. While the competition for funds is fierce, these grants can be a solid base for funding students and so we encourage COMP members to consider applying.

Discovery Grants

Discovery Grants are baseline grants for active researchers with academic affiliations. The Discovery Grants (DG) Program supports ongoing programs of research (with long-term goals) rather than a single short-term project or collection of projects. They provide stable funding for 5 years, in most cases, although shorter periods may apply in particular circumstances. They are primarily used to fund students, post-docs, travel expenses, other routine operating expenses and minor equipment purchases (typically <$7,000 per item).

The first thing to be aware of is that a notice of intent to apply for a grant is needed on August 1 and the final application is due at NSERC on November 1 although most universities have earlier internal deadlines. The applications are handled on-line via http://www.nserc-crsng.gc.ca. There is also a wealth of data and information about the various programs available at this site. The notice of intent is quite short and applicants are asked to suggest 5 potential external referees, a few of whom should be from outside Canada. In the end typically 2 of the applicant's suggestions will be contacted. Nonetheless the list provided is very useful in determining the final set of external referees. For each grant, the other 3 external referees are identified by the lead internal reviewer who is a member of the Physics EG. The 5 external referees are the technical experts and their opinions are important. So if you are asked to do a review, either be sure to do it, or inform NSERC right away that you cannot do it so they can potentially get someone else.

How applications are evaluated

Each application is assigned a 1st internal reviewer, a 2nd internal reviewer and 3 readers (hereafter referred to as 5 readers). The Physics EG meets in Ottawa in February in what is called a Conference Model. The members of the Physics EG are divided into sub-groups (called Sections) but for specific applications the readers may come from different subgroups or even from other Evaluation Groups meeting at the same time (e.g. biology or computing). The idea is to get as much expertise as possible evaluating a given application. The technical expertise comes from the external referee reports as well, hence their importance to the proc-

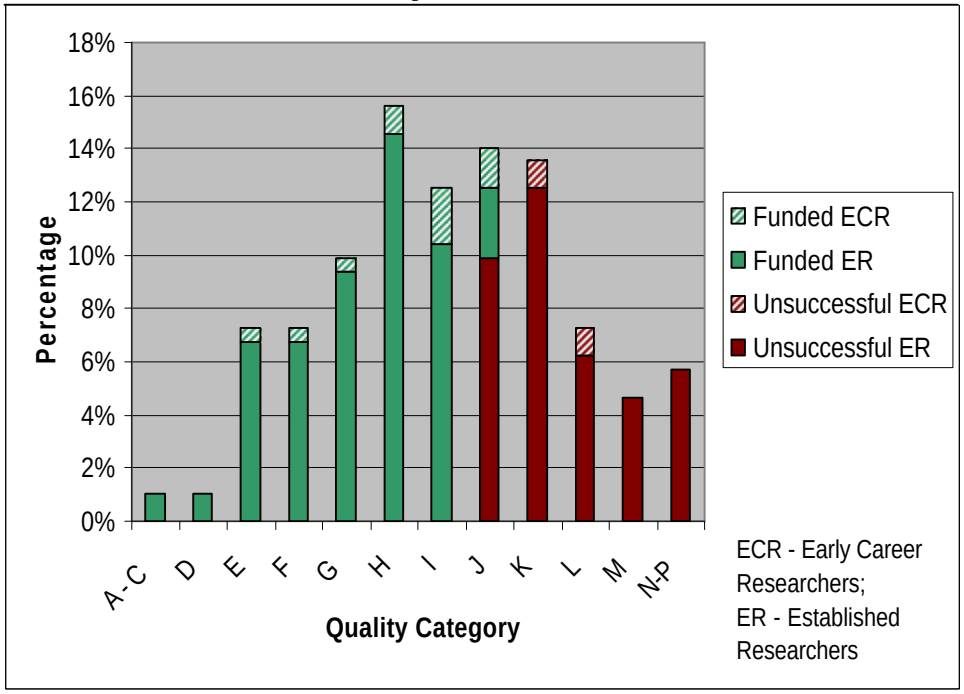


Figure 1: Distribution of applicants into bins for the Physics Evaluation Group in the 2010 competition. Bin J corresponds to a score of 12, e.g., equivalent to 3 "Strong" ratings (from NSERC's ``2010 Competition Statistics: Discovery Grant Program'' available on the NSERC web site).

ess.

Each application is evaluated on 3 criteria: the Scientific or Engineering Excellence of the Researcher(s), the Merit of the Proposal and the Contribution to Training of Highly Qualified Personnel (HQP). Note that each criterion has equal weighting, so that the contribution to training of HQP has the same weight as the excellence of the researcher. The rating is on a six point scale: Exceptional (1), Outstanding (2), Very Strong (3), Strong (4), Moderate (5) and Insufficient (6). We did not see the Exceptional rating used for any of the 60 or so applications we were directly involved with. Details of the criteria used are available on the NSERC web site but in practice it comes down to a discussion between the 5 readers of any given application. The "Outstanding" level implies a very accomplished researcher. In the 2010 competition, receiving 3 "Strong'' ratings was not a guarantee of funding due to the stiff competition.

The discussion of each application lasts for about 15 to 20 minutes and only the 5 readers are allowed to speak. There is then a confidential vote on each of the 3 criteria and the median value of the 5 votes is used to assign the rating for each component (for example, the median ratings may be Very Strong (3), Strong (4), Strong (4) for a total score of 11). It should be pointed out that NSERC is very careful about conflicts of interest, so, for example, any member of the Physics EG must leave the room when the application of any faculty member from the same university or that of any collaborators is to be discussed.

During the review process there is little consideration of the proposed budget unless it has something wildly out of place (e.g. an excessive travel request or an equipment request worth more than $7,000 which should be directed to the RTI program). This reflects the philosophy that Discovery Grants are primarily used for funding students, post-docs and basic operating costs such as conference travel, so the actual grants awarded are independent of the funds requested. There is a slight perturbation on this whereby the evaluators consider whether the cost of a particular line of research is more or less expensive than typical research in physics, and then there may be a slight supplement (or decrement) to the grant (of the order of 10%). So, e.g., if liquid He is needed to run an MRI, an extra $5K/y may be allocated but the applicant would be expected to get the rest of the costs from other grants or their own institution.

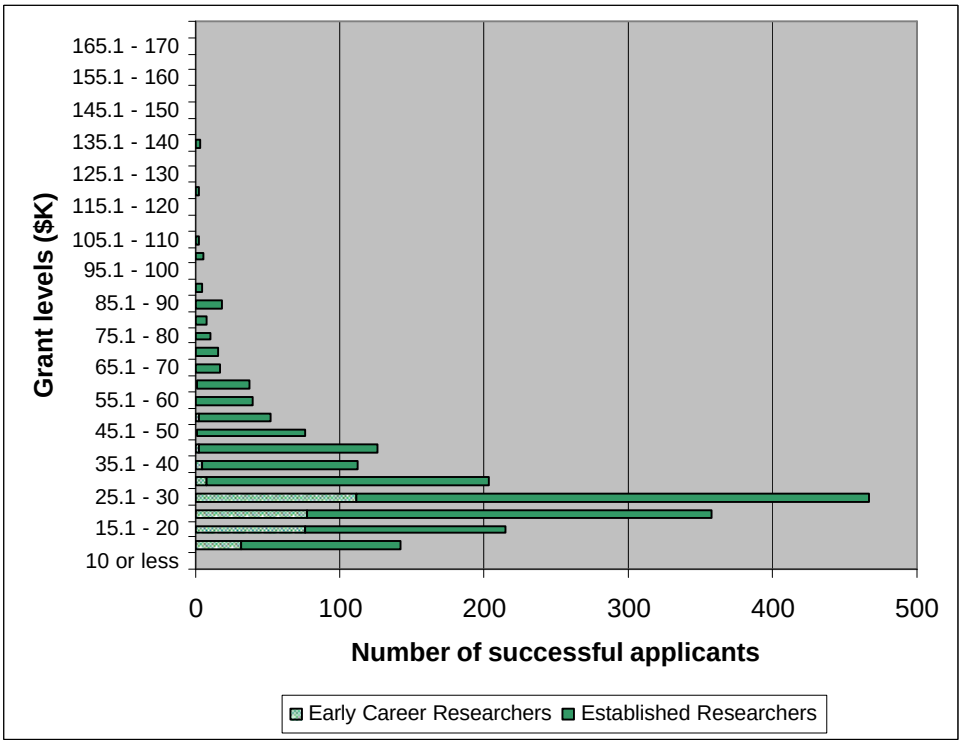


Figure 2: Distribution of NSERC Discovery Grant amounts for the 2010 competition for all disciplines except sub-atomic physics (from *op.cit.*).

Once all applications have been reviewed, each application is placed in one of 16 funding bins (A-P) based on its score resulting from the merit assessment of the three criteria. Figure 1 shows the distribution into bins in this year's competition for the Physics EG. For example, bin A has a score of 3 and refers to 3 Exceptional ratings whereas bin J has a score of 12 and refers to 3 Strong ratings or 1 Strong, 1 Moderate and 1 Very Strong, etc. The grant amount awarded is the same for all applications in a given bin. It is important to note that EG members do not discuss individual grant amounts. Preliminary bin values are assigned based on the previous year's competition and they are later modified after the bins are populated with applications in order to balance the budget and success rate in the context of a highly competitive competition for limited resources.

Funding levels

NSERC Discovery Grants range in value from about $10K/y to a very few over $100K/y with an overall median of $25K to $30K/y. Figure 2 shows the distribution of grant amounts for all disciplines. In the 2010 competition, if one includes the Subatomic Physics Individual and Team grants, there were 223 applications to the Physics EG (which included most but not all of the medical physics grants). There were 139 grants awarded for a success rate of 62% and an average grant of $40,800. Early career researchers (ECRs) are reviewed using the same criteria as all other applicants, except that greater emphasis is placed on the "potential" to make significant contributions to research and to the training of HQP. In the 2010 competition there were 20 ECR applications of which 16 were funded for an average grant of $34K.

Advice

Applications to the Discovery Grant Program must be focused on the natural sciences and engineering (NSE). Reviewers are directed to consider only those aspects of the proposed program related to NSE. Hence, for medical physics applications this means that if the proposal is deemed to be more clinically oriented this may affect the rating for the "Merit of the Proposal". Hence, it is important to stress the NSE discovery / innovations.

The awarded amount on a successful grant application cannot be more than what was requested, even if the application is placed in a higher funding bin. Be sure to build a budget based on the actual

costs for the proposed research program and be sure to provide a detailed budget justification. The budget should not be inflated as this may affect the rating for the "Merit of the Proposal". For medical physics applications it is very important to discuss any scientific or budgetary overlaps with other health related grants and funding sources, such as CIHR.

If the applicant has no or a limited track record of supervising graduate students, requesting funds to supervise a large number of students (e.g. 5 or more) may be viewed as unrealistic. Since training of HQP is so critical in the evaluation, it is important for applicants to establish a track record of supervising graduate students prior to submitting an application (except for early career researchers who are evaluated more on what is proposed, as well as any experience co-supervising students). Proposals should include a HQP training plan that includes details on the student experience including, for example, presentation at COMP and other scientific meetings.

Given how the application will be evaluated, it is important to give the reviewers specific evidence and information related to the three criteria. Things should not be blown out of proportion, and excessive wordiness is a no-no (each member of the EG is reviewing a large pile of applications). However, it is important to give specific examples such as external invited talks, memberships on external task groups or scientific committees, commercial or clinical use of the applicant's work, external collaborations, highly cited papers, book chapters or reports, reviewing or other roles for high impact journals, etc. It is important to remember that each application is rated in comparison to the cohort of grants submitted in that competition year.

Applicants should get several colleagues to read their application. It must be well written, again remembering the impression it will make on a busy reviewer/ reader if he/she has to struggle to read the document.

Summary

In 2009 NSERC formally recognized Medical Physics as a Research Topic within the Discovery Grant (DG) Program. Medical physics applications are a good fit with the DG program provided that the proposed research activities are within NSERC's mandate of natural sciences and engineering research. We encourage medical physicists who have active research programs with this focus, or a good idea for a research program and desire to fund graduate students, to apply to NSERC for some baseline funding.

Interesting Things Medical Physicists Do: Swords into Ploughshares?!

Dr. Alex Vitkin, MCCPM
University of Toronto

A medical physics phenotype is interdisciplinary by his/her very nature. We need to be conversant with various aspects of physics, engineering, biology and clinical sciences through the daily demand of our exciting profession. As such, some of us serve as grant reviewers on different research grant panels – NSERC, CIHR, NCIC/CCSRI, NIH, NSF just to name a few of the more common relevant abbreviations. But did you know that there is also an international granting ("redirecting") program whose unofficial motto is "Turn Swords into Ploughshares"!? (or "Tanks into Tractors" for those with a more modern agricultural bend:) The Canadian government, thru the Department of Foreign Affairs and International Trade (DFAIT -- for funding), and thru NSERC (for the scientific peer-review process), plays a major role in this innovative international venture. For the last few years, I have served on this panel and have found it quite worthy, not well known to my colleagues, and in many ways 'off the beaten path'. So I decided to write a short piece for InterACTIONS to share this interesting experience with the medical physics community.

In essence, this is a program put together by the Western world in the 1990s, following the collapse of the communist block and the aftermath of the Cold War. The European Union, United States, Japan, Australia and Canada have pulled together some funds (don't ask me about the complicated bureaucracy of this aspect!) to enable selected "weapons scientists" from the former Soviet Union and its various splinter republics to redirect their technical, and often classified and secretive, skills towards peaceful scientific ends. The idea of their integration into the larger international scientific community obviously serves the interest of the contributing Western democracies, in minimizing the risk of various biological/chemical/nuclear/rockets/submarine weapons expertise and technologies falling into the 'wrong hands', however these are defined by the political contingencies of the day (Rogue states? Extremist groups? Militia units? I don't want to expound on this controversial designation…). Hence the unofficial name of this whole venture, Swords into Ploughshares, referring to converting weapons scientists into peaceful scientists; the tank/tractor analogy mentioned above is my own current adaptation of the ancient S-into-P Biblical phrase.

So what does all this mean practically, especially for a harried medical physicist such as myself? Well, every several months an NSERC representative sends us a list of applications that have been submitted by various research groups in Russia, Ukraine, Belarus, Georgia, Armenia, Moldova, Azerbaijan, Kazakhstan and other central Asian republics. Having indicated our relative comfort levels for review – and here the panel members have to stretch their expertise and imagination considerably, as the range and scope of topics in the different proposals is really REALLY wide – we convene in Ottawa for a day or two and conduct our review. Here, in addition to the more conventional research grant criteria such as significance, innovation, and methodology, we consider aspects particular to this funding program, such as: does the research involve a significant number (>50%) of former weapons scientists? is the proposed science truly 'peaceful', or may it still have a military/weapons component or application? does the proposal have any particular economic (or security) significance to the sponsoring parties (presently Canada, USA or EU)? will this enable a transition to a long-term self-sustained peaceful operation? As you can well imagine, these are pretty unusual evaluation criteria unfamiliar to most of us, so the discussions can get

interesting, lengthy, and convoluted. Add to this the extreme range of disparate expertise on the review panel (nuclear, solid state, laser and medical physicists; chemists and biochemists; agricultural, electrical and aeronautical engineers; biologists and clinical scientists; entrepreneurial, industrial and government scientists, etc) and the often 'unconventional' writing style of the proposals (the applicants are writing in their non-native language, and many have never applied for a research grant in their careers; a promise to exceed the targets of the Central Committee's five year plan would have often sufficed in the past!), and you have more reasons for a lively discussion. The NSERC officers and the DFAIT representatives present during our panel deliberation try to reign us in, sometimes successfully!

But let's cut to the chase, what kind of grants do we actually get to review? On a given day, we may discuss proposals dealing with algae use for cleaning up chemically contaminated soil, use of weapons tracking technology to optimize commercial railway transport scheduling, novel rotor design for advanced helicopters, low-level electromagnetic irradiation of crop seeds to increase yield, radioactive nanoparticle use in biomedicine, magnetic warning system for lightning interference with technology installations, advanced detection of cosmic ray bursts, lab-on-a-chip approaches for tuberculosis diagnosis, laser biostimulation for speeding up mushroom growth (huh?!), and so on. Interesting you say? Yup! Varied/crazy/difficult to evaluate? Ditto. But overall useful and worthy? Lets' see – trying to change mindsets, manage dangerous hardware, clean up environmental disasters of the Cold War vintage, enable long-term peaceful sustainability and coexistence, etc… Useful indeed, I think!!!

With respect to the last point, NSERC/DFAIT have tried to derive some 'success metrics' to evaluate the effectiveness of this program. This is not an easy undertaking even for conventional granting programs such as NSERC or NIH, and even more difficult here. So the objective evaluation of the utility of Swords into Ploughshares program is

(Continued on page 94)

Welcome New COMP

Full Members

First Name	Last Name	Institute
Malik	Brunet-Benkhoucha	Hôpital Maisonneuve-Rosemont
Matthieu	Lemire	Hôpital Maisonneuve-Rosemont
Ryan	Rivest	CancerCare Manitoba
Mark	Ruschin	Princess Margaret Hospital
Gabriel	Sawakuchi	Carleton University
Steven	Thomas	BC Cancer Agency - Abbotsford
Rebecca	Thornhill	Ottawa Hospital
Roxana	Vlad	Durham Regional Cancer Centre
Ling Bin (Mark)	Xu	Best Theratronics

Associate Members

Désiré	Ngambia Mbamou	
Stephen	Pinter	Robarts Research Institute
Aaron	Ward	Robarts Research Institute

Student Members

Andrew	Alexander	McGill University
Muhammad Naeem	Anjum	McGill University
Alexandra	Bourgouin	Université Laval
Alexandra	Bourque	Université Laval
Lada	Bumbure	Riga Technical University
Derek	Cappon	McMaster University
Eve	Chamberland	Hôtel Dieu de Québec (CHUQ)
Heather	Champion	CancerCare Manitoba
Carling	Cheung	Robarts Research Institute
Eunah	Chung	McGill University
Robert	Cropp	BC Cancer Agency - Vancouver
Charlotte	Curtis	University of Calgary
Michel	D'Amours	Université Laval
Maxime	Desbiens	Hôtel Dieu de Québec (CHUQ)
Claire	Foottit	Carleton University
Jean-Christophe	Gagnon	Hôtel Dieu de Québec (CHUQ)
Jean-François	Gauthier	Université Laval
Mathieu	Goulet	Hôtel Dieu de Québec (CHUQ)
Chad	Hunter	Carleton University
Amjad	Hussain	Tom Baker Cancer Centre

Members!

John	Kildea	McGill University
Izabela	Kowalczyk	Robarts Research Institute
Karl	Landheer	Carleton University
François	Lessard	Université Laval
Daniel	Markel	Odette Cancer Centre
Matthew	Marsh	Queens University
Peter	McCowan	CancerCare Manitoba
Jonathan	Morin	Université Laval
Jennifer	Moroz	University of Alberta
Munira Fardous	Nahin	Carleton University
Nick	Rawluk	Queens University
Micheal	Roumeliotis	University of Western Ontario
Christine	St-Pierre	Université Laval
Justin	Sutherland	Carleton University
An	Wang	University of Western Ontario

Corporate Members

Dragani	Amy	NELCO
Marlay	Ian	Maquet-Dynamed Inc.

Easy Particle Propagation

Jonas Lippuner
CancerCare Manitoba

Epp (Easy particle propagation) is a user code for the Monte Carlo simulation package EGSnrc. Epp is designed for x-ray scatter analysis in x-ray imaging applications. It simulates radiation transport through an arbitrary geometry and propagates the particles that leave the simulation geometry to an image plane where a picture is formed. Epp also tracks the number of Compton and Rayleigh scatter events that a photon undergoes and creates separate images for primary and scattered photons. Currently, Epp only propagates photons, but it could be easily modified to propagate other particles as well.

The EGSnrc code system provides a solid and extensively validated physics model and the framework of the Monte Carlo simulation. In addition to that, Epp is based on the EGSnrc C++ class library, which provides a comprehensive library of geometry objects that can be used to create simple as well as very complex simulation geometries. The simulation geometry is constructed from primitive geometries, such as planes, boxes, spheres, cylinders and cones. These objects can be arbitrarily positioned, rotated and combined to form more complex structures. Defining the simulation geometry in this analytical way has the advantage that it is more accurate and in most cases also much faster to simulate. Voxelized volumes can also be integrated into the simulation geometry and can be directly imported from an existing *.egsphant file.

In a similar fashion, particle sources are constructed from abstract shapes, such as points, lines, rectangles, circles and rings etc. They can be used to construct parallel, collimated or other types of sources. There is also a Gaussian shape to model non-uniformly irradiating sources. Multiple sources can be combined to form a collection of sources where each individual source can be assigned a statistical weight.

Epp and the EGSnrc C++ class library are written in C++ and are designed to be easily modifiable and extendible. If, for example, the user requires a particle source that cannot be constructed with the provided shapes, she can implement a new shape based on an existing one. The user only needs to implement the new aspects of the shape and can rely on the base functionality of the existing shape. The same applies to simulation geometries. To simply use Epp in its current form, no programming whatsoever is required.

The input file for Epp consists of key-value pairs in a keysubkey structure, which makes it very flexible and human readable. Epp also provides the ability to reference other files so that a simulation can be broken up into several input files, which can be reused and shared among users.

To simulate x-ray imaging, the user defines a virtual detector, which is basically an image plane with a given size and number of pixels. Epp will then propagate all photons that leave the simulation geometry to that image plane and score the number of photons and/or the total deposited energy in each pixel. Epp can create five different images, namely one for primary, single Compton, single Rayleigh, multiple scattered photons, and one image with all photons. Epp can also calculate the dose deposited in each voxel of a voxelized volume.
Epp is released under the GPL license and freely available at http://www.physics.umanitoba.ca/~elbakri/epp.

Editor's Note

Idris Elbakri, PhD, MCCPM
CancerCare Manitoba, Winnipeg, MB

This issue of Inter***ACTIONS*** is jam packed with quite the variety of articles: from laptops for Kenya to turning swords into ploughshares! These colleagues who take the initiative and write make my job as editor so much easier. I can focus on layouts and graphics and do not have to worry about chasing after content from the membership.

I am writing this column just a few days before the COMP/CCPM annual meeting in Ottawa. The LAC has prepared a very interesting program for us. I will be looking for volunteers to write a review of the annual meeting!

In the wake of public attention to CT doses, the AAPM held a "CT Dose Summit" in Atlanta, GA at the end of April. I had the pleasure of attending the meeting. It was an intensely focused meeting on all aspects of CT dose reduction. Topics included protocol optimization, cardiac CT, kVp selection, etc...One of the most important lessons learned from the meeting was the need for dose reduction and optimization to be a collaborative team effort. This seems obvious, but to a clinical imaging physicist like myself, is not easy. Unlike our therapy colleagues, imaging physicists in Canada are not always "embedded" in the clinical environment. Here in Winnipeg, we are part of the Division of Medical Physics at CancerCare. This arrangement has both pros and cons, but one challenge is to persistently reach out to the radiology community and convince them that our services are of value. Other imaging physics services in Canada are found in a more regulatory/radiation protection type environments, which also remains a bit isolated from clinical stakeholders. One positive consequence of the recent public attention towards doses from CT and radiation in general is the opportunity it presents us to reach out beyond our cubicles and make the case for the diagnostic imaging branch of medical physics.

I hope you all have a pleasant summer. The next issue is in October. The deadline is September 1!

(Continued from page 92)

not an issue I have sufficient expertise in. (Does anyone? I wonder) Personally, however, and time commitment considerations aside, I thoroughly enjoy the camaraderie of our review meetings and the intellectual stimulation of learning many new concepts at each panel gathering. Given the highly interdisciplinary nature of the panel, the tongue-in-cheek trash talking is inevitable – chemists rule vs physicists rock vs clinicians are tops vs biologists know best vs engineers make it work vs … Well, you get the idea! The overall positivity is further bolstered by my firm conviction that 'this is the right thing to do', both in the programmatic context, and in the personal context of contributing my expertise (such as it is:) for a worthy scientific cause of truly global significance!

If anyone is interested in learning more about this initiative, its official name is Global Partnerships Program IGX, with other relevant abbreviations being ISTC: International Science and Technology Centre of Russia and STCU: Science and Technology Centre of the Ukraine (these identify from which different competition centres within IGX the applications are coming from – see http://www.international.gc.ca/gpp-ppm for more details). In the meantime, if anyone is interested, we're often looking for expert reviewers to help us evaluate a particular grant, and sometimes we seek new members to serve on the panel too.

Happy scatterings!

Dates to Remember

Inter*ACTIONS* Fall Issue Deadline is September 1, 2010!

AAPM Annual Meeting
July 18-22, 2010
Philadelphia, PA

AAPM Summer School
July 22-25, 2010
Philadelphia, PA

International Conference on 3D Radiation Dosimetry
August 22-26, 2010
Hilton Head Island, SC

RSNA Annual Meeting
November 28-December 3
Chicago, IL

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