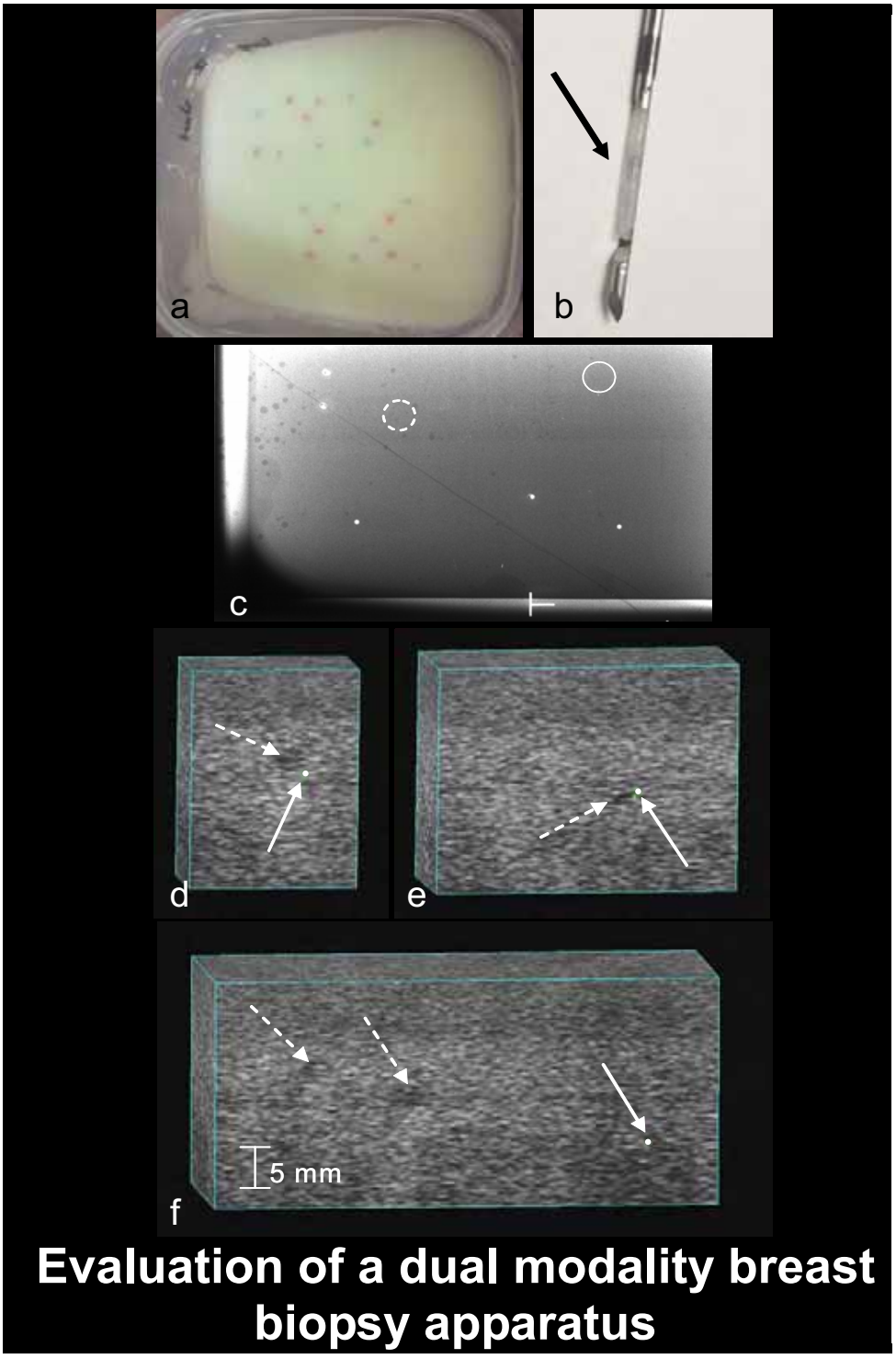
InterACTIONS

CANADIAN MEDICAL PHYSICS NEWSLETTER
Le BULLETIN CANADIEN de PHYSIQUE MÉDICALE



Evaluation of a dual modality breast biopsy apparatus

COMP OCPM

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About our Cover

A dual modality image guided breast biopsy apparatus was evaluated using phantoms. Pre-procedural stereotactic mammography (SM) images were acquired to identify x-ray visible targets. Near real-time 3D ultrasound (US) imaging, registered to the SM coordinate system, provided further information about the targets. Real-time 2D-US imaging allowed for accurate targeting with a biopsy needle. **(a)** A photo of the agar biopsy phantom, before another layer of agar enclosed the 3.2mm spheres. **(b)** The three types of spheres were distinguished upon biopsy by their colour, and their material properties gave them different characteristics in US and SM imaging. **(c)** The purple and red spheres appeared as clusters of microcalcifications in SM (circles). **(d-f)** The purple and blue spheres appeared as hypoechoic masses in US (dashed arrows). The targets of this study were the purple spheres, which were visible in both modalities. In **(d-f)**, the dots (solid arrows) indicate the 3D-US coordinates of microcalcifications identified with SM imaging. The hypoechoic masses in **(d)** and **(e)** are therefore purple targets. The hypoechoic masses in **(f)** (dashed arrows) were not marked and are blue inclusions. The SM marked point in the same image plane (solid arrow) has no associated mass and is a red inclusion. The sensitivity of the dual modality biopsy procedure, using these phantoms, was 70%, the specificity was 90% and the accuracy was 83%.

Images provided by Kathleen Surry, Donal Downey and Aaron Fenster, Imaging Research Laboratory, Robarts Research Institute, London Ontario.

This work was funded by the CIHR.

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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.

Corporate advertising enquiries can be made (until a new Executive Director is found) to:
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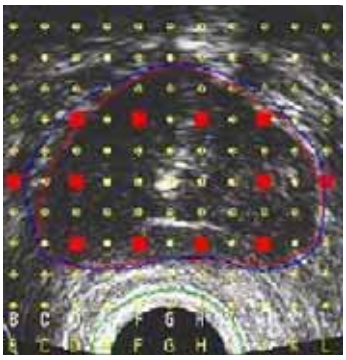


Inside this issue:

Uncertainty analysis of prostate brachytherapy implants….. 124
Patricia Lindsay, Jake Van Dyk, Jerry Battista

Message from the COMP Chair:

...as we move forward it is important that we recognize our outstanding members, that we document our activities and that we maintain accessible archives of interest...

As I begin my term as COMP chair I do so with some trepidation but also with a great deal of pride in Canadian Medical Physics. I have witnessed a tremendous growth in the field since my first days at the old Calgary Cancer Clinic in 1971. In those early days even the relatively small Calgary centre, which offered only radiation therapy, had its own radiology department, including a nuclear medicine facility with a gamma camera and a radiologist on staff. As newer cancer centres were built in the 70's and 80's these imaging facilities were not included. Now we have gone full circle. In 2004 most radiation therapy departments are trying to increase their imaging capabilities with CT, MR and recently PET and most recognize the advantages that would accrue from having a radiologist on staff and dedicated to radiation therapy. This example highlights one of the benefits of working for a long time in the same field – it allows one to see that progress often involves a re-examination of old ideas. The renaissance now underway in radiation oncology is due in large part to developments by medical physicists that have improved imaging quality and dose delivery techniques; both of these have been enabled by developments in computer technology. Likewise, over the first years of COMP there have been many ideas that could not be implemented until COMP had reached a critical size and age. It is time now to re-examine some of those ideas.

As an organization COMP is now solidly established in the Canadian and to some extent, the international medical physics scene. However, it is not clear to me if COMP is known very well outside of that relatively small sphere or how COMP is viewed by other professional organizations that are closely related to ours (CARO, AAPM, etc.). Also, although our annual scientific meetings are now of high caliber, there are some missing elements and also some key questions to ask. Do we want the meeting to be larger and to attract AAPM members, CARO members etc.? Is the format optimum or should we have more keynote speakers? Many of our interactions with other professional groups – particularly the AAPM and CARO - are handled in an ad-hoc manner. It may be time to formalize those links. Also, as we move forward it is important that we recognize our outstanding members, that we document our activities and that we maintain accessible archives of interest to the members. These are a few of the areas in which I hope to have an impact over the next few years and I hope to be able to report on them in this forum.

As I write this article one of the COMP executive's immediate priorities is to recruit a new executive director to replace Michael Henry, who resigned earlier this year. Michael added much needed expertise to the organization and started work in some of the areas I have listed above.

Mr. Peter O'Brien, COMP Chair

The mid-year meetings of COMP and the CCPM will be held at the end of November in Toronto. If you have any issues that you would like discussed at those meetings by your executive, please forward them to me or to another member of the executive.

Finally, I must close by thanking all of those who have gone before, and in particular Clément Arsenault, now the COMP past chair, who worked tirelessly on our behalf and who always remembered that the organization is for the members.

Message from the CCPM President:

One of the topics for discussion at the November CCPM Board meeting will be continuing measures to maintain the credibility and increase the flexibility of the written Membership examination. With the addition last year of an oral examination, the next consideration is a suggestion that the structure of the written part of this examination may now require revision.

Currently, this examination is divided into four parts given over in two 2½ hour sittings with a break for lunch. The first section, written by all applicants, is devoted to general medical physics, relevant clinical anatomy and biological science. The second

Dr. Brenda Clark, CCPM President

section addresses radiation safety and protection and while all the ionising radiation sub-specialties answer the same questions, applicants in magnetic resonance imaging write a different examination. These sections have been working well and no changes are anticipated.

Sections three and four comprise two questions selected at random from the published question bank which is available at least 3 months prior to the examination. There is a separate question bank for each sub-specialty, each consisting of twenty questions specific to the sub-specialty and ten questions covering more general areas of the sub-specialty. Section three consists of a question from the first group of twenty and section four from the second group of ten. It is these two sections of the examination and the use of previously published questions that will be discussed in November. The purpose of this editorial is to share with you some preliminary thoughts and seek input for the discussion.

While these question banks have been of excellent value since their first use in 1984, the inclusion of only two of these questions in the examination tends to place a restriction on the scope of issues addressed. Those of you familiar with the question bank will know that the questions generally address a particular topic in considerable depth so that the inclusion of only 2 of these questions will limit the areas covered by the examination.

One option would be to consider replacing the question bank with a syllabus but this approach would dramatically reduce the information available to candidates. The question bank not only specifies by default a list of topics, but also provides a clear indication of the depth of knowledge required by a clinical medical physicist.

The suggestion to be discussed at the November meeting is to restructure the question bank by dividing each question into several shorter questions such that more than two questions may be included in the examination to cover a wider range of topics. Clearly care must be taken with this approach to appropriately restructure the questions such that each is viable alone.

The mandate of the CCPM Board is to ensure continuing credibility of our examination processes and we are always seeking input not only from the CCPM membership (after all, they have already passed this particular examination!) but also from members of COMP who are possible future members of the College. If you have any comments or suggestion on this or any other topic, please let us know.

With the addition last year of an oral examination, the next consideration is a suggestion that the structure of the written part of this examination may now require revision.

2003 Professional Survey

Richard Hooper, Cross Cancer Institute, Edmonton, AB
for the Professional Affairs Committee, COMP/CCPM

The format and data collection procedure for the 2003 COMP Professional Survey was similar to that used for the 2002 survey. Approximately 295 questionnaires were mailed out to all COMP full members currently residing in Canada, and 123 surveys were returned. All survey responses were handled in the strictest confidence so as to ensure the anonymity of respondents. Responses are summarized by geographic area and degree/ certification in tables 1 and 2 below. Some surveys were incomplete and could not be used in all or parts of the remaining analysis.

Salaries

A summary of the salary data for Medical Physicists working in Canada is provided in table 3 below. Full statistics are provided for groups with at least 11 respondents. Only average and median results are provided for groups of 5 to 10 respondents. Data for groups of fewer than 5 could jeopardize confidentiality and thus are not listed.

	Number of Responses
British Columbia (BC)	12
Alberta (AB)	11
Saskatchewan (SK)	3
Manitoba (MB)	9
Ontario (ON)	55
Quebec (QC)	20
New Brunswick (NB)	4
Nova Scotia (NS) and Prince Edward Island (PE)	5
Newfoundland (NF)	3
Not Specified	1
Total	123

Table 1: COMP 2003 Professional Survey responses by geographical region.

A comparison of average and median salaries for 2002 and 2003 is provided in table 4. Only groups with at least 11 respondents in both years are included in this table. Figure 1 depicts percentile ranges of primary income from 1999 through 2003 for all Medical Physicists working in Canada, and also for subgroups by degree and certification.

Individuals were asked to specify by what percentage their salaries increased or decreased between 2002 and 2003. Of the respondents who had at least three years experience in medical physics, worked as full-time employees, and had not changed jobs in the past two years, 1% reported that their salary decreased, 10% reported that their income did not change, and 89% reported that their income increased. For all these individuals the average increase was 6.4% and the median increase 4.0%. For the 89% who reported an increase in income the average increase was 7.2% and the median increase 5.0%.

The regular hours of work specified in employment contracts for full-time employees was, on average, 37.5 hours per week.

Benefits

The average annual vacation allotment was 22.4 days per year.

Some employers allocate each of their physicists an annual personal travel and/or professional expense allowance, while other employers reimburse these expenses on an ad-hoc basis. Of all the respondents who listed themselves as full-time employees, 70% reported receiving reimbursement of at least $1,000 while 25% either did not answer the question or reported receiving no reimbursement. For those receiving at least $1,000 the average allocation was $3,196 and the median allocation $2,900.

Other benefits data is summarized in table 5.

(Continued on page 119)

	Certification				
Degree	None	CCPM(M)	CCPM(F)	Other	Total
Bachelors	1	0	1	0	2
Masters	14	9	15	3	41
Doctorate	26	16	30	7	79
Other	1	0	0	0	1
Total	42	25	46	10	123

Table 2: COMP 2003 Professional Survey responses by degree and certification.

2003 Professional survey... (Continued from page 118)

			PRIMARY INCOME				TOTAL INCOME			
		Ave Yrs	Average	Percentiles			Average	Percentiles		
	Number	Exper	Income	20th	Median	80th	Income	20th	Median	80th
OVERALL (Canada)	119	13.8	101.0	75.0	104.0	130.0	103.5	75.0	105.0	132.3
PROVINCE										
BC + AB + SK + MB	33	13.4	103.4	75.1	110.0	126.6	104.0	75.1	110.0	131.5
ON	54	15.4	108.3	80.3	112.0	136.0	112.1	80.3	118.5	139.1
QC	19	12.0	83.3	71.5	77.5	102.1	84.9	71.5	77.5	102.8
NB + NS + PE + NF	12	11.4	91.0	67.2	99.5	110.0	94.3	67.2	99.5	110.0
EMPLOYER										
General Hospital	38	14.8	98.7	75.0	101.5	130.9	102.8	75.0	102.0	134.6
Cancer Institute	64	13.6	107.2	80.0	110.0	132.3	109.3	80.0	110.0	136.4
University, Government, or Research Institute	14	13.0	82.8	66.5	81.8	102.5	83.3	66.5	81.8	102.6
FUNCTIONS (>= 50%)										
Service	76	11.5	95.2	73.4	98.5	118.8	96.2	73.4	98.5	120.0
Teaching + R&D	28	14.3	100.1	75.0	96.0	130.9	105.0	76.3	96.1	140.0
Administration	11	24.5	124.8	105.6	120.0	150.7	132.5	105.6	123.5	154.3
SPECIALTIES (>= 50%)										
RT	91	12.3	102.0	75.0	104.0	131.3	103.4	75.0	108.0	132.1
DR + NM + MR	23	17.6	97.2	75.0	92.0	114.9	106.4	76.1	92.3	135.9
RP	3									
YEARS EXPERIENCE										
< 5	25	2.7	68.4	54.5	70.0	82.0	68.4	54.5	70.0	82.0
5 - 9.9	25	7.4	92.5	75.0	90.0	108.3	93.7	75.0	90.0	111.0
10 - 14.9	19	11.5	104.5	86.2	110.0	122.4	106.0	86.2	110.0	122.4
15 - 19.9	18	16.6	116.5	93.2	123.8	139.8	116.7	93.4	123.8	139.8
20+	32	27.3	122.2	106.8	121.0	137.0	129.6	109.7	131.5	152.9
DEGREE/CERTIFICATION										
Bachelors/all	2									
Masters/all	39	13.6	92.7	71.2	87.9	115.8	93.5	71.2	87.9	118.2
Masters/no cert.	13	5.2	68.9	51.2	70.0	79.8	68.9	51.2	70.0	79.8
Masters/CCPM(M)	8	8.1	91.7		84.9		91.7		84.9	
Masters/CCPM(F)	15	20.6	111.4	91.5	110.0	132.0	113.4	91.5	118.0	132.0
Masters/CCPM(M or F)	23	16.3	104.5	82.0	105.0	129.0	105.8	82.0	108.0	129.0
Masters/other cert.	3									
Doctorate/all	77	13.7	106.0	77.8	110.0	132.5	109.5	79.8	110.0	137.0
Doctorate/no cert.	25	9.7	84.2	62.0	81.0	117.9	84.6	62.0	81.0	117.9
Doctorate/CCPM(M)	16	9.3	101.7	86.3	106.3	114.3	102.6	86.3	106.3	117.0
Doctorate/CCPM(F)	29	19.6	126.0	107.9	131.0	139.5	134.2	113.4	136.0	144.1
Doctorate/CCPM(M or F)	45	16.0	117.4	100.0	116.7	137.0	122.9	102.0	121.0	140.0
Doctorate/other cert.	7	13.9	111.1		120.0		111.6		120.0	
DEGREE/YEARS EXPER.										
Masters/< 10	19	4.3	75.3	67.9	75.9	86.1	76.1	67.9	75.9	86.1
Masters/10+	20	22.4	109.2	91.5	110.0	131.5	110.0	91.5	110.0	131.5
Doctorate/< 5	14	3.1	68.9	56.0	64.5	89.2	68.9	56.0	64.5	89.2
Doctorate/5 - 9.9	16	7.5	95.9	75.0	98.5	111.5	96.9	75.0	98.5	114.7
Doctorate/10 - 19.9	27	13.4	113.6	91.7	116.7	137.1	114.2	91.7	117.0	137.1
Doctorate/20+	20	26.6	129.9	119.1	128.0	143.0	141.5	120.0	136.2	161.0

Table 3: Salary data for Medical Physicists working in Canada. Salaries are in thousands of dollars. In order to ensure confidentiality, data are not listed for subgroups of less than 5, and only average and median values are reported for groups of 5 to 10 respondents.

(Continued on page 120)

2003 Professional survey... (Continued from page 119)

	PRIMARY INCOME 2002		PRIMARY INCOME 2003		CHANGE IN PRIMARY INCOME (% of 2002 Income)	
	Average	Median	Average	Median	Average	Median
OVERALL (Canada)	96.4	96.0	101.0	104.0	4.8%	8.3%
PROVINCE						
BC + AB + SK + MB	98.0	104.0	103.4	110.0	5.5%	5.8%
ON	103.1	109.5	108.3	112.0	5.0%	2.3%
QC	78.4	79.0	83.3	77.5	6.2%	-1.9%
NB + NS + PE + NF	88.6	92.0	91.0	99.5	2.7%	8.2%
EMPLOYER						
General Hospital	89.7	86.5	98.7	101.5	10.0%	17.3%
Cancer Institute	100.8	107.0	107.2	110.0	6.3%	2.8%
University, Government, or Research Institute	88.9	76.0	82.8	81.8	-6.9%	7.6%
FUNCTIONS (>= 50%)						
Clinical Service	93.7	94.0	95.2	98.5	1.6%	4.8%
Teaching + R&D	94.1	89.0	100.1	96.0	6.4%	7.9%
Administration	111.4	128.8	124.8	120.0	12.0%	-6.8%
SPECIALTIES (>= 50%)						
RT	98.7	100.0	102.0	104.0	3.3%	4.0%
DR + NM + MR	95.0	90.0	97.2	92.0	2.3%	2.2%
YEARS EXPERIENCE						
< 5	67.6	70.0	68.4	70.0	1.2%	0.0%
5 - 9.9	86.7	86.0	92.5	90.0	6.7%	4.7%
10 - 14.9	102.0	105.0	104.5	110.0	2.5%	4.8%
15 - 19.9	109.5	116.5	116.5	123.8	6.4%	6.3%
20+	112.4	117.8	122.2	121.0	8.7%	2.7%
DEGREE/CERTIFICATION						
Masters/all	85.3	85.0	92.7	87.9	8.7%	3.4%
Masters/no cert.	67.0	65.0	68.9	70.0	2.8%	7.7%
Masters/CCPM(M or F)	94.5	92.0	104.5	105.0	10.6%	14.1%
Doctorate/all	103.2	107.5	106.0	110.0	2.7%	2.3%
Doctorate/no cert.	87.8	90.0	84.2	81.0	-4.1%	-10.0%
Doctorate/CCPM(M or F)	111.2	110.0	117.4	116.7	5.6%	6.1%
DEGREE/YEARS EXPER.						
Masters/< 10	71.1	70.0	75.3	75.9	5.9%	8.4%
Masters/10+	94.5	90.0	109.2	110.0	15.6%	22.2%
Doctorate/< 5	70.1	75.0	68.9	64.5	-1.7%	-14.0%
Doctorate/5 - 9.9	95.7	96.0	95.9	98.5	0.2%	2.6%
Doctorate/10 - 19.9	113.4	114.0	113.6	116.7	0.2%	2.4%
Doctorate/20+	119.2	120.7	129.9	128.0	9.0%	6.0%

Table 4: Comparison of average and median values for primary income in 2002 and 2003. Income values are in thousands of dollars, and change in income is specified as percentage of primary income in 2002. Only groups with at least 11 respondents in both years are included in this table.

(Continued on page 121)

2003 Professional survey... (Continued from page 120)

Additional Questions

COMP members were asked to indicate if they expected to retire from the full-time practice of medical physics within the next 10 years, and if they did, to indicate the expected year of retirement. The results from this question are summarized in table 6.

A new question on the survey this year asked COMP members if they were interested in purchasing extra liability insurance, and if they were, to indicate how much they would be willing to pay annually for such insurance. The results from this question are summarized in table 7. On a related topic, only about one quarter of respondents who work as full time employees reported that they were covered by an employer funded liability insurance program, and about one third did not know if their employer provided this benefit (see table 5).

Additional information regarding survey data, such as a detailed summary for a particular geographical region, is available upon request provided the data can be reported without jeopardizing confidentiality. Requests for further information or comments regarding the survey should be directed to Richard Hooper (rick.hooper@cancerboard.ab.ca).

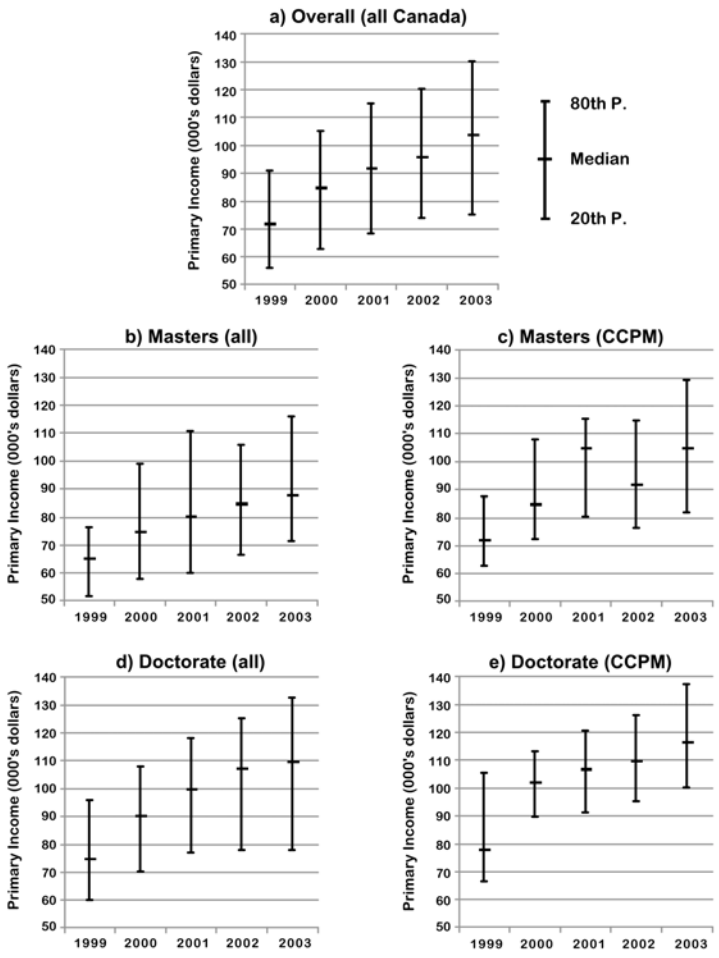


Figure 1: Percentile ranges of primary income from 1999 through 2003 for all Medical Physicists living in Canada, and for subgroups by degree and certification. CCPM designation includes both members and fellows.

Benefit	Yes (%)	No (%)	Unknown or N/A (%)
Medical coverage	83	9	8
Dental coverage	77	16	7
Term life insurance	71	16	13
Disability insurance	72	19	9
Liability insurance	24	44	32
Retirement pension plan (exclusive of CPP or QPP)	86	5	9
Sabbatical leave	23	56	21
Tuition benefits (self)	14	65	21
Tuition benefits (dependent)	8	72	20

Table 5: Percentage of full-time employees who received at least 50% funding from their employer for the listed benefits. Due to roundoff error, totals do not necessarily add up to 100%.

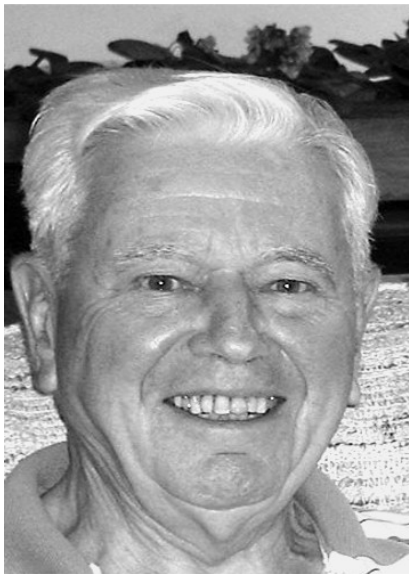
Category	Count	%
Do not expect to retire within the next 10 years	84	75.0
Do expect to retire within the next 10 years		
2004 through 2008	10	8.9
2009 through 2013	14	12.5
Yes, but no year specified	4	3.6

Table 6: Expected retirements in medical physics over the next 10 years.

Category	Count	%
Not interested in purchasing extra professional liability insurance	89	76.1
Interested in purchasing extra professional liability insurance, and willing to pay an annual premium of …		
< $250	13	11.1
$250 - $499	11	9.4
$500 - $999	4	3.4

Table 7: Interest in purchasing extra professional liability insurance.

Message from one of our Emeritus Members – John C. F. MacDonald



I very much appreciate this gesture on the part of COMP in eliminating annual dues for emeritus members.

I was one of the instigators of the organisation that preceeded COMP, back in the 1950's. I was also one of the six founders of the College and its first registrar. As one of the first full-time medical physicists in Canada, we had to go to Britain and Sweden for training in the field. I was also involved in the physics of the first cobalt-60 unit in London (Ontario) in 1951 and I was invited by Jerry Battista to return there in 2001 (along with Jack Cunningham) to participate in the 50th anniversary of that auspicious occasion. How time flies!!

I've always enjoyed the Newsletter and even thought of contributing to it from time to time but retirement leaves you very little time for such things! Please keep me on the membership list. I'm always pleased to read of the developments in our profession.

CAPCA Quality Control Documents

Submitted by Peter Dunscombe, Tom Baker Cancer Centre, Calgary, AB

In response to a request from the Canadian Association of Provincial Cancer Agencies, a Task Group of COMP's Radiation Safety and Technical Standards Advisory Committee has been working on a series of quality control standards for use in radiation therapy. Currently six of these are posted as drafts on medphys.ca for your perusal, with several more in the pipeline. Although these are being developed with the primary intention of allowing the national radiation therapy community to harmonise quality control across the country for the benefit of patients nationally, the implications for Canadian medical physicists may be far greater. It is not beyond the realm of possibility that these standards form a component of both licensing and accreditation activities. For all these reasons, the contents and implications of these standards require very careful consideration before they are finalized. The availability of the Web has allowed us to adopt a national consensus approach to quality control in radiation therapy in Canada, but we need to hear from you. If you like what you see we would be happy to hear that. And if you don't, please give us clear and specific recommendations for changes to these drafts. It tells you on the website how to do this. The Task Group would like to finalise the six draft standards currently (August) posted by the end of this year.

Please take the time to look at the documents as they are now and give us any feedback that you feel would lead to improvement in these standards.

Peter Dunscombe, for the CAPCA Documents Task Group.

Canadian Radiosurgery Society (CaRS) Meeting Announcement

March 4-5, 2005 (Friday & Saturday)

Royal Canadian Lodge,
459 Banff Avenue,
Banff, AB

Course Objectives:
To determine interest in the formation of multidisciplinary Canadian Radiosurgery Society.
To discuss present indications, protocols, and challenges encountered with stereotactic radiosurgery in Canada.
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Across Canada

From the last issue, readers may recall mention of a new newsletter column, to provide informal information about various radiotherapy and imaging centres from across Canada. Well, this our first shot at it, and I would like to thank the first two participants, Clément Arsenault and Jake Van Dyk. They represent a reasonably small and large centre, respectively. In the next newsletter issue, you will (hopefully) see this column expand to four or five entries! Enjoy….

Centre d'oncologie Dr Léon-Richard, St. Moncton, NB
Submitted by Clément Arsenault

Our Oncology Centre is a small but active clinic that has the following treatment units: 3 linacs, one HDR unit, an orthovoltage unit and an LDR unit. Our physics group is made up of 3 physicists, 3 dosimetrists, 2 electronic technologists and one machinist. We treat ~100 EBRT patients per day (~1100 per year). We have an active brachytherapy program (~200 cases per year) that covers all types of Prostate implants (I-125 and HDR), HDR bronchus and esophagus cases as well as both HDR and LDR gynecological cases.

Some staff changes took place recently at our clinic. After 11 years with us, Pierre Courteau has left to work for Varian. We have hired a recent U of Toronto grad, Natalie Pomerleau-Dalcourt, as a junior physicist. She is learning quickly the tricks of the trade and will hopefully be ready for her CCPM exam in a couple of years.

Since our clinic has past the 10-year mark, we are looking to modernize our clinic. Our sim and old Siemens Linacs will be due for replacement in the next few years. We are one of the last Canadian clinics without a CT-Sim and are hoping that this will change soon. With the future replacement of our linacs, we hope to add some of the more modern treatment techniques (IMRT and gating) to our treatment options.

Since we are understaffed, we never seem to have enough time to start new projects. One project we are working on is a full review of our QA program to try to bring it more in line with the proposed COMP Standards (see COMP website). We find this process to be somewhat tedious but well worth it. It does allow us to rethink procedures that are now 12 years old.

London Regional Cancer Program, London, ON
Submitted by Jake Van Dyke

A Cancer Care Ontario Partner

As of 1 January 2004, the London Regional Cancer Centre, like all the other clinics of Cancer Care Ontario, was integrated with its host hospital, the London Health Sciences Centre. Our new name is the London Regional Cancer Program (LRCP), London Health Sciences Centre although we remain "A Cancer Care Ontario Partner". Instead of being paid by Cancer Care Ontario, we are now all employees of the London Health Sciences Centre.

operating room imaging/fluoroscopy system, and a new Varis software upgrade. All of this, except for one accelerator, is now in clinical use. Kudos to the physics staff for making this happen in a very expeditious manner!

On 19 April 2004, Eugene Wong along with Jeff Chen, Glenn Bauman, Tomas Kron, Jerry Battista, Henning Rasmussen, Jake Van Dyk, were informed that they succeeded in acquiring $214,300 over 3 years for a research grant from the National Cancer Institute of Canada entitled *Intensity Modulated Arc Therapy for Radiation Treatment of Cancer*.
The following LRCP related awards were announced in Winnipeg at the COMP annual meeting banquet in June:

1. Kathleen Surrey won first place in the Young Investigators' Symposium. Kathleen at that time was a Ph.D. student at the Robarts Research Institute but has joined us as a Medical Physics Resident as of 21 June 2004. The title for Kathleen's presentation was *Three Dimensional Ultrasound and Stereotactic Mammography Guided Biopsy: A Dual Modality System*. Co-authors: Kathleen Surry, Greg Mills, Donal Downey, Aaron Fenster.
2. William Song placed third in the Young Investigators' Symposium. For a first year Ph.D. student, this is quite a feat! The title for William's presentation was *Limitations of a Convolution Method for Modeling Geometric Uncertainties in Radiotherapy: The Biologic Dose-Per-Fraction Effect.* Co-authors: William Song, Jerry Battista, Jake Van Dyk.
3. Mike Oliver won the best poster award. His poster was a "real eye catcher". The title of his poster was *A Dosimetric Comparison of Four External Beam Techniques for Accelerated Partial Breast Irradiation: Setup of Study and Preliminary Results*. Co-authors: Mike Oliver, Jeff Chen, Eugene Wong, Tomas Kron, Jake Van Dyk, Francisco Perera.

At the end of June, we were informed that Jake Van Dyk, Jerry Battista, and Glenn Bauman succeeded in getting a 5-year CIHR grant for a total of $606,599 for research entitled *Optimization of Radiation Therapy: Uncertainty Analysis and Strategies for Improvement.*

Congratulations are in order to Jerry Battista who became the new Chair of the Department of Medical Biophysics at University of Western Ontario. Now he only spends half of his time at the cancer centre with the other half devoted to university issues. Good luck, Jerry, in this new venture!

(Continued on page 132)

Uncertainty analysis of prostate brachytherapy implants

By Patricia Lindsay*, Jake Van Dyk, Jerry Battista, London Regional Cancer Program, London, Ontario
***Currently at Washington University School of Medicine, St. Louis, MO, USA**

1 - Introduction

1.1 Introduction

Trans-rectal ultrasound-guided brachytherapy is used in the treatment of early stage prostate cancer [1-6]. The procedure is a multi-stage process involving ultrasound imaging for treatment planning, ultrasound image guidance during the implant, and CT or x-ray imaging for verification after the implant is completed. Uncertainties occurring at any stage of this process can limit the ability to deliver the planned dose distributions, interpret the clinical outcomes and design novel techniques. We present here a brief description of the current clinical procedure, work that we have done in assessing the impact of various sources of uncertainty introduced at different stages of this process, and a discussion of other related current topics of research in prostate brachytherapy.

1.2 Clinical Procedure

The following is a description of the implant procedure used at the London Regional Cancer Program. About three weeks before the implant, a trans-rectal ultrasound (TRUS) scan is obtained to determine the size and shape of the patient's prostate. The source positions and needle loading are planned based on these ultrasound images. Typical implants require about 100 ^{125}I seeds with an activity of about 0.35 mCi per seed. The prescription dose of 144 Gy is the minimum dose intended to irradiate the entire prostate volume. In the treatment planning process, a margin is added to the prostate to account for geometric uncertainties. Figure 1.1(a) shows a single transverse ultrasound image of the prostate. This is a pre-planning image, as displayed on a commercial treatment planning system. The semicircle at the bottom of the image is the rectal probe. The prostate is contoured, and a regular grid for seed spacing has been overlaid. Figure 1.1(b) shows an example of a planned dose volume histogram (DVH), with D90 (the dose to 90% of the target volume) and V90 (the percent of the target volume that receives at least 90% of the prescription dose).

The implant is done under the guidance of TRUS imaging. As each of the needles is inserted, it can be visualized in real time and its position is verified against the plan. Immediately following the implant, x-ray fluoroscopic images are taken to verify that all the seeds are accounted for and to provide a qualitative validation of the implant accuracy. There is plastic template attached to the TRUS probe, which is used to guide the needles to the planned locations.

The actual seed positions and dose delivered are assessed at about 1 month after the implant, based on computed tomography (CT) images. CT is used for the post-implant analysis because it provides very good visualization of the seeds, compared with ultrasound imaging. However, the soft tissue boundary of the prostate is less visible on CT images than it is on ultrasound images. Figure 1.1(c) shows a single transverse slice of the CT dataset. The entire (3-D) dataset would consist of about 15 such images, taken 3 mm apart.

1.3 Uncertainties

In the planning and delivery of prostate brachytherapy implants, a number of assumptions are usually made. Among them are the following: there are no changes in prostate shape and volume, either between planning and the implant, or after implantation; all the seeds are placed exactly as planned and do not move subsequently; all the seeds have exactly the same activity and the dose distribution around each seed is spatially isotropic; the actual dose to the tissue surrounding each seed can be calculated exactly; the seeds and prostate can be visualized accurately at the post-implant stage; when using radiobiological models to predict tumour control probability (TCP), the model input parameters are correct for the local patient population. It is known that none of these assumptions is strictly true. In fact,

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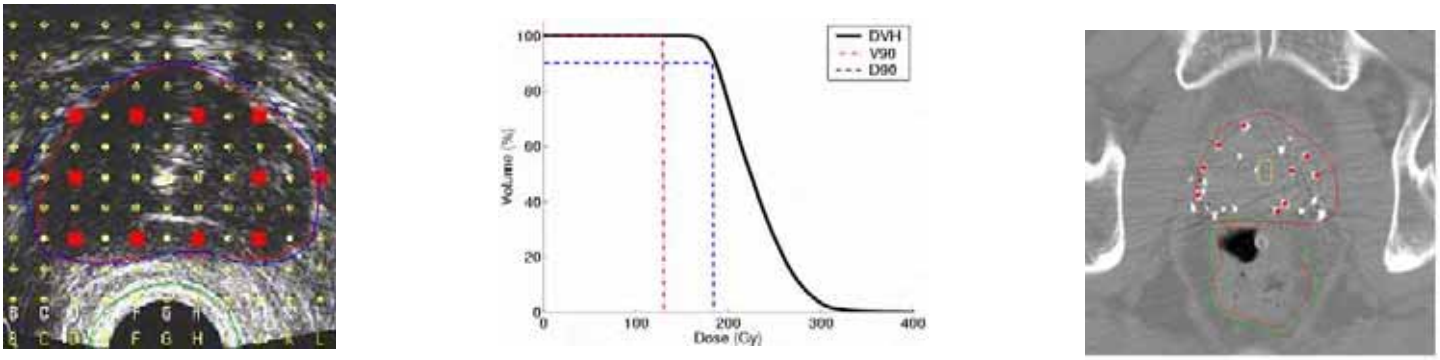

(a) **(b)** **(c)**

Figure 1: Illustration of different parts of the prostate brachytherapy process. (a) treatment planning ultrasound image, (b) sample DVH of a planned implant (c) post implant CT image.

Prostate implants... (Continued from page 124)

the violation of each of these assumptions is a source of uncertainty in the planning, execution, or post-implant evaluation of prostate brachytherapy implants. Some of the geometric uncertainties are currently accounted for by adding a margin (of about 5 mm) to the prostate at the planning phase (i. e., planning to deliver the prescription dose to the prostate plus margin), by increasing the total activity by about 15%, or by increasing the number of seeds or activity per seed, to cover a larger volume with the prescription dose[5].

These uncertainties can have a negative impact on the quality of treatment which the patient receives. They can result in deviations from the desired dose distribution, particularly underdosing of the tumour and overdosing of nearby critical structures (urethra, rectum, and bladder). Additionally, uncertainties make it difficult to accurately assess the dose distribution which the patient is actually receiving, after the implant has been performed. This makes it difficult to predict if an implant for a particular patient is expected to be clinically effective. It also makes retrospective analyses of correlations between dose distributions and clinical outcome very difficult, questionable, and potentially misleading. Hence, a quantitative understanding of such uncertainty analysis is important in clinical brachytherapy, as in any other field of science.

In this paper, we describe investigations of different aspects of uncertainties affecting the prostate brachytherapy process. These include three specific issues: (1) dose anisotropy of individual brachytherapy seeds, (2) imaging uncertainties in the visualization and localization of seeds and in delineating the prostate boundary, and (3) implant execution uncertainties, including needle placement, seed migration, and changes in prostate shape and volume between treatment planning and post-implant evaluation. Additionally, we describe our investigation of factors affecting estimates of α/β, an important radiobiological parameter.

2 – Uncertainties in Prostate Brachytherapy

2.1 Dose Anisotropy

The dose distribution around individual brachytherapy seeds is not isotropic, primarily due to self-attenuation along the axis of the seeds. However, treatment plans are often calculated using the simplified point source formulation (TG43[7]). The effect on anisotropy on the dose distributions for prostate brachytherapy implants has been the topic of a number of publications[8-13]. For various simplified and actual clinical implants, we calculated the difference between the dose distributions and dose-volume histograms for the prostate and rectum when using either the TG43 point source approximation or line source formalism. We also investigated the differences between two models of ^{125}I and ^{103}Pd seeds[14].

The errors caused by neglecting anisotropy (i.e., the differences between the point source and line source calculations) were quantified by the percent of the target volume (or rectum surface area) for which the dose difference was greater than 10% (5%) of D90. We found that the differences were larger for ^{103}Pd seeds than for ^{125}I seeds, and that the differences for the rectum varied more from case to case. As an example, Figure 2 shows the percent of the target volume (a, b) and the percent of the rectum surface area (c, d) for which the differences between the line source and point source dose distributions are greater than 10% (for target) or 5% (for rectum) of D90. This figure shows the differences for 9 cases, for both sources aligned along the intended implant direction, and with simulated randomized source orientations (the average results).

The errors caused by ignoring seed anisotropy were small enough that differences in D90 were negligible. We quantified the impact of anisotropy by the percent of the target volume for which errors (as a percent of D90) were greater than ± 10%. We found that ignoring anisotropy typically resulted in errors of greater than 10% of D90 to 8% of the prostate volume, although this value depended on the isotope emission energy, seed model, and geometry of the implant. We therefore conclude that the

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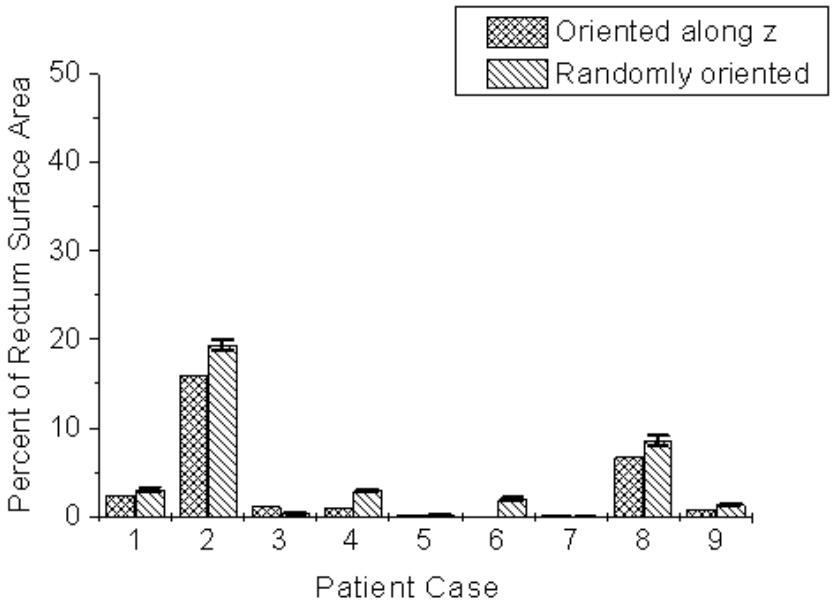

***Figure 2**: Percent of the Target Volume (a, b) and Rectum Surface Area (c, d) for which the dose difference between the point source and line source is greater than 10% of D90 (5 % for rectum surface).*

Prostate implants... (Continued from page 125)

impact of anisotropy of individual seeds is relatively small, and is accounted for sufficiently by using the TG43 *line source* calculation formalism. An interesting modification to the TG43 anisotropy factor has been proposed[8] which would account for the probability distribution of seed angles. Use of this weighted anisotropy factor would improve upon the accuracy of the line source formalism.

2.2 Imaging Uncertainties

The analysis of post-implant dose distributions, and the subsequent correlation of dose distributions with clinical outcomes[15, 16] is based on a number of assumptions. Among these are the assumptions that the prostate volume and all of the seed positions can be accurately identified in the post-implant images, typically using CT scans. The effects of uncertainties due to seed placement[17-19] and prostate definition have been the topic of a number of publications. Investigations of the uncertainties in prostate contouring and their impact have yielded conflicting results. Some authors[20-22] found that inter-observer variability in prostate contouring could have a large impact on the assessment of implant quality. For example, Al-Qaisieh *et al.*[22] investigated both inter and intra-observer variability, and found that the variation in D90 could be as large as 50%. Other authors[23, 24] found the impact to be very small.

In our work[25], we have investigated contouring and seed localization and visualization uncertainties, using Monte Carlo simulations to introduce variations. The uncertainty in localizing each seed was simulated by seed displacements, sampled from Gaussian probability density functions (*pdf*) with standard deviations of 1.5 - 6 mm. The inability to visualize all of the seeds was simulated by randomly removing seeds and replacing them with seeds at newly randomized locations (in order to maintain the correct overall activity). This was done for 5 - 20 % of the seeds removed and relocated (i.e., assuming that 95 - 80 % of the seeds could be visualized). Uncertainty (namely inter- and intra-observer variability) in contouring the prostate was simulated by changes from the nominal prostate contour of between 1-2 mm and 4-8 mm (different uncertainties in different directions). In these simulations, the magnitude of the change in the prostate contour in each direction was sampled from a Gaussian *pdf*. Finally, the combined effect of contouring uncertainties and either seed localization or seed visualization uncertainties were assessed.

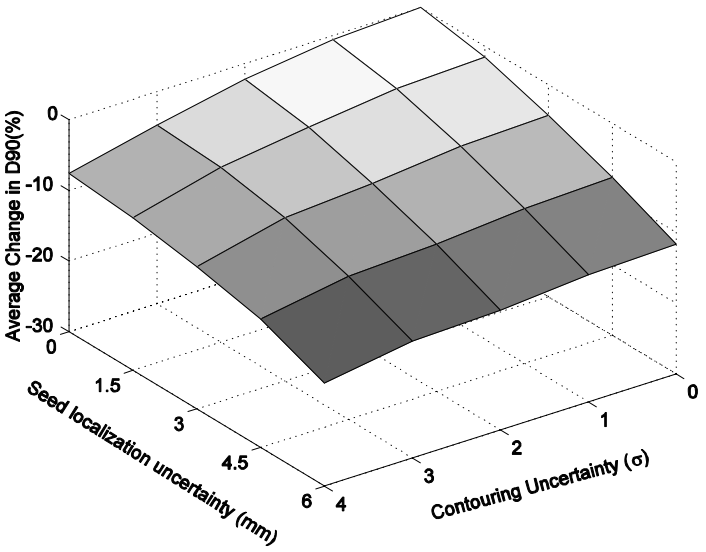

Figure 3: Average change in D90 as a function of seed localization and contouring uncertainties. The units in contouring uncertainty range from 1-2 mm to 4-8 mm.

Figure 3 shows an example of the resulting average changes in D90 from the combination of seed localization and contouring uncertainties. These results are averaged over 500 simulations and over 13 patients. In addition to average changes in dosimetric and radiobiological indices, we quantified the variability (resulting standard deviation of the simulated values) to determine the sensitivity of these metrics to each source of uncertainty.

When either seed localization or inability to localize all the seeds were combined with contouring uncertainty, the overall results showed that although changes in D90 were small on average (less than 5%), the variability was about 9% for typical magnitudes of uncertainties. We demonstrated that most of these effects were traceable to contouring uncertainties. This level of variability brings into question whether meaningful correlations can be made between the calculated dose-volume parameters and clinical outcome without either reducing this uncertainty, or explicitly incorporating it for individual patients. Additionally, this illustrates the potential advantage of using other imaging modalities (i.e., MRI or ultrasound), which may help to identify the prostate volume more precisely.

2.3 Implant Execution

The purpose of this work was to investigate the differences between the planned and actual dose distributions and DVHs. The treatments were all planned to deliver a minimum dose of 144 Gy to the prostate volume. For 35 clinical cases performed at our institution, the average planned D90 was 170 Gy. The *average* achieved D90 value was only 120 Gy, which is significantly lower than the prescription value of 144 Gy. This analysis was intended to identify the causes of discrepancies between planned and achieved implants. This type of information may be useful in improving future treatment plans by taking seed placement limitations and prostate volume changes into consideration.

The observed difference of about 50 Gy between planned and actual D90 values is not likely due to isolated sources of uncertainty such as target volume definition[20-22], seed localization[17, 18], or edema[26]. These sources of uncertainty have been previously studied and their effects on target coverage are of a much smaller magnitude than the overall greater than 25% loss in D90 which is observed in our clinical implants. Even in combination, these sources of uncertainty would likely lead to smaller changes. Instead, we believe that much of this loss in coverage is due to source placement uncertainty and subsequent source migration, as well as differences between prostate shape and volumes, as visualized by ultrasound and CT.

(Continued on page 127)

Prostate implants... (Continued from page 126)

A secondary goal of this work was to develop a Monte Carlo model to *predict* the differences between the planned and achieved implants, in terms of seed positions and prostate changes. To be useful, this model must be capable of predicting the post-implant dosimetric indices which we observe clinically. This topic has also been addressed by other groups with somewhat different approaches[19, 27, 28]. We developed a multi-step method to classify the post-plan seed locations into needle tracks, and to match these post-plan needle tracks to their needles of origin. From this, we determined the probability density functions of various parameters characterizing implant execution and seed migration (needle centre of mass displacement, needle angle, divergence of seeds from needle track, and spacing of seeds along the needle track). In addition to modeling seed placement and migration, we included in this work a simple model of the change in prostate shape and volume between pre-implant ultrasound (US) and post-implant CT imaging. This was done using a full affine transformation.

We then tested this model on our dataset, by generating simulated post-plans and comparing the dosimetric characteristics of these with the actual post-plans. Table 1 shows the D90 and V90 values for our patient dataset and those predicted by our model. The results are show for pre-plan, post-plan and simulated seed locations, as well as US (pre-plan), CT (post-plan) and simulated prostate volumes. The model was designed so that simulated seed locations with the simulated CT volume would predict the actual post-plan (post-plan seeds, CT volume) dosimetry. We found that, although our model predicted well on average as shown in Table 1, the variation in the original data for individual patients was not entirely reproduced.

2.4 Radiobiological Modeling

Radiobiological models are useful for comparing the predicted clinical outcome from different treatment methods, and for quantifying the quality of dose distributions. However, in order to confidently apply radiobiological models in a clinical setting, the model input parameters must be determined from actual patient data. The most important parameter in the linear-quadratic (LQ) model is the α/β ratio. Recent publications [29-33] have shown that, unlike most tumours, the α/β for prostate cancer may be as low as 1.5 Gy, which is likely less than rectum (assumed to be 3 Gy). Much of this analysis was based on the equivalence that has been observed between outcomes for prostate brachytherapy and external beam radiotherapy [30]. In this work[34], we investigated whether inclusion of the population variation in prostate brachytherapy dose distributions, variation in all the parameters in the LQ model (namely Tpot, α, and RBE) as well as some of the aforementioned sources of uncertainty would have any impact on these calculated α/β values. We did not include the effects of hypoxia in our model, which may also have a significant impact on estimated value of α/β[35].

The α/β values are derived by equating the tumour control probability from 70 Gy external beam with the tumour control probability obtained for a particular brachytherapy DVH. As expected, when different brachytherapy DVHs are assumed to represent the average population DVH, the resulting α/β values can be very different. When reasonable ranges of α, Tpot, and RBE are considered, 4 different brachytherapy DVHs yielded α/β values between 0.9 – 3.4 Gy.

When uncertainty in seed localization, prostate contouring, or edema is simulated, a range of α/β values are found. This is illustrated in Figure 4 for two brachytherapy DVHs, one with a relatively low D90 (115 Gy) and one with a higher D90 (132 Gy). This figure shows the range of α/β values. The average α/β when uncertainties are accounted for is about 4 Gy for upper panel and 2 Gy for lower panel. Note that the scale for the contouring uncertainty histograms is from 0 to 50 Gy, illustrating that contouring uncertainty leads to a very broad range of α/β values.

From this work we concluded that variation between prostate brachytherapy dose distributions and contouring uncertainties may present confounding factors when trying to determine the α/β for prostate cancer. Although we found α/β much lower than 10 Gy, as previous authors had found, our "spectrum" of values was generally larger than 1.5 Gy. As the value of α/β is crucial in developing new treatment techniques (e.g., optimizing the fractionation schedule for hypo-fractionated treatments), caution should be applied when applying this low α/β into a clinical case.

(Continued on page 128)

Seeds	Prostate Volume	D90 (Gy)	V90 (%)
Pre-plan	US	170 ± 9	100 ± 0
Pre-plan	CT	142 ± 27	93 ± 7
Pre-plan	Simulated CT	145 ± 27	93 ± 3
Post-plan	US	138 ± 18	90 ± 9
Post-plan	CT	120 ± 26	84 ± 12
Post-plan	Simulated CT	128 ± 15	87 ± 10
Simulated	US	137 ± 9	92 ± 8
Simulated	CT	112 ± 24	82 ± 10
Simulated	Simulated CT	123 ± 9	87 ± 4

Table 1: D90 and V90 values from combinations of pre-plan, post-plan, and simulated seed locations, and Ultrasound, CT, and Simulated CT volumes.

Prostate implants... (Continued from page 127)

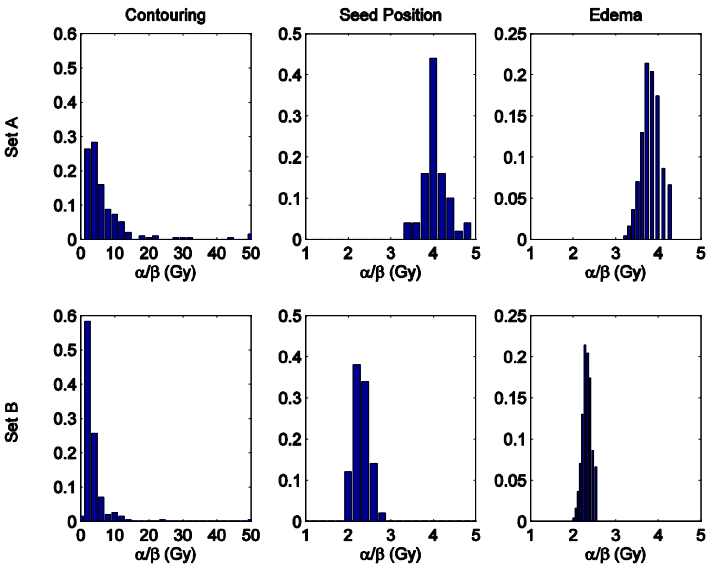

Figure 4: Range of α/β values as a function of seed localization, contouring, and edema uncertainties. The upper figures are for a brachytherapy DVH with a relatively low D90, the lower figures are for a brachytherapy DVH with a higher D90.

3 – Discussion

3.1 Recent Developments in Prostate Brachytherapy

The approach to prostate brachytherapy described in this paper is similar to what is now commonly used in many clinics. However, there are some new and exciting developments and alternative approaches to prostate brachytherapy which are described below. Some of the sources of uncertainty described in this work are directly addressed by these approaches.

3.1.1 Robotically Assisted Implants

A recent publication [36] describes a robotically assisted system for prostate implants. This system was proposed to specifically overcome the problem of pubic arch interference. It includes a robot for guiding the needle placement and 3D TRUS imaging. With this prototype it was shown that very accurate needle placement and needle angles could be achieved.

3.1.2 Intra-operative Treatment Planning

Many groups [4, 37-42] have described systems for intra-operative treatment planning. In this model, the prostate is imaged (using either TRUS or MRI), the treatment plan is generated while the patient is in the operating room, and the treatment plan can modified interactively "on the fly", based on where the seeds have actually been placed. This overcomes changes that may occur in prostate shape and volume between the pre-planning and the implant time [43], and also addresses the issue of accurate seed placement.

3.1.3 Magnetic Resonance Spectroscopy (MRS) Targeted Implants

In treatment planning of radiation therapy for prostate cancer, it is usually assumed that the entire prostate volume is tumour, and planning and delivery of treatment is made under this assumption. Using CT imaging, even visualization of the prostate volume can be difficult, and identification of tumour burden within the prostate is not feasible. However, MRI imaging can identify the different zones in the prostate, and MRS can identify regions of high ratio of choline and creatine to citrate[44, 45], which has been demonstrated to correlate with high tumour burden. Using such MRS images, some groups [46-48] are delivering a brachytherapy boost to specific subvolumes within the prostate.

3.1.4 HDR Prostate Brachytherapy

Although this article has focused on permanent seed brachytherapy implants, the application of high dose rate (HDR) to temporary prostate brachytherapy is another alternative with specific potential advantages. HDR for prostate has been used in combination with external beam radiotherapy [49, 50], and as monotherapy for favorable risk patients [51]. In HDR procedures, the needles are also placed under the guidance of ultrasound, but they can be imaged immediately using CT or radiographic film to verify their placement. This ability to verify the needle locations before the dose is delivered offers an advantage in terms of accurate source placement. Additionally, given that the low α/β for prostate cancer makes hypofractionation an advantageous treatment option, HDR is ideal for delivering hypofractionated doses.

3.2 Summary

Uncertainties in the delivery of prostate brachytherapy implants may compromise the quality of the dose distributions delivered to the patient. In the post-implant analysis of these dose distributions, uncertainties in contouring, seed localization, and dose calculation may lead to difficulties in accurately determining the actual dose delivered. These in turn may call into question evaluations and comparison of the correlation between doses and clinical outcome, and lead to errors in subsequent radiobiological analyses. We have described our evaluation and modeling of various sources of uncertainty in the delivery and evaluation of prostate brachytherapy implants. The incorporation of uncertainties and the magnitude of their effect on treatment into the treatment planning process may lead to improvements in implant quality, and in the accuracy of post-implant evaluation. Whether this will lead to future improvements in patient outcome must be evaluated in a clinical setting.

Acknowledgements

This paper contains figures, tables and results from the Ph.D. thesis of P. Lindsay[52]. The authors would like to thank Vitali Moiseenko, Tim Craig, Craig Lewis, G. Bauman, and many others at the LRCP whose discussion and input was greatly valued.

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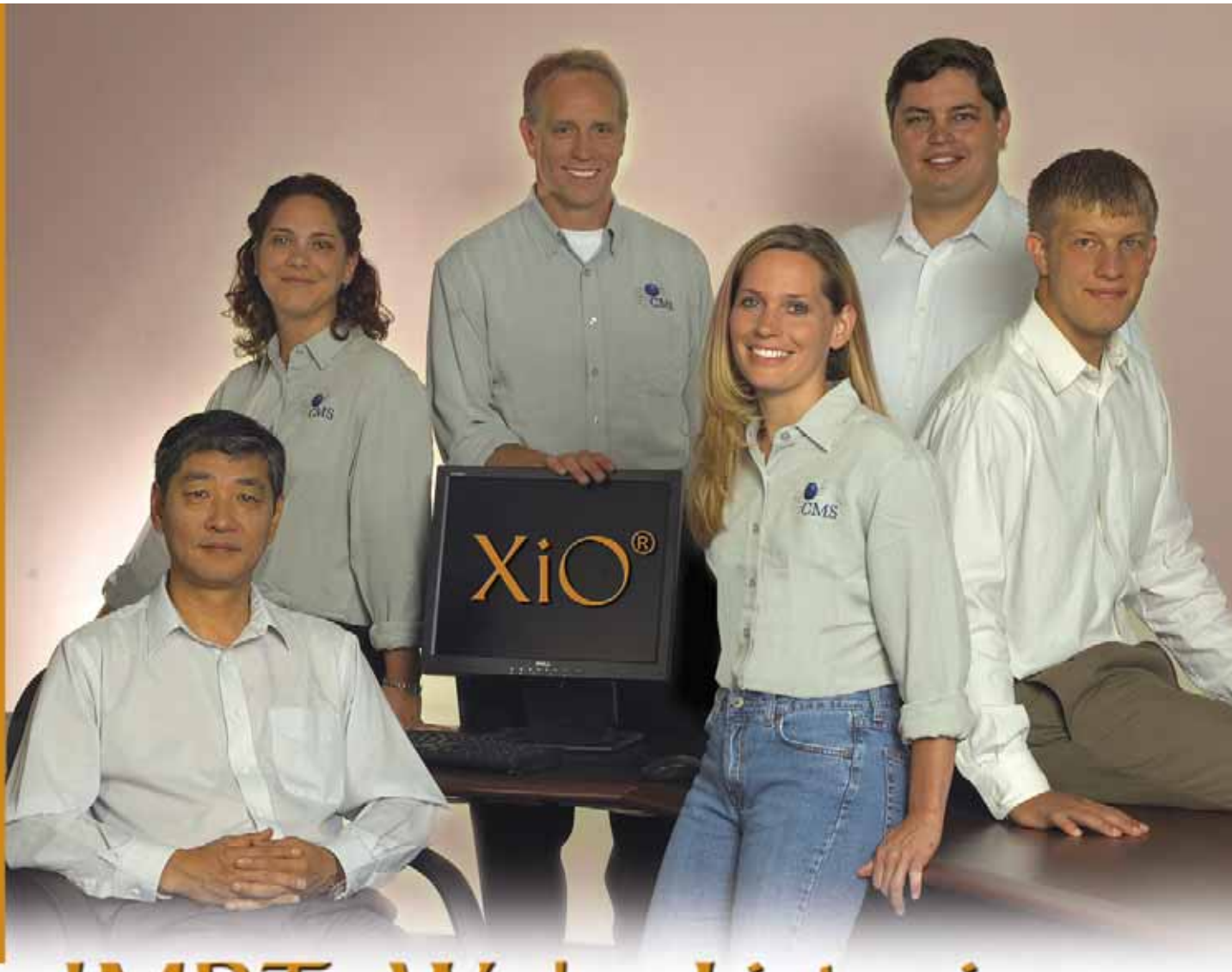

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Prostate implants... (Continued from page 128)

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(Continued on page 131)

Prostate implants... (Continued from page 130)

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Canadian College of Physicists in Medicine Examination Schedule 2005

Membership Examination:
Applications due: 7 January 2005
Examination date: Written 19 March 2005
Oral 28 May 2005
Fee: $450.00
Decisions announced on February 11

Fellowship Examination:
Applications due: 7 January 2005
Examination date: 1-2 days prior to COMP Meeting in Hamilton
Fee: $300.00 (in Hamilton)
Decisions announced on February 11 (or later for those who do the membership exam)

Note:
- The application forms, exam study guide, and sample exams are available on the COMP website under the heading "Certification with CCPM". Application forms must be the ones currently posted on the COMP website.
- Membership & Fellowship examination application deadlines are set to the same date. This allows the Credentials Committee to review all applications in one time period.
- **It is critical for the success of your application that you respect the deadlines**.

For further information contact the Registrar:

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Victoria, British Columbia, V8R 6V5
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Brief report on the recent McGill conference "Current Topics in Monte Carlo Treatment Planning, Advanced Workshop" May 3-5, 2004

Submitted by Jan Seuntjens and Frank Verhaegen,
McGill University, Montreal, QC

The use of Monte Carlo techniques in radiotherapy treatment planning is fast becoming a reality with currently two commercial vendors having the capability of providing FDA approved Monte Carlo-based treatment planning systems and more systems are appearing on the horizon. However, proper implementation and QA procedures as well as clinical evaluation of the impact of introducing this novel technology are in a stage of constant evolution. In addition, given the sometimes significant dose differences between conventional and Monte Carlo dose distributions, especially for the organs at risk, our understanding of the parameters affecting complication and control requires reassessment. An increasing number of groups around the world are working on a variety of aspects involving the clinical implementation and evaluation of this technology. In this context, we organized at McGill University an Advanced Workshop on Monte Carlo treatment planning. The workshop was intended to provide an opportunity to present and attend a series of high-level research-oriented contributions to focus the work that needs to be carried out to help make the introduction of this technology a success.

The workshop was the Second International Workshop in this style held at McGill University where the first Workshop, held in October 2001, dealt more with Monte Carlo applications to fundamental radiation dosimetry. The recent workshop was financially supported by the Institute of Cancer Research of the Canadian Institutes of Health Research, by the National Cancer Institute of Canada, by the McGill University Research Grant Office and the Post Graduate Student Society. The workshop was endorsed by the International Atomic Energy Agency, the American Association of Physicists in Medicine and the Canadian Organization of Medical Physicists. The proceedings of this event will consist of peer-reviewed papers in a special edition of the journal Physics in Medicine and Biology (IOP, UK) to be published early 2005.

Table 1 shows the participant distribution to the workshop. There were 104 participants (83 external + 21 local) from 17 different countries around the world. Noteworthy is that at least five of the participants from the US were expatriated Canadians. There were 14 invited presentations, 28 proffered presentations and 18 posters in 11 sessions and one moderated poster session with European-style coffee breaks. The workshop discussions revolved around novel variance reduction techniques, some low-energy cross section work, new developments including 4D Monte Carlo and new general purpose front ends for treatment planning. We had an animated session on different approaches to smoothing of dose distributions as well as Monte Carlo techniques in brachytherapy, electron beam treatment planning, conformal radiotherapy and IMRT Monte Carlo dose calculations. There was a special session about Monte Carlo dose calculations in proton therapy. Of special interest were also the presentations and discussions about CT to material composition conversion.

The American Association of Physicists in Medicine is sponsoring a Task Group on the clinical implementation of Monte Carlo techniques (TG-105) chaired by I. Chetty of the U. of Michigan. The task group charge is very similar to many of the issues discussed at the workshop, hence, a TG meeting was held to plan the recommendations and to advance the development of the report.

Overall the meeting was a great success as assessed from the participants feedback. With the increasing importance of accurate planning and delivery Monte Carlo techniques for treatment planning are of paramount importance. We hope that this workshop and its upcoming proceedings will be a useful resource both for clinical and academic medical physicists.

USA	30	Spain	2	Japan	1
Canada	20	Italy	2	Serbia	1
UK	8	France	2	Finland	1
Belgium	4	Austria	1	Australia	1
Sweden	4	Korea	1	Switzerland	1
Germany	3	Israel	1		

Table 1: Participant distribution for the external participants to the Monte Carlo treatment planning workshop. Total number of external participants: 83.

London Regional Cancer Program (Continued from page 123)

In August we performed our first megavoltage CT scan on a patient with our new Tomotherapy machine and on 2 Sept 2004, we performed our first Tomotherapy clinical treatment. All systems are now geared up for increased clinical activity on this new adaptive treatment modality. Hats off to the leadership provided by Tomas Kron for making this happen! In the meantime we have also treated more than 60 patients (>1400 fractions) with intensity modulated arc therapy (IMAT) on conventional linacs. In this context, we have also started a hypofractionated prostate cancer protocol using IMAT with ultrasound guidance for patient set-up.

Our new graduate students arrived early in September and we now have a total of nine in radiation oncology related medical physics.

This only highlights some of the activities at the LRCP as of the beginning of 2004. It is clear that Medical Physics is alive, active, exciting and productive at the London Regional Cancer Program!

Carleton UNIVERSITY
Canada's Capital University

ANNOUNCEMENT

The R.L. Clarke Symposium in Celebration of 15 Years of the Ottawa Medical Physics Institute

Friday November 5, 2004
14:00
Senate Chamber, Robertson Hall
Carleton University, Ottawa

The Ottawa Medical Physics Institute (OMPI) was established in 1989. To celebrate its 15-year anniversary a ½ day Symposium will be held on November 5. The Symposium is named in honour of Robert L. ("Bob") Clarke, Professor Emeritus, who was instrumental in establishing both the OMPI (originally known as the Medical Physics Organized Research Unit, or MPORU) and the medical physics graduate program in the Physics Department at Carleton. The OMPI has 28 members in the Ottawa area who are active in medical physics research, graduate teaching, and student supervision. The OMPI holds monthly seminars at different locations around the national capital region and has been instrumental in the development of a strong graduate program. See www.physics.carleton.ca/ompi for details.

The Symposium will be held in the Senate Chamber of Carleton University, in Robertson Hall, on November 5 starting at 14:00. Four OMPI speakers - Bob Clarke, Peter Raaphorst, Dave Rogers, and Ian Cameron - will highlight the progress made in their respective fields over the last 15 years and the prospects for the future, with emphasis on the role of their graduate students. The keynote lecture will be given by Dr. C.-M. Charlie Ma who is a former OMPI member and currently is the Director of Radiation Physics at the Fox Chase Cancer Center in Philadelphia. Charlie will talk about exciting possibilities in the future of medical physics.

A reception at the university will follow the Symposium, after which there will be an informal dinner (pay-your-own) at a local restaurant.

We invite all current OMPI members and their students, medical physics postdocs, friends of Bob and Vera Clarke, and all those with past involvement in medical physics in the nation's capital, including M.Sc. and Ph.D. graduates of the Carleton program, former postdocs, and former members of the OMPI. Guests are most welcome.

There is no registration fee for the Symposium, but please confirm your attendance by sending email to Marilyn Stock, Administrator of the College of Natural Sciences:
marilyn_stock@carleton.ca
If you plan on coming to the dinner, please indicate this in your email, and also indicate if you will bring one or more guests, so that we can reserve the required number of seats.

We look forward to seeing you!

For further information please see http://www.physics.carleton.ca/ClarkeSymposium

Report on COMP 2004 Meeting

Submitted by Martin Shim, Joe Hayward, and Tom Farrell
Juravinski Cancer Centre, Hamilton, ON

The 2004 COMP/CCPM Annual Meeting was held in Winnipeg, Manitoba (affectionately known as "The Peg") from June 13 to June 16. In fact some residents of this fair city claim that it is the geographical centre of North America. It will be left as an exercise to the reader to verify this "fact". This year the meeting was held in conjunction with the 59th Canadian Association of Physicists Annual Congress. The conference venue was the centrally-located Delta Hotel.

Partnering with the larger group of physicists allowed a rich and diverse series of scientific sessions ranging from Single Molecule Polymer Physics to the Medical Applications of Sound. In particular, the Herzberg Memorial Public Lecture delivered by internationally-renowned astronomer (and University of Manitoba alumnus) Dr. P. James E. Peebles entertained the audience with numerous spectacular images of the cosmos.

As usual the COMP/CCPM sessions were both interesting and informative. Session topics ranged from Brachytherapy and Thermal Therapy to Radiobiology and Tissue Characterization. The CAP/COMP plenary session entitled, "Monte Carlo Simulation of Electron-Photon Transport: From Particle Physics to Cancer Radiotherapy" was presented by Dave Rogers from Carlton University.

The Young Investigator's Symposium included a large number of high quality talks and gave the seasoned professionals a warm feeling regarding the caliber of scientific talent in the young medical physics community. The prize winners were as follows:

1. Kathleen Surry from the Robarts Research Institute who presented the talk, "Three Dimensional Ultrasound and Stereotatic Mammography Guided Biopsy: A Dual Modality System";
2. Brad Warkentin of the Cross Cancer Institute for his paper entitled, "3-D Verification of IMRT Treatments Using Flat-Panel EPID"; and
3. William Song of the London Regional Cancer Centre for "Limitations of a Convolution Method for Modeling Geometric Uncertainties in Radiotherapy: The Biologic Dose-Per-Fraction Effect".

The following participants shared the top prize in the poster session:

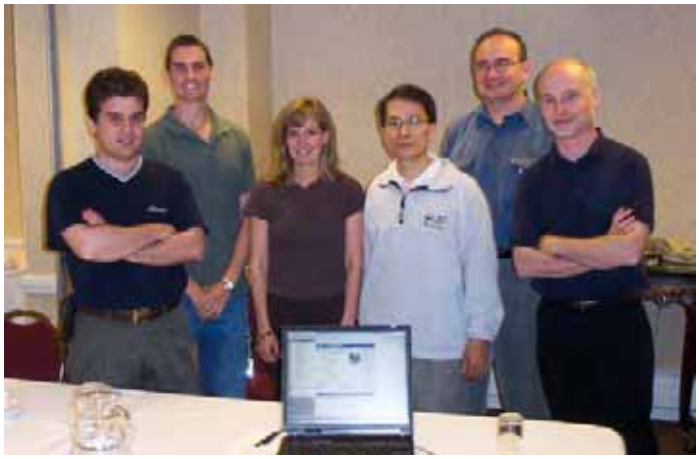
- Jean-Francois Carrier *et al*. from Laval University for "Simulation of a Radioactive Eluting Stent Using Geant4", and
- Mike Oliver *et al*. from the London Regional Cancer Centre for the poster entitled, "A Dosimetric Comparison of Four Beam Techniques for Accelerated Partial Breast Irradiation: Set-up of Study and Preliminary Results".

The banquet and awards ceremony was held in The Grand Ballroom of the Delta Hotel on the Tuesday evening. The CAP/COMP Peter Kirby Memorial Medal for Outstanding Service to Canadian Physics was presented to Robert Barber from the University of Manitoba. Entertainment for the evening was provided by The Renaissance Singers who delighted the audience with renditions of songs with a local flavour. Many delegates were able to build new acquaintances within the physics community while dining on tasty entrees and sampling a selection of wines.

The 2005 Annual Meeting will be held in Hamilton, Ontario. It remains unclear as to what Hamilton is the geographical centre of . . . nevertheless the members of the local conference committee promise to provide attendees with an exciting and entertaining program. In particular, delegates can look forward to events celebrating the World Year of Physics which commemorates the centenary of the publication of Einstein's three famous papers.

P.S. Some of us are wondering . . . where were those infamous Winnipeg mosquitoes?

Authors and friends practice for hosting COMP AGM in 2005.



Proof that the COMP Communications Committee *does* work occasionally.

Pictures from COMP 2004 Meeting

So many posters, so little time…..

Awards,...

Important COMP/CCPM business discussions (note empty wine bottles on table).

...awards,

The new COMP *Past* Chair demonstrates elation at handing over the reigns to the new COMP Chair.

...and yet more awards! Jack Cunningham gives a few tips to some youngsters here.

So far so good, nobody has been bitten by a mosquito yet!

Report on AAPM 2004 Meeting

Submitted by Boyd McCurdy
CancerCare Manitoba, Winnipeg, MB

This year, the 46th annual AAPM meeting was held in Pittsburgh, PA, on July 25-29. Despite the reputation of the 'Steel City', I found Pittsburgh to be a very pretty city, nestled in amongst the heavily treed and gently rolling foothills of the Appalachians. The city has done an excellent job of converting defunct steel mill locations along the three main rivers into parks and useful buildings such as the David L. Lawrence convention centre. The AAPM meeting was held at this spacious and modern convention centre, with an attendance of 2679, of which Canadians comprised 123.

As for scientific content, this year's meeting was typical for volume of material offered (ie. nearly overwhelming!). However, I felt the overall quality of the scientific program was somewhat improved over previous years. 557 oral presentations were delivered in upwards of 8 parallel tracks, and 379 scientific posters were displayed. Similar to last year, several topic-specific subsets of these posters were presented in 'moderated poster sessions', where the authors could discuss their poster and interact with a small audience. The Young Investigator's competition was held on the first day of the conference (July 25). Two out of the ten entries were from Canada (Charlie Kirkby from the Cross Cancer Institute in Edmonton, and J. Belec from McGill University in Montreal). Despite giving excellent presentations, neither Canadian entry ranked in the top three (1st: Amit Sawant, 2nd: Wesley Culberson, 3rd: Joel Wilkie). As usual, every day of the meeting began with early morning refresher courses (7:30-9:30). For the record (ie. in case my boss reads this), I did attend several and yes, they were very useful!! Incidentally, the speaker notes or handouts for all the refresher sessions are available on-line at the AAPM website.

The dominant topic in the radiotherapy-related scientific sessions again this year was IMRT. However, there were also a large number of presentations in the area of 4D imaging, planning, and therapy. This appears to be the next 'hot' topic in the field. As for diagnostic imaging, mammography was dominant, with plenty of talks also presented on CT and ultrasound.

The AAPM President's Symposium ("The Future of Diagnostic Imaging and Radiation Therapy") was delivered by several excellent speakers. The initial talk, given by the RSNA President, Dr. B. Lentle, was a bit odd to say the least, amounting to a recruitment drive for the RSNA. Andrew Maidment spoke of "Nine Orders of Magnitude: Imaging from Man to Molecules", while Edward Siegel talked on "Radiology: 3D and Beyond". Former Canuck Rock Mackie gave the final talk of the session, gazing into the crystal ball with "The Future of Radiotherapy". For those young medical physicist's just entering the profession, Rock promised that radiotherapy does have a future! In fact, "Aging will be reversed before cancer (anti-aging is a much bigger market!)."

I am very happy to report that Canadian content featured heavily in the AAPM Awards Banquet. Several Canadians and ex-Canadians were newly designated 'Fellows', including Karen Breitman (Tom Baker Cancer Centre, Calgary), Michael Bronskill (Sunnybrook and Women's College Health Sciences Centre, Toronto), Dick Drost (St. Joseph's Health Centre, London), Gino Fallone (Cross Cancer Institute, Edmonton), and John Wong (William Beaumont Hospital, Detroit, USA). This year's AAPM William Coolidge Award went to Clifton Ling of the Memorial Sloan-Kettering Cancer Center. Dr. Ling does have a Canadian connection, spending some time at the Princess Margaret Hospital in Toronto, as the 'Ray Bush Visiting Professor'. Finally, the Daniel Farrington Award for the best dosimetry paper published in *Medical Physics* was won by Brad Warkentin, Stephen Steciw, Satyapal Rathee, and Gino Fallone for "Dosimetric IMRT verification with a flat-panel EPID" Med. Phys. 30(12): 3143-3155 (2003). Congratulations to all the award winners!

The traditional Canadian 'night out' was transformed into a Canadian luncheon, due to time restraints this year. Sherry Connors did an excellent job of organizing the event at a very nice restaurant in the US Steel Building. Approximately 60 Canadians enjoyed the lunch, eh.

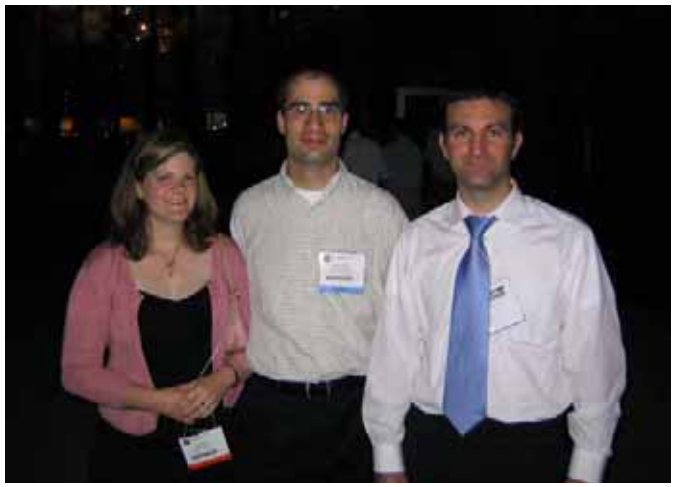
For the AAPM organized 'Night Out', the Carnegie Science Centre was completely taken over. There were several interesting and interactive exhibits, as well as a tour of a vintage WWII submarine. After the official 'Night Out', many attendees broke into groups and several smaller, informal 'nights out' occurred. A group of Canadians (and socialist-leaning Americans that wanted to hang with us) managed to navigate on foot to a live jazz club during a summer shower. Lady luck was smiling on the group, as there turned out to be representatives from Varian and Siemens present. They did an admirable job keeping their existing and potential customers distracted from their wet clothes, via wet palates.

See you in Seattle next year!

Just some of our Canadian award winners!

Pictures from AAPM 2004 Meeting

Between exhibits (ie. drink stations) at the Carnegie Science Center.



Finding a restaurant open after 9 pm in Pittsburgh is challenging!

Ahhhh, the Canadian lunch. Follow the smell of back-bacon sandwiches and listen to the complaints of high taxes!

Drying out (clothing only!) at a downtown jazz club.

River view from the convention centre… who would have guessed so many steel bridges in Pittsburgh?

Report on AMPC Meeting 2004

**Submitted by Donia MacDonald,
Dr. H. Bliss Murphy Cancer Centre,
St. John's, NL**

The sixth annual Atlantic Medical Physics Group Meeting was held at the Dr. H. Bliss Murphy Cancer Centre in St John's Newfoundland, September 24 - 25. The attendees consisted of physicists, dosimetrists and electronic technologists from all six Atlantic centres.

The meeting opened on Friday afternoon, with a talk on PET CT Treatment Planning by invited speaker Allan J. Caggiano, Senior Medical Physicist, Holy Name Hospital, Teaneck, New Jersey. The meeting continued with presentations from some of the attendees, and the day closed with a banquet at Django's Restaurant.

Saturday's session included talks from the attendees, in addition to two invited speakers. Boyd McCurdy, Medical Physicist, Cancer Care Manitoba spoke about daily fiducial marker tracking for prostate patients, and compensator-based IMRT delivery. Dean Willems discussed some of the newest technologies available from TomoTherapy Inc. The afternoon ended with a business meeting to discuss matters of common interest and cooperation between the centres. It was decided that the next meeting would be held in Saint John, New Brunswick. Saturday evening consisted of some fine Newfoundland entertainment. Participants were duly "Screeched In" and made honorary citizens of The Rock, and were then treated to a performance of the Irish Descendants in a George Street pub.

The organizers would like to acknowledge the generous financial support of Varian Medical Systems, Philips Medical Systems, Harpell Associates, the Newfoundland and Labrador Health Board Association, and the Newfoundland Cancer Treatment and Research Foundation. We would also like to thank all the participants whose contributions and enthusiasm made the conference a memorable one.

Photo list: Andre Robichaud; Serge Godin; John Grant; Allan Caggiano; Donia MacDonald; Debby Kavanagh; David Goodyear; Tim Healey; Jason Schella; Mike Gillard; Vern Doyle; Mike Hale; John Andrew; Natalie Pomeleau-Dalcourt; Maria Corsten; Jason Forward; Narayan Kulkarni; Jim Clancey; Boyd McCurdy; Ningyuan Feng.

Honorary Newfoundlander's, after getting 'Screeched In'

One needs to kiss a 'true Newfoundlander' as part of the ceremony…. a codfish is considered appropriate.

Metal artifact reduction in helical CT for radiation therapy treatment planning

By Mehran Yazdi and Luc Beaulieu
Département de Radio-Oncologie et Centre de Recherche en Cancérologie, Hôtel-Dieu de Québec, QC

The application of CT in radiation therapy treatment planning has been tremendously increased in recent years and is vital for 3D-CRT and IMRT planning. Meanwhile, the image artifacts produced by metal hip prostheses or tooth filling, referred as metal artifacts, make the planning extremely difficult. An example of this problem in given in Fig.1b. Metal artifacts arise because the attenuation coefficient of a metal in the range of diagnostic X-rays is much higher than that of soft tissues and bone. The results of scanning a metal object are gaps in CT projections. The reconstruction of gapped projections using standard CT reconstruction algorithms, i.e. filtered backprojection (FBP), causes the effect of bright and dark streaks in CT images (Fig. 1b).

Two categories of approaches have been used to reduce the artifact: iterative reconstruction and projection interpolation. In iterative reconstruction methods, the projection data associated with metal objects are disregarded and reconstruction is applied only for non-corrupted data[1-4]. In projection interpolation based methods,[5-9] the projection data corresponding to rays through the metal objects are considered as missing data to be completed.

There are still no commercial options available to radiation oncology departments to deal with this problem. Moreover, to our knowledge, there are no automatic and robust algorithms for metal artifact reduction which can be practical for routine clinical applications. We have therefore developed an algorithm based on projection interpolation for its simplicity and speed. However, extensions were introduced: 1) a robust detection algorithm of the projections affected by metal implants directly on the sinogram (raw data) that takes into account deformation or change of orientation of the metallic prostheses during an helical scan and 2) a new interpolation scheme algorithms for replacing the missing projection in the sinogram. These algorithms are implemented in version 7 of MathLab and are now used in our clinics since June 2004.

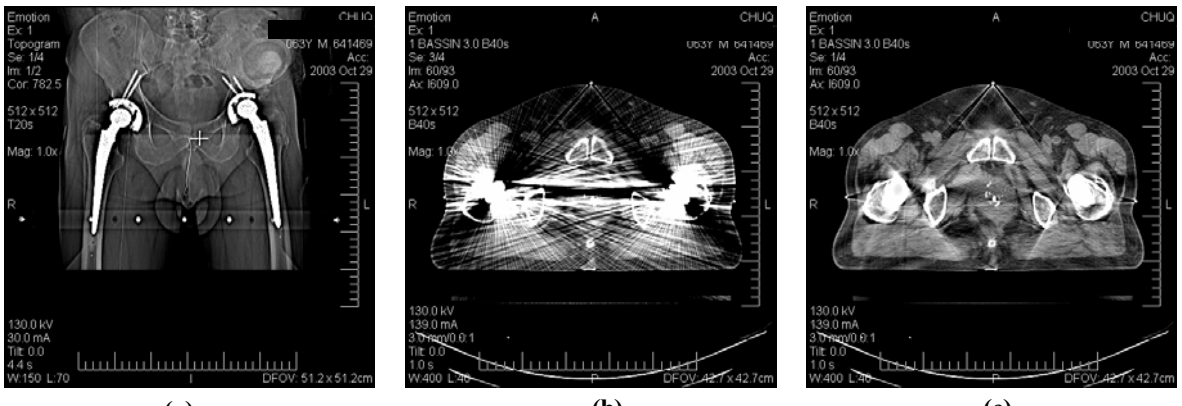
To quantitatively evaluate the performance of this algorithm for reducing metal artifacts, a phantom was used. This phantom is routinely employed for our CT scanner calibration.

The phantom consists of several cylindrical inserts of various densities (such as lung, muscle, liver, bone, etc.) embedded in a block of masonite in the form of human abdomen. Two steel rods were inserted on each side of the phantom to represent the hip prostheses. The size of the rods was chosen to produce the same quantity of artifacts as in a real case. The phantom was scanned by a Siemens Somatom in helical mode with a pitch of 1.5 and 3-mm slice thickness with 130kVp and 168 mA (which are the typical parameters for a pelvis scan) for two cases: without rods (case A) and with rods (case B). Figures 2 (a) and 2(b) show the original reconstructed images (512x512 pixels) for case A and case B and Fig. 2(c) illustrates the significant improvement when the metal artifact reduction algorithm is applied on projection raw data of case B. We name this image case C.

Canny edge detector was used to automatically detect the boundary of different objects in the phantom. We used the same parameters in all three cases. Figures 2(d), 2(e), and 2(f) show the results for cases A, B, and C respectively. Many objects are missing in case B because artifacts are strong in their area. Especially, it is impossible to find the round objects located in the middle of the phantom and only the line segments representing the artifacts in the image are detectable. Meanwhile most round objects especially the three objects in the middle of the phantom can be successfully distinguished in case C. It proves that the algorithm not only improves the image quality, but also it does not introduce any major deformation of the shape of the objects. When we try manually to find the objects in the image, all objects can be detected in case C.

We have also computed the statistical parameters of CT numbers, i.e. mean and standard deviation (std), for three regions representing the three objects in the middle of the phantom (see Figs. 2(g), 2(h), and 2(i)). Table I resumes the results for cases A, B, and C. Comparing case B to the original case (A), we can see that the noise (std) is very high in case B and the mean values are negative and quite different for the three regions. On the other hand, in case C, the values are close to

(Continued on page 140)



(a) **(b)** **(c)**

Figure 1: Patient test; (a) Topogram of a patient with two hip prostheses, (b) reconstructed image using the Siemens Somatom scanner, (c) result of applying the metal artifact reduction algorithm.

Metal artifact reduction (Continued from page 139)

the original case and consequently represent the objects almost with the same material density as those in case A.

From these validations, we conclude that the proposed approach improves the overall image quality and more importantly preserves the form and, in a large proportion, the representative CT number of objects in the image

In conclusion we present a clinical case. Figure 1(a) shows a topogram for a patient with two hip prostheses. Figures 1(b) and 1(c) are representative slices of the patient and its modified image resulting from our artifact reduction algorithm. As it can be seen, the artifacts due to the prostheses (Fig. 1(b)) are almost completely eliminated in Fig. 1(c). The remaining minor streaking artifacts are due to metal markers which are not removed by the algorithm (these markers are needed for the virtual simulation process!).

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	Region 1		Region 2		Region 3	
	mean	std	mean	std	mean	std
Case A	47.4	19.8	57.7	21.3	238.7	20.9
Case B	-189.3	360.8	-272.2	432.5	-94.2	325.6
Case C	37.0	24.3	42.1	30.3	215.6	26.3

Table I: Statistical parameter comparison.

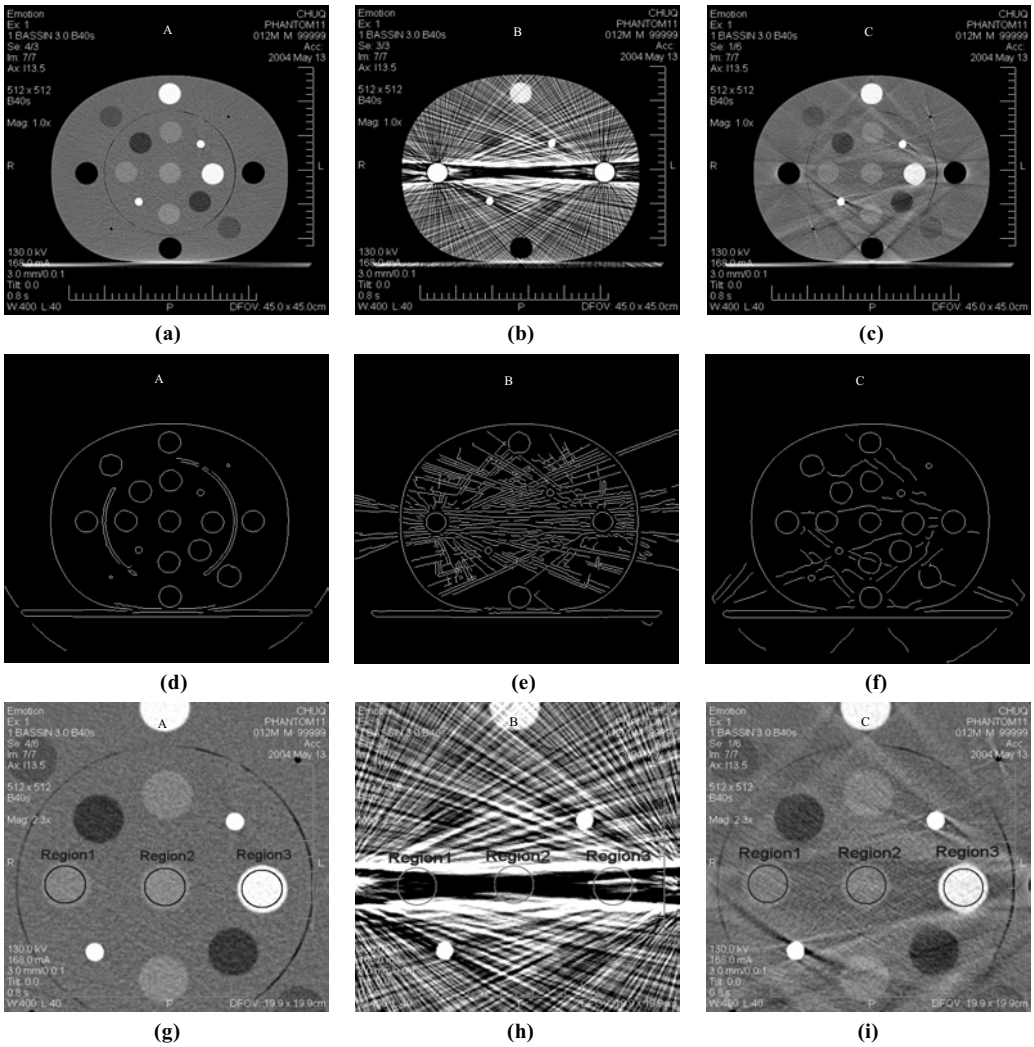

Figure 2: Phantom test; (a) original phantom image without inserting metallic rods, (b) presence of artifacts because of metallic rods, (c) result of artifact reduction algorithm, (d) result of applying an automatic edge detection algorithm on original phantom image, (e) on phantom image with metallic rods, (f) on artifact reduction image, (g) computing the mean and standard deviation for three objects in the middle of the phantom in original phantom image, (h) in phantom image with metallic rods, and (i) in artifact reduction image.

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