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Original Article

Radiation therapist perspectives on cone-beam computed tomography practices and response to information

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Abstract

Introduction: With recent technological advances in image-guided radiation therapy (IGRT), through cone-beam computed tomography (CBCT), more image-related clinical information is being collected, at more frequent intervals throughout the treatment course. As radiation therapy (RT) programmes further develop IGRT technology, the aim of this study is to assess whether the distribution and communication of professional responsibilities is evolving to ensure appropriate use of the technology.

Methods: Radiation therapists practicing at any of the 14 Ontario RT centres were sent an electronic survey ($n = 400$). Closed-ended quantitative items addressed perceptions regarding policies, comfort, and professional responsibility in addressing CBCT concerns. Focus was on gynaecological, lung, head and neck (H&N) disease sites. Options for qualitative comments and explanations were included where appropriate.

Results: Seventy-nine surveys were submitted. Respondents from 12/14 (85·7%) centres used CBCT for at least one of three disease sites, most commonly on a daily basis. Five of these centres (41·7%) did not require radiation oncologist CBCT review, with others requiring it Day 1 or weekly. Potential CBCT observations of concern were grouped as set-up issues, tumour changes, organ-at-risk (OAR) changes, contour changes and ancillary findings (especially lung and airway changes). Respondents believed they consulted another professional about a CBCT in 20·2% of H&N patients, 19·6% of lung patients and 9·7% of gynaecological patients. The level of comfort in doing so varied from 77·0% for H&N to 89·5% for lung. Respondents were most likely to believe themselves responsible for changes in OARs (92·2% believing themselves responsible), and least likely for ancillary findings (62·7%).

Conclusions: Through preliminary insight from Ontario therapists, a degree of inconsistency is apparent between perceptions, practices and assigned roles in the management of CBCT information. Clear definition of the scope and nature of therapists' responsibility for interpreting and addressing changes on CBCT images should be developed within each centre.

Keywords: cone-beam computed tomography; image-guided radiation therapy; interprofessional radiation medicine practice; professional roles and responsibilities

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INTRODUCTION

With the recent technological advances in image-guided radiation therapy (IGRT), more image-related clinical information is being

collected, at more frequent intervals throughout the course of radiation therapy. The use of cone-beam computed tomography (CBCT), on a daily basis in some institutions and disease sites, better enables the radiation therapist to ensure the reproducibility of the patient's positioning for treatment.[1,2] The ever-improving quality of these images also has the potential to provide additional information relating to interfraction anatomical changes,[2,3] disease regression or progression,[3,4] and even critical ancillary findings. Technological innovations can necessitate broad stroke shifts in practice making it imperative that teams collaborate to make use of new technology in an effective and efficient manner.[5–7] As radiation medicine programmes work to introduce or further harness IGRT technology within their institutions, it is important to consider whether the distribution of professional responsibilities has evolved appropriately and formally to maximise the safe use of the technology.

The image quality available with kV-CBCT far exceeds the quality previously available with the primary megavoltage treatment beam, offering benefits such as improved soft-tissue visualisation and volumetric information.[3,7,8] A number of studies have recognised the need to ensure radiation therapists possess the knowledge and skills necessary to manage new clinical information presented during the course of treatment delivery.[6,7,9–11] Studies to date have focused primarily on acquisition of skills relating to cross-sectional anatomy and soft-tissue visualisation,[12] to better ensure the reproducibility of the patient's positioning for treatment. Some have also discussed a shift in responsibility for assessment of positioning accuracy and approaches to achieve this.[7,11,13] More recently, however, there has been increased focus on the evolving uses of CBCT images made possible through harnessing this additional soft-tissue information, such as adaptive planning, without considering the consequences for radiation therapists or the interprofessional team in which they work.[14,15]

It is important to ensure that practice keeps pace with technology, and that considerations are made for how to handle clinical information that was not previously available. As acknowledged by Dawson and Jaffray[8] the use of IGRT can highlight unexpected changes during the course of treatment and imaging practices and methods of response must be evaluated frequently to ensure they are making the most appropriate use of the technology and the expertise within the team. Defining and redefining the roles, responsibilities, and interactions of the interprofessional team members is essential to optimising the use of IGRT in a changing practice environment. With the possibility of increased responsibility being assigned to the radiation therapist in terms of image interpretation, considerations must be made for appropriate education, culture and infrastructure to ensure therapists are adequately equipped to manage this responsibility. Clear communication and direction about how this responsibility is assigned are also necessary.

A survey of the practices and opinions of radiation therapists across Ontario who employ CBCT can serve as the preliminary insight that can direct further work to ensure that the information provided by CBCT is being interpreted and harnessed appropriately. The objectives of this exploratory study are to gain an understanding of the practices of Ontario centres with respect to CBCT acquisition and radiation oncologist (RO) review, and to determine the types of changes that therapists observe on these CBCTs and their comfort in addressing concerns with other members of the team. This study will focus on three major disease sites—lung, gynaecological, and head and neck (H&N). These high-volume sites are treated by most centres and represent different areas of the body where there are commonly-observed anatomical changes that can present during the course of treatment.

METHODS

Study population

Radiation therapists practicing at any of the 14 radiation therapy centres in Ontario were considered for inclusion. The initial population consisted of the 400 full-practice Ontario members of the Canadian Association of Medical Radiation Technologists (CAMRT). This was expanded to include radiation therapists who were practicing in Ontario who were not members of their professional association, which is not mandatory in many areas of the province.

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Survey

A survey was developed to garner preliminary insight on current practices relating to decision-making based on information provided by CBCT in three major disease sites—H&N, lung and gynaecological malignancies. These represent three sites in different anatomical regions with commonly observed set-up variations and anatomical changes over the course of treatment. Basic demographic information was collected, namely number of years in practice, centre of employment, and number of years employing CBCT. Perspectives and opinions relating to the general use of CBCT and the resultant anatomical information provided by CBCT were sought using closed-ended quantitative questions (mainly multiple choice and Likert scale). Options for qualitative comments and explanations were included where appropriate.

The survey was developed by the investigators. A draft survey was reviewed by subject matter experts for preliminary content validity. Reviewers included radiation therapy experts in IGRT and survey methodology, the registrar for the provincial regulatory body for medical radiation technologists, and the Radiation Therapy Program Manager at the provincial cancer agency.

The survey was developed for dissemination using an online survey tool.

Recruitment and distribution

The survey link and a letter of introduction were distributed via e-mail by the CAMRT head office to all members listed as registered for full practice in Ontario ($n = 400$) in 2012. A request was included in the introductory letter inviting further distribution to non-member colleagues, thus increasing the distribution of the survey link. The link remained active for a period of 3 weeks, with a reminder e-mail sent after 2 weeks.

Local Research Ethics approval was received before survey dissemination.

Data analysis

Survey data were compiled and a descriptive analysis was performed. Qualitative responses were categorised by investigators according to common themes.

RESULTS

Seventy-nine surveys were submitted, with at least one from each of the 14 radiation therapy treatment centres in Ontario. Just over half (51·9%) of respondents spend at least 90% of their work time on the treatment unit, and 57·0% ($n = 45$) report being in practice for 10 years or less.

Two respondents (2·5%) noted not employing CBCT for any of H&N, gynae or lung patients, and they were each the sole respondents from their centres (Centres D&F) (Table I). All other centres used CBCT for at least one of the three disease sites, and the majority did so on a daily basis, though in some cases this depended on whether treatment used conventional fields or intensity-modulated radiation therapy (IMRT). The use of IMRT as a treatment technique tended to correspond with more frequent CBCT imaging (Centres B&K) and the existence of a policy requiring review by the radiation oncologist (RO) (Centre G). Respondents from the same centre were not always in agreement for any given practice or policy. The most frequent response is reported here in those instances.

Of those centres employing CBCT, there was a lack of consistency in CBCT review policies (Table I). Five centres (41·7%) reported not requiring any CBCT to be reviewed by an RO for any of the three disease sites. Day 1 or weekly CBCT were reviewed offline for all three disease sites in another five centres (41·7%). Centres E and G each required Day 1 online review for one of the three disease sites (lung and IMRT gynae, respectively).

When asked to list findings seen on a CBCT, for any disease site, that might cause concern to the therapist, responses were grouped by investigators under five headings, based on emergent themes (Table II): set-up issues, tumour changes, organ-at-risk (OAR) changes, contour changes, and ancillary findings. Changes in shape or size of the target volume or OAR were the most commonly-reported issues, usually relating to the gross tumour or the

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Table I. *CBCT practices*

Centre	H&N		Gynae		Lung	
	Frequency	**Review[a]**	**Frequency**	**Review[a]**	**Frequency**	**Review[a]**
A	Daily	Day 1			Daily	Day 1
B	Weekly	Day 1	Varies[b]	Day 1	Daily	Weekly
C	Daily	na			Daily	na
D						
E					Daily	Weekly (Day 1—online)
F						
G	Daily	na	Daily	Varies[c]	Daily	na
H	Daily	na			Daily	na
I	Daily	na	Daily	na	Daily	na
J	Weekly	Day 1	Daily	Day 1	Daily	Day 1
K	Daily	na			Varies[d]	na
L	Daily	na	Daily	na	Weekly	na
M	Daily	Day 1			Daily	Day 1
N	Daily	Weekly			Weekly	Weekly

Notes: [a] offline RO review unless stated otherwise.
[b] Pre-operative: Days 1–3 and weekly/post-operative: daily.
[c] IMRT: Day 1 (online)/non-IMRT: na.
[d] IMRT: daily/non-IMRT: Days 1–3 and weekly.
Abbreviations: CBCT, cone-beam computed tomography; H&N, head and neck; RO, radiation oncologist; IMRT, intensity-modulated radiation therapy.

Table II. *Types of changes on a CBCT that might cause concern*

Type of Concern	Concern	Number	
		Individuals	**Centres**
Set-up issues ($n = 15$)	Large rotations	4	3
	Large shifts	2	2
	Gaps in bolus	2	2
	General/other	7	5
Tumour changes ($n = 49$)	Growth	13	9
	PTV/CTV coverage	10	5
	Shrinkage	6	5
	New disease	3	2
	General/other	17	6
OAR changes ($n = 36$)	Bowel/bladder	14	5
	OAR into high dose	4	4
	Cord/brainstem	2	2
	General/other	3	3
Contour changes ($n = 33$)	Weight loss/gain	13	8
	External contour	8	4
	General/other	12	7
Ancillary findings ($n = 27$)	Lung collapse/inflation	15	7
	Airway changes	5	4
	Pleural effusion	4	2
	General/other	3	3

Abbreviations: CBCT, cone-beam computed tomography; PTV, planning target volume; CTV, clinical target volume; OAR, organ-at-risk.

bladder and bowel. External contour changes were also noted frequently, with many respondents specifically identifying these as patient weight loss or gain. A number of respondents listed lung and airway changes as concerning issues, and these were classified under ancillary findings, not necessarily relating to the treatment volumes or other volumes of interest.

Respondents noted contacting a physicist or RO regarding a concern on a CBCT image in 20·2% of H&N patients, 19·6% of lung patients

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Table III. Perceived frequency and comfort of reporting concerns

Site	Average perceived % of patients requiring contact with RO (no. respondents)	% Rating comfort in contacting the oncologist as ≥4/5 (no. respondents)
Head and neck	20·2 ($n = 41$)	77·0 ($n = 61$)
Lung	19·6 ($n = 45$)	89·5 ($n = 57$)
Gynaecological	9·7 ($n = 35$)	84·2 ($n = 38$)

Abbreviation: RO, radiation oncologist.

Table IV. Perceived responsibility for recognising changes

Type of change	% believing themselves responsible (≥4/5) ($n = 51$)	Average rating (/5)
Tumour	76·5	4·1
OAR	92·2	4·6
External contour	82·4	4·3
Ancillary finding	62·7	3·8

Abbreviation: OAR, organ-at-risk.

and 9·7% of gynaecological patients (Table III). The level of comfort in reporting unusual findings was high in all disease sites, ranging from 77·0% for H&N to 89·5% for lung (Table III). Differences were observed between centres, but small sample sizes for most centres precluded assessments of significance. When asked to suggest the perceived level of responsibility of radiation therapists for recognising changes relating to various types of changes seen on CBCT, respondents were most likely to believe themselves responsible for changes in OARs (92·2% believing themselves responsible), and least likely for ancillary findings (62·7%) (Table IV).

Respondents acknowledged the need for education to manage the information provided by CBCT, and the lack of consideration of how to do this in practice. One respondent noted that he/she '[did]n't think the department has really thought about some of the issues that are related to CBCT'. Another suggested the 'need [for] provisional guidelines when using CBCT & education software in every centre for [radiation therapists] to learn off line'. It was mentioned that in some centres radiation therapists are considered the experts, 'despite a lack of training to recognize changes'. Others found that the radiation therapist experience with CBCT in certain departments suggested that problems tended to be well identified and that 'oncologists appreciate us for notifying them when we notice a change'. Regardless of expertise, one respondent noted that 'as professionals we are responsible and as we do more and more CBCT that will only continue'.

DISCUSSION

Imaging practices and policies

The use of volumetric imaging using kV-CBCT in Ontario is moving from a period of rapid implementation to a push for standardisation in many centres.[16] Among other things, this requires consideration of the most appropriate distribution of professional responsibilities and potential shifts in resources to optimise a model of care for patients. Great variability was reported across the province in this investigation relating to the disease site-by-site use of CBCT, frequency of imaging, and RO image review policies. This suggests either a lack of consensus in CBCT practice, or a lack of reflection on practice to consider and address the relevant issues. While some of the variability must be attributed to differences in technological infrastructure and patient populations, the impact of evidence-based guidelines, standardised policies, professional culture and training practices should also be considered. As was observed in this study, therapists working in the same centre often reported different workflow or policies relating to imaging frequency and RO review,

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suggesting a lack of consistent practice or knowledge of procedures. Congruence between therapists' stated responsibilities and the existence and content of departmental policies and procedures has yet to be assessed.

Consultation with the RO

In a recent white paper published by the American Society of Radiologic Technologists (ASRT) on the role of radiation therapists in radiation therapy safety, it was acknowledged that 'the radiation therapist is the ultimate gatekeeper' in treatment delivery.[17] As professionals who practice at the interface between treatment technology and patients, therapists are best positioned to observe patient changes or issues, optimising the use of the image guidance technology.[10,11,16] Therapists in this investigation reported contacting the RO for up to one-fifth of their patients, to address an observation made on a volumetric image during the course of treatment. The degree to which this activity is impacted by imaging frequency and image review policies has yet to be determined. Clinical data collected at an Ontario institution with online daily CBCT guidance not requiring RO image review for its H&N patients, demonstrated that in 18·1% of these patients consultation with the RO was sought to address a finding on a CBCT image.[18] This suggests that perceptions of the respondents in this investigation were not only reasonable estimates, but also that objective measures of these interprofessional communications are feasible and valuable to optimal treatment delivery. As such, efforts should focus upon categorisation and quantification of the common issues found in an era of volumetric image guidance and how they were addressed, to further standardise practices.

Responsibility for CBCT image interpretation

To raise concern regarding patient images with the RO implies that the therapist must be confident in recognising an anomaly on a treatment image that is not related to the physical set-up position of the patient, which could usually be addressed directly by the therapist on the treatment unit.[16] Historically, with megavoltage portal imaging, the inherently poor contrast provided only enough information to assess positioning relative to bony anatomy in a limited field of view. Additionally, these images were generally acquired infrequently and reviewed by the RO.[8] With more frequent imaging, greater anatomical detail, and imaging workflows effectively transferring a significant portion of the responsibility for routine image assessment from the RO to the therapist,[10,19] the level of responsibility expected of the therapist, and appropriateness thereof, require formal consideration.

Work to date has focused on assessment of patient positioning required for treatment, which has traditionally been within the scope of a therapist's responsibility, with the oversight of the RO. In a publication sponsored by the American Society for Radiation Oncology and endorsed by the ASRT, it stated that 'the physician is responsible for the supervision and review of [IGRT] images and shifts in order to ensure the therapy delivered conforms to the original clinical and dosimetric plans. Similarly, management of organ motion during treatment delivery, when indicated, is the responsibility of the treating physician'.[20] While there are inherent differences in professional practice in different jurisdictions that suggest that such statements might not reflect professional opinions in all practice environments, incongruence is apparent in some contexts between practice and assigned responsibility.

In this investigation, respondents believed themselves responsible for discerning changes in OARs and external contours, with three-quarters also claiming that they should be able to assess changes in the tumour itself. In many instances, this perceived scope of responsibility extends beyond strict reproducibility of patient positioning. The fact that a small majority of respondents also believed themselves responsible for appreciating ancillary findings, which could be entirely outside of the volume of interest, was an unexpected result in this investigation, and should be explored further. An evaluation of how the level of responsibility assumed by therapists aligns with the level of responsibility assigned through departmental policies and practices is also warranted. It is expected that there would be variations between centres in terms of both perception and practice, and that

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these might be attributable, at least in part, to the extent to which there is a culture of interprofessional collaboration within a department.

Ensuring appropriate knowledge and judgement

There is little consideration in the literature as to whether therapists are equipped, or should be equipped, to recognise the spectrum of changes in an era of volumetric image guidance.[16,21] The potential impact on the entire radiation therapy department of equipping therapists 'with the knowledge and skills necessary to manage the wealth of new information now presented to them at the time of treatment delivery' was acknowledged by White and Kane,[10] but they stopped short of identifying what the content of that education and training needs to be. The value and necessity of both entry-to-practice and continuing education in areas such as relational and cross-sectional anatomy has not been adequately explored.[9,20] Burow et al.[21] suggest that soft tissue image interpretation, such as is required for CBCT image interpretation, is not addressed in entry-level radiation therapy certification programmes in Australia. They note that further training would be required to warrant role expansion, which would increase workflow efficiency within radiation medicine. In the Canadian context, continuing education initiatives have been developed to address this in some jurisdictions.[12,22]

While the level of comfort in contacting the RO in response to such information was consistently high in this investigation, variations were reported between respondents, disease sites and centres. This suggests that factors such as infrastructure, policy, therapist skills and knowledge, and the culture of collaboration at each institution should be further explored. In order to optimise a model of care for patients for whom we employ CBCT, it is essential that roles and responsibilities between professionals be thoroughly defined and informed by scopes of practice and available skill sets. This would include expectations regarding appreciation of potential ancillary findings, such as the lung and airway-related issues identified in this investigation. If it is determined that therapists are the most appropriate professionals to fulfil a given role in image interpretation and assessment, it must be ensured they are trained and educated to manage the associated responsibilities. Any legal liability implications relating to responsibility for clinical image assessment must also be determined and addressed.

CONCLUSIONS

As the use of CBCT technology and the understanding of its capabilities continue to expand, it is important that practice evolves in a fashion that is evidence based and assures the most appropriate distribution of roles and responsibilities in the delivery of care to the patient. It is apparent from the preliminary insight from Ontario therapists in this investigation, that there is a degree of inconsistency between perceptions, practices, and assigned roles in the management of CBCT information, and possibly a lack of consideration of the pertinent issues in each area. Mechanisms to ensure appropriate workflows, communication and skill development must be established and guided by policy. A clear definition of the scope and nature of therapists' responsibility for interpreting and addressing changes on CBCT images should be developed within each centre, based on input and consensus between all professional groups. Only through engaging in these necessary assessments and conversations can the most efficient, effective and safe practice be defined.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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