Technical Note

Use of image guided radiation therapy techniques and imaging dose measurement at Indian hospitals: A survey

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ABSTRACT

A national survey was conducted to obtain information about the use of image-guided radiotherapy (IGRT) techniques and IGRT dose measurement methods being followed at Indian radiotherapy centers. A questionnaire containing parameters relevant to use of IGRT was prepared to collect the information pertaining to (i) availability and type of IGRT delivery system, (ii) frequency of image acquisition protocol and utilization of these images for different purpose, and (iii) imaging dose measurement. The questionnaire was circulated to 75 hospitals in the country having IGRT facility, and responses of 51 centers were received. Survey results showed that among surveyed hospitals, 86% centers have IGRT facility, 78% centers have kilo voltage three-dimensional volumetric imaging. 75% of hospitals in our study do not perform computed tomography dose index measurements and 89% of centers do not perform patient dose measurements. Moreover, only 29% physicists believe IGRT dose is additional radiation burden to patient. This study has brought into focus the need to design a national protocol for IGRT dose measurement and development of indigenous tools to perform IGRT dose measurements.

Key words: Computed tomography dose index measurements, image guided radiotherapy dose burden to patients, image guided radiotherapy survey

Introduction

Since the last few years, in-room volumetric imaging systems which include MV computed tomography (CT)[1,2] and MV[3,4] or kV[5,6] cone-beam computed tomography (CBCT) are being used for greater soft tissue definition and improved target localization. After results, this technology helps in escalating target dose while decreasing normal tissue doses. This improves the therapeutic ratio of radiotherapy. Radiotherapy is a team work of radiation oncologists, medical physicists, and radiation therapy technologists who always work in tandem through mutual consultation. However, the medical physicist is the main chain in the safe implementation of technology in radiation therapy. To reduce the planning target volume margin and to understand changes happing during the course of treatment, intense image guided radiotherapy (IGRT) protocols are adopted. Additional imaging dose due to intense IGRT protocol is a concern for deterministic and nondeterministic radiobiology effect. Radio therapy patients are already being exposed to very high and localized doses of radiation; the additional dose from IGRT imaging has a risk, and it should be kept as low as reasonably achievable.[7] As per the international tolerance limit, the absorbed dose rate due to leakage radiation excluding neutrons at any point outside the maximum size of useful beam at the normal treatment distance shall not exceed 0.2% of the absorbed dose rate on the central axis

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at the treatment distance.[8] Leakage radiation, for a 60 Gy treatment delivered over 30 fractions will be <120 mGy. The total dose associated with IGRT imaging can be significantly more than the limit for background dose from the beam and can increase the therapeutic dose by several percent.[9] Although there is vast interest in IGRT techniques, and its utilization for the different tasks of radiotherapy process, it is unclear how radiotherapy centers in the country are practicing this advanced technique. To understand the use of IGRT procedure and IGRT dose issues in the country, a nationwide survey was conducted. It is worth mentioning here that IGRT is a vast subject and it is difficult get complete information through one survey. However, a questionnaire was developed to get the maximum information about the availability of IGRT systems, their usage in clinics and imaging dose measurement. This survey was conducted among working medical physicists, and an effort has been made to gather the important information. As the subject is wide, the scope of information collected is limited, and one may argue that some aspects have not been included. This paper presents the main results of the survey.

Materials and Methods

A questionnaire containing parameters relevant to IGRT use and imaging dose was evolved to collect the information about the exact practice of IGRT being followed at the hospitals. As the aim of this survey was to understand and extract the information about the IGRT practice being used by the hospitals and to understand the difficulties in measurement of IGRT dose, emphasis was given on multiple choice answers over descriptive type answers. Questions on kV, mA, time, field of view, filters, no filters, and acquisition time for IGRT, random and systematic errors, etc., were not included in our survey (conducted during November, 2014 to February, 2015). These could be a part of another survey. Table 1 shows the IGRT questionnaire which was prepared for conducting the survey. It has three major parts namely: (i) Availability and type of IGRT delivery system, (ii) frequency of image acquisition protocol and utilization of these images for different purpose, and (iii) imaging dose measurement. Under availability of IGRT system, questions regarding the number of machines having capability of IGRT and type of energy (kV or MV) used were included. Under the second part, frequency of image acquisition and use of images for different tasks were evaluated. Third part of the questionnaire was pertaining to IGRT dose measurement. It included a question on the measurement of dose on phantom/patient and the procedure of measurement. The questionnaire was sent to 75 centers across India via email and 51 (68%) centers responded.

Table 1: The questionnaire sent to different hospitals participated in this survey

Image Guided Radiotherapy Dose Survey

1) How many linear accelators are there in your hospital ○1 ○2 ○More Than 2

2) Of these linear accelerator ,how many have additional volumetric image -guided radiotherapy capabilities (i.e in addition to MV portal imaging) ○1 ○2 ○More Than 2

3) Among available volumetric IGRT capabilities how many have MV energy ○0 ○1 ○2 ○More Than 2

4) For your chosen method of volumetric IGRT what is your frequency of imaging ○ Daily ○ Weekly ○ Patient Specific

5) What is choice of imaging at your center for following cases?

	Volumetric	Planner	Both		
				Volumetric	Planar
CNS	○	○	○		
H&N	○	○	○		
Breast	○	○	○		
Lung	○	○	○		
GI	○	○	○		
GU	○	○	○		
GYN	○	○	○		
Pediatric	○	○	○		
Lymphoma	○	○	○		

6) Information from volumetric IGRT system is used for
- ○ To correct the patient set-up
- ○ To find out patient spesific margin
- ○ To modify patient contour

7) Weather volumetric patient data is used for dose calculation
○ Yes ○ No

8) Do you measure Imaging dose (CTDI) in phantom
○ Yes, Describe methods in brief
○ No, Reason ○ Non-availibility of suitable protocol
○ Non-availbility of Equipment ○ if any other
○ Considering imaging doses are insganificant

9) Do you measure imaging dose in patient
○ Yes, Dosimeter used
○ No, Reason
○ Non-availbility of Dosimeter
○ Considering imaging doses are insganificant

10) Do you believe IGRT imaging dose is additional radiation burden on patient
○ Yes ○ No ○ Can't say

if yes,
Do you believe published value of dose to critical structure for vendor and scanning protocol specific is sufficient?
○ Yes ○ No
OR
Do you believe in accounting the imaging dose during treatment planning?
○ Yes ○ No

11) Do you have any non-ionizing IGRT system in your clinic ?
○ Yes ○ No

Name of Hospital
Make and Model of Imaging System
Name of the Physicist
Date

Results

Survey reveals that out of 51 radiotherapy centers, 33 radiotherapy centers have only one medical linear accelerator, 14 radiotherapy centers have two medical linear accelerators, and four radiotherapy centers have more than two medical linear accelerators. Percentage of surveyed hospitals with three-dimensional (3D) IGRT facility is shown in Figure 1. Volumetric imaging capability is available

in 86% of these medical linear accelerators. Out of these, 78% of volumetric imaging systems use kilo-voltage X-ray while 22% use megavoltage X-ray beam.

In megavoltage X-ray beam based imaging system, two centers use 3.5 MV X-rays beam, and others use 6 MV X-ray beams.

Frequency of IGRT imaging is shown in Figure 2; it was observed that 68% centers have patient-specific imaging protocol, 18% of centers have weekly imaging protocol while 14% of centers do daily imaging. Survey results point out large variation in the number of volumetric and planar images acquired during the complete course of treatment in each of the sites. From the data, it was observed that imaging is most commonly applied for head and neck patients and least frequently applied to breast and pediatric cases. For other treatment sites, large variation in number was observed for both planar and volumetric imaging. Use of IGRT images is shown in Figure 3, all centers use images for patient setup verification, 27% of centers use these images to find patient specific margin and 29% of center uses to modify contours. Hospitals' response for the use of IGRT images for dose calculation is presented in Figure 4. This shows that 21% of the centers use volumetric CBCT images for dose calculation. Results about computed tomography dose index (CTDI) measurement at surveyed hospitals are presented in Figure 5. This shows 75% of hospitals do not perform CTDI measurement. From Figure 6 it can be observed that non-availability of the equipment is the main reason for non-performing of CTDI measurements. While 86% of the responded centers cited the non-availability of equipment as the reason, the remaining 14% centers believed dose was insignificant, and hence they did not perform CTDI measurements. Twenty five percent of the hospitals who performed CTDI measurements used standard CTDI phantom. In response to a question about measurement of patient dose due to CBCT, 89% of the centers stated that they did not measure the patient dose while 11% centers carried out patient dose measurements using optically stimulated luminescence dosimeter and metal oxide semiconductor field effect transistor [Figure 7]. The reasons for not performing patient dose measurements are as shown in Figure 8. This survey reveals that 69% of medical physicists believe that non-availability of dosimeter is a major hurdle for not measuring patient dose during IGRT while 24% of physicists believe that the dose is insignificant, and 8% medical physicists feel it may have been some other reason.

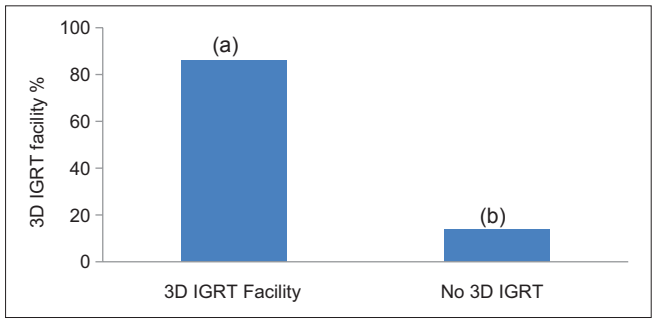

Figure 1: Number of hospitals with (a) three-dimensional image-guided radiotherapy Facility (b) No three-dimensional image-guided radiotherapy facility

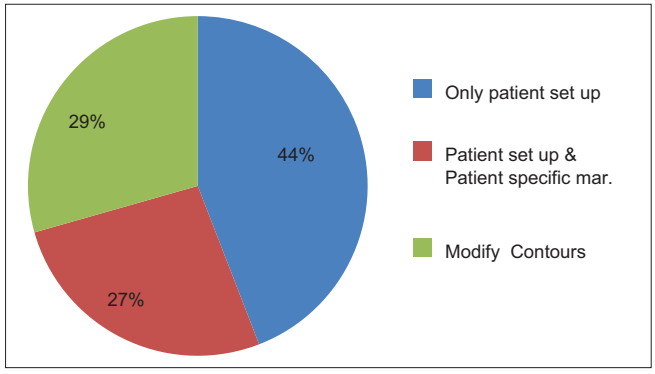

Figure 3: Use of image guided radiotherapy images at participating hospitals

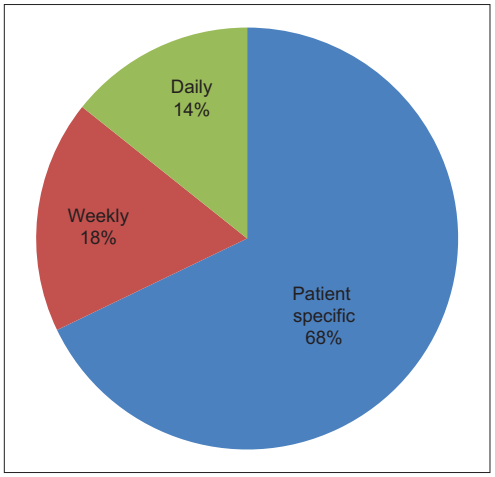

Figure 2: Frequency of imaging in image guided radiotherapy at studied hospitals

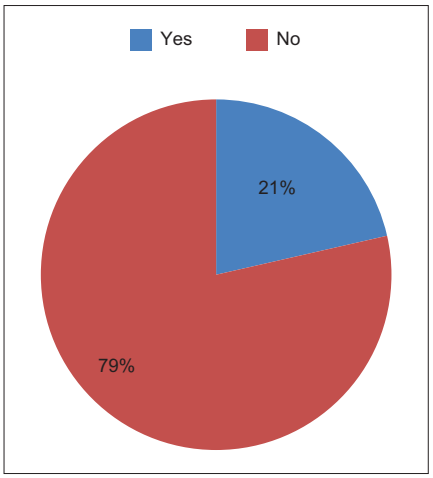

Figure 4: Percentage of hospitals uses image guided radiotherapy images for calculation

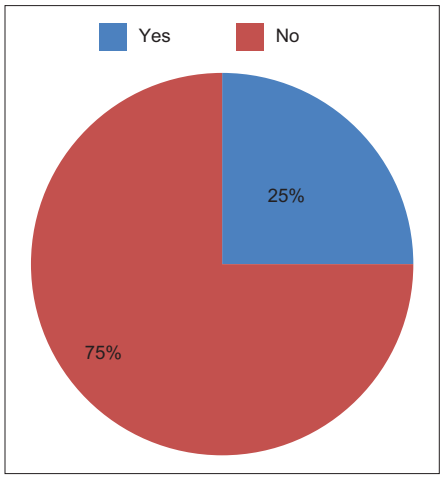

Figure 5: Percentage of hospitals performing computed tomography dose index measurements

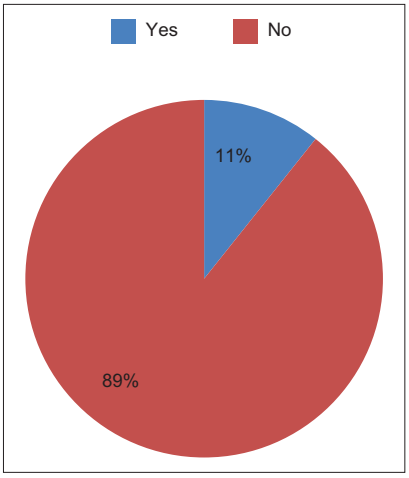

Figure 7: Percentage of hospitals performing image guided radiotherapy patient dose measurements

Physicists' responses for believing IGRT to be an additional dose burden to the patient are shown in Figure 9. It can be observed that there is no clear consensus when physicists were asked whether imaging dose was additional radiation burden on the patient. While 32% of the medical physicists believed IGRT dose was additional burden to patient, 39% believed it was not and the remaining 29% were not sure about it. Among those who believed that imaging dose was a radiation burden to the patient, 90% were of the opinion that imaging dose should be accounted for during treatment planning, and 10% thought literature published values were sufficient. In this survey, it was also observed that 8% centers have non-ionizing IGRT facility such as Clarity (Clarity Elekta Medical System, Sweden) and Calypso (Varian Medical Systems, USA).

Discussion

The intention of our survey was to assess the utilization of IGRT technologies and understand status of IGRT dose

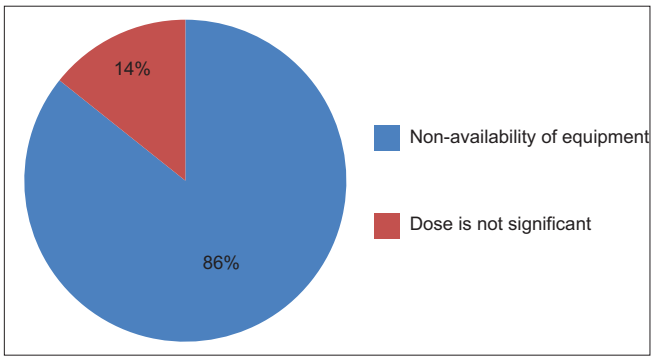

Figure 6: Reason for not measuring computed tomography dose index

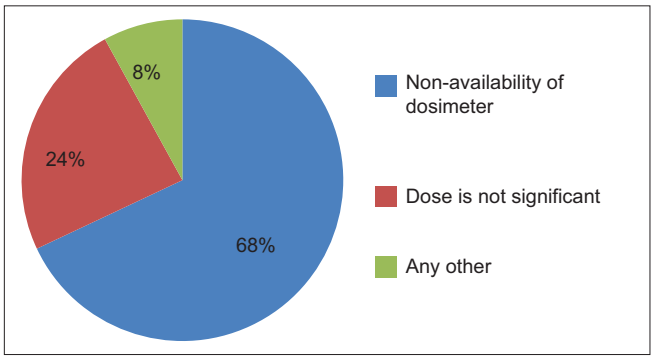

Figure 8: Reason for not measuring patient dose during image guided radiotherapy

measurement in India. This was the first of its kind survey in India. The sample size of our survey is very limited, so it is very difficult to draw a definite conclusion. Nevertheless, the survey shows the trend of use of IGRT techniques and imaging dose measurement at Indian hospitals. There are similar surveys published in literature about IGRT in developed countries. Simpson *et al.*[10] conducted a survey among radiation oncologists in the USA to understand which IGRT technologies were used and to what extent, and how they were being applied, and Korreman *et al.*[11] conducted a survey in European nations to provide an overview and current standing of 3D CT-IGRT systems. On the basis of the survey data, we found that a majority of radiotherapy centers have facilities of volumetric imaging, and most cancer centers use kV X-ray based volumetric imaging. As per American Association of Physicists in Medicine (AAPM) TG 142[12] and 179[13] recommendations, the imaging dose should be measured, but it was found that only 25% centers performed CTDI measurements. Maximum centers (86%) do not perform measurements because of non-availability of dose-measuring equipment. One of the major reasons for non-availability of dose-measuring equipment is the cost of the phantom and dosimetry system. Stress should be given for indigenous fabrication of the CTDI phantom with an insert of farmer type ionization chamber so that the measurements become cost effective. As per TG111[14] report, farmer type ionization chamber is recommended for measuring radiation dose in CT. In India, there is a regulatory

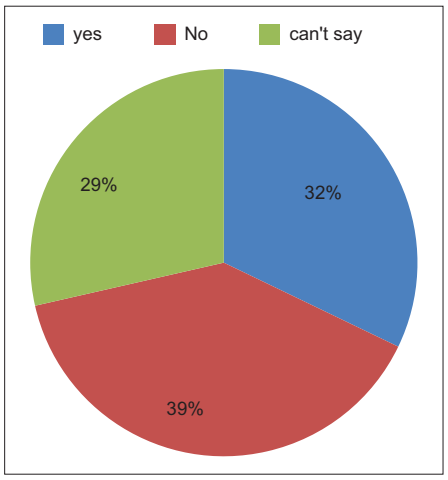

Figure 9: Percentage of Physicists' response for believing image guided radiotherapy as an additional dose burden to patient

requirement that every center should have at least one working farmer type ionization chamber. In order to partly overcome the problem of non-availability of dose-measuring equipment, it is suggested that the Radiation Standard Section, Bhabha Atomic Research Center may provide calibration factor for farmer type ionization chamber at kV X-ray beam. In this way the farmer type ionization chamber available with every radiotherapy center can be put into use for CTDI measurement as well. This will make the imaging dose measurement cost effective and thereby encourage the physicists to do such measurements. A number of hospitals have informed that they were not able to perform the QA due to non-availability of dose-measuring/QA equipment. Association of Medical Physicists of India and regulatory board can propose and standardize the methodology to outreach the QA program of such facilities. It was also observed that non-ionizing IGRT solution is not popular in our country. Any amount of radiation dose to normal tissue is an additional burden for the patient. "ALARA" principle should be strictly implemented to reduce dose to the patient. Frequency of IGRT protocol can also be decided based on dose gradients of treatment techniques. International Commission on Radiological Protection is in the process of publishing a report on radiological protection in cone beam computed tomography; this report will also help medical physicists to carry out dose measurements for CBCT.[15] AAPM has constituted task group TG 180 to address issues related to modeling and accounting for the imaging guidance radiation doses to radiotherapy patients in treatment planning. All of these new guidelines will help medical physicists in managing the imaging dose in IGRT.

Conclusion

IGRT is widely used across the country for different sites however the frequency of volumetric imaging is non-uniform across the centers. Measurement of IGRT dose is not a common practice in India. As per our survey, two main reasons for this apathy toward imaging dose measurements are the lack of dose-measuring equipment and lack of proper guidance and recommendations. To overcome the problem of lack of a device, there is a need for indigenous development of QA equipment. We believe that one of the implicit reasons for lack of device is the cost of equipment, and indigenous development of instruments will help reduce the cost and increase overall participation. Furthermore, calibration laboratories should play a proactive role by providing an additional calibration factor at kV energy range. It is also believed that regulatory body should come out with standard recommendations in due course of time to standardize imaging dose measurement. Further research is required to determine the safety, cost-efficacy, and optimal applications of these technologies.

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Conflicts of interest

There are no conflicts of interest.

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