Practical Radiation Oncology (2011) **1**, 226–231

practical radiation oncology
pro
www.practicalradonc.org

Special Article

Addressing connectivity issues: The Integrating the Healthcare Enterprise-Radiation Oncology (IHE-RO) initiative

Ramesh Rengan MD, PhD [a], Bruce Curran MS, ME [b], Charles Able MS [c], May Abdel-Wahab MD, PhD [d], Akkamma Ravi MD [e], Kevin Albuquerque MS, MD [f], Colin Field MS [g], Sidrah Abdul BS [h,*], Rishabh Kapoor MS [i], Prabhakar Tripuraneni MD, FACR [j], Jatinder Palta PhD [k]

[a]*Department of Radiation Oncology, University of Pennsylvania, Philadelphia, Pennsylvania*
[b]*Department of Radiation Oncology, Rhode Island Hospital, Providence, Rhode Island*
[c]*Department of Radiation Oncology, Wake Forest University School of Medicine, Physicist, North Carolina*
[d]*Department of Radiation Oncology, University of Miami, Sylvester Comprehensive Cancer Center, Miami, Florida*
[e]*Department of Radiation Oncology, New York Hospital, Weill Medical College, Flushing, New York*
[f]*Department of Radiation Oncology, Loyola University Medical Center, Maywood, Illinois*
[g]*Department of Physics, Cross Cancer Institute, Edmonton, AB, Canada*
[h]*American Society for Radiation Oncology, Fairfax, Virginia*
[i]*Department of Radiation Oncology, University of Florida, Gainesville, Florida*
[j]*Department of Radiation Oncology, Scripps Clinic, La Jolla, California*
[k]*Department of Radiation Oncology, University of Florida/Davis Cancer Center, Gainesville, Florida*

Abstract In today's world, treating a patient successfully with radiation requires the integration of complex data from a variety of systems. In a typical radiation oncology clinic, data move from the treatment management system to treatment planning system to treatment delivery system. When there is a lack of interconnectivity between the systems, the potential for medical error is increased. Integrating the Healthcare Enterprise-Radiation Oncology (IHE-RO) is dedicated to the identification of connectivity problems encountered in the modern day radiation oncology clinic and the development of solutions to these problems. These solutions are then integrated and made available to the radiation oncology community. This article introduces the IHE-RO initiative, outlines the relevance of IHE-RO for the radiation oncology community, and provides a resource so that therapists, physicists, dosimetrists, administrators, and physicians alike can best understand which vendor equipment can effectively communicate between platforms because it has been deemed IHE-RO compliant through a series of connectivity tests.

Conflicts of interest: None.

*Corresponding author. American Society for Radiation Oncology, 8280 Willow Oaks Corporate Drive, Fairfax, VA 22031.
E-mail address: sidraha@astro.org (S. Abdul).

1879-8500/$ – see front matter
doi:10.1016/j.prro.2011.06.016

Introduction

Radiation oncology is a technology driven field, from the imaging that we use to identify the tumor and surrounding vital organs, to the computers that we use to generate a treatment plan, to the hardware that we use to deliver the dose and confirm the accuracy of its delivery. This requires integration of software and hardware from a variety of vendors using a multitude of systems. For this integration to be done successfully we need a series of data transfers to occur with 100% fidelity and reliability (see Fig 1). When these connections falter, errors occur, and patient safety is compromised. Integrating the Healthcare Enterprise-Radiation Oncology (IHE-RO) is dedicated to identifying and correcting connectivity and compatibility issues affecting members of the radiation oncology community in their everyday clinic and to developing solutions to these problems. It is a unique organization where administrators, clinicians, industry representatives, physicists, and information technologists work together. Support for the IHE-RO initiative is an important component of a larger commitment by all to improve patient safety.[1]

The American Society for Radiation Oncology (ASTRO) 6-point "Target Safely" plan for patient protection and IHE-RO.[2]

In February of 2010, the ASTRO committed to a 6-point patient protection program with the goal of improving the safety and quality of radiation treatment and reducing the chance of medical treatment errors. This plan, known as the Target Safely initiative, was approved by the Board of Directors of ASTRO, motivated in part by a series of *New York Times* articles entitled the "Radiation Boom" by Walt Bogdanich that examined issues arising from the increasing use of medical radiation and the new technologies that deliver it.[3-7] In this series of articles, a number of disturbing radiation treatment delivery errors and the consequence to patients were highlighted. The Target Safely initiative consisted of 6 separate domains through which ASTRO would focus future efforts in order to improve the quality of patient care.

1. Working with the Conference of Radiation Control Program Directors and other stakeholders to create a database for the reporting of linear accelerator- and computed tomography-based medical errors.
2. Launching a significantly enhanced practice accreditation program, and beginning the development of additional accreditation modules specifically addressing new, advanced technologies such as intensity modulated

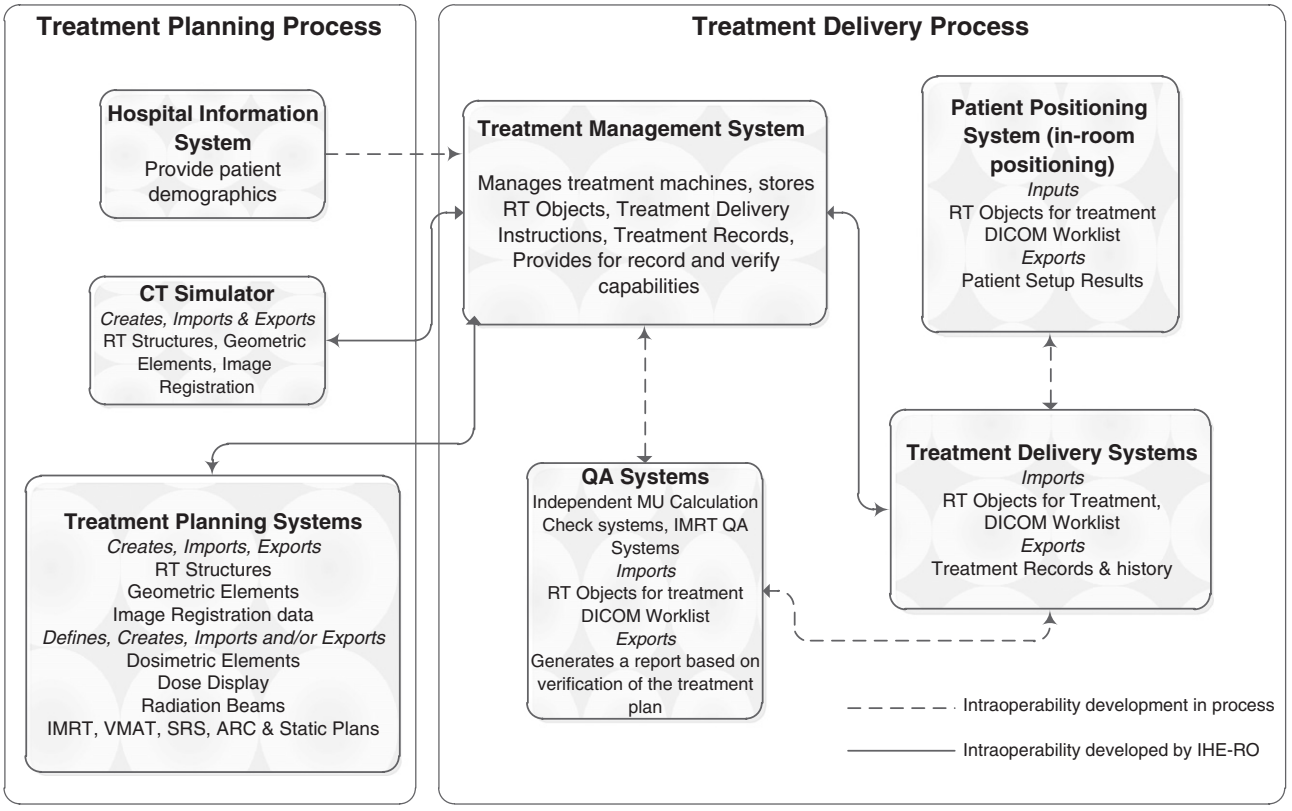

Figure 1 Schematic representation of critical data handoffs within a typical radiation oncology clinic. Solid lines represent connectivity issues for which Integrating the Healthcare Enterprise-Radiation Oncology (IHE-RO) has developed an agreed upon standard (also known as integration profiles). Hatched lines represent a connectivity issue for which IHE-RO is currently working to develop a standard.

radiation therapy (IMRT), stereotactic body radiation therapy, and brachytherapy.
3. Expanding our educational training programs to include specific courses on quality assurance and safety, and adding additional content to other educational programs.
4. Working with patient support organizations to develop tools for cancer patients and caregivers for use in their discussions with their radiation oncologist to help them understand the quality and safety programs at the centers where they are being treated. These tools will include questions to ask their treatment team, such as, "Do you have daily safety checks?" and "What kinds of safeguards do you have to make sure I'm given the right treatment?"
5. Further developing our Integrating the Healthcare Enterprise-Radiation Oncology (IHE-RO) connectivity compliance program to ensure that medical technologies from different manufacturers can safely transfer information to reduce the chance of a medical error.
6. Providing our members' expertise to policymakers and advocating for new and expanded federal initiatives to help protect patients, including the following: support for immediate passage of the Consistency, Accuracy, Responsibility and Excellence in Medical Imaging and Radiation Therapy Act to require national standards for radiation therapy treatment team members; additional resources for the National Institute of Health's Radiological Physics Center to evaluate the safety of treatments; and funding for a national reporting database.

Although the treatment errors identified in the *New York Times* articles had many causes,[3-7] it was clear that connectivity errors arising from the failure to properly integrate the various hardware and software commonly utilized in a radiation oncology clinic can compromise patient safety. Interoperability errors can result in safety hazards as well as inhibit efficiency. IHE-RO works on developing both workflow and interoperability solutions to allow the clinical environment to operate safely and efficiently. One important goal of IHE-RO workflow development is to enable incorporation of automated safeguards that are designed to identify and correct errors before they can do harm to the patient. Therefore, support for the IHE-RO initiative became one of the tenets of the ASTRO Target Safely initiative.

What is IHE-RO?

IHE (Integrating the Healthcare Enterprise) is an international collaborative effort that aims to improve compatibility across all segments of health care technologies. The goal of IHE is to enable sharing of information that is relevant to a patient's care among all health care systems, thereby eliminating interoperability challenges. The hope is that this will ultimately improve patient care and reduce medical errors.[8]

ASTRO sponsors the Radiation Oncology domain of IHE (IHE-RO). In 2004, ASTRO formed a multi-society, multi-national, and multi-specialty IHE-RO task force to address issues of information sharing between various health care systems in radiation oncology and is working to resolve them in a systematic way using established industry standards. First, IHE-RO seeks connectivity problem submissions from users in the clinic. Once a problem is identified, it is then articulated into a standardized form developed into a solution that serves as an implementation roadmap for vendors (see Table 1).[9] Once the vendors have implemented the connectivity solution, they come together annually for the IHE-RO Connectathon to demonstrate that the connectivity problem has been resolved.[10]

Testing connectivity solutions at a Connectathon

After the Connectathon, solutions are finalized and vendors integrate these solutions into their products and test their systems. Successful completion of the testing requires the vendor's system to receive information from at least 3 other vendors who support the previous step in the information flow, and to transmit information to 3 vendors whose applications represent the next step. The vendors who passed the Connectathon for 1 or more of the tests are provided the opportunity to demonstrate successful integration of the connectivity solution into their product for consumers by ASTRO. This usually takes place in the exhibit hall during the ASTRO Annual Meeting. A product that has passed a Connectathon can then be deemed as "IHE-RO Compliant" once the product has been market released within 1 year after passing.[10]

The first connectivity problem solved by IHE-RO was in the realm of basic radiotherapy planning in 2007. IHE-RO recognized the fundamental importance of the treatment planning system (TPS) and the connectivity issues surrounding its ability to communicate seamlessly with the radiology picture archiving and communication systems, treatment management systems (TMS), and other TPSs. This connectivity solution provides the structural mechanisms required for image-based treatment planning.[11]

What can IHE-RO do for me as a radiation oncologist or a medical physicist: IHE-RO can improve patient safety and treatment effectiveness in radiation oncology

Radiation overdoses and mistreatments have been labeled as one of the most important technology hazards

Table 1 Common clinical challenges and description of IHE-RO solution

Clinical challenge	IHE-RO standardization protocol that addresses this problem (integration profile)	Description of IHE-RO solution
Transferring CT images and treatment planning data between 2 different treatment planning systems	Basic radiation therapy objects integration profile	Specifies protocols for each component in the PACS system. This allows users to move data between systems. It establishes baseline interoperability for simple RT objects from image acquisition through dose display.
Transfer of registered data (with spatial coordinate sets) from one system to another without loss of integrity. For example (head-first, feet-first, supine, prone, etc)	Multi-modality image registration integration profile	Specifies how images, RT structure sets, RT doses, and associated spatial registration information can be exchanged, stored, processed and displayed.
Use of distinct vendor solutions for treatment planning, dose review, plan review, virtual simulation, etc	Advanced radiation therapy objects integration profile	Specifies protocols for data (ie, treatment schedule information, plan, and treatment records) transfer between the treatment planning system, treatment management system, and delivery system.
Use of different treatment machines with a single treatment management system in the clinic	Treatment delivery workflow integration profile	Specifies data and handoffs required for sophisticated treatment planning for computer-controlled accelerators in external-beam treatment delivery. This allows for treatment planning data to be transferred from one TPS to another without loss of integrity.
Sum multiple (planned or delivered) dose distributions derived from different phases of treatment (initial vs cone-down, etc)	Dose compositing integration profile	Specifies protocols for dose deposition data to be tagged with coordinate and phase of treatment. This would facilitate dose summation.

CT, computed tomographic; IHE-RO, Integrating the Healthcare Enterprise-Radiation Oncology; PACS, picture archiving and communication system; RT, radiotherapy; TPS, treatment planning system.

for 2011 by the ECRI institute (a designated federal patient safety organization).[12] Technology is a double-edged sword. It can function as a valuable adjunct to the human brain serving to remind and ensure completeness.[13] However, it can also magnify the scale of errors when it is relied on excessively or taken for granted.

IHE-RO is working intensively on a connectivity problem that can occur because of poor interconnectivity between different TPSs, TMSs, and treatment delivery system (TDSs) (see Table 1).[8] A recent incident that highlighted this miscommunication between the TPS and TDS resulted in severe consequences for the patient.[3-7] While this kind of interconnectivity mismatch is rare and can be corrected by human oversight, often it is undetectable until it is too late. Another problem is human error resulting from an individual's incorrect use of technological systems.[14-16] An example of such a safety-related connectivity problem could be the incorrect setup by a few centimeters in 1 axis of an IMRT patient on the table by a new therapist working alone after the initial isocenter was verified and filmed but not marked on the patient mask. Unfortunately there is no automated discovery of this error until the next port film day after as many as 6 fractions, as all other parameters of treatment delivery such as monitor units, beam angles, etc, are correct.

IHE-RO proposed a safety connectivity issue to address this: an automated quality assurance system, where the desired treatment plan is verified by the TMS to be correct and then transferred to the TDS. The TDS in turn will have an internal check and verification of this plan and will stop delivery of the treatment if these parameters do not match. While this is only in the developmental phase, the ultimate goal is automated quality assurance (AQuA) of all these different connections. The role of IHE-RO is to verify accuracy of connections between diverse TPS and TDS systems that are available on the market. We are currently working to test this in the 2012 Connectathon.

An extension of AQuA would be for the TMS to perform automated checks of the different QA parameters required prior to treatment initiation. The Medical Imaging and Technology Alliance has published recommendations that attempt to create a high safety environment in radiation oncology departments.[17] One of the recommendations has included the performance of an accurate and complete QA test prior to the delivery of radiation therapy. QA should cover all steps in the treatment delivery process; any step vital for accurate radiation dose delivery should be included. Systems of checklists and verifications are available but this is subject to human discipline and does not require that the checklist is completed prior to

delivery of the fraction. The downside of all this is that this can slow the treatment process and may reduce efficiency in the treatment. However, if this is automated, as proposed by the IHE-RO safety connectivity solution or AQuA, this will certainly speed up things.

IHE-RO interconnectivity increases efficiency of the clinic and reduces costs

The demands of the competitive marketplace often compel departments to invest in diverse planning and delivery platforms so that they can attract patients to the "latest and greatest" treatments. It would not be unusual to find a Cyberknife (Accuray, Inc, Sunnyvale, CA), a standard linear accelerator, and a Gamma Knife (Elekta AB) all under one roof. Communication among all the hardware and software components of these machines can result in interconnectivity problems with consequent inefficiency in clinical workflow. Additional time is often spent by dosimetrists, physicists, and physicians to circumvent these connectivity hurdles in order to deliver quality care. This time impedes workflow and ultimately affects the bottom line of the clinic.

In order to assess the financial impact of connectivity problems faced in the clinic, let us take a common scenario, the re-irradiation of a patient. The exact percentage of patients requiring re-irradiation is unclear, but estimates from literature review range from 3%-10% for central nervous system tumors.[18] Re-treatment of the same or adjacent body sites requires intensive effort by the RO team for re-planning, recalculation, and re-verification of treatments. The process of doing this is simpler if the patient is being treated in the same institution using the same TPS. It becomes more problematic if the patient was initially treated elsewhere using a different TPS. Based on an informal survey in a large academic department, the following were found: on an average, the dosimetrist spends an extra day for re-planning a complex IMRT re-treatment, the physicist spends an extra hour, and the physician spends an extra 2 hours (K. Albuquerque; personal communication, 2011). This is required for checking and looking at different data sets for images that cannot be fused due to being generated on different platforms. The time and effort and the work value involved in re-treatments is significant.

To estimate the cost of this extra effort on an annual basis, consider a large radiation department in an academic center treating approximately 1000 to 1200 patients a year. If we estimate that 5% of the cases are for re-irradiation, this would translate into 20-25 re-treatment patients per year. Using US national median salaries as a measure of work value, the additional dollar cost for planning these would be $22,250 per year.[19] In a clinic that sees a higher percentage of head and neck, central nervous system, and lung tumors, we may estimate that 10% of the cases are re-irradiation, and then the additional dollar value to the clinic for planning these patients climbs to $45,000. This does not include the stress and anxiety created because of uncertainty of the actual dose and location of dose delivered due to inability of different planning systems to have dose composting, one of the goals of IHE-RO.

Thus, complete interconnectivity among all of the treatment delivery, planning, and management platforms would create a state of "nirvana" (Sanskrit word which refers to the state of being free from suffering) in the radiation oncology clinic and increase efficiency while reducing cost.

How can I ask for IHE-RO compliant technologies?

To benefit from the results of the IHE-RO initiative, be sure to request IHE-RO-compliant products from your vendors. The technical aspects of the clinical solution specific to your clinic must be incorporated into your purchasing process. The most effective and efficient way to communicate your needs to the vendor is by providing purchase specifications that define IHE-RO compliance. The purchasing process can be very different depending on the size and administrative culture of the institution. In general, 2 purchasing models are followed; community hospital-freestanding clinic model and academic-corporate model. The primary difference in the models is the role of the radiation oncology team (radiation oncologist, physicist, and administrator). In the community hospital, the radiation oncology team initiates and drives the purchasing process and the purchasing department acts as the agent in final negotiations. The team must clearly define its clinical and technical specifications to the vendors solicited for sales quotations. The quotations are evaluated based on compliance to each vendor's ability to meet the specifications and pricing. In academia, the radiation oncology team initiates the request-justification, and the purchasing department is the primary driver of the process. The purchasing agent uses industry standard specifications to generate a purchase proposal that several approved vendors are asked to respond to with sales quotations. The purchasing agent is usually unfamiliar with the specifics and will collaborate with the radiation oncology team to evaluate the purchase proposal and quotations received. In each model it is the role of the radiation oncology team to define clinical and operational specifications for the hardware or software purchase. IHE-RO-compliant purchase specifications should be an integral component of the purchase request regardless of the model followed by your institution. IHE-RO compliance can be required for any product upgrade or new purchase request. To simplify the procurement of compliant products IHE-RO has developed a purchase specification template. This

site is currently under development but can be accessed at www.astro.org/ihero.

Figure 1 provides a graphical description of transfer of data among the variety of systems that exist within a typical radiation oncology clinic. It details some of the elements that are included in current IHE-RO interoperability solutions. The multifaceted functionality of radiation oncology systems requires that you specify which particular functions are critical to your clinic. The purchase specification template provided by IHE-RO gives you the ability to target those clinical processes that impact your particular practice and clearly communicate these requirements to the vendor. The template is a living document and will be maintained and updated as additional clinical solutions are completed by IHE-RO.

IHE-RO Helper: Your guide to interconnectivity

One of IHE-RO's current initiatives is to develop a web-based tool that will help the end user determine whether or not he or she will face interoperability issues in the clinic when matching one system with another. For example, if you are planning to purchase a treatment planning system capable of generating plans (eg, volume modulated arc treatments) and are concerned whether the TPS can successfully transfer such plans to your TMS and then from your TMS to your linear accelerator (TDS) for delivery, the IHE-RO Helper would identify whether such a connectivity problem has been identified to which a connectivity solution has been developed, and finally which vendors have successfully passed an IHE-RO Connectathon proving their adherence to the solution. IHE-RO Helper is currently under development and will be available soon to the community.

Conclusions

IHE-RO is dedicated to identifying and solving the connectivity problems that arise in radiation oncology clinics on a daily basis. As the demands to integrate newer technologies into existing clinics increase from patients, clinicians, physicists, and the hospital administration alike, the challenge of successful integration of these systems will become increasingly complex. Greater support for IHE-RO by the radiation oncology community at large is essential to the identification and solving of these problems before clinic workflow and patient safety is compromised. If successful, this initiative will result in an improvement of the quality and efficiency of the care that can be delivered to patients with cancer.

Acknowledgments

The authors would like to thank Kate Dodd for her assistance with the review of the paper. The IHE-RO initiative is partially supported by Florida Biomedical Research Program Grant No. 09BW-09-26833.

References

1. Abdel-Wahab M, Rengan R, Curran B, et al. Integrating the healthcare enterprise in radiation oncology plug and play—the future of radiation oncology? *Int J Radiation Oncology Biol Phys.* 2010;76:333-336.
2. ASTRO Staff. Web Exclusive: ASTRO calls on Congress to implement patient safety plans. ASTRO Web Exclusive Available at: http://cs.astro.org/blogs/astronews/pages/web-exclusive-astro-calls-on-congress-to-implement-patient-safety-plans.aspx, March 2010. Accessed June 19, 2011.
3. Bogdanich W, Rebelo K. The Radiation boom: A pinpoint beam strays invisibly, harming instead of healing. *New York Times* (New York Edition). December 28, 2010; section A:1.
4. Bogdanich W. Safety features planned for radiation machines. *New York Times* (New York Edition). June 10, 2010; section A:19.
5. Bogdanich W. VA is fined over errors in radiation at hospital. *New York Times* (New York Edition). March 18, 2010; section A:20.
6. Bogdanich W, Ruiz RR. Radiation errors reported in Missouri. *New York Times* (New York Edition). February 25, 2010; section A:17.
7. Bogdanich W. Radiation offers new cures, and ways to do harm. *New York Times* (New York Edition). January 24, 2010; section A:1.
8. Able C. Creating building blocks for the future. *ASTRONews.* 2010:56.
9. Able C, Field C, Linton N, Ravi. Radiation Therapy, re-integrated. *ACR Bulletin.* 2011;66:17-19.
10. Abdul S. ASTRO hosts fourth annual Connectathon. ASTRO-News 2010;10-11 Winter 2010.
11. Able C, Field C, Linton N. IHE-RO use cases from conception to the clinic. Proceedings of the XVIth ICCR, Amsterdam, The Netherlands, May 31-Jun 3, 2010.
12. Top 10 technology hazards for 2011. A guide for prioritizing your patient safety initiatives. *Health Devices* 2010;39:404-416.
13. Kralj B, Iverson D, Hotz K, Ashbury FD. The impact of computerized clinical reminders on physician prescribing behavior: evidence from community oncology practice. *Am J Med Qual.* 2003;18:197-203.
14. Leveson NG, Turner CS. An investigation of the Therac-25 accidents. *Computer* 1993;26:18-41.
15. Patton GA, Gaffney DK, Moeller JH. Facilitation of radiotherapeutic error by computerized record and verify systems. *Int J Radiat Oncol Biol Phys.* 2003;56:50-57.
16. Fraass BA, Lash KL, Matrone GM, et al. The impact of treatment complexity and computer-control delivery technology on treatment delivery errors. *Int J Radiat Oncol Biol Phys.* 1998;42:651-659.
17. MITA. Manufacturers unveil radiation therapy Readiness check Initiative. 2010. Available at http://www.medicalimaging.org/2010/06/manufacturers-unveil-radiation-therapy-readiness-check-initiative/. Accessed June 8, 2011.
18. Bahl A, Kumar M, Sharma DN, et al. Reirradiation for progressive brain metastases. *J Cancer Res Ther.* 2009;5:161-164.
19. US National Median Income Figures- Radiation Oncology Professional Salary Data. Available at: www.salary.com. Accessed March 1, 2011.