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Telemedicine in Radiation Oncology: Challenges and Opportunities

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Abstract: Telemedicine is an emerging technology and Radiotherapy and cancer care are areas which can utilize these in appropriate application. Telemedicine can provide services in all aspects of cancer control from prevention to palliation. Radiotherapy planning, verification and treatment execution are components which have employed telemedicine. OncoNET Kerala is a telemedicine application in Kerala which has helped to provide cancer patient follow up at peripheral centres and in providing cancer related information to the community.

Introduction

Cancer is emerging as a major public health problem in India. Cancers of epithelial origin predominate and Radiation therapy as a single modality or as part of multidisciplinary management is essential in the treatment of these neoplasms. Radiation oncology needs a certain level of infrastructure, trained personnel and continuous quality assurance, all of which are not available uniformly. Health services at remote and geographically hostile locations can be augmented by providing more personnel or by transporting patients from the location to centres with all the facilities both of which are time consuming and expensive

Telemedicine which is defined by the American Telemedicine Association, as "the use of medical information exchanged from one site to another via electronic communication for the health and educaton of the patient or health care provider and for the purposes of improving patient care" is a technical advancement linking information technology and heatlh care and can have a large number of applications in oncology and in radiotherapy. Telemedicine, or telehealth, involves the remote management of disease. When medical practitioners apply information and telecommunication technologies, together with robotics and such advances as lasers, they become capable of dispensing clinical care hundreds or even thousands of miles away from medical centres. Medical personnel in a small rural hospital faced with a difficult clinical problem are able to consult specialists at the foremost medical facilities in the country or in the world, and to even conduct operations under the remote guidance of these specialists - all in real - time. For less complicated procedures, robots may assist in operations, while guided from afar. Clinical tests, such as x-rays and biopsies, can be transmitted to tertiary centres, analyzed, and transferred back within short periods of time.

The first documented use of visual communication in health care was in 1959. Information Technology has become a major component of Health Care in the 21st Century. By combining images, text and data, doctors and technicians can help their patiens and each other without the impediments of geography or time. The major limitations for telemedicine applications are in the areas of infrastructure, human resources, hospital systems, referral practices and illiteracy. However, the scenario is improving with fast connectivity becoming a reality. The scope and applications of Telemedicine in Radiotherapy can be considered under the following areas :-

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(a) Information Disssemination
(b) Tele-consultation
(c) Tele-Radiation Oncology and following up of cancer patients
(d) Palliative care

(a) Information Dissemination : An interactive web-portal in English and in regional languages can be a major avenue for providing information about risk factors for cancer, management of risk factors, early detection of cancer, cancer treatment strategies and palliative care. An interactive website can also provide information on various queries raised by the public and by cancer patients. Continuing medical education is an area that can benefit from telemedicine as it can provide live case demonstrations in addition to tele-teaching by experts.

(b) Teleconsultation : Teleconsultation is one of the main areas of telemedicine appliations in cancer in which an expert at a specialty centre can be consulted from a remote site. Unlike communication over the telephone, tele-consultation makes available medical records, results of investigations and other medical details to the consultant first hand so that the consultations can be made more meaningful and effective. Cancer treatment is a field, which needs multiple specialties to interact and more than one specialist can log on to the network at the same time. A multi-disciplinary consultation can be provided which would be the optimal approach in cancer.

Interpretation of investigations including cytology smears, pathology slides and pictures of imageological investigatiosn may require a specialist's opinion. This can be provided through teleradiology and telepathology.

(c) Application to Telemedicine in Radiotherapy : In addition to the above applications, radiotheapy is an area where telemedicine has many applications. In essence, Radiotherapy involves determination of the tumour volume, radiation portals, radiation planning and execution of radiation treatment. Most data required in the planning process can be transferred and stored digitally. New standards for data transfer such as 'Digital Imaging and Communications in Medicine' (DICOM), and its radiotherapy extension (DICOM-RT) and HL7 have substantially improved image and data flow management. Inoue et al suggest that image quality with a 640x 400 matrix transmitted via a 64 kbps ISDN though insufficient for radiodiagnosis is probably sufficient for radiotherapy treatment planning[1].

Telemedicine facilitates decentralized treatment planning. Olsen and colleagues define three levels of telemedicine support. A Level I facility features video conferencing and display of radiotherapy images and dose plans. Level I support is extensively used in telemedicine in general and is restricted by its functional limitations to chart rounds and video-conferencing about treatment plans and options. Remote online operations are not supported. Level II facilitates replication of selected plans from the remote data base and its manipulation thereof. However real time operation is not feasible. Image segmentation and planning is usually performed at the tertiary site and the final treatment plan transferred to the peripheral clinic with basic radiotherapy facilities. A Level III facility supports real-time remote opeation. The manipulation of 3D-imges cannot be performed using conventional telecommunication lines, since flow of large amounts of data need to be managed. Both level II and level III establishments therefore, require an interactive radiotherapy database, both at the tertiary and peripheral institutions. The required segments of the database alone are transferred between the clinics. Verification-and-record (V&R) system is currently the protocol that is used for data transfer. More advanced applications would require a larger data handling system analogous to PACS in digital radiology. Both level II and level III systems are cost-prohibitive at the moment. There are also legal issues to be resolved[2].

Advance radiotherapy facilities are usually located at tertiary referral centres and university hospitals. Hashimoto S. et al have developed a remote teletherapy planning system, THERAPIST (Telecommunication-Helped Radiotherapy Planning and Information System)[3]. The system consists of a planning computer, a digital scanner, and a video camera at the peripheral clinic linked via ISDN to the teritary university hospital and is used to exchange the patient's image data, teleconferencing in real-time, and transfer of dose calculations and distributions, and treatment planning images including portal images. This arrangement has also been tested on the ground - radiation oncologists at the university hospital were able to suggest dose schedules and verify treatment plans in 12 patients with malignant spinal cord compression who required emergency spinal cord decompression[4]. Image quality and transmission time, according to the authors was "satisfactory". A cost benefit is also suggested though a comparison of the actual figures has not been mentioned. Most significantly, the mean time between onset of symptoms and start of radiotherapy was reduced from 7.1 days to 0.8 days. The quality of such digitally compressed images using a human thoracic phantom has been verified; there was no clinically significant loss of data[5]. Investigators at the IGD-Fraunfoffer Institute of Computer Graphics, Darmstadt in Germany have evolved a virtual radiotherapy treatment planning Simulation protocol designated EU-VIRTUOSO[6]. The treatment planning is carried out on a virtual patient using the CT data of the actual patient. The physician is supplied with different volume rendering and volume interaction techniques such as digital reconstruction radiographs (DRR), mixed integer programs (MIP), gradient surfaces, and isosurfaces to simulate the actual treatment planning workstation environment. Radiation oncologists working at different locations can collaborate to plan and/or validate a treatment plan on-line in real time.

On a similar scale and allowing for interactive educational sessions, is the Internet-based 3D Radiotherapy planning and Information System (IRIS) which was developed at the Department of Medical Physics, German Cancer Centre, Heidelberg[7]. IRIS is a client-server system which incorporates an atlas of preoptimised treatment planning dose distributions, a hypertext oriented multimedia tutorial about the basic methods in radiotherapy, teleconferencing softwae (e.g. Microsoft Netmeeting), and a discussion forum for radiation oncologists.

On a smaller scale, within the hospital itself, Santos et al. suggests the use of the local area network (LAN) to facilitate image segmentation of magnetic resonance images by the physician on his personal computer (PC) and fusion with CT images at the treatment planning workstation without the physical presence of the radiation oncologist[8].

A secure framework is required for tele-cooperation in virtual simulation procedures[9]. There exists a potential role for telemedicine in oncology as an educational tool for learning advanced planning techniques as exemplified by IRIS. The advantages include interactivity, flexible learning schedules, saving in terms of cost of transport cost and cost effective access to learning material[10]. Multidisciplinary clinics networking experts in various disciplines in the multimodality management of cancer can also be established to evaluate treatment decisions and form consensus. A French group, which has established just such a multidisciplinary clinic in digestive tract cancer, feels that such a system is cost-effective[11].

d) Palliative care : Pain management and palliative care in advanced cancer is a major load on Radiotherapy clinics and clinicians. Patients who need pain relief and palliative care can be looked after in their homes with minimum technical support locally and with technical advice from a cancer centre. This application is relevant to India as majority of the cancer patients who attend the cancer treatment centers are in an advanced stage and will need palliative care, which is currently being provided at the tertiary care level. Through telemedicine network, patients can be provided the necessary care at their homes or nearby medical facilities. Sensitization and training of the local health providers are needed and this can be achieved. Telemedicine will help to optimize the resources for providing good quality palliative care in cancer.

Onconet - Kerala

The Regional Cancer Centre Trivandrum is a tertiary referral cancer hospital catering to South India. Approximately ten thousand new patients are registered and undergo treatment here annually. The number of patients on follow-up is approximately one hundred thousand per year. These patients have to travel great distances, at great expense for regular follow-up examinations. Regional Cancer Centre has six peripheral centres with essential infrastructure at Kollam, Kochi, Palakkad, Kodungalloor, Kannur and Kozhencherry. Monthly follow-up clinics have been established at these centres. Cancer patients in nearby areas presently attend these centres for follow up. A high speed ISDN-based data network was established connecting Regional Cancer Centre (RCC), Trivandrum with these centres. This telemedicine programme, doubbed Onconet Kerala was developed in collaboration with Electronic Research and Development Corporation of India located in Trivandrum with the support of the Ministry of Information Technology. This system serves to provide telemedicine services

in cancer detection, patient follow up, and palliative treatment and thereby continuity of care at these nodal centres (Fig.1). Case records are securely available over the internet at these centres and using the linkage identification number of each patient, the relevant information can be retrieved. The remote clinics are provided with text, video and audio chat facilities. Patients therefore communicate with their doctors in real time over the net. Regional Cancer Centre can thus use its resources optimally and concentrate on quality treatment for those who need active treatment. Teleclinics have proved to be a boon for those patients on chemotherapy who need regular check on their blood counts and frequent advice on side effects. The software also provides facilities for registration of new patients and for preparation of patient records. The recent introduction of Very Small Aperture Connectivity (VSAT) linking all the peripheral centres to Regional Cancer Centre will translate into better network performance, faster connectivity, and reduced operational costs.

Telemedicine offers several advantages in the practice of oncology. The number of emergency visits to the hospital can be reduced. Unnecessary admissions can be avoided. At the same time, early intervention is facilitated. Routine follow-up visits by the patient can be limited to the peripheral clinic. Physician visits from the tertiary hospital to the rural/peripheral centres can be cut down. However, there are disadvantges too. Telemedicine might disrupt the tradiational physician-patient relationship. Patient privacy is an area of concern when information is exchanged over the internet; network and software security protocols consistent with national and state legal requirements should be provided. Some patients need to feel the "healing touch" to the care-giver. Prescriptions given over the internet can be misunderstood.

The primary aim of telemedicine in oncology as in any other field of telemedicine is deliver high quality health care in those areas where it is not easily available. Level I applications based on an ISDN backbone can readily be established in underdeveloped areas, where it has been provided to be cost-effective. Level II support which includes video conferencing and remote image viewing is more technology-intensive. The establishment of level III clinics is even more technology driven as it demands real time image manipulation. The cost-effectiveness of level II and level III support needs to be established. Experience with these clinics is limited.

Telemedicine offers various avenues, which can find useful applications in cancer treatment and control and in radiotherapy in particular. The various infrastructure constraints are being addressed as part of the Information Technology advances and it is for the Radiation Oncologists and other professionals to come out with appropriate applications and content for use of technology for the benefit of the society.

Recommended Reading

1. Bazioglou, M. et al. Multimedia educational services in stereotactic radiotherapy. Cancer Radiotherapie 1999;3(3):249-53.
1. Inoue, T. et al., Image-transmission of radiotherapy planning using 64kbps-ISDN videophone. Nippon Acta Radiologica 1993;53(4):481-3.
2. Dag Rune Olsen, Oyvind S. Bruland, Brian J. Davis. Telemedicine in radiotherapy treatment planning: requirements and applications. Radiotherapy and Oncology, 2000;54(3):255-59.
3. Huh SJ, Shirato H, et al. An integrated service digital network (ISDN)-based international telecommunication between Samsung Medical Center and Hokkaido University using telecommunication helped radiotherapy planning and information system (THERAPIST). Radiotherapy and Oncology, 2000;56(1):121-3.
4. Hashimoto S, Shirato H et al, Clinical efficacy of telemedicine in emergency radiotherapy for malignant spinal cord compression. Journal of Digital Imaging 2001;14(3):124-30.
5. Hashimoto S, Shirato H, et al. Remote verification in radiotherapy using digitally reconstructed radiography (DRR) and portal images: A pilot study. International Journal of Radiation Oncology, Biology, Physics 2001;50(2):579-85.
6. Cai WL, et al. Collaborative virtual simulation environment for radiotherapy treatment planning. Computer Graphics Forum 2000;19(3):379.
7. Luttgau, A. and Bendl, R. Technical aspects of Internet-based knowledge presentation in radiotherapy. Medical Informatics and Internent in Medicine 2001;26(4):235-81.
8. Santos, A. et al, Multimodality image integration for radiotherapy treatment: An esy approach. Proceedings of SPIE: Medical Imaging 2001: Visualization, Display, and Image-Guided Procedures 2001.
9. Ntasis E. et al, Secure tele-cooperation in virtual simulation of radiotherapy treatment planning. Proceedings of the 9th Mediterranean Conference on Medical and Biological Engineering and Computing, Vol 1. University of Zagreb, Croatia, Zagreb, Croatia, Publishrs, 2001.
11. Sezeur, A. et al. Contribution ot Telemedicine applied to digestive cancer. Gastroenterol Clin Biol 1999;23(3):342-7.