Intensity modulated radiotherapy (IMRT) the white, black and grey: a clinical perspective

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ABSTRACT

The radiotherapy community has in the past few decades witnessed dramatic shift in the treatment modalities from conventional 2-D radiotherapy to the now widely practiced 3-DCRT, IMRT and evolving IGRT. IMRT has generated so much interest because of its unique dosimetric modulation to concentrate doses to the targets of interests while also being able to relatively spare neighboring normal tissue. However IMRT is not the all in one solution for radiotherapeutic management of solid malignancies. The current enthusiasm in IMRT most be tempered with an understanding of the complexities of IMRT planning, treatment delivery, quality assurance, monitoring and clinical limitations. The widespread implementation of this technological innovation may have been a bit premature considering that clinical information regarding the same is still being generated. This article tries to give an overview of the potential advantages/disadvantages of IMRT in the clinical set up and the few controversies (Grey Zone) that are still being resolved. There is evidence to indicate that indiscriminately used IMRT may even harm the patient or have an inferior therapeutic index to 3DCRT. This and other pertinent issues will be covered by the authors in this short review of IMRT in clinical practice.

KEY WORDS: intensity modulated radiotherapy, conformal radiotherapy, dose optimization, advances in radiotherapy

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INTRODUCTION

Current status of IMRT

IMRT is the most exciting technological and conceptual advance in radiotherapy since the introduction of CT based dose planning in late 1970's. The benefits of IMRT are correlated to dose escalation, potential for improved locoregional control and anticipated superior treatment results. However most compelling justification for this expensive time consuming modality is its established ability of normal tissue sparing and improved quality of life. These features make IMRT the treatment of choice in clinical situations where there is a clear cut relationship between dose delivered and clinical response and where normal tissue provide a constraint on its delivery. This is especially applicable to head and neck cancers where it is being widely applied. A few other common tumor sites that may fit into this category include carcinoma prostate, cervix and breast [1–9].

Prostate cancer

This site to date provides the largest clinical experience with IMRT. There is comparative data to show benefit over 3DCRT in several clinical issues [10].

Zelefsky et al have reported the largest clinical experience with IMRT used for patients with localised carcinoma prostate. They have also done a comparative study with 61 patients undergoing 3DCRT. Normal tissue toxicity was considerably reduced. The 2 year acturial risk for grade 2 bleeding was 2% for IMRT vs 10% for 3DCRT($p<0.001$). An updated report by Zelefsky and colleagues evaluating 772 patients undergoing IMRT showed a very promising 3 year acturial biochemical control rate for favorable (92%), intermediate (86%) and unfavourable risk patients (81%) [11–12].

The SIB technique (Simultaneous Integrated Boost) with hypofractionated radiotherapy with greater than 2 Gy/fraction is currently being evaluated for its potential to improve upon their results.

Head and Neck cancer

The most convincing data of the superior therapeutic gain achievable with IMRT are

from tumors close to base of skull such as Nasopharynx and Sinonasal cancers in which a higher rate of local control and lower incidence of complications have been documented [13, 14]. In terms of clinical outcome reports from University of California Sanfransisco and Memorial Sloan Kettering Cancer Center (MSKCC) show excellent locoregional control, greater than 90% and substantially lower rates of Xerostomia [15–16]. Additional potential functional gains from IMRT compared with conventional RT include improved swallowing and speech , thus translating into improvements in broad aspects of Quality of life.

Clinical data on other Head and Neck sites are still quite limited on account of small numbers, heterogenous tumor sites and relatively short follow up. Although providing the preferred treatment for most Head and Neck sites on account of less anticipated motion and proximity to critical normal tissue; there are situations where it may be less than optimal. To cite a few clinical examples, Early Vocal cord carcinoma with anterior comissure involvement may risk having a geographical miss on account of the dose characteristics of low energy photons. In this situation conventional radiotherapy may provide an equivalent therapeutic index, as normal tissue toxicity is not unduly compromised with the recommended portals used for this stage. A well lateralized T1 oral cavity lesion can be efficiently treated with 3DCRT with a comparatively lower dose if any to opposite parotid. IMRT in such a situation would contribute atleast a marginal low dose to the opposite side of the face and neck (increased integral dose and low dose volume).

The 3DCRT technique would have equivalent clinical results with the advantage of being more time and cost effective.

Carcinoma Breast

Theoretically and practically, IMRT at this site does provide some clinical benefit. It improves dose homogeneity within breast tissue in comparison to conventional/conformal treatment.

When IMC/Axillary nodal regions are a part of the clinical target volume, it can provide a comparatively better sparing of ipsilateral lung/cardiac volumes. This may be even more significant pertaining to left sided tumors. IMRT studies with treatment of intact breast has shown lower incidences of acute and chronic skin reactions compared to retrospective series. However several unsolved issues prevent it from being the standard of care. Specific measures may be required to counteract the effect of breathing motion .Respiratory gating is still not an accessible option for majority of centers with IMRT facilities. The improvement in dose homogeneity within the target volume and restriction of high dose to normal tissue , comes at the cost of subjecting contralateral lung to lower doses of RT not normally irradiated. We are now observing an increasing incidence in younger patients who may have many expected years of survival to be accounted for by the increased incidence of developing a secondary cancer [17]. With current limited data on the long term risks of 2nd malignancy with IMRT it may be required to limit IMRT to the subset of patients most likely to achieve a therapeutic gain especially considering the fact that 3D radiotherapy at this site provides acceptable dose distribution and limited normal tissue toxicity.

Gynecological cancer

IMRT is receiving increasing attention in the treatment of these sites because of established dosimetric advantages of normal tissue sparing. In fact it can benefit over conformal/3D technique in any situation/site where Teletherapy is being planned. Eg. Pelvic/Extended Pelvic or Pelvic-Inguinal fields. The controversialrole of IMRT include its ability to provide dose escalation in situations whereICBT is not possible or suitable. [18–21].

A few special clinical settings where IMRT may show some clinical benefit over 3D techniques include management of recurrent disease in previously irradiated patients. It may even have a limited role for palliation in situations where the target is very near to or wraps around normal tissue, Eg. retroperitoneal lesions and paraspinal tumor/nodes. Of course any treatement in the palliative setting should be limited to a potential extended survival and a risk for anticipated late effects.

An interesting concept being evaluated in this set up include dose escalation for sus-