The Role of Intensity Modulated Radiotherapy in Cancer Treatment

Kin Yin Cheung, Ph.D.

Prince of Wales Hospital, Hong Kong
e-mail: kycheung@ha.org.hk

ABSTRACT

Intensity modulated radiotherapy (IMRT) is an advanced but expensive form of 3-dimensional conformal radiation therapy technique. While the initial clinical data appear to be promising for some treatment sites, the cost effectiveness of the treatment modality has yet to be justified by long-term clinical outcome. This presentation reviews the potential efficacy and limitation of IMRT in respect of the practicality, dosimetry, and resource aspects. It tries to explore and draw conclusions on the strategies for using this sophisticated and expensive treatment technique from AFOMP perspective.

INTRODUCTION

IMRT is technically becoming a matured modality in cancer treatment in many countries. It has been demonstrated that the technique can have significant dosimetric advantages over conventional radiotherapy techniques in some clinical situations, particularly in the treatment of nasopharyngeal carcinoma (NPC). Recent clinical results suggested that IMRT treatments cause lesser degrees of treatment complications [1, 2, 3]. However, the efficacy of the technique in improving the long-term local regional control and survival rate has yet to be proven. Furthermore, there are several practical problems in clinical implementation of the IMRT treatments on a routine basis. Among them are the high cost (capital, recurrent and manpower) implication, the requirement for high level of physics and clinical expertise, the ability of the center in handling the extra workload induced, and the radiation protection implication. In view of the limited resources available and the many competing priorities in most AFOMP countries, large-scale implementation of this state-of-the-art treatment technique on a routine basis may deserve special consideration and careful planning.

THE TREATMENT HYPOTHESES

IMRT was developed based upon two hypotheses. One of these hypotheses was to minimize normal tissue irradiation by applying a standard radiation dose that conforms closely to the treatment target volume so that less treatment complications might be achieved. The other hypothesis was to escalate the amount of conformal radiation dose to the target volume with the aim to improve local control and hence achieving a better cure rate without increase in treatment complication rate. These hypotheses should be tested to prove its clinical efficacy before full-scale implementation of IMRT on a routine basis.

To put the hypotheses to a fair testing, the IMRT treatments must be properly executed in every procedure according to the treatment plan and with a compatible level of precision.

CHALLEGNES IN IMRT IMPLEMENTATION

Consideration should be given to a number of pre-requisites prior to clinical implementation of IMRT treatment, including the following:

Appropriate equipment facility and technology for planning, verifying, delivering, and monitoring the treatments

A compatible IMRT QA program to ensure that the required standard of accuracy in target localization and delineation, dosimetry and treatment delivery can be achieved and sustained

Availability of the manpower and expertise to execute the IMRT procedures

Satisfactory assessment of the effect on radiation safety and protection and the effects on the patients and members of the public arising from the increase in leakage radiation dose due to the increase in treatment MU

The high cost implications of the treatment

Other treatment services of the center should not be hampered by implementation of the IMRT technique

CURRENT LIMITATIONS

Because of the high conformal index of IMRT treatments, the effect of any geometrical misses can be much more serious then that of conventional radiotherapy. Appropriate QA procedures must be designed and implemented to ensure that the

treatments have the required precision and quality. Currently the precision and quality of IMRT treatments are mainly determined by the following limiting factors:
Efficacy of the dosimetry and planning algorithms, particularly their ability in handling the effect of inhomogeneous tissue structures on dose and dose distribution
The uncertainties in localizing and delineating appropriately the target volumes and in determining appropriate the treatment margins
The ability to monitor and make appropriate real time correction on the radiation beams during treatment
The efficiency of the current treatment and pretreatment procedures
The problem of organ motion and patient movement during treatment and other procedures

Much research and development have been carried out aiming to resolve or minimize these limitations. Techniques such as respiratory gating or control, motion compensation or tracking during treatment portal imaging and dosimetry, multi-modality imaging and image fusion, cone beam or helical CT treatment verification prior or during treatment, Monte Carlo dosimetry planning and calculation algorithm are being developed to address these problems. Some of these techniques are becoming matured and are likely to be effective in improving the accuracy and efficacy of IMRT treatments. However, the investment on the technology may be too high for many radiotherapy centers, particularly those in the AFOMP region. This indicates that the effectiveness of this treatment technique be tested to justify its cost.

RECENT CLINICAL DATA

Our dosimetric studies suggested that IMRT is capable of delivering treatment with higher degree of dose conformity than conventional techniques, including conventional 3-dimensional conformal treatments. The technique is particularly useful for head and neck treatments such as nasopharyngeal carcinoma (NPC), because of the numerous sensitive tissue structures in the close vicinity of the PTV. The treatment can minimize the irradiation of the dose limiting critical normal tissue structures. Clinical trials are being conducted in our clinic to test the IMRT hypotheses. The initial clinical results on reduction of treatment complications are encouraging. Reduction in treatment complication with IMRT treatments have also been reported by other centers [1, 2, 3]. These results basically confirm the validity of the first hypothesis. However, the treatment technique may not necessary be able to achieve a higher local and regional control rate [5].

Clinical results on local regional control and survival rates in dose escalation studies are not yet available to prove the second hypothesis of IMRT. However, clinical trial on dose escalation using other treatment techniques have been reported to achieve positive results [6, 7] indicating that dose escalation may have a role in IMRT. Until more clinical data become available, it is too early to draw a conclusion on the efficacy of dose escalation with IMRT.

DISCUSSION

It has been clearly demonstrated that IMRT treatments have significant dosimetry advantage over conventional radiotherapy treatments. Currently available clinical data have confirmed that the treatment technique can better protect normal tissue structures which are in the close vicinity of the treatment target and cause less treatment complications in head and neck and prostate treatments. Whether the technique can better improve the local regional control and survival rates in cancer treatment with or without dose escalation has yet to be observed. It is, however, not expected that dose escalation by IMRT would yield much better survival data than treatments delivered by stereotactic radiotherapy, brachytherapy, or even conventional 3-D conformal therapy because of the following reasons:
The dose response curve saturates beyond a certain dose level
Distant metastases may already developed before diagnosis and treatment of the disease, especially in diseases of late stages for which dose escalation is thought to be beneficial
The benefits of dose escalation of the high conformal index IMRT treatments may be trade off by the effect of tight treatment margins which may not appropriately cater for the uncertainties and errors associated in the microscopic spread of the disease, organ motion or patient movement during treatment
The presence of cold spots, caused e.g. by tissue inhomogeneity especially in head and neck cancers, cannot be eliminated by dose escalation [8]

It appears that there is sufficient evidence to support the routine implementation of IMRT for treatment in which protection of normal critical structures is important. However, the effectiveness of using IMRT for dose escalation is uncertain. This has to be tested by well-designed clinical trials at centers where resources are available. Until the efficacy of this treatment is proven by clinical evidence, large-scale implementation of this expensive technique for dose escalation treatment on a routine basis may not be considered justifiable. [9, 10]

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