Cost utility considerations with new radiotherapy modalities

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Abstract

Despite the recent advances in cancer biology and therapeutics, cancer control is still a difficult job and implementation of newer radiotherapy modalities could help advance our war against this lethal disease while minimizing the incidence of treatment-related morbidities.

However, wide implementation of such high tech radiotherapy techniques has grave economic consequences that should be dealt with cautiously and scientifically with detailed cost utility /effectiveness analyses to properly employ limited health care resources in low/middle income countries.

Cancer care is expensive

The economic burden of cancer is the largest imposed by any medical illness. The high expense associated with cancer is related to a number of factors, including an increase in the prevalence of cancer as people live longer, the high rate of comorbid medical illness in cancer patients, and high costs associated with diagnosis, treatment, and end-of-life and palliative care as new, more expensive treatments become available(1). Cost is a major determinant of the type and intensity of cancer care, particularly related to reimbursement of high-tech and high-cost procedures and pharmaceutical products for cancer patients. The physician has a large role in determining the medical costs incurred by individual patients ***(8).***

It is obvious that not all medical novelties can be offered to all patients. Each pound can be spent only once, and investment into one treatment therefore often is a decision against another, perhaps better approach. Enthusiasm for a novel technology should be the basis for its scientifically sound, academic evaluation but not be the basis for its general introduction into routine clinical practice (13).

Considerations in Delivery of Radiation Therapy in Low- and Middle-Income Countries

Challenges to delivering cancer control and radiation therapy in limited-resource settings may include lack of cancer awareness and knowledge among health care workers and the public, lack of diagnostic and treatment equipment and infrastructure, limitations in referral systems, challenges due to geography and population distribution, and inadequate cancer registry data. Often there can be a mismatch between resources and need, and the nature of this varies. For instance, there may be insufficient human resources but fair equipment supply, or adequate brachytherapy equipment but inadequate supply of teletherapy equipment. In addition, there is an overall shortage of health care workers in many countries in the developing world that limit available trainees for radiation oncology and other specialties (2***).***

Types of Economic Analyses

Cost-effectiveness analysis provides information about the value of an intervention or therapy in relation to its costs compared to a competing alternative when effectiveness is measured in clinical terms. The analysis compares two or more interventions and provides information about the differences in costs and effects between comparators. Whereas cost-utility analysis is a subset of cost-effectiveness analysis in which the measure of effectiveness is a utility or value. Utilities provide a measure of overall quality of life and are applicable across different types of cancer ***(1,3).***

Examples of cost effectiveness and cost utility analyses with different modern radiotherapy techniques:

1- Particle beam therapy

Proton beam therapy has been in use for many decades; although its theoretical benefits are not in doubt, there is remarkably little published data strongly supporting its use over other forms of radiation, with the exception of ocular and skull-base tumors and malignancies of children. However, these cancers are rare and the patient demand would be insufficient for new proton therapy centers ***(4).***

Currently, proton therapy is undergoing transitions that will move it into the mainstream of cancer treatment. For example, proton therapy is now reimbursed, there has been rapid development in proton therapy technology, and many new options are available for equipment, facility configuration, and financing. During the next decade, new developments will increase the efficiency and accuracy of proton therapy and enhance our ability to verify treatment planning calculations and perform quality assurance for proton therapy delivery. With the implementation of new multi-institution clinical studies and the routine availability of IMPT (intensity modulated proton therapy), it may be possible, within the next decade, to quantify the clinical gains obtained from optimized proton therapy. During this same period several new proton therapy facilities will be built and the cost of proton therapy is expected to decrease, making proton therapy routinely available to a larger population of cancer patients ***(5).***

The current literature on cost-effectiveness of particle therapy is scarce, non-comparable, and largely not performed according to standard health technology assessment criteria. Besides, different perspectives for cost evaluations have been used, making it difficult to compare and to determine the relative impact in terms of costs for this new treatment modality. Evidence on the cost-effectiveness of particle therapy is scarce. Adequate reimbursement is necessary to support such innovative yet costly treatments ***(7).***

A systematic literature review of the clinical and cost-effectiveness of hadron (i.e. neutron, proton and light or heavy ion) therapy (HT) in cancer was done by ***Lodge and coworkers.*** Seven hundred and seventy three papers were identified. For proton and heavy ion therapy, the number of randomized trials was too small to draw firm conclusions. Based on prospective and retrospective studies, proton irradiation emerges as the treatment of choice for some ocular and skull base tumors. For prostate cancer, the results were comparable with those from the best photon therapy series. Heavy ion therapy is still in an experimental phase. So, Existing data do not suggest that the rapid expansion of HT as a major treatment modality would be appropriate (6).

2- 3D conformal radiation therapy:

Three-dimensional conformal radiation therapy (3DCRT) is a sophisticated technique that allows high doses of radiation to be focused safely on a target. This technique is more expensive to implement and deliver compared with conventional radiation techniques. A consensus, however, is emerging after reviewing the data that shows three-dimensional conformal radiation therapy to be cost-effective when the clinical benefit is most apparent ***(9).***

The cost effectiveness considerations of 3DCRT have been discussed in a number of disease sites particularly in cancer prostate. ***Poon and colleagues*** have discussed this subject, activity based costing has been used to create a model of radiotherapy related costs for prostate cancer. A process map was developed which separated the process in five activities for conventional radiotherapy and six activities for dose escalated conformal radiotherapy. The majority of the cost differences arose from the cost of the additional time needed for treatment per day as well as the extra fractions per patient when compared to conventionally treated patients. The average treatment times per fraction for six field conformal, four field conformal and four field conventional have the median times of 22.72, 20.63 and 11.07 minutes respectively. Planning costs for conformal radiotherapy were up to three times the cost of conventional therapy. The direct costs of dose escalated conformal external beam radiotherapy are over 2.5 times that of conventional external beam radiotherapy for early stage prostate cancer. These direct costs are a reflection of the additional capital and human resources needed to provide state-of-the-art radiation therapy.

3- Intensity modulated radiation therapy:

Intensity-modulated radiotherapy (IMRT) is a newer method of radiotherapy that uses intensity-modulated beams that can provide multiple intensity levels for any single-beam direction and any single-source position, allowing concave dose distributions and dose gradients with narrower margins than those possible using conventional methods. IMRT is ideal for treating complex treatment volumes and avoiding close proximity organs at risk that may be dose limiting and provides increased tumour control through an escalated dose and reduces normal tissue complications through organ at risk sparing(19).

The impact of learning effects on the variability of costs of new health technologies in a prospective payment system (PPS) through the case of intensity modulated radiation therapy (IMRT) was studied by ***a*** series of consecutive patients treated in nine medical centers was enrolled in a prospective study. Direct costs were assessed from the perspective of the healthcare providers. Two-level model was used to explain the variability of costs: patients nested within centers. The authors reached the conclusion that learning effects are a strong confounding factor in the analysis of costs of innovative health technologies involving learning effects. In a PPS, innovative health technology involving learning effects necessitates specific reimbursement mechanisms (11).

And in another French study, an economic evaluation of intensity modulated radiotherapy (IMRT) in head and neck cancer was carried out to assess the cost of treatment and compare it to reimbursement paid to hospitals in the French Prospective Payment System. Planning required in average 20 hours of work for the physician and 6 hours for the radiation oncologist. Radiation consisted of 33 fractions in average and required 29 hours of work for the radiotherapy technician, 8 hours for the physician and 3 hours for the radiation oncologist. As more patients were treated, unit cost of treatment was decreasing. In the French Prospective Payment System, mean reimbursement of IMRT was euro 6,987. For 70 % of the patients, reimbursement did not offset the cost of treatment. A financial support for hospitals implementing the technique is essential during the whole learning period ***(12).***

4- Image guided radiation therapy:

For IGRT as for all other developments in the field of radiation oncology, all patients should have guaranteed access to technological advances if they profit from this technology. Large and high quality prospective data bases, and models which relate details of the patient (if possible including tumour and normal tissue biobanking) with details of the treatment and detailed outcome parameters, are necessary for supporting rational decision making. For this it is a great advantage that radiobiology and radiotherapy are highly quantitative sciences and that radiation dose can be measured with great accuracy. The question whether the results were obtained from randomized trials or not will eventually lose much of its current attention if it can be demonstrated that the models in use can validly and reliably predict outcome, thereby supporting decision making and individualization of therapy ***(14).***

5- Stereotactic irradiation:

As a minimal access surgical approach, stereotactic radiosurgery fits well into the patient goals of functional preservation, risk reduction, and cost-effectiveness. Longer-term results have been published for many intracranial as well as extracranial indications. It can be performed alone when lesion volume is not excessive or as part of a multimodality strategy with resection or endovascular surgery. The combination of high-resolution imaging, high-speed computer workstations, robotics, patient fixation techniques, and radiobiological research has put radiosurgery into the practice of almost all neurosurgeons as well as neuro-oncologists. However, the issue of cost effectiveness –particularly in a limited resource setting- is very challenging (17).

A number of studies has been undertaken to analyze the cost effectiveness of innovative stereotactic irradiation techniques, of these a preliminary investigation of costs and quality of life (QoL) for two modalities [brachytherapy (BT) and robotic radiosurgery] used to boost radiation to the primary tumors following external beam radiotherapy was done. Quality of life (pain and difficulty swallowing) was established in long-term follow-up for patients undergoing BT and over a one-year follow-up in robotic radiosurgery patients. Total hospital costs for both groups were computed. Efficacy and quality of life at one year are comparable for BT and robotic radiosurgery. Total cost for robotic radiosurgery was found to be less than BT primarily due to the elimination of hospital admission and operating room expenses. The present study shows how a preliminary assessment of a new medical technology such as robotic radiosurgery with its typical hypofractionation characteristics might be based on short-term clinical outcomes and assumptions of equivalence ***(15).***

And another cost-utility study evaluated the cost-effectiveness of cyberKnife stereotactic radiosurgery (SRS) in comparison to external beam radiation therapy in the treatment of metastatic spinal malignancies. Costs of care were derived from Centers for Medicare and Medicaid Services fee schedules. Because cancer therapies bear significant health and economic consequences, the impact of treatment-related toxicities was integrated into the analysis. Given the terminal nature of these conditions and the limited life expectancy of the patient population, the time horizon for the analysis was limited to 12 months. Cost-utility analysis demonstrated that cyberKnife SRS was a superior, cost-effective primary intervention for patients with metastatic spinal tumors compared with conventional external beam radiation therapy ***(16).***

In another study, Cost-effectiveness analysis was done for trigeminal neuralgia regarding Cyberknife vs. microvascular decompression. Direct healthcare costs from hospital's perspective attributable to Cyberknife and microvascular decompression were collected. The two procedures resulted equally effective at 6 month follow-up, with different resources consumption: Cyberknife reducing hospital costs by an average of 34% per patient. The robustness of these results was confirmed in appropriate sensitivity analyses. Cyberknife resulted to be a cost-saving alternative compared with the surgical intervention ***(18).***

Conclusions

Despite the recent advances in cancer biology and therapeutics, cancer control is still a difficult job and implementation of newer radiotherapy modalities could help advance our war against this lethal disease while minimizing the incidence of treatment-related morbidities.

However, wide implementation of such high tech radiotherapy techniques has grave economic consequences that should be dealt with cautiously and scientifically with detailed cost utility /effectiveness analyses to properly employ limited health care resources in low/middle income countries. So conduct of cost effectiveness analyses for these newer techniques should be considered as a priority for academic institutes in the Arab region.

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