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EDITORIAL

Promises and pitfalls of new technology in radiotherapy

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Promises

The last 50 years have witnessed an explosion in both our understanding of cancer and in the range of treatments to slow or even halt the progression of cancer. Change has accelerated in the last 10 years with the advent of powerful new modalities such as image-guided radiotherapy (IGRT), intensity-modulated radiotherapy (IMRT), and stereotactic body radiotherapy (SBRT). Much of this recent progress is due to increased computing power, which allows for nearly instantaneous dosimetric calculations and real-time imaging. IMRT has been called “the most significant technical advance in radiation therapy since the linear accelerator” [1] and there is no doubt that IMRT is a significant improvement over 3D-CRT, which, until very recently, was the standard of care [2, 3].

Both IGRT and IMRT give us the ability to conform doses to irregular shaped tumors through sophisticated dosimetric systems—systems which will continue to improve into the future. In fact, even now, intelligent planning systems capable of automatically identifying anatomical structures with minimal or even no human intervention are being tested [4]. Likewise, advanced diagnostic imaging (computed tomography, magnetic resonance, positron emission, and image fusion) is increasingly being used to locate tumors with ever greater precision.

Much of this new technology is not only incredibly sophisticated, but also expensive. As a result, before we buy and start to use any new technology, we must first be sure that it will actually improve clinical results. Fortunately, current evidence is strong and getting stronger, as numerous studies have demonstrated the superiority of IMRT vs. 3D-CRT. To date, the biggest advantage of IMRT over conventional radiotherapy appears to be reduced toxicity. However, several studies have also found that IMRT improves local control. That said, only a few studies thus far have shown a clear survival benefit. Staffurth [5] reviewed 61 studies to assess the evidence for IMRT; of these, 6 were randomized controlled trials (RCT). Staffurth concluded that IMRT reduces both acute and late effects of radiotherapy in many localizations. Theoretically, this reduced toxicity should lead to better quality of life (QOL) outcomes, and that is precisely what some authors have found. For example, in a study published just this year (2012), Chen et al. reported that IMRT improves QOL in head & neck cancer [6].

Despite the good data with regard to reduced toxicity and better QOL, more data are still needed to confirm the expected survival benefit of IMRT and other new technologies. To date only a few studies have reported better survival. For example, Liao et al. [7] showed that not only does 4DCT-IMRT yield less toxicity than 3D-CRT, but also better survival in non-small cell lung cancer (NSCLC). Similarly, Lanni et al. [8] found SBRT to be less expensive than standard fractionated EBRT and also associated with

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superior local control and overall survival in stage I NSCLC patients. As more results are published, it is expected that these sophisticated new technologies will prove to yield superior survival outcomes. For the moment, we must be satisfied with reduced toxicity and improved QOL, and the strong expectation that survival will also improve.

To those of us involved with brachytherapy (BT), it often seems that these "glamorous" new external beam techniques receive the lion's share of the attention. Certainly, the excitement surrounding these new technologies is justified, but we must be careful not to forget the spectacular advances that have been achieved in BT [9]. In the last two decades, developments in functional imaging (ultrasound, power doppler imaging, PET, and MRI), many which can now be used in real time, have greatly expanded the potential for BT. Moreover, BT has an important advantage in that the tumor tissues can be irradiated directly, without having to pass through healthy tissue as is the case with all external beam techniques, no matter how sophisticated. In addition, the combination of functional imaging with intraoperative dose calculation and optimization opens new possibilities for BT. Real-time, image-guided brachytherapy (IGBT) now provides excellent conformal RT and is a clear alternative to EBRT in many tumor localizations. Indeed, the use of BT for prostate cancer (both HDR and seeds) and, more recently, for accelerated partial breast irradiation (APBI), is strong and growing stronger [10, 11].

Potential pitfalls

Implementation of these new technologies is not without risk because, although they clearly solve some problems, they may also create new ones.

The need for RCTs

As new radiotherapy technologies are introduced, we must be sure that they are actually better (and not just newer) than the technologies they are replacing. It has been said before, but newer is not always better. Before we adopt new technologies, we must remember that existing technologies are usually less expensive and their safety and effectiveness have already been proven; as a result, it behooves us to perform comparative, evidence-based studies [12]. This is not as easy as it sounds because randomized trials are often prohibitively expensive. In addition, adoption of new approaches and technology is often slow, even when the evidence is strong. To give just one example, Fairchild et al. [13.] showed that most radiation oncologists continued to prescribe multifractionated schedules for bone metastasis even when strong evidence in favor of hypofractionation was available. Inertia is a strong force to overcome.

Expenses

New technology is one of the causes of the enormous increase in health care costs and it seems clear that before adopting a new technology, we must consider not only its safety and efficacy, but also its cost-effectiveness. The effect of implementing new technology implies significantly higher capital investments and personnel cost. Likewise, the power and complexity of these machines require strict quality assurance, which further increases cost. One recent study found that these expenses make IMRT 38 –88 % more expensive than standard conformal RT [14].

In addition, we should keep in mind that the burden of cancer is growing [15], and this means that we may need to treat a larger number of patients, with the corresponding increase in costs. Smith et al. [16] estimate that between 2010 and 2020, the total number of patients undergoing RT is expected to increase by 22 % in the United States. As Sullivan [15] so accurately pointed out "the cancer profession and industry should take responsibility and not accept a substandard evidence base and an ethos of very small benefit at whatever cost". In short, if we are to adopt new technologies, we need a real cost–benefit advantage.

Other concerns

An important question is whether these technologies bring with them new problems. Unfortunately, the answer is "quite possibly". One important challenge is the need for precisely contoured volumes—if a mistake is made here, we might very well miss part of the tumor volume that is undetected by current diagnostic tests, or we might deliver high doses to healthy tissues [17]. This could lead to increased carcinogenesis, although at least to date, there is no evidence of that occurring.

Conclusion

As we all know, radiation oncology has made spectacular improvements in recent decades. The advantages are evident and clear: we can now treat more localizations with lower toxicity and better clinical results. But as scientists, we must always remember that although a new technology seems to be more powerful or accurate, it should only be adopted when the evidence proves its superiority to conventional methods.

Conflict of interest None.

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