The Incorporation of Real Time Imaging into Clinical Practice

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The quest to improve the accuracy of radiotherapy delivery began right after the introduction of radiotherapy in the early 1900s. Some of the initial data for external beam radiation therapy of head and neck tumors was reported in the1960s confirming the improved clinical efficacy with periodic portal films. This has led to bony landmark verification with periodic portal film verification.

The two components that can affect the radiotherapy delivery are the external movement of the body and the internal organ motion. Various external body techniques such as application of 3-point setups, and immobilization devices such as thermoplastic casts, vac locs, and temporary rigid fixed frame placements, etc., are commonly used along with more frequent portal film verification. However, all these can do is limit external body motion and will verify only the bony landmarks. Until only recently, we were vaguely aware of internal organ motion. With the advent and incorporation of ultrasound, more rapid and quick turnaround electronic portal imaging displays (EPIDs), cone beam and fan beam CTs, etc., we are now able to check internal organ motion each day just before treatment and correct any deviation. In some instances such as with prostate cancer, fiducial markers placement is needed for either kilo or megavoltage EPIDs. This daily EPID verification of inter-fraction motion movement and correction for prostate fiducials may be the most commonly used form of Image Guided Radio Therapy (IGRT). The cone beam CT and the fan beam CT are currently being tested in various clinical centers. It is anticipated that this CT verification prior to the daily treatment or in some periodic fashion will probably become the de facto standard for curative radiation therapy in the near future. However, in organs such as lung and liver where there is known motion during the delivery of radiation therapy, newer strategies are needed to track the motion in real time, or to limit the motion, or perhaps both. This additional information will open the way for newer concepts such as adaptive therapy, etc. Among various strategies in IGRT, the Calypso beacon system is perhaps the most novel and revolutionary technology. The Calypso beacon system is a transponder-equipped fiducial system with the ability to give the location of the beacons implanted into the organ every few seconds during the delivery of radiation therapy and, for the first time, gives us the ability to track organ motion in real time. Another strategy is periodic orthogonal kilo-voltage filming with bony and soft tissue matching. With rapid incorporation of new technologies such as computers, imaging with inter-fraction movement verification and the recent introduction of intra- fraction movement verification, radiation therapy delivery has become more accurate and precise. These tools give us the ability to deliver higher doses to the target, resulting in higher cure rates and at the same time minimizing the dose to critical organs and surrounding normal structures with a decrease in both acute side effects and long range complications.

It will take several years, perhaps even a decade, to fully assess the impact of these technologies, the clinical utility, and rational use with appropriate clinical algorithms of tolerances and corrections in a cost effective way that lead to the most optimal benefit. With all these newer advances that lead to a decrease in human suffering and improving longevity, this is the most exciting time in the history of radiation therapy.

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