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Concurrent Integrated Protection: An Innovative Approach To High-Precision Radiation Therapy

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Abstract:

Objective: Extra care must be taken when administering stereotactic radiation close to serial organs at risk (OAR). Simultaneous integrated protection (SIP), a novel intensity-modulated radiotherapy (IMRT) prescription concept, is described for quantifiable and comparable dose prescription to targets very close to OAR. Materials and procedures: An intersection volume of a planning risk volume (PRV) with the total planning target volume (PTV) defined theprotection volume (PTVSIP). The remainder of the PTV represented the dominant PTV (PTVdom). IMRT was used for the planning process. PTVdom was prescribed a dose in 3, 5, 8, or 12 fractions based on the ICRU. The restrictions on OARs were stated in terms of equieffective doses at 2 Gy (EQD2) and as absolute limits. The dose to an OAR's gross risk volume was to be considerate of the limitations. breach of OAR's constraints.

In summary: For PTV, SIP produces a median dose of ≥100% in orderto achieve low toxicity and high local control. This new approach in chest and abdomen stereotactic body radiotherapy is currently being tested in a prospective clinical trial; longer follow-up is necessary to confirm results.

Keywords: Radiation Therapy, Stereotactic body radiation therapy, Intensity-modulated radiotherapy,Organs at risk.

Introduction

Stereotactic radiotherapy (SRT) has developed into a potent tool over the last 20 years for controlling lesions, particularly those in the liver, lungs, and brain. However, reports of high-grade toxicities following the administration of stereotactic body radiation therapy (SBRT) for lesionsnear the intestines or stomach, as well as for central lung tumors, showed that these conditions cannot be safely treated with SBRT, evenwith the use of multimodal imaging, precise motion management, intensity-modulated radiation therapy (IMRT), and image-guidedradiation therapy (Bhangu, 2014).

The idea behind SRT is to use high spatial precision to avoid organs atrisk (OARs). Due to the clinical issue that prompted the development ofthe recently described novel concept of simultaneous integrated protection (SIP), SRT and SBRT were naturally limited when the target lesions were too close to OARs. Examples of injuries seen included esophageal, stomach, and small bowel perforations, as well as central airway and bronchial hemorrhage. Reducing the total dose to the full planning target volume (PTV) is a common strategy used to lower the risk of high-grade toxicities. Lowering local tumor control is the price paid for reducing the overall dose (Chang, et al., 2009). Individual dose reductions at the interface of target lesions with a critical organ at risk (OAR) are frequently used to address this issue when a change in dosage or fractionation is insufficient, at the discretion of the treating physician. Apart from the paucity of available data, these compromisesstemming from apprehension about complications with normal tissue may result in the administration of inadequate tumor doses and impedelocal control. Moreover, a major contributor to inconsistencies is the absence of interobserver and interinstitutional comparability, which poses a challenge for future trials (Chetty , 2013).

Technique of the SIP :

By keeping the dose to the remaining PTV at effective levels, the SIPconcept's described technique offers a fully quantified way to protect OARs and prevent toxicity in a deliberate and repeatable manner. This approach's primary benefit is its high degree of transparency, which minimizes the potential for interinstitutional technical differences to be an error source in multicenter SBRT trials. But the idea is not limited to SBRT; it could also be applied to brachytherapy or traditional IMRT. The SIP concept prescribes a lower dose to a subvolume of a PTV with respect to local control, whereas the SIB method prescribes an escalated dose to a small subvolume inside a PTV.

The functional subunit (FSU) model is used to propose the SIP concept for serial OARs. In comparison to parallel OARs like the lungor liver, the defect of a few FSUs has a higher risk of toxicity for serialorgans like the spinal cord, esophagus, and colon (Corradetti, 2012).

Using the SIP concept:

An outer shell that serves as a volume for the sharp dose gradient that exists between the OAR and the tumor protects the OAR. It is crucial tounderstand that an OAR's protection volume is determined by its specific nature; for example, PTVSIP may be smaller to protect the chiasm than the stomach because of motion. The respiratory movements of OARs are particularly significant for lesions located in the chest. In the abdomen, peristalsis of the gut is therefore crucial [24].In upper abdominal SBRT for IGRT, it is advised to use oral contrast before each fraction in order to see daily changes. In summary, IGRT is essential for confirming that clinical trials and the used margins of OARs are accurate (Guckenberger, 2014).

Radiation biology:

It is important to emphasize that the tumor front may contain particularly radioresistant tumor subvolumes from the perspective of radiation biology. In rectal cancer, this kind of pattern was noted following

neoadjuvant therapy and resection. It has been reported thatepithelial mesenchymal transition (EMT) is more common in residual tumor subvolumes at the invasion front, and that these subvolumes are enriched in cancer stem cells. Hypoxia, which is not limited to the tumor core but is also present in subvolumes of the invasive front andagain warns from low doses at the tumor edge, is another significant factor contributing to radiotherapy resistance. Currently, we are unable to image patient regions of hypoxia, stemness, and EMT well enough,so the dose sacrifices (Kim, 2014).

Advantages:

Based on the SIP approach, the prescription technique for SBRT presented here enables precise quantification of the dose administered to dose-limiting OARs. There are two benefits to this system: Because of its close proximity to a dose-limiting OAR, the dose sacrifice to the PTV is fully quantifiable and useful for local control analysis. In addition, the dose administered to OARs and PRVsof OARs can be precisely measured and utilized in toxicity assessments. This approach is appropriate for multicenter trials and can be used for SBRT with any SBRT equipment (Momm et al., 2010).

Recommendations:

1- We go over how the SIP idea is applied clinically. Six patients who had indications for SBRT of targets near OAR underwent high- precision positioning 4D treatment planning imaging.
2- Patients who had an indication for SBRT but were not eligible because the SIP concept did not adequately protect the OAR at the maximum number of planned fractions—12—in this case.
3- Individual dose reductions at the interface of target lesions with a critical organ at risk (OAR) are frequently used to address this issuewhen a change in dosage or fractionation is insufficient, at the discretion of the treating physician.

Conclusion:

We offer a strategy for SBRT and IMRT near high-risk OARs that shouldbe both safe and efficient while also being appropriate for multicenter clinical trials. We are

confident that by using this approach, which we are currently testing in a single center phase I trial on patients with thoracic and abdominal lesions, SBRT safety will be further increased.

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