Author(s): Klasila, Päivikki; Pulkkinen, Maiju; Jussila, Aino-Liisa

Title: The MR-Linac : using the new technology in lung cancer radiation therapy

Year: 2021

Version: Publisher's version

The MR-Linac – using the new technology in lung cancer radiation therapy

Päivikki Klasila
Radiographer student
Oulu University of Applied Sciences

Maiju Pulkkinen
Radiographer student
Oulu University of Applied Sciences

Aino-Liisa Jussila
Principal Lecturer, PhD
Oulu University of Applied Sciences

INTRODUCTION

The MR-Linac is quite a new radiation therapy technology to combine an MRI scanner with a linear accelerator in a single system. With the MR-Linac doctors can "see" tumor tissue more clearly — and adapt the radiation dose while a patient is being treated. Because it can safely deliver higher doses of radiation to a tumor, treatment is expected to be more precise and more effective than ever before. It could also reduce the number of treatment sessions, providing more convenience for patients.

MRI provides excellent soft-tissue visualization of tumors deep within the body and has real-time imaging capabilities and enables treatments precisely every time. The technology provides real-time information on tumor location, organ function and therapeutic targeting that has not been available before: Physicians can monitor and assess the tumor's position while a patient is being treated.

USING THE MR-LINAC IN LUNG CANCER RADIATION THERAPY

According to Bainbridge et. al. (2017 a), the current survival rates in patients with non-small cell lung cancer is poor so their study investigates the feasibility and potential benefits of radiotherapy with a 1.5 T MR-Linac for locally advanced non-small cell lung cancer (LA NSCLC) patients. Ten patients with LA NSCLC were retrospectively re-planned six times: three treatment plans were created according to a protocol for conventionally fractionated radiotherapy and three treatment plans following guidelines for isotoxic target dose escalation. In each case, two plans were designed for the MR-Linac, either with standard (-7mm) or reduced (-3mm) planning target volume (PTV) margins, while one conventional linac plan was created with standard margins. Treatment plan quality was evaluated using dose-volume metrics or by quantifying dose escalation potential. All generated treatment plans fulfilled their respective planning constraints. For conventionally fractionated treatments, MR-Linac plans with standard margins had slightly increased skin dose when compared to conventional linac plans. Using reduced margins alleviated this issue and decreased exposure of several other organs-at-risk (OAR). Reduced margins also enabled increased isotoxic target dose escalation.

According to Bainbridge et. al. (2017 b), lung cancer causes more cancer-related deaths than other forms of cancer. Most of lung cancer cases are non-small cell cancers and about 30 % of these patients present with locally advanced disease. Surgery plays a small role in this group, but radiotherapy connected with chemotherapy is the most common treatment of choice for majority of patients. Overall, survival outcome is poor, but efforts in research are continuous in exploring potentially successful outcomes. For instance, it is being investigated if a combination of advanced radiation techniques will contribute to the intensification of safe treatment. One improvement is that of magnetic resonance imaging which has been integrated in the treatment pathway. This provides anatomical and functional information with exceptional soft tissue contrast, and importantly, the patient is unexposed to radiation. The diagnostic staging accuracy of F-18 fluorodeoxyglucose position emission tomography may be complemented or even improved by MRI. In addition, computerized tomography imaging is also effective for identification of nodal and distant metastatic disease. This is particularly true in assessing local tumor invasion. The incorporation of anatomical MRI sequences into lung radiotherapy treatment planning is an innovative application. Not only may it increase target volume, but organs at risk delineation reproducibility as well. Additionally, functional MRI might facilitate heterogeneous target volumes dose painting and guide adaptive strategies in predicting toxicity of normal tissue. Even though there is an acknowledged issue of intra-thoracic motion, which has historically hindered the quality of MRI because of the effect of motion, MRI sequences are developing rapidly, and the field is constantly making progress. It is foreseeable that 4D CT and 4D F-18-FDG PET will be complemented or superseded by four-dimensional MRI, providing spatial resolution that is superior to the aforementioned ways of imaging. Currently, there is a variety of MR-guided radiotherapy delivery units available that combine a radiotherapy delivery machine with MRI at multiple magnetic field strengths. Even though there are many technical challenges to overcome, the novel hybrid technology is advancing. Using "beam-on" imaging, MR-guided radiotherapy can adapt treatment on the fly. This can be done for each fraction and in real-time. It is expected that the clinical benefits of MR-guided radiotherapy can be derived from this ability. The Atlantic MR-Linac consortium group focusing on the lung tumor site, is working to produce a challenging MR-guided adaptive workflow which can be used for multi-institution treatment intensification trials in patient group.

CONCLUSION

According to both research studies the MRI-guided workflow in Lung cancer radiation (MR-Linac) enables increased OAR (organs-at-risk) sparing and isotoxic target dose escalation for the respective treatment approaches. This will allow treatment plans to be generated with smaller treatment margins. With the potential for daily plan adaption immediately prior to treatment to take account of inter-fraction changes and for development of real-time image-guided and an dose guided treatment to take account of intra-fractions changes, further gains in the therapeutic index may be made.

In the light of these research studies it would appear that the future use of MR-Linac will play a major role in radiotherapy units. During treatment we are able to change the subject of radiation and thus save other organs from radiation. Here, the patient's potentially altered body due to the disease is considered.

REFERENCES

Bainbridge H, Salem A, Tijssen R, Dubec M, Wetscherek A, Van Es C, Belderbos J, Faivre-Finn C, McDonald F. 2017 a. Magnetic resonance imaging in precision radiation therapy for lung cancer. Translational Lung Cancer Research 6(6), 689-707.

Bainbridge H, Menten M, Fast M, Nill S, Oelfke U, McDonald F. 2017 b. Treating locally advanced lung cancer with a 1,5T Mr-Linac – Effect of the magnetic field and irradiation geometry on conventionally fractionated and isotoxic dose-escalated radiotherapy. Radiotherapy and oncology. 125(2), 280–285.