Elekta

Case Study

Single fraction lung SABR

Monaco, Agility and High Dose Rate Mode allow single fraction SABR treatment of a malignant lung neoplasm within a 20-minute treatment slot

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Location
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Summary

Patient demographics

76-year-old male

Diagnosis

- T1bN0M0 squamous cell carcinoma of the right bronchus and lung
- 9 x 10 x 11 mm in size

Treatment

- 34 Gy in a single fraction
- 2 partial VMAT arcs
- 6 MV FFF

Treatment planning and delivery system

- Monaco® 5.11
- Elekta Synergy® with Agility™
- BodyFix®
- XVI
- MOSAIQ® 2.64

Patient history and diagnosis

A 76-year-old male patient presented with a cough and chest pain. Investigation revealed a malignant neoplasm of the right bronchus and lung, diagnosed as squamous cell carcinoma (T1bN0M0). This tumor measured 9 mm x 10 mm x 11 mm in size and was located in the right upper lobe.

The patient had no underlying health conditions or previous radiation therapy. Because the tumor was located more than 1 cm from the chest wall and more than 2 cm outside the "no-fly zone"[1], the patient was eligible for single-fraction stereotactic ablative radiotherapy (SABR), in accordance with UK guidance on reduced fractionation for radical radiotherapy during the Covid-19 pandemic.[2] A dose of 34 Gy to be delivered in a single-fraction was prescribed. The usual treatment option for this patient would have been to deliver 54 Gy in three fractions. The patient was considered medically and technically operable, but the multidisciplinary team and the patient opted for the SABR approach in view of the additional risks associated with Covid-19. Under these circumstances, reduced visits to the hospital are better for the patient and for radiation therapists.

Treatment planning

The treatment plan to deliver 34 Gy in a single-fraction, using a 6 MV flattening filter free (FFF) beam and volumetric modulated arc therapy (VMAT), was generated using Monaco® version 5.11.

A 4D and free-breathing CT scan was used to outline the OAR and target volumes, in accordance with UK SABR consortium guidelines.[3] The ITV volume was 2.2 cm^3 and the PTV volume was 10.9 cm^3 (Figure 1). The prescribed dose and OAR constraints followed the Royal College of Radiologists Covid-19 guidelines.[2]

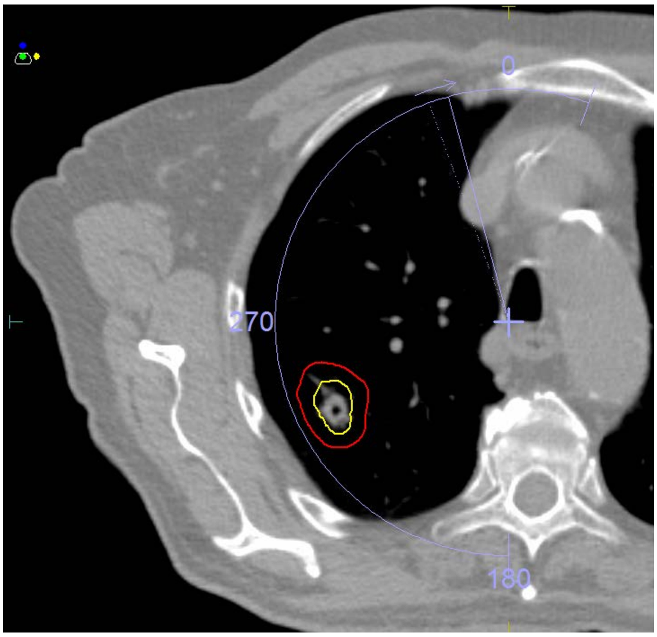

Figure 1.
The internal target volume (ITV – yellow) and the planning target volume (PTV – red)

The department's 54 Gy in 3 fractions template involves a single, 200-degree arc, with the isocenter placed centrally within the patient—placement of the isocenter in this location lessens the risk of gantry collision with the patient. However, for this single-fraction technique, two arcs of 200 degrees were used, the second re-tracing the path of the first. The first arc had a collimator twist of 0 degrees and the second arc had a collimator twist of 90 degrees. A single arc created a good plan, but the size of the 50% isodose caused the R50 to be outside tolerance.[2] Using two partial arcs with a collimator twist provided increased flexibility for the optimizer to improve dose conformity and reduce low dose spillage, allowing application of the Agility dynamic jaws and virtual leaf width in more than one plane.

The Monaco automated multicriterial optimization (MCO) function was used to reduce lung dose so that intermediate dose constraints (R50) could be achieved. With the application of MCO to automatically drive down OAR doses, overmodulation can be a concern. This is easily controlled with Monaco flexible sequencing parameters. These allow the user to define parameters, such as fluence smoothing and the total number of control points per arc, to produce segments that keep the degree of modulation low, ensuring robust dose delivery for the moving target.

Figure 2 shows the 34 Gy and the 17 Gy isodose distributions.

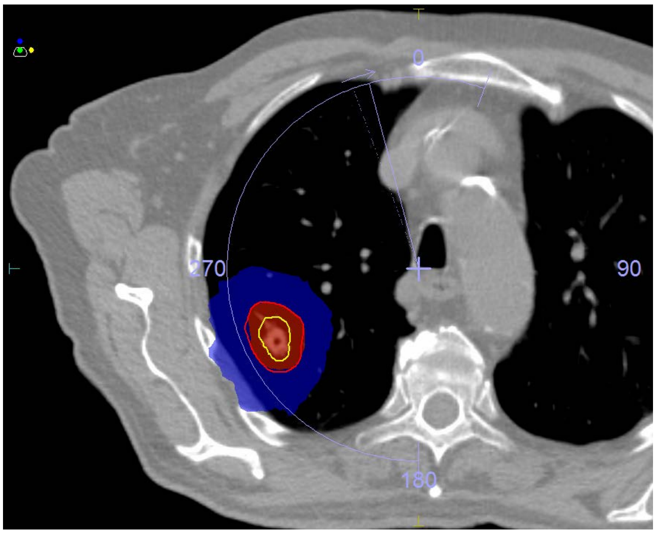

Figure 2.
The 34 Gy (red) and 17 Gy (blue) isodose distributions.

Quality assurance

Pre-treatment QA included a point-dose measurement taken with a SemiFlex chamber (PTW, Freiburg) and a 3D array measurement using the Delta 4 phantom (Scandidos, Sweden). The point dose measurement was within 2 percent of the planned dose and 100 percent of the points satisfied the 2 percent 2 mm gamma criteria.

The good QA results for SABR lung treatments can be attributed to an excellent beam model, the accuracy of the Monte Carlo dose calculation algorithm in Monaco, the ability of Versa HD to deliver the treatment plan accurately, and the robust production of VMAT segments, as described earlier. The number of control points specified in the lung SABR planning template is set to a maximum of 50 per beam.

Treatment delivery

Treatment was delivered using an Elekta Synergy Linac equipped with Agility™ MLC. The department's fleet of Elekta Synergy and Versa HD Linacs are all beam matched and share a common beam model within the Monaco TPS. The patient was immobilized, as for simulation, using BodyFix® immobilization.

XVI 3D CBCT imaging was performed before treatment (Figure 3), for localization, and after treatment to confirm tumor position and assess whether displacement occurred during treatment.

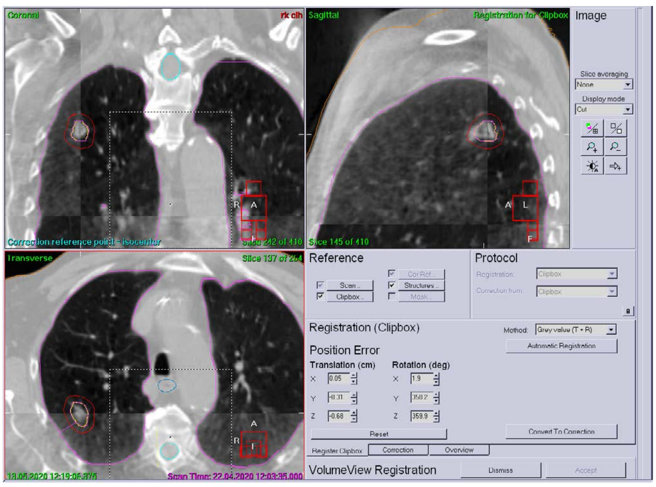

Figure 3.
XVI 3D CBCT imaging prior to treatment

Motion management was not required since tumor movement was minimal and the patient was thoroughly compliant. This was aided by a relatively short beam-on time of only six minutes. The total treatment, including patient setup and imaging, was completed within a 20-minute appointment.

Outcome and follow up

At six months post treatment, the patient was doing well. Toxicities were consistent with the hypofractionated (54 Gy in 3 fractions) technique.

Discussion and conclusions

Single-fraction deliveries to the lung are possible, particularly with the tools available to us, such as VMAT, High Dose Rate Mode (FFF) and the unique, advanced capabilities of Monaco and Agility that help us to harness the full potential of our Elekta Linacs. Monaco achieves high dose rates at treatment by producing robust VMAT segments, while incorporating dynamic jaw tracking for a virtual leaf width when needed. The plan is delivered with IntelliBeam to maximize delivery efficiency, ensuring a high quality, robust SABR plan with rapid delivery.

Evidence suggests that this approach has equivalent clinical outcomes to other hypofractionated SABR schedules.[2]

Minimizing patient attendance to the hospital was the key motivation for using the single-fraction technique in this case. Since there was very limited movement of the tumor and the patient met all the criteria for single-fraction lung treatment as outlined in recent UK guidelines[2], we were confident to proceed with this approach.

Single-fraction lung SABR is now being used routinely at this hospital, with seven patients treated using this approach as of October 2020. As this method becomes increasingly established, we hope to offer this excellent treatment option as an alternative to surgery in selected cases to help ease our surgical workload.

References

1. National Comprehensive Cancer Network. NCCN guidelines for non-small cell lung cancer. Available at: https://www.nccn.org/professionals/physician_gls/pdf/nscl_blocks.pdf.

2. Faivre-Finn C, Fenwick JD, Franks KN, et al. Reduced Fractionation in Lung Cancer Patients Treated with Curative-intent Radiotherapy during the COVID-19 Pandemic. Clin Oncol (R Coll Radiol). 2020;32(8):481-489. doi:10.1016/j.clon.2020.05.001

3. UK SABR Consortium. Stereotactic ablative radiotherapy: A resource. 2019. Version 6.1.

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