peer reviewed **CASE REPORT**

Case report on the role of adaptive radiotherapy for Pancoast tumour

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ABSTRACT

This case report is of a female patient who had a left lung Pancoast tumour. She received volumetric modulated arc therapy (VMAT) to a total dose of 62Gy in 31 fractions. The acquisition of daily cone-beam computed tomography (CBCT) displayed the tumour response to the treatment. An adaptive radiotherapy approach was used; the treatment plan was changed during the course of treatment in order to re-conform the radiation dose distribution to the changing tumour shape and size. The changes, benefits and use of adaptive radiotherapy in accounting for these changes are discussed.

Keywords image guided radiation therapy, volumetric modulated arc therapy, cone beam CT

LAY ABSTRACT

This case report is of a patient who was treated for Pancoast tumour. The radiotherapy treatment radiation dose was successfully changed during treatment.

CASE REPORT

A 57-year-old female presented to the emergency department with a 4-month history of worsening pain and weakness of the left upper limb. She had a history of smoking but reported no shortness of breath. Clinical examination revealed left sided Horner's syndrome with reduced range of motion of the left shoulder, power of 4/5 and reduced sensation of the left arm.

CT staging reported a large solid 12 x 7cm lesion in the left apex with extension to the base of neck with entrapment of C5-T1 brachial plexus trunks. There was encasement of the proximal left subclavian artery as well as erosion of the posterior aspect of the left 1st and 2nd ribs and vertebrae at those levels. There was no suspicious lymphadenopathy. Her clinical stage was that of a brachial plexopathy secondary to Pancoast's tumour with a clinical stage T4N0. Her metastatic status was unknown due to the funders denying payment for further local or staging imaging to be performed.

Core biopsy confirmed a moderately differentiated squamous carcinoma of the left lung. The tumour was deemed inoperable based on local brachial plexus and rib involvement. Lung function assessment reported reduced lung capacity with a restrictive pattern but was significantly hindered by the patient's inability to expire adequately due to pain. The patient assessed to have a European 38 Cooperative Oncology Group (ECOG) 1 performance status.[1]

Her treatment was definitive chemo-radiation therapy using a volumetric modulated arc therapy (VMAT) technique to a daily dose of 2Gy for 31 fractions, with concurrent weekly carboplatin 300mg and paclitaxel 100mg. The external beam radiation therapy was followed by two additional cycles of carboplatin 900mg; paclitaxel 400mg given three days per week every 21 days. Her treatment is discussed in detail below.

DISCUSSION

Pancoast tumours are one of the more complex tumours to treat due to the close location and invasion of the thoracic wall, brachial plexus, and spinal cord and subclavian vessels.[2] The use of concurrent chemo-radiation followed by surgical resection was shown to be the most effective form of management for these tumours.[2]

The use of advanced radiation treatment techniques for cases of Pancoast tumours allows for a more homogenous, high-dose gradient delivery, resulting in better coverage of the target volume and maximum shielding of the surrounding organs at risk (OAR).[3] Due to the plan conformity, precise set-up of the patient and strict control of the targeted area are required.[3] The use of daily IGRT ensures set-up accuracy and monitors the treatment target for physiological changes.[4]

Radiation treatment planning localisation scan was performed with the patient in this case report in the supine position using a 4-point thermoplastic mask as immobilisation with the arms alongside the body. The mask extended from her forehead to mid-chest. A free-breathing contrast enhanced 3D-CT scan using Omnipaque 300 (50ml) hand injection, with 5mm slices was acquired.

The Varian Eclipse© treatment planning system was used to plan this case. The delineation of the gross tumour volume (GTV) included the primary tumour extent obtained from the diagnostic CT staging reports. The clinical target volume (CTV) was created by adding a 0.6mm margin to the GTV in all dimensions. The planning target volume (PTV) was obtained by adding a 0.5mm to the CTV as per departmental protocol for setup uncertainties.

The OAR considerations in this case was the left lung, right lung, combined lung volume, heart, left anterior descending coronary artery (LADCA), spinal cord as

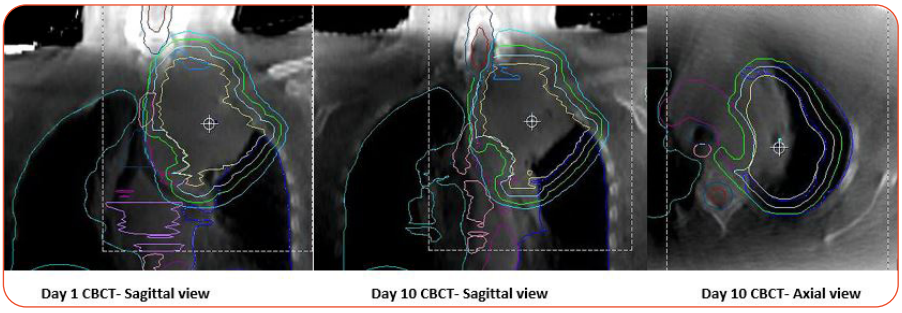

Figure 1. Reduction of clinical tumour visible from day 1 to day 10 on CBCT.

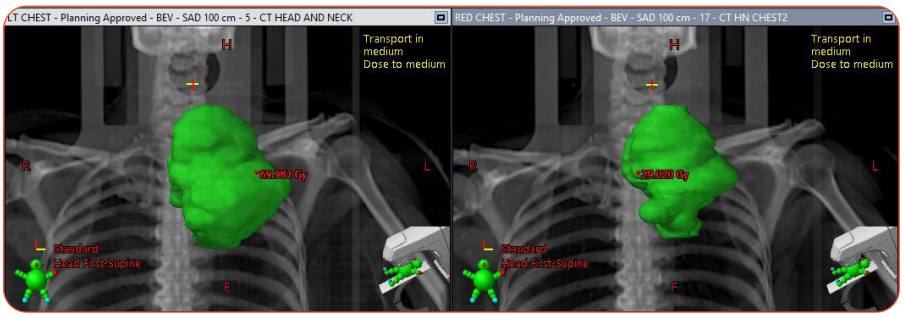

Figure 2. Plan 1 initial PTV on the original planning scan (Left), and the Plan 3 reduced PTV on the re-planned scan (Right).

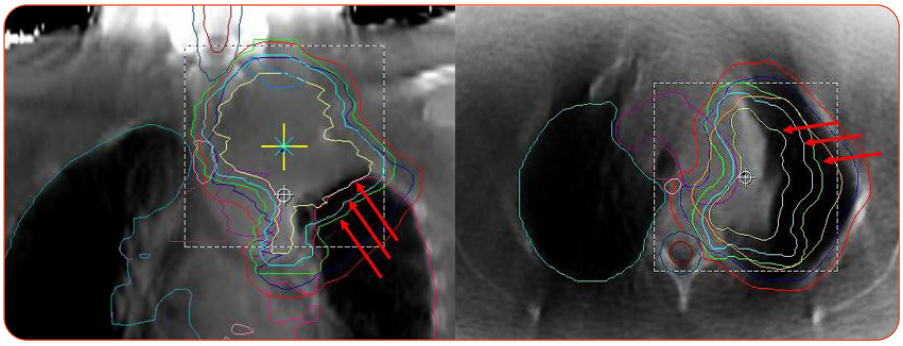

Figure 3. Plan 3 – Re-delineation and re-planning of GTV, CTV and PTV volumes at total CTV dose of 36Gy (Yellow, turquoise, green).

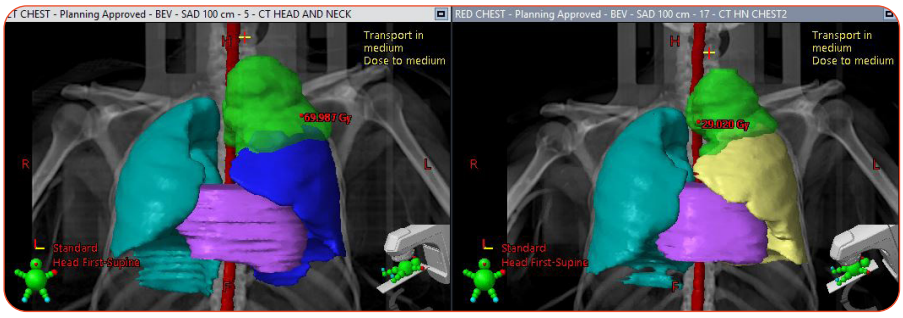

Figure 4. Comparison of PTV volume in relation to surrounding OAR for Plan 1 (on the left) and Plan 3 (on the right).

well as the brachial plexus. During the plan modification process these OAR doses were limited according to ICRU guidelines.[5]

A clinically optimal VMAT plan was generated using four partial arcs with 6MV photons for the Elekta Versa HD treatment machine. The ICRU 83 guidelines were adhered to during the plan evaluation ensuring that 95% of the prescribed dose was covering 98% of the PTV while considering the dose constraints to the OAR's.[5]

For precise, accurate target localisation and set-up verification, prior to daily treatment delivery, cone beam computer tomography (CBCT) using Elekta XVI© on board imaging system was performed. All clinical changes identified during daily CBCT imaging, such as a reduction in a GTV, were documented and reported with the use of in-house departmental IGRT protocols. These guidelines stipulate changes of more than 1cm to a GTV require further investigation: the treating oncologist is responsible for a judgement of re-scanning and re-planning.

During the first 10 days of treatment a clinically significant reduction in the size of the GTV was observed of approximately 1.5cm in the inferior and medial aspect on the CBCT. A decision was made by the oncologist, after the patient had received 20Gy to the PTV, that she should be re-planned with the 95% dose coverage to the CTV instead of the PTV (Figure1).

Further GTV shrinkage of 124.3cm^3 was observed after a further eight fractions at a total CTV dose of 36Gy on the adapted plan. At this point re-scanning and re-planning was indicated in accordance of internal departmental IGRT and ART guidelines. The median GTV, CTV, PTV volume sizes on the initial plan (plan 1) and re-plan (plan 3) to the PTV are depicted in Table 1 (see also Figure 5).

New tumour volumes were delineated by the oncologist. Commencement of plan 3 was undertaken as depicted in Figures 2 and 3. The new PTV volumes in relation to the OAR are depicted in Figure 4. Figure 5 is a bar graph showing GTV, CTV and PTV volume changes from plan 1 and plan 3.

Considering tumour control and normal tissue complication probability curves, there is a narrow therapeutic window where maximum tumour control may be achieved without increasing normal

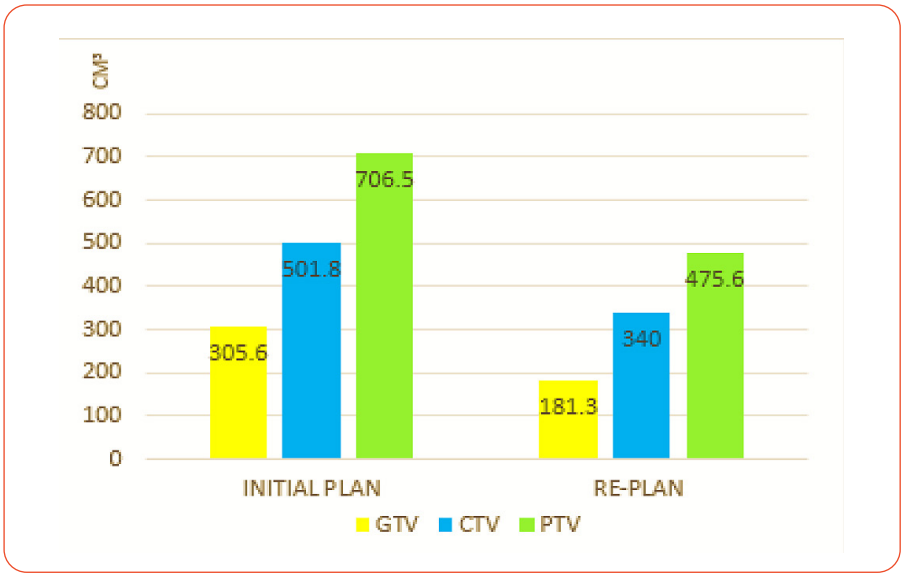

Figure 5. Bar graph depicting GTV, CTV & PTV volume changes from Plan 1 and Plan 3.

Table 1. GTV, CTV & PTV volume changes from Plan 1 and Plan 3

Delineated structure	Plan 1	Plan 3	Median reduction (%)
GTV (cm^3)	305.6	181.3	40.6%
CTV (cm^3)	501.8	340	32.2%
PTV (cm^3)	706.5	475.6	32.7%

tissue complications especially in doses exceeding 60Gy. The use of ART in a clinical setting greatly assisted in overcoming these threats.

Due to re-scanning and re-planning after 36Gy the reduction in the treatment volumes explains the reduction of dose to the OAR observed, in particular the V20, heart, LADCA and spinal cord doses. Re-planning during treatment was deemed beneficial to protect the OAR as well as reduce acute and long-term radiation-induced toxicities.

A dose volume histograms (DVH) comparison was done to analyse the impact of the re-plans on the critical OAR. The results of the DVH are depicted in Table 2.

Considering the plan adaptation, when evaluating the DVH results from all three plans many critical OAR doses reduced consequentially, particularly in the case of the maximum and mean doses of the heart, left lung, brachial plexus and LADCA. There was a slight change in doses to the combined lungs with a minor reduction in mean doses. Given the location of the volume, and extent of disease,

Table 2. OAR dose modification during the adaptive planning process

	Plan 1 10 fractions Total PTV dose 20Gy		Plan 2 to CTV 8 fractions Total CTV dose 16Gy		Plan 3 (re-scan & re-plan) 13 fractions Total PTV dose 26Gy	
Organ at risk	max dose (Gy)	mean dose (Gy)	max dose (Gy)	mean dose (Gy)	max dose (Gy)	mean dose (Gy)
Spinal cord	14.41	4.1	11.45	2.99	23.67	4.97
Heart	17.51	1.15	7.61	0.62	3.92	0.72
LADCA	17.10	4.60	4.87	2.44	4.34	1.89
RT lung	10.82	1.31	6.72	0.83	17.9	1.34
LT lung	22.33	7.06	17.55	4.54	28.89	6.15
Combined lung	22.33	3.69	11.79	2.36	28.89	3.29
Brachial plexus	21.54	19.24	16.86	13.88	28.01	24.41

Table 3. Comparison of OAR doses from original plan with summated doses from adaptive plans

	Original plan of 31 fractions		Summation doses of Plan 1, 2 & 3	
Organ at risk	max dose (Gy)	mean dose (Gy)	max dose (Gy)	mean dose (Gy)
Spinal cord	44.67	12.73	49.53	12.06
Heart	54.29	3.56	29.04	2.49
LADCA	22.01	14.3	16.31	8.93
RT lung	33.58	4.06	35.44	3.48
LT lung	69.23	21.88	68.01	17.75
Combined lung	69.2	11.45	63.01	9.34
Brachial plexus	66.7	59.6	66.41	57.53

it was difficult to minimise the dose to the spinal cord.

The adaptation of the plans following tumour shrinkage assisted in lowering the doses to the OAR. Comparatively looking at the OAR doses in Table 3 it can be deduced that the maximum doses for the spinal cord and right lung increased in the dose summation of all three plans. A major reduction in the maximum dose was observed for the heart. In addition to this there was a reduction in mean doses to the spinal cord, heart, right lung, left lung, LADCA as well as the brachial plexus.

CONCLUSION

The use of adaptive radiotherapy for the patient in this case report played a pivotal role in controlling the doses received by majority of the OARs in the affected area. This further contributed to the reduction of radiation induced long term side effects and improved outcomes.

CONFLICT OF INTEREST

None to declare.

CONTRIBUTION OF THE AUTHORS

MB (ICON) was the main researcher and provided information on the adaptive radiotherapy case, NV (DCC) assisted with the clinical patient information, NI (ICON) provided literature information and assisted in the write up of the case report.

INFORMED CONSENT TO PUBLISH

Permission was obtained from the patient to use her records for this case report.

ETHICS APPROVAL

Approval was granted by ICON Oncology to partake in this case report.

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