Optimisation of SABR lung CBCT verification

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AIMS/OBJECTIVE: **Establish and optimise a clinical 'spotlight' CBCT mode for use in SABR lung verification and assess its impact on dose and workflow.**

CLINICAL IMPACT: **CBCT dose has been optimised ALARP whilst fulfilling the clinical requirement. Delivery time has been reduced, improving patient experience and clinic throughput.**

Background

CBCT verification is arguably more critical to ensure set-up accuracy in hypo-fractionated SABR regimens. At our clinic all SABR lung patients receive pre-treatment 4D CBCT and post-treatment 3D CBCT imaging. The current default is Varian TrueBeam 'thorax' mode (125kV, 15mA, 46cm FoV). This is a full trajectory scan, taking 60 seconds to acquire. To improve on-set efficiency and optimise imaging dose alternative 'spotlight' CBCT exposures were investigated. Spotlight offers a shorter 200° trajectory and the smaller 25cm FoV is sufficient for SABR lung PTV's. These modes were tested on the post-treatment imaging to determine if they are clinically suitable for verification.

Method

Two thorax spotlight modes (A, B) were optimised using a CIRS lung phantom. Exposure parameters were reduced in both cases to 100kV and 10mA and 15mA for modes A and B, respectively. 5 patients were selected randomly for clinical testing (including gated and non-gated cases). For each patient, standard 'thorax' mode was replaced by 'spotlight' A or B, on subsequent fractions in no particular order. Treatment radiographers were blinded to which mode was of higher mA.

Images were reviewed and scored offline by 4 RTTs of various experience and 1 physicist. Scorers were blinded to which exposures had been used. The CBCTs were scored using an adapted 5 point scoring system, where 1 is the highest score (Figure 1). A score ≤3 was deemed clinically suitable. For each image, the highest and lowest scores were discarded.

Score	Description
1	Very good quality image. Able to define all interfaces between tumour and lung. Excellent lung window contrast. Appropriate for auto PTV matching and clinical decision making.
2	Good quality image. Able to identify interfaces between tumour and lung. Good lung window contrast. Appropriate for clinical decision making and PTV matching.
3	Moderate quality of image. Quality of image beginning to blur around tumour edge but still appropriate for auto PTV match. Artefacts present. Appropriate for clinical decision making.
4	Low quality image. Difficult to auto PTV match due to poor contrast. Artefact. Appropriate for clinical decisions.
5	Unable to auto or manual match tumour due to poor contrast and artefacts. Visual artefacts affecting image contrast. Unable to view anatomy on all planes of scan volume Inappropriate for clinical decision making.

Figure 1. Quality scoring scale guidance for 3D spotlight thorax. Adapted from Boylan et al 2012 [1].

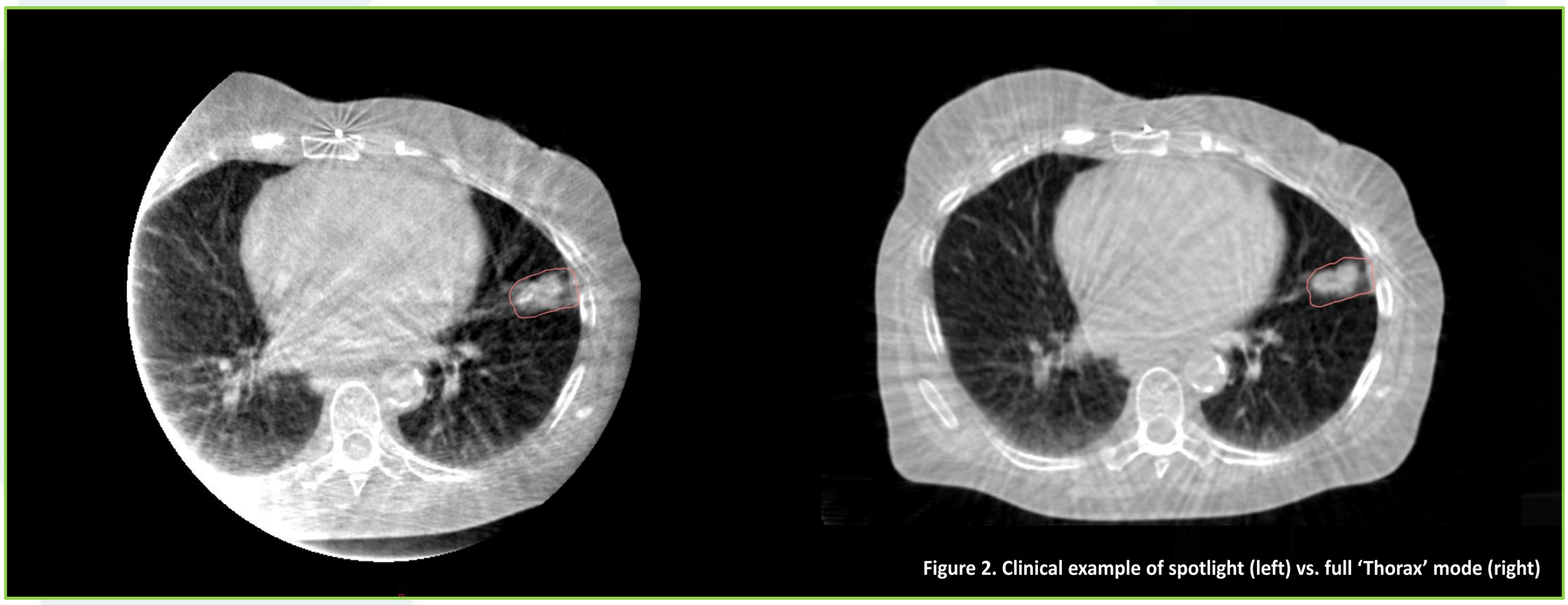

Figure 2. Clinical example of spotlight (left) vs. full 'Thorax' mode (right)

Outcomes

CTDIw was established as 0.78 mGy (A) and 1.16 mGy (B). This represents a dose reduction of 71%-80% compared with the current standard 'thorax' mode (CTDIw=3.94mGy) (Figure 2). This also corresponds to an effective dose of roughly 0.4mSv (A) and 0.6mSv (B) which is about a lifetime cancer risk of 1 in 42000 and 1 in 28000 respectively compared with the current standard 'thorax' mode which is 1 in 8000 (2.2mSv).

Spotlight A and B achieved an average scoring of 2.4 and 2.5 across all patients, respectively. Both would therefore be suitable for clinical use. With minimal scoring difference, the lower dose Spotlight A is preferable for its reduced dose.

CBCT delivery time was reduced from 60 seconds to 33 seconds.

80% Dose Reduction
33 Second Delivery
45% Time Saving

Conclusion

The use of spotlight mode for verification of lung SABR has been demonstrated. Imaging dose has been optimised as low as reasonably practicable whilst fulfilling the clinical requirement for verification. Delivery time has been reduced, improving patient experience and clinic throughput. The new mode will be introduced as the clinical standard for 3D CBCT in lung SABR.

[1] Boylan, C., Marchant, T., Stratford, J., Malik, J., Choudhury, A., Shrimali, R., Rodgers, J. and Rowbottom, C. (2012). A megavoltage scatter correction technique for cone-beam CT images acquired during VMAT delivery. Physics in Medicine and Biology, 57(12), pp.3727-3739.

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