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Assessing dosimetric quality of respiratory-gated VMAT plan delivery on Varian TrueBeam

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INTRODUCTION

- Deep inspiration breath hold (DIBH) delivery of volume modulated arc therapy (VMAT) treatments allow reduced dose to organs at risk while maintaining target volume coverage[1-3]
- The respiratory gating system on Varian TrueBeam linacs allows for the accurate delivery of DIBH VMAT plans by interrupting the beam based on the position of an infrared-reflecting marker block
- At our centre, DIBH is a well-established technique used for static-gantry breast cancer treatments but has not previously been commissioned for VMAT delivery
- This study assessed the dosimetric impact of respiratory gating on VMAT plan delivery

METHODS AND MATERIALS

- The study was performed using a Varian TrueBeam linac equipped with the respiratory gating system
- Five sample VMAT plans were selected from previously treated mediastinal lymphoma patients
- Two experimental phases were conducted: Phase 1 consisted of a portal dosimetry study and Phase 2 consisted of in-phantom film measurements

Phase 1

- Ungated and gated portal dosimetry measurements were performed for all arcs of all five plans
- Setups were identical between ungated and gated deliveries
- Gating was done using the Varian-provided motion phantom placed at the head of the bed in view of the infrared cameras with the gating marker block placed on top (see Figure 1)
- Analysis of portal images was done using gamma criteria of 3%/2mm and a 10% threshold

Phase 2

- Phantom deliveries were done using the Quasar pRESP QA phantom (Modus Medical): an acrylic body oval into which movable cylindrical inserts are placed which can be driven by the phantom motor to mimic breathing (see Figure 2)
- A custom acrylic insert was used, which allowed a 7.2×14.5 cm^2 piece of Gafchromic film to be placed in the coronal or sagittal plane
- All plans were delivered to the film while the phantom was static (no gating) and while the phantom was moving in a DIBH-like pattern (gated)
- Two phantom motion patterns were developed to represent good and poor patient DIBH breathing (see Figure 3)
- Film doses were compared to TPS data using FilmQA Pro software (Ashland), with gamma criteria of 3%/2 mm and a 10% threshold (see Figure 4 for an example)

Figure 1. Portal dosimetry setup with Varian motion phantom and marker block.

Figure 2. Film dosimetry setup with Quasar pRESP phantom and Varian marker block.

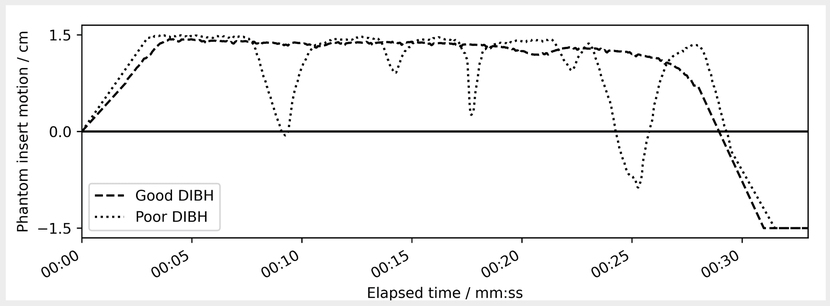

Figure 3. Phantom motion patterns used in the study. They approximate good (dashed) and poor (dotted) DIBH breathing patterns.

RESULTS

- Portal dosimetry results were in excellent agreement with TPS dose distributions for all arcs from all plans (γ > 98.9) (Table 1)
- Additionally, outputs from ungated and gated deliveries were within 0.01 MU of each other and with the planned MU
- Film dose agreed well with the TPS plan for both the static (ungated) and gated deliveries (γ > 96% for all cases) (Table 2)
- Poor quality DIBH breathing (resulting in more beam holds) did not have a statistically significant impact on agreement

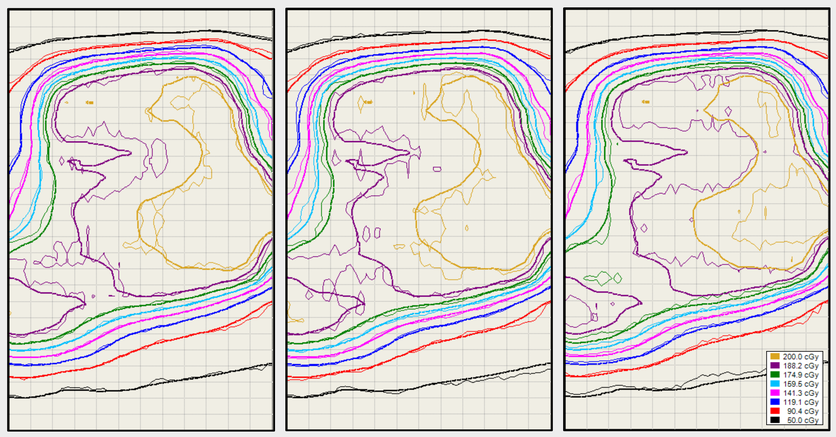

Figure 4. Example of comparison of of film (thin lines) to TPS (thick lines) dose distributions for static delivery (left), gated delivery with good DIBH (middle), and gated delivery with poor DIBH (right). Plan 5, coronal films.

Table 1. Gamma pass rates for gated and ungated portal dosimetry measurements.

Plan	Gamma pass rate (3%/2mm, 10% threshold) / %			
	Ungated delivery		Gated delivery	
	Arc 1	Arc 2	Arc 1	Arc 2
1	99.5	99.8	99.1	99.8
2	100	99.9	99.9	99.9
3	100	99.9	100	99.9
4	100	n/a	100	n/a
5	99.3	100	98.9	99.9

Table 2. Gamma pass rates for gated and ungated film deliveries

Plan	Gamma pass rate (3%/2mm, 10% threshold) / %					
	Coronal film			Sagittal film		
	Static	Good DIBH	Poor DIBH	Static	Good DIBH	Poor DIBH
1	100	99.08	99.43	99.87	99.34	99.67
2	99.98	99.06	99.18	100	99.64	96.72
3	99.80	98.75	99.39	99.93	97.46	99.16
4	99.99	99.99	99.99	98.01	98.13	98.29
5	100	99.94	98.34	100	98.47	96.40

DISCUSSION

- Respiratory gated deliveries resulted in comparable quality plan delivery to static deliveries measured using portal dosimetry
- Output agreement between ungated and gated deliveries were well within the 1% threshold recommended by TG-142[4]
- No significant differences were observed between static delivery and DIBH-gated delivery to film, even for poor DIBH breathing patterns with many beam interruptions
- Are portal dosimetry and film results were well within the 95% tolerance limit recommended by TG-218[5] for QA verification of dose distributions
- These results indicate that the TrueBeam linac respiratory gating system is capable of delivering accurate gated treatments
- Work is ongoing to develop policies and procedures to enable full clinical implementation of the DIBH VMAT technique

CONCLUSIONS

- The TrueBeam system is able to accurately control the delivery of a DIBH-gated VMAT plan, with all gated deliveries resulting in delivery of comparable quality to the reference static delivery
- Quality of DIBH breathing had little impact on agreement between planned and delivered dose distributions.
- The TrueBeam gating system is ready for use for DIBH VMAT plan deliveries

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