2026 JOINT AAPM | COMP MEETING
JULY 19–22 | VANCOUVER, BC

Dosimetric Impact of Density Variations in Wet Towel Bolus

Samantha Maragioglio, MS; Joseph Caletri, MS; Matthew Goss, MS
Allegheny Health Network

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Abstract

The aim of this study is to determine the necessary use parameters for wet towel as a clinical substitute for Superflab bolus. The reasoning for exploring this substitution was the observation that during treatments, Superflab bolus shows limited conformality to the body and leaves air gaps which may affect the delivered dose.

The first goal of the study is to determine the ideal saturation (water to towel ratio) in order to ensure reproducibility on treatment days. Then, using CT scans and the institutional CT to ED curve, we aimed to determine the electron density of the wet towel relative to that of the Superflab bolus in the treatment planning system. Finally, we calculated the necessary thickness of towel to equate to the effective thickness of Superflab.

Introduction

Many different materials are used for bolus in the clinic. Most commonly, Superflab, wet towel bolus, and ultrasound gel are used. Wet towel bolus can be created in many different ways – some clinics use layered wet paper towels, some clinics use wet terrycloth towels, or blanket or sheet material. The sizing, shape, absorbency and density of each of these may be different. The goal of this study is to standardize a method for creating wet towel bolus in a way that can be recreated consistently each treatment across multiple institutional sites, and be modeled correctly in the treatment planning system to ensure accurate delivery of clinical dose.

One of the most important yet inconsistent aspects of wet towel bolus is the amount of water to add. If the towel is too wet, it will drip and possibly damage the head of the linear accelerator when at gantry angles beneath the couch. If it is not wet enough, then the density may be inconsistent throughout the towel. Recommending an optimal ratio of towel to volume of water can eliminate these issues and create consistency when making a wet towel bolus.

Methods and Materials

Superflab, various samples of wet towel, and ultrasound gel were scanned with a Siemens SOMATOM Confidence CT scanner. Each single towel (10x10cm) was saturated with different amounts of water from 10cc to 30cc in increments of 5cc. Additionally, three towels saturated with 20cc each of water were stacked on top of each other in order to create approximately 1cm thick towel. This scan was imported into electron the Monaco TPS and electron densities were evaluated.

An anthropomorphic phantom was also scanned and a clinically realistic Monte Carlo plan was created in Monaco, using 0.8cm of density 1.0 bolus. An open 10x10cm field delivered to solid water was also created. The plans were delivered with an Elekta Versa linear accelerator using a 6MV beam, and MOSFETs placed in various specified locations to measure the delivered dose.

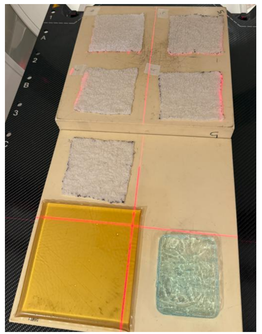

Figure 1. 10x10cm towels with varying amounts of water, Superflab, and ultrasound gel on solid water for CT scan.

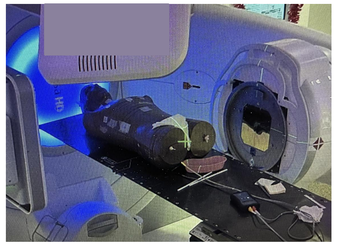

Figure 2. RANDO phantom with ideal wet towel bolus and MOSFETs for dose measurements on the linac.

Results

Our study showed that 20cc of water per 100cm^2 of towel was the ideal amount. 2 layers of wet towel results in an effective thickness of 0.5cm bolus. 4 layers of wet towel results in an effective thickness of 1cm bolus. When planning with Monaco Superflab, substituting a wet towel bolus with equivalent effective thickness results in a dose difference of up to 16%.

Solid Water	Expected	Measured	Difference
Center	75.8	81.49	1.08
2cm left	76.9	88.82	1.16
2cm right	75.9	80.74	1.06
2cm sup	76.4	82.95	1.09
2 cm inf	75.8	84.52	1.12

Table 1. Expected and measured dose values for a 10x10cm open field 6MV beam delivered to solid water with wet towel. Bolus in Monaco kept to conventional properties – 0.5cm thick and electron density = 1.

Anthropomorphic	Expected	Measured	Difference
Center	5652.9	5959.8	1.05
1.7cm sup	4762.4	6414	1.35
3cm inf	5832.7	6326.7	1.08

Table 2. Expected and measured dose values for a typical GYN plan delivered to the anthropomorphic phantom with wet towel, with the bolus properties in Monaco kept conventional.

Anthropomorphic	Expected	Measured	Difference
Center	6569.2	6191.2	0.94
1.7cm sup	6098.1	6217.8	1.02
3cm inf	6501.5	6476	1.00

Table 3. Expected and measured dose values for a typical GYN plan delivered to the anthropomorphic phantom with wet towel, with the bolus properties forced to match the wet towel (0.9cm thick, 0.788 electron density)

Discussion

20cc of water for a 100cm^2 gives a relative electron density of 0.678. When layering 3 wet towels saturated with the appropriate amount of water, the thickness is approximately 0.9cm and the relative electron density is approximately 0.788, resulting in an effective thickness of approximately 0.7cm. Layering 2 wet towels saturated with the appropriate amount of water results in a thickness of approximately 0.6cm and the relative electron density is approximately 0.733, resulting in an effective thickness of approximately 0.45cm. When planning with Monaco Superflab, substituting a wet towel bolus with equivalent effective thickness results in a dose difference of up to 16%, with one point measuring a 35% dose difference. This point is excluded from analysis as upon examination, it was found to be in an area of high dose gradient and is thus more susceptible to human error when placing the MOSFET. The most accurate dose (within 6%) is given when making the bolus thickness and electron density in Monaco match that of the wet towel, but the difference when using conventional properties is not significant enough and thus does not need to be taken into account.

Conclusions

20cc of water per 100cm^2 of towel when creating wet towel bolus creates a clinically acceptable substitution for Superflab bolus. Our study found that using this saturation, two layers of towel should be used as a substitute for a 0.5cm thick piece of Superflab, and four layers of towel should be used as a substitute for 1cm thick piece of Superflab. The density and size properties of the bolus in Monaco do not need to be manually changed as long as these proper ratios are followed.

Contact

Samantha Maragioglio
Allegheny Health Network
Samantha.Maragioglio@ahn.org

Allegheny Health Network