CLINICAL INVESTIGATION

METHODS OF BOLUSING THE TRACHEOSTOMY STOMA

JONATHAN J. BEITLER, M.D., M.B.A.,*† RAVINDRA YAPARPALVI, M.S.,*
CESAR DELLA BIANCIA, M.S.,* AND DORACY P. FONTENLA, PH.D.,*†

Departments of *Radiation Oncology and †Otolaryngology, Montefiore Medical Center, Bronx, NY

Purpose: The tracheostomy stoma is a potential site of recurrence for patients who have subglottic cancer or subglottic spread of cancer. In these patients, it is important that the anterior supraclavicular field does not underdose the posterior wall of the tracheostomy stoma when using a 6-MV anterior photon field. Conventionally, this problem is surmounted with placement of a plastic tracheostomy tube, which is uncomfortable for the patient, potentially traumatic, and can interfere with vocalization via a tracheal esophageal puncture. Our study was designed to investigate the dosimetry of this region and see if alternate methods would be effective.

Methods and Materials: A phantom was constructed using a No. 6 tracheostomy tube as the model for the tracheostomy curvature and size. Using the water-equivalent phantom, film dosimetry, and films oriented parallel to the en face field, we investigated the dose at the depth of the surface of the posterior wall of the phantom’s tracheostomy stoma. Dose was measured both in space and at the tissue interface by scanning points of interest both horizontally and vertically. We measured doses with a No. 6 and No. 8 plastic tracheostomy tube, either 0.5 cm and 1.0 cm of bolus (1-cm airhole) with no tracheostomy tube, as well as 0.3 cm and 0.6 cm tissue-equivalent Aquaplast (Med-Tec Co., Orange City, Iowa) over the tracheostomy. Dosimetry at the posterior interface was confirmed using thermoluminescent dosimeters.

Results: Three mm and 6 mm of Aquaplast produced a posterior tracheal dose of 93% and 100%.

Conclusion: There is no need for these patients to wear a temporary plastic tracheostomy tube during their external radiation therapy. Aquaplast should allow better position reproducibility, reduce trauma, not interfere with patient respiratory efforts, and be compatible with vocalization via a tracheal esophageal puncture. © 2001 Elsevier Science Inc.

Tracheostomy, Subglottic, Subglottic extension, Tracheostomy bolus, Laryngectomy.

INTRODUCTION

Total laryngectomy is still necessary for patients who fail to respond to nonsurgical therapy. For those patients with subglottic extension who require a total laryngectomy, the tracheal stoma is at risk for local recurrence according to prominent textbooks (1–3). Wang agrees that postoperative radiation to the tracheal stoma is indicated for subglottic extension but also feels that routine postoperative radiation to the neck and tracheostomy stoma are indicated for postoperative advanced glottic and supraglottic cancers if multiple nodes are present (3). Million and Cassisi (2) point out that, “The most frequent sites of local failure after total laryngectomy are around the tracheal stoma, in the base of the tongue, and in the neck lymph nodes.”

The tracheostomy geometry ensures that the posterior mucosal wall is directly exposed to anterior supraclavicular field photons, and due to lack of build-up, it was feared that the mucosal surface of the tracheostomy stoma would be underdosed.

Conventionally, this problem is surmounted with placement of a plastic tracheostomy tube, which is uncomfortable for the patient, potentially traumatic, and can interfere with vocalization via a tracheal esophageal puncture. We concentrated on the area of the posterior tracheal wall, which by virtue of geometry of the tracheal stoma had no “natural” bolus. Our study was designed to investigate the dosimetry of this region and see if alternate methods would be effective.

METHODS AND MATERIALS

A polystyrene water-equivalent phantom (see Figs. 1–3) was constructed using a No. 6 tracheostomy tube as the model for the tracheostomy curvature and size. The trachea...
Fig. 1. Polystyrene water-equivalent phantom with a No. 6 tracheostomy tube and inner cannula bisected; tracheal diameter of 2 cm.

Fig. 2. Polystyrene water-equivalent phantom. The photograph shows a medial view of one-half of the phantom. Dose in space was measured along straight line.

Measurements made along a straight line to 2cms
of the model was 2 cm in diameter. Film (X-Omat V film, Eastman Kodak Co., Rochester, NY) for film dosimetry was oriented parallel to the incoming anterior photon beam and located in the midline of the phantom model. The irradiated films were scanned on a commercial film dosimetry system (RIT Inc., Colorado Springs, CO). Depth dose was measured in space until the posterior tracheal wall (depth = 2 cm) as shown by Fig. 2 with the results shown by Fig. 4.
Fig. 5. Posterior tracheal interface dose-film dosimetry.

Fig. 6. Aquaplast bolus with 1-cm airhole.
Dose was also measured in the midline at the surface of the posterior pharyngeal wall as shown by Fig. 2 with the results shown by Fig. 5. Dose was measured both in space and at the tissue interface by scanning points of interest both horizontally and vertically. Dose was prescribed to a depth of 3 cm for all measurements.

Both dosimetric studies were performed on our model and then repeated after 6 interventions. Standard, tissue-equivalent bolus of thickness 0.5 cm and 1.0 cm with an approximately 1-cm airhole were placed on the phantom. A No. 6 and No. 8 plastic tracheostomy tube was placed in our phantom with inner tracheostomy tube cannulas in place. For the No. 8 tracheostomy tube, our phantom was enlarged through the use of additional bolus between the two halves of the model. For the final set of interventions, we used 0.3 cm and 0.6 cm tissue-equivalent Aquaplast (Med-Tec Co., Orange City, IA) over the tracheostomy, with approximately 1 cm airholes over the tracheostomy stoma (Fig. 6).

Posterior tracheal interface doses were also measured using thermoluminescent dosimeters (Bicron, Silon, Ohio, 44139) at depths of 1 cm, 2 cm, and 3 cm (Fig. 7). After the experiments were performed, dosimetry at the skin surface, directly beneath a 6-mm Aquaplast bolus was performed using film dosimetry and prescribing to a depth of 3 cm.

**RESULTS**

Figure 4 displays depth doses measured under all the configurations described above in air. Figure 5 displays percent depth doses at the posterior tracheal interface.

Data on Figs. 4 and 5 were both obtained with film dosimetry. Figure 6 displays posterior tracheal interface doses obtained using thermoluminescent dosimeters (TLDs).

Using film dosimetry, dose on the skin surface under 6 mm of Aquaplast was 84%, and depth doses of tracheostomy in air range from 98% to 100%. Posterior tracheal interface doses, shown in Fig. 5, range from 93% to 95%

TLD measurements lead to similar results at the interface.

**DISCUSSION**

Dosimetry without any bolus or with only 0.5 cm of bolus (with a 1-cm airhole) as measured in air at 0.5 cm was 61% and 65%, which we considered to be substandard. Most of the other alternatives will likely provide an acceptable dose to the posterior tracheostomy wall, but, dosimetrically, the best technique was to use 6 mm of Aquaplast. Even with the 1-cm airhole (as we move this into the clinic, we will determine if this airhole is necessary), 6 mm of Aquaplast produced a minimum dose of at least 93%. The Aquaplast should allow better position reproducibility, reduce trauma, not interfere with patient respiratory efforts, and be compatible with vocalization via a tracheal esophageal puncture. Dosimetry on the skin surface, directly beneath 6 mm of Aquaplast (without an airhole), was 84%, which we considered acceptable.
REFERENCES

