

# Does Laryngectomy Improve Swallowing After Chemoradiotherapy?

## A Case Study

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Organ preservation protocols of high-dose chemoradiotherapy have become fairly common to treat head and neck cancers. However, significant swallowing problems can occur. This study examines swallowing, oral tongue pressures, and tongue base-to-pharyngeal wall pressures in a patient who underwent total laryngectomy for improvement of swallowing after chemoradiotherapy for treatment of a hypopharyngeal tumor. The patient underwent concurrent videofluorographic and manometric examination of swallowing and examination of oral tongue pressures after the laryngectomy. One healthy subject was used as a control. After the laryngectomy, the patient no longer aspirated; however, he could swallow only liquids and pureed foods. He demonstrated difficulty with bolus clearance through the oral cavity and pharyngocervical esophagus. Pharyngeal pressures were reduced compared with those of the control subject. While total laryngectomy will stop unremitting aspiration, swallowing after chemoradiation may be severely compromised. This may not be overcome by total laryngectomy.

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Organ preservation protocols consisting of high-dose chemoradiotherapy have become fairly common for treatment of head and neck cancers.<sup>1,2</sup> However, significant swallowing problems often occur after this treatment.<sup>3,4</sup> Total laryngectomy has been an option for patients having undergone head and neck cancer treatment and who exhibit unremitting posttreatment aspiration.<sup>5</sup> However, no study has examined swallowing after total laryngectomy for chronic aspiration in patients having undergone high-dose chemoradiotherapy. This study examines (1) swallowing, (2) oral tongue pressures, and (3) tongue base-to-pharyngeal wall pressures in a patient who underwent total laryngectomy for improvement of swallowing after primary chemoradiotherapy for treatment of a hy-

popharyngeal tumor. The same study was completed in an age- and sex-matched control subject.

## RESULTS

Total laryngectomy successfully eliminated aspiration. However, the patient reported that he was initially able to swallow only liquids by mouth. After several weeks he could swallow only some pureed foods, as determined by VFG results and patient report. Results revealed that after total laryngectomy the patient had difficulty with bolus clearance through the oral cavity and pharyngocervical esophagus during swallows (**Table 1**). The percentage of oral residue was higher for liquids and pastes in the patient than it was in the control subject. Percentages of pharyngocervical esophageal residue also increased with thicker boluses (pastes); most of the bolus remained in the pharyngocervical esophagus after the patient swallowed. Bolus clearance through the pharyngocervical esophageal region was also

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## PATIENT AND METHODS

A 72-year-old man was treated for a newly diagnosed stage IV squamous cell cancer of the hypopharynx. He underwent organ preservation treatment of concurrent external beam radiotherapy and chemotherapy, receiving a total radiotherapeutic dose of 7000 rad and chemotherapy consisting of cis-platinum, fluorouracil, and hydroxyurea. A videofluorographic (VFG) swallow study completed mid-treatment revealed poor tongue-base motion, reduced laryngeal elevation, and closure during swallowing, all of which resulted in poor bolus clearance and aspiration after the swallow. A gastrostomy tube was subsequently placed because of impaired swallow function and poor oral intake. This patient also required a tracheostomy tube for airway maintenance and management of secretions. The patient underwent swallow therapy to improve tongue-base posterior motion, laryngeal elevation, and closure for swallowing. A second VFG swallow evaluation 1 month following completion of his chemoradiotherapy revealed no improvement in swallow function. He continued to receive all nutrition through a gastrostomy tube and continued swallow therapy.

Over the year after his chemoradiotherapy, the patient's swallowing did not improve. Because of his strong desire to eat normally, and his unremitting aspiration despite therapy procedures, he subsequently underwent total laryngectomy without hyoid bone resection. After surgery, he was still unable to swallow and was reevaluated using concurrent VFG and manometric (manofluorographic) examination,<sup>6</sup> as well as a study of oral tongue pressures. One age- and sex-matched healthy subject, a 67-year-old man, served as a control. He underwent an in-depth interview that revealed no history of swallowing problems or diagnoses that might affect swallow function. The control subject underwent one manofluorographic study and one evaluation of oral tongue pressures.

Oropharyngeal swallowing was assessed using VFG, the modified barium swallow procedure.<sup>7</sup> Subjects were given 2 swallows each of 1, 3, 5, and 10 mL of liquid and 3 mL of paste boluses. Subjects were then instructed in the effortful swallow, designed to improve tongue-base posterior motion,<sup>8</sup> with each subject performing 2 swallows in this manner on 3-mL pastes. The radiographic image was recorded on a Sony Umatic VO-9600 videotape recorder (Bensenville, Ill) coupled to a Thalner Electronics (Ann Arbor, Mich) counter-timer (TEL VC436) for subsequent slow-motion and frame-by-frame analysis. Observations and swallow measures were made for each swallow, including (1) observation of the approximate percentage of residue in the oral cavity and pharyngocervical esophagus after the swallow; (2) temporal measures of bolus movement through the oral cavity and pharyngocervical esophagus; and (3) measures of structural movement over time for each swallow. Temporal measures of bolus movement through the oral cavity and pharyngocervical esophagus included (1) oral transit time (time from the onset of the posterior movement of the bolus head until the bolus head reached the point where the tongue base crossed the ramus of the

mandible); (2) pharyngocervical esophageal transit time (time from the onset of the bolus head reaching the point where the tongue base crosses the ramus of the mandible until the bolus tail passes through the esophagus at the horizontal level of superior C5); and (3) duration of bolus transit through the cervical esophagus at the horizontal level of superior C5 (time from when the bolus head reached the esophagus at the horizontal level of superior C5 until the bolus tail passed this point) (**Figure**). This last measure was used instead of cricopharyngeal opening duration, since the cricopharyngeal region cannot be reliably identified after total laryngectomy.

Measures of pharyngeal structural movement during the swallow included (1) tongue-base movement to the posterior pharyngeal wall (PPW) (from the onset of posterior movement of the tongue base until it first contacts the PPW); (2) duration from first to last contact of the tongue base to PPW at mid-C2; (3) duration from first to last contact of the tongue base to PPW at inferior C2; (4) duration from first to last contact of tongue base to PPW at superior C3; (5) duration of velopharyngeal closure (from first to last contact of the palate to the PPW); and (6) duration of hyoid movement (from first to last movement of the hyoid). Interobserver and intraobserver reliability measures were performed on 2 swallows per subject. Pearson correlation coefficients of intraobserver and interobserver reliability for all swallow observations and measures averaged 0.99 (range, 0.98-1.00) and 0.99 (range, 0.94-1.00), respectively.

Manometry was used concurrently with VFG to examine tongue base-to-PPW pressures.<sup>6</sup> Manometry was accomplished using an intraluminal transducer system with a 2-channel solid-state catheter, the transducers of which were 3 cm apart. The manometric catheter was inserted transnasally with the transducers oriented posteriorly. The catheter was passed through the pharyngocervical esophageal region, and was then withdrawn until the proximal transducer was situated behind the tongue base. Catheter pressures (millimeters of mercury) were recorded for each swallow. Subjects were seated upright and viewed in the lateral VFG plane.

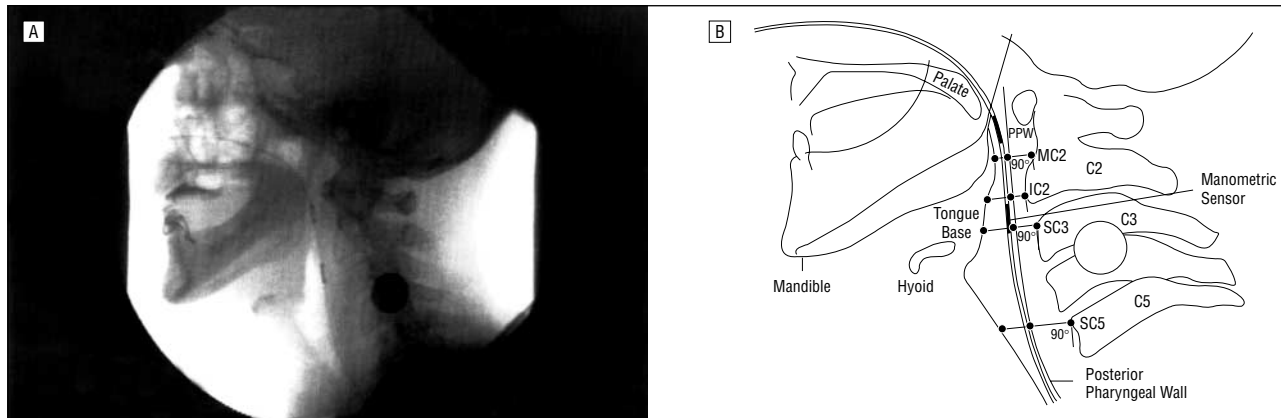
Oral tongue pressures were assessed in a separate session on the same day as the VFG swallow evaluation using the Iowa Oral Performance Instrument.<sup>9</sup> Subjects performed 3 tongue-pressure tasks during which maximum pressures were measured and 1 task during which duration was measured, including (1) maximum isometric pressure ( $P_{\max}$ =strength); (2) normal dry swallows; (3) effortful swallows; and (4) sustained submaximal pressure generation (50%  $P_{\max}$ =endurance [duration]). Subjects performed 3 trials of each.

Data on the swallow observations of percentage residue and temporal and pressure measures of swallowing were averaged across trials for each bolus volume, viscosity, and condition. For maximum tongue pressure testing, the greatest value for the 3 trials was used as  $P_{\max}$ . The greatest value for the 3 trials of tongue endurance was used as the tongue endurance measure for each subject. Tongue strength values during normal and effortful swallowing were averaged for each task.

slowed, with prolonged pharyngocervical esophageal transit times, particularly on paste swallows, compared with measures in the control subject. Tongue-base contact to the pharyngeal wall was incomplete for some swallows

at the inferior C2 level and was incomplete for all swallows at the superior C3 level.

Tongue base-to-pharyngeal wall pressures during the swallow for the patient were lower than those in the



A, Radiographic lateral view of the patient with the manometric catheter in place; note the lower sensor behind the tongue base. B, Schematic lateral view with marked points identifying the mid-C2 (MC2), inferior C2 (IC2), superior C3 (SC3), and superior C5 (SC5) vertebrae. PPW indicates posterior pharyngeal wall.

**Table 1. Swallow Observations and Measures of Bolus and Structural Movement During the Swallow for 1, 3, 5, and 10 mL of Liquid and 3-mL Paste Boluses and the Effortful Swallow in the Patient (P) and Control Subject (C)\***

Swallow Measure	OTT		PCETT		BOT to PPW		BotmC2		BotiC2		BotsC3		CE Duration		Oral Residue, %		Pharyngeal Residue, %		No. of Swallows per Bolus	
	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C
1 mL of liquid	0.38	0.24	1.08	0.96	0.14	0.16	1.33	0.33	1.09†	0.32	0‡	0.27	0.82	0.21	5.50	2.00	53.00	3.00	1.50	2.00
3 mL of liquid	0.37	0.29	0.73	0.82	0.17	0.10	0.59	0.29	0.50†	0.25	0‡	0.22	0.44	0.24	12.50	4.00	45.00	2.00	2.00	2.00
5 mL of liquid	0.20	0.22	0.74	1.03	0.19	0.17	0.32	0.28	0.31†	0.24	0‡	0.23	0.61	0.29	22.50	3.50	52.50	5.00	1.50	2.00
10 mL of liquid	0.26	0.39	0.68	0.95	0.12	0.17	0.73	0.30	0.29†	0.27	0‡	0.26	0.55	0.36	8.00	4.50	22.00	9.00	2.50	2.00
3 mL of paste	0.28	0.31	4.52	0.98	0.15	0.10	0.86	0.42	0.78†	0.34	0‡	0.30	3.73	0.21	13.50	2.00	86.50	1.50	2.50	1.50
Effortful	0.13	0.33	4.78	0.63	0.12	0.13	2.34	1.52	2.28†	1.42	0‡	1.40	4.05	0.2	16.50	0.67	83.50	2.67	1.50	1.67

\*Values reported are the means of 2 swallows on each bolus type, and unless otherwise indicated, they are measured in seconds. OTT indicates oral transit time; PCETT, pharyngocervical esophageal transit time; BOT to PPW, time from onset of tongue base movement to first contact with the posterior pharyngeal wall; BotmC2, duration of tongue base contact to the posterior pharyngeal wall at mid-C2; BotiC2, duration of tongue base contact to the posterior pharyngeal wall at inferior C2; BotsC3, duration of tongue base contact to the posterior pharyngeal wall at superior C3; and CE, passage of the bolus past superior C5 (bolus head to tail).

†No tongue base-to-pharyngeal wall contact on 1 swallow trial.

‡No tongue base-to-pharyngeal wall contact on either swallow trial.

**Table 2. Tongue Base-to-Pharyngeal Wall Pressures During Swallows of 1, 3, 5, and 10 mL of Liquid, 3-mL Paste Boluses, and the Effortful Swallow for the Patient Control and Control Subject\***

	Patient	Control
1 mL of liquid	27.50	70.00
3 mL of liquid	30.00	103.50
5 mL of liquid	37.50	82.50
10 mL of liquid	18.50	122.00
3 mL of paste	10.50	68.50
Effortful	52.50	67.00

\*Values reported are the means of 2 swallows on each bolus type and are measured in millimeters of mercury.

control subject (**Table 2**) and lower than pressures typically generated after total laryngectomy (mean pressure, 86 mm Hg).<sup>6</sup> Pharyngeal pressures across all volumes on liquid swallows were similar to those in patients with total laryngectomy and tongue impairment (mean pressure, 31 mm Hg).<sup>10</sup> Although the patient's tongue base-to-pharyngeal wall pressures increased with use of the effortful swallow, they did not approach those reported in patients with total laryngectomies without

**Table 3. Oral Tongue Pressure Measures of Maximum Strength and Endurance Tasks, and During Normal and Effortful Swallow in the Patient and Control Subject\***

Oral Tongue Pressure Measures	Patient	Control
Maximum strength ( $P_{max}$ ), kPa	56.00	30.00
Endurance (50% $P_{max}$ ), s	4.00	13.00
Dry swallow, kPa	9.30	11.00
Effortful swallow, kPa	22.00	21.67

\* $P_{max}$  indicates maximum isometric pressure.

tongue impairment,<sup>6</sup> and bolus clearance through the pharynx did not improve over the normal swallows.

Mean values for maximum isometric tongue pressures (**Table 3**) were higher for the patient than for the control subject, although still within normal limits for healthy older adults.<sup>11</sup> Tongue endurance measures were shorter for the patient than for the control subject, both measures being below those of normal older adults.<sup>12</sup> Oral tongue pressures during dry swallowing were not appreciably different for the patient and the control subject, and both showed values that were below normal for older

adults.<sup>11</sup> Tongue pressures increased during effortful swallows for both subjects.

## COMMENT

Total laryngectomy eliminated the risk of aspiration in this patient. However, for this patient with compromised swallow functioning after chemoradiotherapy, total laryngectomy did not significantly improve his diet. Pressure is generated during swallows by the tongue, tongue base, and pharyngeal walls.<sup>6,10,13</sup> Studies of total laryngectomy show that individuals must typically generate pressures greater than normal during the swallow to achieve bolus transit.<sup>6</sup> This patient's chemoradiation resulted in poor tongue-base motion prior to his total laryngectomy, and he was unable to produce the higher-than-normal pressures needed to clear thicker boluses through his reconstructed pharyngocervical esophagus after his laryngectomy.

The fact that this patient demonstrated higher maximum oral tongue pressures than the control subject may represent his attempt to generate the higher pressures needed to swallow efficiently. The patient was edentulous at the time of his tongue function assessment and the control subject had some teeth. Greater tongue strength has been observed in the healthy edentulous population than in similar subjects with teeth or dentures.<sup>14</sup>

Radiotherapy to the head and neck often results in fibrosis and scarring of the pharyngeal tissues and structures. These changes can contribute to a reduction in the range of motion of the tongue base and pharyngeal musculature and structures.<sup>4</sup> Patients of this sort might benefit from tongue-base range-of-motion exercises, including the tongue-hold maneuver, tongue-base retraction, and the effortful swallow because pharyngeal pressures during swallowing are known to improve with use of these maneuvers.<sup>15</sup> In addition, tongue-strengthening exercises might improve tongue-base strength for swallowing in this patient, since the tongue creates the major bolus-driving pressure.<sup>13</sup> However, with impaired range and flexibility of the pharyngeal musculature, it is unclear to what degree this patient would benefit from this therapy.

This case study highlights the importance of careful laryngectomy swallow preassessment in the patient with unremitting aspiration after chemoradiation treatment. Ex-

amination of the patient's ability to generate pressures adequate to swallow a normal diet before the laryngectomy will contribute significantly to prelaryngectomy patient counseling.

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