Dysphagia 11:254–258 (1996)

Dysphagia

Effect of Occlusion of a Tracheotomy Tube on Aspiration

Steven B. Leder, PhD,[1] John M. Tarro, MD,[1] and Morton I. Burrell, MD[2]

Yale University School of Medicine, [1]Department of Surgery, Section of Otolaryngology, and [2]Department of Diagnostic Radiology, New Haven, Connecticut, USA

Abstract. The purpose of the present study was to investigate the effect of occlusion of a tracheotomy tube on aspiration utilizing fluoroscopy. Twenty consecutive tracheotomized patients referred for a modified barium swallow were included. Selection criteria were ability to tolerate tracheotomy tube occlusion during the modified barium swallow procedure, no surgery of the upper aerodigestive tract except tracheotomy, and no history of oropharyngeal cancer or stroke. There was 100% agreement among 3 independent reviewers on ratings of the presence or absence of aspiration. It was found that the occlusion status of the tracheotomy tube did not influence the prevalence of aspiration. Nine of 10 (90%) subjects who exhibited aspiration were over 65 years of age ($\overline{X}$ = 72 years 2 months). No trends were observed for bolus consistency, type of tracheotomy tube, or presence/absence of a nasogastric tube and ratings of aspiration.

Key words: Aspiration — Larynx — Tracheotomy — Tracheotomy tube — Modified barium swallow — Fluoroscopy — Dysphagia — Deglutition — Deglutition disorders.

In man, the two diverse and mutually exclusive functions of deglutition and respiration share the same anatomic structures in the upper aerodigestive tract. Swallowing is a highly complex activity requiring precise coordination of anatomic structures and sequencing of physiologic events occurring within a closed aerodigestive system. Tracheotomy inherently violates the closed aerodigestive system and alters the precise interrelated coordination involved in breathing and swallowing [1,2], i.e., glottic reflexes have been shown to be less sensitive in experimental animals following tracheotomy [3,4].

Although the majority of patients with a tracheotomy swallow successfully, a number of studies have reported on aspiration associated with tracheotomy. Explanations as to the cause of aspiration following tracheotomy and placement of a tracheotomy tube included (1) fixation of the larynx causing impaired mechanical ability of the supraglottic larynx to achieve closure and protect the airway by limiting the rostrocaudal excursion of the laryngotracheal complex [1,5–7]; (2) esophageal compression caused by a distended trachea secondary to an inflated tracheotomy tube cuff [8,9]; (3) desensitization of the larynx secondary to diversion of normal airflow through the tracheotomy [1,6]; (4) adductor vocal fold dysfunction and a weakened closure response after long-term tracheotomy; and (5) alterations in respiratory abductor function of the larynx secondary to bypassing the upper airway via tracheotomy [1,3,4].

The last three explanations, i.e., physiologic changes secondary to bypassing the upper airway with a tracheotomy, have been investigated directly. This has been done by occluding the tracheotomy tube, thereby reinstating the normal closed aerodigestive tract and allowing expired air to exit via the upper airway, followed by unoccluding the tracheotomy tube and diverting expired air out the tracheotomy tube. Aspiration can then be investigated under these two conditions in the same patient.

A case study [5] reported that the presence of an open tracheotomy tube appeared to have an adverse effect on swallowing; upon plugging and subsequent removal of the tube the dysphagia resolved. Although tracheotomy caused neurophysiologic changes in both abductor and adductor laryngeal responses, when the tracheotomy cannula was occluded for 3 min, some motor return was observed [1,4]. Muz et al. [10] reported on patients with tracheotomy and head and neck cancer. An initial report

Address offprint requests to: Steven B. Leder, Ph.D., Yale University School of Medicine, Section of Otolaryngology, Communication Disorders Center, 20 York St., YPB-468, New Haven, CT 06504, USA

found that aspiration increased when the tracheotomy tube was unoccluded. A subsequent study reported that aspiration occurred in all patients with an unoccluded tube but only in half of the same patients with an occluded tube [11].

There is a paucity of objective data on aspiration in the tracheotomized population in general, and in the nonhead and neck cancer population in particular. The purpose of the present study was to investigate the effect of occlusion of a tracheotomy tube on aspiration utilizing fluoroscopy.

Methods

Subjects

Twenty consecutive tracheotomized patients referred for fluoroscopic assessment of suspected oropharyngeal dysphagia, i.e., a modified barium swallow [12,13], were included (Table 1). Selection criteria were ability to tolerate tracheotomy tube occlusion during the modified barium swallow procedure, no surgery to the upper aerodigestive tract except tracheotomy, and no history of oropharyngeal cancer or stroke. There were 13 males and 7 females, ages from 17 years 8 months to 85 years 1 month. Time from tracheotomy to modified barium swallow ranged from 8 days to 546 days. At time of testing, 12 subjects had a nasogastric tube and 8 subjects did not. Also, 14 subjects had a plastic tracheotomy tube with an air cuff, 1 with a foam cuff, and 5 had metal tracheotomy tubes.

Procedures

The modified barium swallow procedure [12,13] was performed with each subject positioned upright and viewed in the lateral plane. Radiographic visualization of the oral cavity, pharynx, upper airway, and cervical esophagus was confirmed prior to start of the procedure. Adequate descriptive information was obtained from the lateral views to satisfy the goals of the present study. Small amounts, i.e., 1.2 mL–1.8 mL (two-thirds to one teaspoon) of both liquid barium (E-Z Paque, EZEM, Westbury, NY) and liquid barium mixed with custard to puree consistency were used to investigate swallowing difficulty with different bolus consistencies. Three swallows each of liquid and puree consistency were given, first with an occluded tracheotomy tube (six swallows) and then with an unoccluded tracheotomy tube (six swallows), for a total of 12 swallows. The tracheotomy tubes were occluded for approximately 3–5 minutes, as tolerated, prior to the start of the modified barium swallow [1], and were either cuffless or had deflated cuffs during the procedure. All subjects were instructed to hold the material in their mouths until told to swallow. The fluoroscopic image of the swallow was recorded (All-Tronics Medical Systems, HRV-3000EM, Seekonk, MA) on videotape for both real-time and slow motion analysis.

The videotapes were examined for aspiration, i.e., the entry of material into the airway below the true vocal folds [12], in real-time and slow motion by 1 speech-language pathologist and 2 radiologists experienced in performing and interpreting the modified barium swallow procedure. Repeated viewings of the videotapes were allowed in order to confirm the presence or absence of aspiration. The speech-language pathologist knew that the tracheotomy tube was occluded during the first six swallows and unoccluded during the last six swallows. The radiologists were not aware of tracheotomy tube occlusion status. The 3 reviewers made independent ratings of presence or absence of aspiration and were blinded to the ratings of the other two reviewers.

Results

There was 100% agreement among the 3 independent reviewers on ratings of presence or absence of aspiration for both liquid and puree bolus consistencies swallowed first with an occluded tracheotomy tube and then with an unoccluded tracheotomy tube in the same subjects (Table 2). Specifically, aspiration of both liquid and puree boluses occurred in 9 of 20 (45%) subjects (#2–4,10, 13,17–20; mean age 72 years 2 months) regardless of whether the tracheotomy tube was occluded or unoccluded. Conversely, no aspiration was observed with either consistency in 10 of 20 (50%) subjects (#1,6–9, 11,12,14–16; mean age 46 years 9 months) when the tracheotomy tube was first occluded and then unoccluded. One of 20 (5%) subjects (#5; age 82 years 10 months) aspirated only liquid boluses both with and without an occluded tracheotomy tube, but did not aspirate puree boluses occluded or unoccluded.

Nine of 10 (90%) subjects who exhibited aspiration were over 65 years of age, but only 1 of 8 (13%) subjects under 65 years of age exhibited aspiration. No trends were observed regarding bolus consistency, type of tracheotomy tube, or presence/absence of a nasogastric tube and ratings of aspiration.

Discussion

In no case did a subject aspirate first with an occluded tracheotomy tube and then not aspirate with an unoccluded tube or, conversely, not aspirate with an occluded tube and then aspirate when the tube was unoccluded. It was concluded, therefore, that the occlusion status of the tracheotomy tube did not influence the prevalence of aspiration.

These findings do not agree with the results found when observing aspiration during the modified barium swallow procedure in head and neck surgical patients with occluded and unoccluded tracheotomy tubes, i.e., aspiration increased with an unoccluded tube and decreased when the tube was occluded [10,11]. In the present study, there were no factors influencing upper airway anatomy and physiology except a tracheotomy and tracheotomy tube. That is, subjects with possible confounding factors such as cancer, surgery, or stroke were not included. Consistent with a previous report [14], prevalence of aspiration was not influenced by type of tracheotomy tube or presence/absence of a nasogastric tube. Since the results showed no differences in prevalence of aspiration based on occlusion status of the tracheotomy tube, the individual patient's disease, medical status, and oral and pharyngeal physiology were most likely the causative factors when aspiration was observed.

Table 1. Subject characteristics

S	Sex	Age (yrs:mos)	Diagnosis	Days since tracheotomy	Nasogastric tube	Type of tracheotomy tube
1	M	32:6	HIV+ PCP pneumonia	15	Y	Air cuff
2	M	79:2	Squamous cell carcinoma left frontoparietal region	107	Y	Metal
3	M	75:4	Motor vehicle accident/ multiple nonfacial trauma	19	Y	Air cuff
4	F	77:3	Adult respiratory distress syndrome	88	N	Air cuff
5	F	82:10	Coronary artery disease	18	N	Metal
6	F	70:8	Chronic obstructive pulmonary disease	11	Y	Air cuff
7	M	38:0	C4-5 transection with quadriplegia	546	Y	Air cuff
8	M	33:6	Amyotrophic lateral sclerosis	436	N	Air cuff
9	M	58:9	ETOH cirrhosis/cardiopulmonary arrest	43	N	Air cuff
10	M	74:2	Chronic obstructive pulmonary disease	10	N	Foam cuff
11	M	21:3	Motor vehicle accident/ multiple facial trauma	22	N	Air cuff
12	F	49:0	Lung cancer/adult respiratory distress syndrome	25	Y	Air cuff
13	F	85:1	Adenocarcinoma sigmoid colon	26	N	Air cuff
14	F	82:6	Adult respiratory distress syndrome	33	Y	Air cuff
15	M	65:5	Necrotic left lung	29	Y	Air cuff
16	M	17:8	Motor vehicle accident/ multiple nonfacial trauma	20	N	Metal
17	M	70:0	Assault/multiple facial trauma	18	Y	Air cuff
18	F	71:3	Adult respiratory distress syndrome	43	Y	Metal
19	M	49:1	Motor vehicle accident/ multiple nonfacial trauma	20	Y	Metal
20	M	68:9	Paramesencephalic hemorrhage	8	Y	Air cuff

Dysphagia has been shown to be a problem in both head and neck cancer [10,11] and non-head and neck cancer [2,6–9] tracheotomized populations. It appears that alterations in oral, pharyngeal, and laryngeal anatomy and physiology secondary to either the cancer and subsequent surgical resection and reconstruction or changes secondary to bypassing the upper airway with a tracheotomy, place each of these populations at risk for various swallowing difficulties, including aspiration. When the populations overlap, i.e., patients with both head and neck cancer and a tracheotomy, the prevalence of aspiration increases [11].

It is of interest that 9 of 10 (90%) subjects who exhibited aspiration were over 65 years of age. Only 3 of 12 (25%) 65+ year old subjects (#6,14,15) did not exhibit aspiration following tracheotomy. In addition, only 1 of 8 (13%) subjects (#19) in the present study under 65 years of age aspirated during the modified barium swallow. Aging affects all four phases of swallowing, i.e., oral preparatory, oral, pharyngeal, and esophageal [15]. It is well known that aspiration is more prevalent in the elderly due to the normal aging process, e.g., muscular weakness, atrophy, and decreased tone; neuromuscular and vascular changes in the pharynx and esophagus, e.g., delayed triggering of the swallowing reflex, muscular dysmotility, and decreased peristalsis; and anatomical changes, e.g., loss of dentition, degenerative osteophytes, cervicothoracic kyphoscoliosis, and rheumatoid arthritis

Table 2. Reviewers' ratings of presence (+) or absence (−) of aspiration (asp.) for liquid and puree bolus consistencies swallowed first with an occluded tracheotomy tube and then with an unoccluded tracheotomy tube in the same subjects (n = 20)

	Occluded tracheostomy tube				Unoccluded tracheostomy tube			
	Liquid		Puree		Liquid		Puree	
Subject	− Asp.	+ Asp.	− Asp.	+ Asp.	− Asp.	+ Asp.	− Asp.	+ Asp.
1	*		*		*		*	
2		*		*		*		*
3		*		*		*		*
4		*		*		*		*
5		*	*			*	*	
6	*		*		*		*	
7	*		*		*		*	
8	*		*		*		*	
9	*		*		*		*	
10		*		*		*		*
11	*		*		*		*	
12	*		*		*		*	
13		*		*		*		*
14	*		*		*		*	
15	*		*		*		*	
16	*		*		*		*	
17		*		*		*		*
18		*		*		*		*
19		*		*		*		*
20		*		*		*		*

* = agreement of independent reviewers.

[16–19]. The added variable of a tracheotomy in elderly patients may increase the risk of aspiration. Particular care, therefore, should be taken when assessing dysphagia and making recommendations for oral feeding in the elderly, tracheotomized individual.

Unlike the swallowing rehabilitation recommended for head and neck surgical patients with a tracheotomy tube, i.e., occluding the tube during the swallow to decrease incidence of aspiration [11–13], non-head and neck surgical patients did not benefit from occlusion of the tracheotomy tube during swallowing. The focus with the latter patients should be on traditional dysphagia rehabilitation strategies, that is, bolus consistency, and swallowing steps—swallow—clear throat—swallow again, and aspiration precautions—eat sitting up at 90°, small bolus sizes, chin tuck posture, and clearing oral cavity completely before next bolus, to decrease risk of aspiration when dysphagia is exhibited.

Although laryngeal motor function exhibits some return following 3 min of tracheotomy tube occlusion [1], what is not known is the length of time a tracheotomy tube needs to be occluded before laryngeal motor function returns to normal. It may be that "short-term" tracheotomy tube occlusion is not as effective as "long-term" occlusion for return of normal laryngeal functioning. (Both short- and long-term need to be carefully defined and investigated in future studies.) There is, however, evidence that partially reinstating the integrity of the normally closed aerodigestive tract decreases aspiration [20–23]. That is, a one-way tracheotomy speaking valve attached to the hub of a tracheotomy tube, either cuffless or with a deflated cuff, permits inspiration through the tube, but upon exhalation the tube is blocked and air must exit through the larynx and out the mouth or nose [24]. It is not known if valve use decreases the risk of aspiration before, during, or after the swallow. It may be that expired air directed through the larynx and oropharynx allows for maintenance of upper airway clearance and decreases the risk of aspiration after the swallow by allowing a cough to remove any residual supraglottic bolus.

It has been postulated that by occluding the tracheotomy tube, thereby directing airflow through the larynx, the potential exists to allow for normalization of subglottic pressures, to improve true vocal fold adduction during swallowing, and therefore, to decrease risk of aspiration [1,4,12,13,25,26]. It would be of interest to investigate this hypothesis using pharyngeal manometry to measure pharyngeal pressure differences, if any, in tracheotomized patients swallowing with an occluded and an unoccluded tracheotomy tube.

Acknowledgment. This research was supported, in part, by the McFadden, Harmon, and Mirikitani Endowments.

References

1. Buchwalter JA, Sasaki CT: Effect of tracheotomy on laryngeal function. *Otolaryngol Clin North Am 17:*41–48, 1984
2. Nash M: Swallowing problems in the tracheotomized patient. *Otolaryngol Clin North Am 21:*701–709, 1988
3. Sasaki CT, Fukuda H, Kirchner JA: Laryngeal abductor activity in response to varying ventilatory resistance. *Trans Am Acad Opthalmol Otolaryngol 77:*403–410, 1973
4. Sasaki CT, Suzuki M, Horiuchi M, Kirchner JA: The effect of tracheostomy on the laryngeal closure reflex. *Laryngoscope 87:*1428–1433, 1977
5. Kremen AJ: Cancer of the tongue—a surgical technique for a primary combined en bloc resection of tongue, floor of mouth, and cervical lymphatics. *Surgery 30:*227–240, 1951
6. Feldman SA, Deal CW, Urquhart W: Disturbance of swallowing after tracheostomy. *Lancet 1:*954–955, 1966
7. Bonanno PC: Swallowing dysfunction after tracheostomy. *Ann Surg 174:*29–33, 1971
8. Robbie DS, Feldman SA: Experience with fifty patients treated with artificial ventilation. *Br J Anaesth 35:*771–782, 1963
9. Betts RH: Post-tracheostomy aspiration. *N Eng J Med 273:*155, 1965
10. Muz J, Mathog RH, Nelson R, Jones LA: Aspiration in patients with head and neck cancer and tracheostomy. *Am J Otolaryngol 10:*282–286, 1989
11. Muz J, Hamlet S, Mathog R, Farris R: Scintigraphic assessment of aspiration in head and neck cancer patients with tracheostomy. *Head Neck 16:*17–20, 1994
12. Logemann JA: *Evaluation and Treatment of Swallowing Disorders.* San Diego: College-Hill Press, 1983
13. Logemann JA: *Manual for the Videofluorographic Study of Swallowing,* 2nd ed. Austin: Pro-Ed, 1993
14. Cameron JL, Reynolds J, Zuidema GD: Aspiration in patients with tracheostomies. *Surg Gynecol Obstet 136:*68–70, 1973
15. Jaradeh S: Neurophysiology of swallowing in the aged. *Dysphagia 9:*218–220, 1994
16. Sheth N, Diner WC: Swallowing problems in the elderly. *Dysphagia 2:*209–215, 1988
17. Feinberg MJ, Knebl J, Tully J, Segall L: Aspiration and the elderly. *Dysphagia 5:*61–71, 1990
18. Logemann JA: Effects of aging on the swallowing mechanism. *Otolaryngol Clin North Am 23:*1045–1056, 1990
19. Ergun GA, Miskovitz PF: Aging and the esophagus: common pathologic conditions and their effect upon swallowing in the geriatric population. *Dysphagia 7:*58–63, 1992
20. Siebens AA, Tippett DC, Kirby N, French J: Dysphagia and expiratory air flow. *Dysphagia 8:*266–269, 1993
21. Stachler RJ, Hamlet SL, Choi J, Fleming SM: Scintigraphic quantification of aspiration reduction with the Passy-Muir valve. *Otolaryngol Head Neck Surg 111(2):*P132, 1994
22. Dettelbach MA, Gross RD, Mahlmann J, Eibling DE: The effect of the Passy-Muir valve on aspiration in patients with tracheostomy. *Head Neck 17:*297–302, 1995
23. Lichtman SW, Birnbaum IL, Sanfilippo MR, Pellicone JT, Damon WJ, King ML: Effect of a tracheostomy speaking valve on secretions, arterial oxygenation, and olfaction: a quantitative evaluation. *J Speech Hear Res 38:*549–555, 1995
24. Leder SB: Perceptual rankings of speech quality produced with one-way tracheostomy speaking valves. *J Speech Hear Res 37:*1308–1312, 1994
25. Gilbert RW, Bryce DP, McIlwain JC, Ross IR: Management of patients with long-term tracheotomies and aspiration. *Ann Otol Rhinol Laryngol 96:*561–564, 1987
26. Gross RD, Dettelbach MA, Eibling DE: Measurement of subglottic air pressure during swallowing in a patient with tracheostomy. *Otolaryngol Head Neck Surg 111(2):*P133, 1994