

Effect of a One-Way Tracheotomy Speaking Valve on the Incidence of Aspiration in Previously Aspirating Patients with Tracheotomy

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Abstract. The purpose of the present study was to investigate the incidence of aspiration in previously aspirating patients with tracheotomy after use of a one-way tracheotomy tube speaking valve. Twenty consecutive inpatients from the acute care setting of a large urban tertiary care teaching hospital were included. All subjects had objective documentation of aspiration by a fiberoptic endoscopic evaluation of swallowing prior to placement of a one-way tracheotomy speaking valve, from 2 to 7 days of valve use with intelligible speech production, and no surgery to the upper aerodigestive tract except tracheotomy. Results indicated that incidence of aspiration was not affected by use of a one-way tracheotomy speaking valve. These results are in agreement with previous observations that subjects either aspirated or swallowed successfully regardless of tracheotomy tube occlusion status. Also, no significant differences were found between aspiration status and time since tracheotomy, time off ventilator, or duration of valve use. It was concluded that use of a one-way speaking valve provided mostly nondeglutitive benefits and should not be considered to promote successful swallowing for patients with tracheotomy in the acute care setting.

Key words: Aspiration — Silent aspiration — Tracheotomy — Tracheotomy tube — Speaking valve — Fiberoptic endoscope — Dysphagia — Deglutition — Deglutition disorders.

Aspiration in patients requiring tracheotomy due to head and neck cancer, trauma, or respiratory failure is of major concern [1,2], with an incidence of aspiration reported to range as high as 50–87% [3–6]. Thus, manage-

ment of aspiration is a primary goal in treating patients with both acute [1,2] and long-term [7,8] tracheotomy.

One strategy used to promote successful swallowing involves occluding the tracheotomy tube, thereby reinstating the normally closed aerodigestive system [1]. There is controversy, however, regarding whether tracheotomy tube occlusion affects incidence of aspiration. It was shown that in the acute care setting the occlusion status of the tracheotomy tube did not affect the incidence of aspiration for both medical [1] and head and neck cancer [2] patients. Specifically, all subjects either aspirated or swallowed successfully regardless of tracheotomy tube occlusion status, i.e., no subject aspirated first with an unoccluded tube and then did not aspirate when the tube was occluded or vice-versa.

Conversely, in an effort to improve the swallowing abilities of individuals who required long-term tracheotomy, it was reported that occluding the tracheotomy tube with a plug [9,10] or one-way tracheotomy speaking valve [11–13] either decreased or eliminated aspiration during swallowing [9–13]. The physiologic mechanism(s) for this improvement is unknown [10], but it was suggested that subglottic air pressure played a role [12]. That is, occlusion of the tracheotomy tube allowed for increased subglottic air pressure, which permitted a more normal swallowing environment [12]. Swallowing dysfunction and aspiration, however, may persist after decannulation [8], indicating that variables other than subglottic air pressure may be of importance for swallowing success.

The impetus for the present study was the conflicting reports concerning the importance of tracheotomy tube occlusion status on swallowing abilities and especially how occlusion status affects aspiration. It was hypothesized that the incidence of aspiration in individuals with tracheotomy who were previously shown to aspirate would not be effected by the subsequent use of a one-way tracheotomy tube speaking valve.

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Methods

Subjects

Twenty consecutive inpatients from the acute care setting of a large urban tertiary care teaching hospital were included (Table 1). There were 14 men (mean age = 66 years) and six women (mean age = 72 years). Time since tracheotomy was 18.5 days (range = 4–49 days), time off ventilator was 3.3 days (range = 2–8 days), and duration of one-way tracheotomy speaking valve use was 3.9 days (range = 2–7 days).

Patient selection criteria were (a) tracheotomy and placement of a plastic tracheotomy tube, (b) nonventilator dependence, (c) objective documentation of aspiration by fiberoptic endoscopic evaluation of swallowing (FEES) [14,15] prior to placement of one-way tracheotomy speaking valve, (d) no prior use of a speaking valve, (e) ability to tolerate placement of one-way valve without oxygen desaturation, (f) at least 2 days use of one-way valve with intelligible speech production, (g) no motor speech disorders, and (h) no surgery to the upper aerodigestive tract except tracheotomy.

Equipment

Equipment consisted of one-way tracheotomy speaking valves (Passy-Muir, PMV-005) that permit inspiration through the tube, but with expiration the tube is blocked and air must exit through the larynx and upper airway [16–18]; 3.6-mm-diameter flexible fiberoptic rhinolaryngoscope (Olympus, ENF-P3); endoscope sheaths (Smith-Nephew Richards); light source (Olympus, CLK-4); camera (ELMO, MN401E); and color monitor (Magnavox, RJ4049WA01).

Procedures

Aspiration was defined as the entry of material into the airway below the true vocal folds [19] and can be of two types: overt, as demonstrated by coughing or choking, and silent, without any external behavioral signs [20]. Aspiration was objectively documented prior to one-way valve placement with a FEES [14,15]. Approximately 5 ml (1 teaspoon) of a blue-dyed puree bolus were given first, followed by 5 ml of a blue-dyed liquid bolus, if indicated. All FEES evaluations were done at bedside, with the patient in an upright position and without administration of topical anesthesia to the nasal mucosa, thereby eliminating any potential adverse anesthetic reactions and ensuring a reliable physiologic evaluation [21]. The tracheotomy tube cuff was always deflated during all FEES evaluations.

After 2–7 days of one-way valve use, a second FEES was done with the one-way valve on to assess aspiration status. If aspiration was observed again, the examination was stopped. If no aspiration occurred, the one-way valve was removed, and a third FEES was performed immediately to assess aspiration status.

Results

All subjects were grouped by aspiration status following one-way valve use. Student's *t* tests showed no significant differences ($p > 0.05$) regarding time since tracheotomy for aspiration (mean = 12.6 days) versus no aspiration (mean = 16.9 days), time off ventilator for aspiration (mean = 3.5 days) versus no aspiration (mean

= 3.0 days), and duration of one-way valve use for aspiration (mean = 3.9 days) versus no aspiration (mean = 3.9 days).

Table 2 shows aspiration results from the initial, pre-one-way valve FEES evaluation and post-one-way valve FEES evaluations performed with and then without one-way valve placement. Thirteen subjects who aspirated on the initial, pre-one-way valve FEES aspirated again with one-way valve use. Seven subjects did not aspirate with one-way valve use, and all seven did not aspirate when the one-way valve was removed. These subjects were started successfully on an oral diet.

Three subjects (nos. 10, 14, and 15) were able to be evaluated after continued valve use. Subject 10 was evaluated after 7 and 19 days of one-way valve use, with aspiration observed at both times. Subjects 14 and 15 were evaluated after 11 and 41 days, respectively, of valve use, and no aspiration was observed for the with and without valve use conditions.

Silent aspiration occurred in 11 of 13 (85%) subjects who aspirated pre-one-way valve use. Seven of seven (100%) subjects who aspirated silently pre-one-way valve use also aspirated silently with one-way valve use, whereas three of four (75%) subjects who aspirated silently pre-one-way valve use did not aspirate with valve use.

Discussion

Consistent with results of previous reports on aspiration status of both medical and head and neck cancer patients with tracheotomy in the acute care setting [1,2], incidence of aspiration was not affected by occlusion status of the tracheotomy tube by a one-way speaking valve. That is, subjects either continued to aspirate with valve use or did not exhibit aspiration for the valve-on and valve-off conditions.

Unlike previous studies that have reported on selected subjects [9,11,12], the present study followed 20 consecutive subjects who used a one-way speaking valve for the first time. If no aspiration was observed with valve use on the second FEES, a third FEES was done immediately with the valve off to determine whether valve use influenced aspiration status. In all cases, no aspiration was observed, indicating that valve use per se was not the critical variable necessary to eliminate aspiration.

An opportunity to evaluate longer-term valve use was provided by three subjects. Consistent with short-term valve use, i.e., 2–7 days, these subjects did not exhibit any differences regarding incidence of aspiration dependent on 11, 19, or 41 days of valve use. This result

Table 1. Subject characteristics

Subjects ^a /gender	Age (yr)	Diagnosis/procedure	Time since tracheotomy (days)	Time off ventilator (days)	Duration of one-way valve use (days)
1/M	70	Left nephrectomy/ARDS ^b	25	2	4
2/M	77	Thoracic aortic aneurysm repair/postoperative CVA ^c	14	1	3
3/M	62	Legionaire's disease	10	2	4
4/F	81	Respiratory failure	19	Daytime trials	3
5/M	77	Right hemicolectomy	42	1	5
6/F	72	Adult-onset diabetes mellitus/gastroparesis	21	4	2
7/M	50	Left frontal intracranial hemorrhage	6	2	2
8/F	81	Left cerebrovascular accident	18	4	3
9/M	78	Perforated duodenal ulcer repair; respiratory failure	6	4	4
10/M	51	Adenocarcinoma; esophagectomy	17	7	3
11/M	69	Motor vehicle crash	13	8	2
12/M	62	Motor vehicle crash	12	2	6
13/F	53	ARDS	14	3	7
14/M	44	Motor vehicle crash	49	2	6
15/M	78	Incarcerated hernia repair	31	3	3
16/M	45	Motor vehicle crash	28	6	4
17/F	78	Colon cancer resection; COPD ^d	29	3	4
18/M	77	Small bowel resection	5	2	5
19/M	86	Motor vehicle crash	4	2	3
20/F	68	Respiratory failure	6	5	4
Mean					
M	66		18.5	3.3	3.9
F	72				

^a*n* = 14 men, six women.

^bARDS = acute respiratory distress syndrome.

^cCVA = cerebrovascular accident.

^dCOPD = chronic obstructive pulmonary disease.

corroborates the finding that valve use was not the critical variable for facilitation of a successful swallow.

One-way valve use has provided mostly nondeglutitive benefits for the patient with a tracheotomy, including expiratory airflow through the larynx allowing for reinstatement of laryngeal abductor and adductor reflexes [22,23], decreased amounts of upper airway secretions [17,24], better clearing of any pharyngeal or laryngeal residue after the swallow [10,25], enhanced olfaction [24], and renewed ability for both a productive volitional cough and verbal communication [1,16–18].

Potential key factors allowing for eventual swallowing success were objective identification of aspiration [20] and appropriate oral or nonoral feeding recommendations [26]. If oral feeding was recommended, dysphagia rehabilitation strategies were implemented to prevent prandial aspiration [1,2]. Also, the patient's medical status, functional abilities and orientation [26], nutritional requirements [27], and changes in systemic factors [28] were monitored closely to assess the effects of renewed oral intake.

Although the present study did not quantify amount of aspiration, the findings are in agreement with

those of a study that used scintigraphy to quantify aspiration in head and neck cancer patients with long-term tracheotomy. It was reported that all subjects aspirated both with and without speaking valve use, although amount of aspiration was less with the valve on [13]. It was not known whether this reduction in aspiration was enough to allow for resumption of oral feedings. In the present study, clinical judgment did not permit resumption of oral feeding in patients who continued to aspirate with valve use.

It was hypothesized that aspiration increased with an open tracheotomy tube because positive subglottic air pressure could not be generated [9]. Only preliminary data, however, were reported concerning the need for positive subglottic pressure to improve swallowing [12]. In contrast, in the canine model, positive intrathoracic pressure inhibited the glottal closure reflex [29]. Because the pulmonary system contains no valves and is inferior to the glottis, subglottic and intrathoracic air pressures are continuous and can be considered equivalent. Thus, it is counterintuitive that positive subglottic air pressure, which inhibits the laryngeal closure reflex, would improve swallowing in patients with tracheotomy [9,11–13].

Table 2. Aspiration results from the initial, pre–one-way valve FEES evaluation and post–one-way valve FEES evaluations performed with and without placement of the valve

Subject	Initial, pre–one-way valve FEES	FEES with one-way valve on	FEES with one-way valve off
1	Aspiration	Aspiration	Not done
2	Aspiration	Aspiration	Not done
3	Aspiration ^a	No aspiration	No aspiration
4	Aspiration ^{a,b}	Aspiration ^a	Not done
5	Aspiration ^a	No aspiration	No aspiration
6	Aspiration ^a	Aspiration ^a	Not done
7	Aspiration	No aspiration	No aspiration
8	Aspiration ^a	Aspiration ^a	Not done
9	Aspiration	Aspiration	Not done
10	Aspiration ^a	Aspiration ^a	Not done
		Aspiration ^a	Not done
		(7 days valve use)	
		Aspiration ^c	Not done
		(19 days valve use)	
11	Aspiration	No aspiration	No aspiration
12	Aspiration ^a	Aspiration ^a	Not done
13	Aspiration	No aspiration	No aspiration
14	Aspiration	Aspiration	Not done
		No aspiration	No aspiration
		(11 days valve use)	
15	Aspiration ^{a,b}	Aspiration ^a	Not done
		No aspiration	No aspiration
		(41 days valve use)	
16	Aspiration ^{a,b}	Aspiration ^a	Not done
17	Aspiration	No aspiration	No aspiration
18	Aspiration ^{a,b}	Aspiration ^d	Not done
19	Aspiration ^a	No aspiration	No aspiration
20	Aspiration ^b	Aspiration	Not done

FEES = fiberoptic endoscopic evaluation of swallowing.

^aSilent aspiration.

^bOnly puree consistency used secondary to severe aspiration.

^cDecannulation occurred 7 days prior to the third FEES and a 1–2-mm opening remained at the tracheotomy site.

^dCough reflex but inadequate to clear bolus from trachea.

Alternatively, it appears convincing that efficient bolus transport is due primarily to tongue driving force aided secondarily by a combination of clearing forces from contraction of the pharyngeal walls and pharyngeal shortening [30–33]. Subglottic air pressure, therefore, may not be a key component for success during the swallow, but positive subglottic pressure can aid in clearance of residual bolus from the upper airway, i.e., a cough, if necessary, after the swallow [10,16,17,24,25]. Although unreported, this may have contributed to the reduction in incidence and amount of aspiration noted in previous studies [11,13]. In addition, since the vocal folds are abducted before and after a swallow, when aspiration frequently occurs, subglottic air pressure does not play a role in these aspiration events.

It was reported that, although true vocal fold closure duration was shorter for patients with tracheotomy

than for normal controls, all patients with a tracheotomy achieved complete vocal fold adduction without aspiration during a water swallow [34]. Also, even the presence of vocal fold dysfunction in patients with tracheotomy did not result in significantly higher amounts of aspiration [13]. Therefore, reduced closure duration or vocal fold dysfunction still allowed for an adequate approximation of the normally closed aerodigestive system [1]. Factors other than positive subglottic air pressure, e.g., delayed triggering of the swallow reflex, base of tongue dysfunction, and weak pharyngeal swallow, may predispose patients with tracheotomies to aspirate.

Because during a swallow the true vocal folds adduct regardless of tracheotomy tube occlusion status [34] and the closed glottis is superior to the open tracheotomy site, occluding the tracheotomy tube may be of secondary importance in approximating the closed aerodigestive system. What is of primary importance is tongue driving force accompanied by pharyngeal shortening and contraction [30–33]. Research using pharyngeal and esophageal manometry is currently underway to investigate whether there are specific areas of pressure changes during swallowing in both aspirating and non-aspirating patients with tracheotomy.

It was not known whether laryngeal reflexes were intact in all subjects. It has been reported that long-term tracheotomy results in diminished and eventual loss of abductor (posterior cricoarytenoid muscle) activity [22] and a weakened, poorly coordinated laryngeal closure (thyroarytenoid muscle) response [35]. The laryngeal closure reflex in different populations, including patients with tracheotomy and ventilator dependency, needs to be investigated with the FEES with a sensory testing technique [36].

Conclusions

A one-way tracheotomy speaking valve, although providing nondeglutitive benefits, did not prevent aspiration in previously aspirating patients with tracheotomy in an acute care setting. Factors other than tracheotomy tube occlusion status may predispose patients with tracheotomy to aspirate. Further research is needed to investigate the laryngeal closure reflex and pharyngoesophageal pressure changes during swallowing in both aspirating and nonaspirating patients with tracheotomy.

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