

## Videofluoroscopic Predictors of Aspiration in Patients with Oropharyngeal Dysphagia

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**Abstract.** The purpose of this investigation was to determine the relationship between aspiration and seven other variables indicative of pharyngeal stage dysphagia. Additionally, we looked at the relationship between aspiration and oral stage dysphagia. Multiple logistic regression analysis identified five independent predictors of aspiration that were significant at the  $p = 0.05$  level: vallecular stasis, reduced hyoid elevation, deviant epiglottic function, diffuse hypopharyngeal stasis, and delayed initiation of the pharyngeal stage of the swallow. A linear trend was observed in that, as the severity of vallecular stasis, pyriform sinus stasis, diffuse hypopharyngeal stasis, or delayed initiation of the pharyngeal stage of the swallow increased, the proportion of patients who aspirated also increased. A stepwise logistic regression model furnished estimates of the odds ratio for each independent variable and can be used by clinicians to calculate the risk of aspiration in patients who demonstrate pharyngeal stage dysphagia.

**Key words:** Oropharyngeal — Dysphagia — Aspiration — Deglutition — Deglutition disorders.

Passage of a food or liquid bolus through the pharynx without penetration into the trachea is an important factor in successful swallowing. When penetration of the vocal folds (aspiration) occurs, an individual is at risk for a variety of pulmonary complications [1–5].

At this time, the gold standard for evaluation of

disordered oropharyngeal swallowing (dysphagia) is the videofluoroscopic examination (VFE) [6]. The primary advantage of the VFE is that it permits assessment of the dynamic aspects of swallowing as well as often identifying the underlying cause(s) of aspiration. Although it is easy to observe swallowing events with VFE, interpretation requires knowledge and experience. As the relationships among many of the variables that are assessed during VFE are better understood, our ability to interpret the VFE results will improve.

Clinical observations while performing videofluoroscopic examinations of oropharyngeal swallowing function have suggested that, when food or liquid penetrates the vocal folds, other indicators of oropharyngeal dysphagia are often present. Consequently, the ability to recognize the risk factors associated with aspiration will be useful to clinicians who are attempting to devise treatment plans.

The purpose of this investigation was to determine the relationship between aspiration and seven other variables indicative of pharyngeal stage dysphagia. Those variables were vallecular stasis, pyriform sinus stasis, diffuse hypopharyngeal stasis, reduced hyoid elevation, reduced laryngeal elevation, deviant epiglottic function, and delayed initiation of the pharyngeal stage of the swallow. Additionally, we looked at the relationship between aspiration and oral stage dysphagia. A model based on the statistical relationships was developed.

### Methods

#### *Patients and Procedure*

Videotapes of 330 patients who had been referred for videofluoroscopic evaluation of swallowing dysfunction were reviewed. The patients

This work was conducted while all authors were at the VA Medical Center, Iowa City, Iowa, USA.

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ranged in age from 23 to 95 with a mean age of 66 years. Patients who had no initiation of the pharyngeal response and patients who had undergone surgical procedures that involved removal of the epiglottis or hyoid bone were not included in the study.

Of these 330 patients, 101 (30.6%) had a primary diagnosis of cerebrovascular accident, 58 (17.6%) had a primary diagnosis of oral, pharyngeal, and/or laryngeal cancer (excluding total laryngectomy and supraglottic laryngectomy), 34 (10.3%) had a primary diagnosis of neurological disease other than Parkinson's disease, and 21 (6.4%) had a primary diagnosis of Parkinson's disease. Fifteen (4.6%) patients with diagnoses of gastrointestinal disease had been referred because they also complained of pharyngeal dysphagia. Six patients had suffered a closed head injury (CHI) (1.8%), and 5 patients (1.5%) were referred for evaluation because they had a history of aspiration pneumonia. Forty-three (13.0%) patients comprised a category we called "other." This group had a compilation of primary diagnoses where some link could be made to dysphagia, but where the group numbers were too small (<5) to keep them as separate categories. Finally, 47 (14.2%) patients fell into an "unknown" category; that is, they had a complaint of dysphagia, but their primary diagnosis seemed unrelated to their swallowing problem.

Because many of the patients had been evaluated more than once, only the first examination of each patient was included in the data base. All swallows performed by a patient were evaluated. Most patients had at least 6 swallows to evaluate; however, the range was between 3 and 10 swallows.

Two speech pathologists who had extensive experience in the diagnosis and management of dysphagia (ALP and JPG) reviewed each videotape. Frame by frame and slow motion analysis of each swallow was performed. In those instances where there was disagreement, the tape was reviewed until consensus was reached. Except for aspiration, if a variable was present in at least two of the swallows, it was considered present. If aspiration was visible in one swallow, it was considered present.

The two speech pathologists independently rated 33 patients post hoc for the presence or absence of each of the variables during each bolus swallow. A total of 261 bolus swallows were evaluated. Percent agreement was calculated for each variable. Reliability tests performed on each variable resulted in high levels of agreement ranging from 100% on aspiration and 94% on reduced laryngeal elevation, to the lowest value of 70% for reduced hyoid elevation. All other values ranged from 82% to 88% agreement.

### *Definitions of Variables*

#### **Vallecular Stasis (VS)**

Vallecular stasis was considered present when barium remained in one or both of the vallecular spaces after the swallow or series of swallows executed with each bolus. Severity of the stasis was rated on a scale of 1–3 where 1 represented mild stasis and 3 represented severe vallecular stasis.

#### **Pyriiform Sinus Stasis (PSS)**

Pyriiform sinus stasis was considered present when barium remained in one or both of the pyriiform sinuses after the swallow or series of swallows executed with each bolus. Severity of the stasis was rated on a scale of 1–3 where 1 represented mild stasis and 3 represented severe pyriiform sinus stasis.

#### **Diffuse Hypopharyngeal Stasis (DHS)**

Diffuse hypopharyngeal stasis was considered present when barium remained in the valleculae, pyriiform sinuses, and on the walls of the

hypopharynx after the swallow or series of swallows executed with each bolus. Severity of the stasis was rated on a scale of 1–3 where 1 represented mild stasis and 3 represented severe hypopharyngeal stasis.

#### **Deviant Epiglottic Function (DEF)**

We have previously described four types of epiglottic function that deviate from the description of the normal position or motion during swallowing [7]: (1) no epiglottic movement, 2) incomplete inversion, 3) prolonged inversion, and, 4) inability to visualize the valleculae because the base of tongue (BOT) approximates the epiglottis.

#### **Reduced Hyoid Elevation (RHE)**

The presence of hyoid elevation was rated by observation of swallows recorded in the lateral plane. Hyoid elevation was considered reduced (RHE) if both speech pathologists agreed that there was limited superior movement and/or anterior motion of the hyoid during the swallow. Movement was treated as a dichotomous variable and rated as either present or absent.

#### **Reduced Laryngeal Elevation (RLE)**

The presence of laryngeal elevation was rated by observation of swallows recorded in the lateral plane. Laryngeal elevation was considered reduced (RLE) if both speech pathologists agreed that the larynx did not ascend during the swallow. Therefore, laryngeal elevation was treated as a dichotomous variable and rated as either present or absent.

#### **Delayed Initiation of the Pharyngeal Stage of Swallow (DPS)**

The swallow was considered delayed when the first swallow of a bolus did not trigger within a minimum of 1 sec after barium entered the valleculae. Severity of the delay was rated on a scale of 1–3 where 1 represented mild delay (>1 but <2 sec) and 3 represented a severe delay (>5 sec). A time-date generator (FOR-A) had been used during the recording process, and measures were made from the times marked on the video frames.

#### **Oral Involvement**

The presence of oral involvement implied that the patient exhibited one or more of the following during videofluoroscopic examination: inadequate lip closure demonstrated by drooling; poor mastication characterized by absence of the rotary component of chewing, slow labored chewing, jaw misalignment during chewing, or the inability to chew; incomplete tongue-to-palate contact visualized on the video tape; decreased anterior/posterior tongue movement visualized on videotape; tongue thrust characterized by interdental, anterior movement of the tongue during the oral preparatory and/or oral transport phases; oral stasis characterized by residual barium in the anterior and/or lateral oral sulci or on the tongue; incomplete or uncoordinated velopharyngeal closure visualized on videotape; absence of oral preparation characterized by no visible tongue motion; poor bolus formation characterized by inability to form a cohesive bolus or prolonged preparation of a bolus for the swallow; adherence to the hard palate as observed on videotape; tongue pumping characterized by pressing of the tongue against the teeth or palate multiple times preceding the swallow; piecemeal swallow characterized by two or more swallows in order to empty the mouth of the bolus; nasal regurgitation characterized by barium entering the nasopharynx; or tremor of oral structures visualized on videotape. For the purposes of this study, oral involvement was treated as a dichotomous variable and rated as either present or absent.

### Statistical Analysis

The relationships between each of the independent variables and aspiration, and between pairs of independent variables were examined with Chi-square tests of independence. Next, logistic regression was used to identify which independent variables were the strongest predictors of aspiration. Logistic regression is a multivariate approach to modeling a dichotomous dependent variable, such as aspiration (present/absent), in which the probability of aspiration is expressed as a function of a group of independent variables [8].

In this regression model, the coefficients are the log odds ratios in which the odds ratio expresses the relative odds of aspiration associated with the presence of an independent variable compared with the odds of aspiration associated with its absence. This relative risk model allows us to identify which independent variables significantly increase the risk of aspiration when controlling for the other variables in the model. A stepwise approach to identifying significant independent variables was used, with a  $p$ -value criteria of 0.05 for a variable to enter the model. The overall fit of the model was examined.

### Results

Of the 330 patients, 129 (39.1%) exhibited aspiration during their examination. Of these 129 patients, 80% had some form of deviant epiglottic function, 80% had valvular stasis, 66% had at least one form of oral stage involvement, 57% had delayed initiation of the pharyngeal stage of the swallow, 57% had pyriform sinus stasis, 48% exhibited diffuse hypopharyngeal stasis, 34% had reduced hyoid elevation, and 18% had reduced laryngeal elevation. A breakdown of the percent of aspiration for each diagnostic category is shown in Table 1. Table 1 also shows the breakdown of the percent of each of the other variables by diagnostic category.

All patients who had experienced a closed head injury were found to aspirate. Other categories where over 50% of the patient's exhibited aspiration included aspiration pneumonia (60%), subcortical stroke (87.5%), and surgery for head and neck cancer. The worst outcome for cancer patients occurred among those who had undergone surgery to the anterior floor of mouth; 90% of that group aspirated during their first examination.

In order to test for the association between aspiration and each independent variable, pairwise Chi-square tests of independence were performed. These tests showed that each independent variable was strongly associated with the presence of aspiration (Table 2). Of patients with valvular stasis, 50% were found to aspirate compared with 21.0% of those without valvular stasis ( $p < 0.001$ ). Similarly, 50% of those patients with a delay in initiating the pharyngeal stage of the swallow were found to aspirate, whereas aspiration was observed in only 30% of those patients with no delay ( $p = 0.002$ ). Of those patients with reduced laryngeal elevation, 82.1% had aspirated whereas only 35.1% of those with normal laryngeal elevation were observed to aspirate

( $p < 0.001$ ). Similarly, 71% of patients with reduced hyoid elevation aspirated compared with 31.7% of patients with normal hyoid elevation ( $p < 0.001$ ). Of those patients with diffuse hypopharyngeal stasis, 63.3% aspirated compared with 28.9% without diffuse hypopharyngeal stasis ( $p > 0.001$ ). Of those patients with some form of oral involvement, 46.7% aspirated compared with 29.7% of those without any oral problems ( $p = 0.002$ ).

We found that the relationship between deviant epiglottic function and aspiration varied by type of dysfunction. Overall, 55.9% of the patients with deviant epiglottic function were found to aspirate whereas only 17.8% of those with normal epiglottic function experienced aspiration during examination. Patients who demonstrated the radiographic finding of obliteration of the valleculae because the base of tongue approximated the epiglottis were most likely to aspirate (66.7%); they were closely followed by patients with no epiglottic inversion (64.5%). Those with incomplete inversion (47.3%) and prolonged inversion of the epiglottis (38.5%) were more likely to aspirate than those with normal epiglottic function (17.8%).

A linear trend was observed within each of the ordinal variables, valvular stasis, pyriform sinus stasis, hypopharyngeal stasis, and delayed initiation of the pharyngeal stage of the swallow. Specifically, increasing severity of the condition was associated with increased proportions of patients with aspiration.

Although oral stage dysphagia was treated as a dichotomous variable for the overall model, we did break it down to determine which specific problems were associated with aspiration. This analysis was independent of the overall model. We found that statistical significance was present between aspiration and drooling ( $p = <0.001$ ), incomplete tongue-palate contact ( $p = 0.001$ ), tongue pumping ( $p = 0.013$ ), poor bolus formation ( $p = 0.016$ ), oral stasis ( $p = 0.007$ ), nasal reflux ( $p = 0.042$ ), uncoordinated velopharyngeal function ( $p = 0.48$ ), and piecemeal swallowing ( $p = 0.049$ ). Variables not significantly related to aspiration were absence of bolus preparation ( $p = 0.836$ ), poor mastication ( $p = 0.715$ ), adherence to the hard palate ( $p = 0.2899$ ), decreased anterior-posterior tongue movement ( $p = 0.131$ ), and incomplete velopharyngeal closure without nasal regurgitation ( $p = 0.067$ ). It is likely that the absence of bolus preparation was not found to be significant, because such a severe oral impairment generally resulted in short studies where the examiner cleared the patient's mouth of barium. Most of those patients swallowed very small amounts of each bolus.

The stepwise logistic regression model identified five independent variables as significantly associated with the risk of aspiration while controlling for the presence of each other and the remaining independent vari-

**Table 1.** Percent of aspiration for each diagnostic category

Disease category	Percent					
	N	ASP	DPS	PSS	HPS	RLE
Asp. Pneum.	5	60.0	60.0	80.0	40.0	60.0
CHI	6	100.0	100.0	66.7	33.3	16.7
CVA	101	39.6	44.0	39.6	32.6	17.8
Brainstem	12	25.0	50.0	41.7	25.0	8.3
Left	39	35.9	56.4	41.0	18.0	7.7
Other	16	43.8	68.8	50.0	50.0	12.5
Right	26	38.5	38.5	30.8	38.5	11.5
Subcort	8	75.0	87.5	37.5	62.5	0.0
Ca	58	69.0	34.5	53.4	51.7	47.5
BOT	14	78.6	57.1	57.1	57.1	78.6
FOM	10	90.0	40.0	60.0	60.0	80.0
Glossec	6	83.3	16.7	83.3	66.7	100.0
Hemilaryn	5	60.0	0.0	20.0	40.0	40.0
Other	13	61.5	46.2	38.5	30.8	69.2
XRT only	10	40.0	10.0	60.0	60.0	20.0
GI	15	6.7	40.0	33.3	6.7	0.0
Neuro/Other	34	32.4	35.3	41.2	26.5	8.8
Neuro/Parkin	21	28.6	42.9	33.3	19.1	0.0
Other	43	34.9	46.5	34.9	25.6	11.6
Unknown	47	14.9	29.8	25.5	12.8	6.4
Total	330	39.1%	44.2%	40.0%	29.7%	18.8%

Disease category	Percent				
	N	VS	DEF	ORAL	RHE
Asp Pneum.	5	100.0	80.0	80.0	60.0
CHI	6	83.3	66.7	50.0	16.7
CVA	101	57.4	51.5	61.4	8.9
Brainstem	12	41.7	25.0	41.7	8.3
Left	39	59.0	59.0	69.2	7.7
Other	16	62.5	56.3	62.5	12.5
Right	26	53.9	46.2	57.7	11.5
Subcort	8	75.0	62.5	62.5	0.0
Ca	58	84.5	84.5	70.7	65.5
BOT	14	92.9	100.0	92.9	78.6
FOM	10	70.0	70.0	80.0	80.0
Glossec	6	83.3	66.7	100.0	100.0
Hemilaryn	5	40.0	60.0	20.0	40.0
Other	13	92.3	92.3	69.2	69.2
XRT only	10	100.0	90.0	40.0	20.0
GI	15	33.3	33.3	40.0	0.0
Neuro/Other	34	61.8	52.9	44.1	8.8
Neuro/Parkin	21	76.2	52.4	71.4	0.0
Other	43	60.5	48.8	51.2	11.6
Unknown	47	44.7	42.6	29.8	6.4
Total	330	62.4%	55.8%	55.2%	18.8%

BOT = base of tongue cancer; FOM = floor of mouth cancer; CHI = closed head injury; CVA = cerebrovascular accident; ASP = aspiration; DPS = delayed; initiation of pharyngeal stage of swallow; PSS = pyriform sinus stasis; HPS = diffuse hypopharyngeal stasis; RLE = reduced laryngeal elevation, VS = vallecular stasis; DEF = deviant epiglottic function; ORAL = oral involvement; RHE = reduced hyoid elevation.

ables (Table 3). Deviant epiglottic function was specified as a variable indicating the presence of any kind of epiglottic dysfunction. The remaining significant variables were delayed initiation of the pharyngeal stage of the swallow (specified as an interval variable from 0 to 3), hypopharyngeal stasis (an interval variable from 0 to 3),

vallecular stasis (an interval variable from 0 to 3), and reduced hyoid elevation (present/absent). There was ample evidence that this model provided an adequate fit to the observed data.

Further exploratory logistic regression analysis indicated that if vallecular stasis was not included as an

**Table 2.** The relationship between aspiration and all other variables assessed by videofluoroscopy

Total no. patients observed with this variable	No. & (%) who aspirated
<b>Delayed initiation of the swallow</b> ( <i>P</i> = 0.002) <sup>a</sup>	
None	184 56 (30.4)
Mild	48 20 (41.7)
Moderate	34 19 (55.9)
Severe	64 34 (53.1)
<b>Pyriiform sinus stasis</b> ( <i>P</i> = 0.001) <sup>a</sup>	
None	198 56 (28.3)
Mild	78 34 (43.6)
Moderate	30 22 (73.3)
Severe	24 17 (70.8)
<b>Hypopharyngeal stasis</b> ( <i>P</i> < 0.001) <sup>a</sup>	
None	232 67 (28.9)
Mild	55 33 (60.0)
Moderate	29 19 (65.5)
Severe	14 10 (71.4)
<b>Vallecular stasis</b> ( <i>P</i> < 0.001) <sup>a</sup>	
None	124 26 (21.0)
Mild	84 27 (32.1)
Moderate	65 38 (58.5)
Severe	57 38 (66.7)
<b>Laryngeal elevation</b> ( <i>P</i> < 0.001) <sup>a</sup>	
Normal	302 106 (35.1)
Reduced	28 23 (82.1)
<b>Hyoid elevation</b> ( <i>P</i> < 0.001)	
Normal	268 85 (31.7)
Reduced	62 44 (71.0)
<b>Deviant epiglottic function</b> ( <i>P</i> < 0.001)	
Normal function	146 26 (17.8)
No movement	76 49 (64.5)
Incomplete	74 35 (47.3)
Prolonged	13 5 (38.5)
BOT approximates epiglottis	21 14 (66.7)
<b>Oral involvement</b> ( <i>P</i> = 0.002) <sup>a</sup>	
No	148 44 (29.7)
Yes	182 85 (46.7)
<b>Total</b>	<b>330 129 (39.1)</b>

<sup>a</sup>Chi-square test of independence.

independent variable, the relationship between aspiration and both pyriform sinus stasis and reduced laryngeal elevation became significant whereas the relationship between aspiration and reduced hyoid elevation was no longer significant. Other significant variables remained the same.

An analysis associating hyoid elevation and laryngeal elevation revealed that the likelihood of having reduced hyoid elevation in the presence of reduced laryn-

**Table 3.** Results of final logistic regression model for aspiration

Variable	Coefficient	S.E.	Odds ratio	<i>p</i> value
Delayed swallow	0.37	0.11	1.4	0.0012
Hypopharyngeal stasis	0.37	0.17	1.4	0.0300
Vallecular stasis	0.67	0.31	1.9	0.0300
Reduced hyoid elevation	1.32	0.35	3.7	0.0001
Deviant epiglottic function	1.48	0.30	4.4	0.0001

SE = standard error; odds ratio = exp (coefficient).

geal elevation was extremely high. Of 28 patients with reduced laryngeal elevation, 26 had reduced hyoid elevation. However, reduced hyoid elevation occurred even when reduced laryngeal elevation did not; of 62 patients with reduced hyoid elevation, 36 had normal laryngeal elevation.

The logistic regression model allows us to estimate the odds ratio (OR) for each independent variable by taking the exponent of the coefficient (Table 3), recalling that the coefficient is the model's estimate of the log odds ratio. Therefore, patients with deviant epiglottic function have over four times the risk of aspiration (OR = 4.0) compared with patients without DEF when controlling for the effects of the other variables in the model. Similarly, patients with reduced hyoid elevation have 3½ times the risk of aspiration compared with those with normal elevation of the hyoid.

The odds ratios for hypopharyngeal stasis, vallecular stasis, pyriform sinus stasis, and delayed initiation of the pharyngeal stage of the swallow depend upon the level of severity for these variables. To obtain the odds ratio, the coefficient for each variable is multiplied by the code for whether the condition is absent, mild, moderate, or severe (coded as 0, 1, 2, 3). Therefore, the OR for a patient with a moderate delay in initiation of the swallow is 2.1 (exp[0.37\*2]) compared with a patient with no delay in initiation of the pharyngeal stage of the swallow.

These estimates of the odds ratio described above reflect the odds of aspiration for single variables. From the model we can also calculate the increased risk for patients with two or more conditions. For example, the odds ratio for aspiration for a patient with deviant epiglottic function *and* reduced hyoid elevation would be calculated as exp(1.48 + 1.32) = 16.4. In other words, a patient with both conditions would be over 16 times as likely to aspirate as a patient with neither condition.

## Discussion

Clinical observation has suggested that aspiration is often accompanied by other indicators of oropharyngeal dysphagia. We were interested in finding out to what extent

these other symptoms of oropharyngeal dysphagia may be predictors of aspiration. The present study revealed that certain variables are strongly associated with aspiration and that there is a linear trend between the severity of certain variables and the likelihood of aspiration. These findings have profound clinical implications. In addition, the outcome of the logistic regression model for aspiration provided a means for predicting the relative likelihood of aspiration in patients with isolated or combined deviancies in the pharyngeal stage of swallowing.

The observation of aspiration during a VFE dysphagia evaluation is limited in part by the controlled conditions under which such evaluations are typically conducted, as well as by the constraints of the imaging technique. Consequently, it is possible that a patient in whom signs of oropharyngeal dysphagia other than aspiration are observed during a dysphagia evaluation may in fact be aspirating in natural eating situations. Also, some imaging techniques, such as ultrasound, do not provide a clear view of aspiration. Given the limitations inherent in testing situations and faced with the task of determining those patients who are most at risk for aspiration, the clinical importance of identifying variables that appear to be associated with aspiration is obvious.

Several critical findings with potential predictive value resulted from the present analysis. First, pairwise tests of independence revealed a linear trend between the incidence of aspiration and severity of four conditions, namely, vallecular stasis, pyriform sinus stasis, hypopharyngeal stasis, and delay in the initiation of the pharyngeal stage of the swallow. In other words, a patient with mild stasis is not much more likely to aspirate than a patient with no stasis, but a patient with severe stasis is very likely to aspirate. This finding confirms clinical intuition, but, more importantly, provides clinicians with an empirical basis upon which to develop feeding recommendations.

The stepwise logistic regression model distinguished five of the eight independent variables as being strongly associated with the risk of aspiration. These variables included delayed initiation of the pharyngeal stage of the swallow, moderate-to-severe hypopharyngeal stasis, moderate-to-severe vallecular stasis, and reduced hyoid elevation. In addition, when vallecular stasis was removed from the model, moderate-to-severe pyriform sinus stasis and reduced laryngeal elevation also proved to be significantly associated with aspiration, and the relationship between aspiration and reduced hyoid elevation was diminished. These model changes occurred largely because pyriform sinus stasis was very strongly associated with vallecular stasis ( $p < 0.001$ ),

and reduced laryngeal elevation was also strongly associated with vallecular stasis ( $p < 0.001$ ) and reduced hyoid elevation ( $p < 0.001$ ). Therefore, when vallecular stasis was included in the model, this variable accounted for much of the association between pyriform sinus stasis and reduced laryngeal elevation with aspiration.

These results suggest that moderate-to-severe pyriform sinus stasis and reduced laryngeal elevation are strong independent predictors of aspiration, but that the presence of moderate-to-severe vallecular stasis and reduced hyoid elevation are stronger. When the relationship between these latter two variables and aspiration is included in the model, pyriform sinus stasis and reduced laryngeal elevation have no independent effect.

In addition to identifying variables that were strongly associated with, and thus may be considered predictors of aspiration, the stepwise logistic regression model furnished estimates of the odds ratio for each independent variable (Table 3). The odds ratios reflect the odds of aspiration for individual variables, and can be used by clinicians to calculate the risk of aspiration in patients who demonstrate multiple aberrations or who demonstrate different severity levels on the ordinal variables. That is, on completion of the videofluoroscopic examination of swallowing function, a clinician who did not see aspiration during the examination, but who suspects that the patient is at risk for aspiration, can calculate that risk based upon a database of 330 patients. Thus, recommendations for nutritional intake can be made with greater confidence. In conclusion, this model provides clinicians with empirically derived information upon which to make therapy recommendations that are intended to reduce the possibility of aspiration.

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