

## ENDOSCOPIC AND VIDEOFUOROSCOPIC EVALUATIONS OF SWALLOWING AND ASPIRATION

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A new procedure for evaluating oropharyngeal dysphagia utilizing fiberoptic laryngoscopy was compared to the videofluoroscopy procedure. Twenty-one subjects were given both examinations within a 48-hour period. Results of the fiberoptic endoscopic evaluation of swallowing (FEES) and videofluoroscopy examinations were compared for presence or absence of abnormal events. Good agreement was found, especially for the finding of aspiration (90% agreement). The FEES was then measured against the videofluoroscopy study for sensitivity, specificity, positive predictive value, and negative predictive value. Sensitivity was 0.88 or greater for three of the four parameters measured. Specificity was lower overall, but was still 0.92 for detection of aspiration. It was concluded that the FEES is a valid and valuable tool for evaluating oropharyngeal dysphagia. Some specific patients and conditions that lend themselves to this procedure are discussed.

KEY WORDS — aspiration, deglutition disorders, diagnosis, fiberoptics, instrumentation, pharynx, radiology.

### INTRODUCTION

Otolaryngologists have become increasingly more involved in the diagnosis and treatment of patients with oropharyngeal dysphagia. When a patient's symptoms suggest difficulty with swallowing, the clinical examination will usually include indirect laryngoscopy or fiberoptic endoscopy. This is often followed by referral to radiologists and speech pathologists for a videofluoroscopic study, sometimes called the modified barium swallow study. This radiographic procedure has become the "gold standard" for assessment of oropharyngeal dysphagia, primarily because it provides information about bolus flow through the entire oropharynx, hypopharynx, and upper esophagus.

While the videofluoroscopic examination is an excellent procedure for imaging the dynamics of the swallow, there are many conditions that prevent the successful use of videofluoroscopy to evaluate dysphagia. Unavailability of fluoroscopy equipment on site may necessitate transfer of the patient to another facility for the study. Even when fluoroscopy is available, patients are regularly encountered in whom it cannot be used to assess dysphagia:

1. Patients who are in the intensive care unit and cannot easily be moved to the fluoroscopy suite.
2. Patients who are unable to be positioned adequately on the fluoroscopy platform or table because of severe weakness, limited mobility, or contractures.
3. Patients who are very ill and unable to tolerate the risk of aspirating even very small quantities of food.

4. Patients who need an immediate examination.

In order to adequately evaluate these patients at our medical center, the Speech Pathology and Otolaryngology Departments have jointly developed a technique that we call the fiberoptic endoscopic examination of swallowing (FEES). While the use of fiberoptic laryngoscopy to assess voice and to examine for structural abnormality or neuropathology<sup>1-7</sup> is well established, only a few investigators have described the use of this tool to directly assess swallowing function.<sup>8-11</sup> Several key events that characterize the abnormal swallow can be observed in this examination, the most important of which is aspiration, which signals that the patient may not be safe when eating and is at risk for pulmonary complications.

If the endoscopic examination is to be used as an alternative procedure to the videofluoroscopic study, its validity needs to be established. It is important to know whether endoscopy is as sensitive as fluoroscopy in detecting the major signs of oropharyngeal dysphagia, especially aspiration. Bastian<sup>12</sup> compared the results of double studies (endoscopic and videofluoroscopic) done on 10 subjects and found good agreement between the two examinations. In order to expand this preliminary work and help establish the validity of the FEES, the following investigation was carried out.

### SUBJECTS AND PROCEDURE

Twenty-one subjects were studied. A wide variety of patients were included: 9 with a history of one or more cerebrovascular accidents, 5 with other

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TABLE 1. INCIDENCE OF ABNORMAL FINDINGS ON TWO SWALLOWING EXAMINATIONS (N = 21)

Event Scored	Abnormal(+) Findings		Percent of Identical Findings on Both Examinations (Positive or Negative)
	Video-fluoroscopy	Fiberoptic Endoscopy	
Premature spillage	12	13	66
Pharyngeal residue	15	17	80
Laryngeal penetration	9	12	85
Tracheal aspiration	8	8	90

Positive findings on videofluoroscopy and fiberoptic endoscopic examination of swallowing did not necessarily occur in same subjects; thus percent agreement figure does not correspond directly to figures in first two columns.

neurologic disease, 2 with vocal cord paralysis, 2 with diagnoses of gastroesophageal reflux, 1 with a diagnosis of syncope, 1 post-coronary artery bypass graft, and 1 post-hemilaryngectomy. The mean subject age was 63, with a range of 35 to 94. All subjects were men. Subject selection depended solely on who could be given both dysphagia examinations within a short period of time.

The protocol for performing the FEES has been described in some detail elsewhere<sup>9</sup> but will be reviewed here briefly. Patients were examined in the clinic or at bedside in a posture typical of that in which they normally ate. The endoscope was passed transnasally to view the larynx and pharynx. Swallowing was directly evaluated with measured quantities of food and liquid dyed with blue food coloring for contrast. Two 5-mL swallows each of thin liquid, thick liquid, and applesauce and two small bites of bread were presented to each patient, always in that order.

The videofluoroscopic examination was conducted in the radiology suite, with the patient seated on a platform directly in front of the fluoroscopic unit. The same food and liquid consistencies and amounts as those used in the FEES were given to the patient. The food and liquid were mixed with barium powder to provide contrast.

The videofluoroscopy and FEES examinations were always completed within a 48-hour period, and usually within a 24-hour period. Four of the subjects had concurrent radiographic and endoscopic examinations. Examinations were scored by separate investigators, without knowledge of the results of the other examination. Each investigator performed an approximately equal number of FEES and videofluoroscopic examinations.

The occurrence of four abnormal features was scored in each examination: premature spillage, laryngeal penetration, tracheal aspiration, and pharyngeal residue. Laryngeal penetration was defined as material spilling into the laryngeal vestibule, but not passing below the vocal cords. Aspiration was defined as material falling below the glot-

tis. This was observed either directly as the bolus fell between abducted vocal cords or after the swallow, as it rested on the subglottic "shelf" — the mucous membrane covering the lower part of the thyroid and cricoid cartilage, just below the anterior commissure. Alternatively, it could be observed as the patient coughed and expectorated green material that had been aspirated. Each event was scored as present (+) or absent (−) and a note was made as to the bolus consistency on which this event occurred. Findings for each subject on the two examinations were then summarized and submitted to statistical analysis to determine the extent of agreement between the two examinations.

## RESULTS

All patients with one exception manifested one or more abnormalities on either or both of the swallowing examinations. Table 1 shows the incidence of abnormal findings on both examinations and the percentage of examinations that yielded identical findings on both examinations (either positive or negative findings). As seen in this Table, agreement was very high for three of the four parameters — aspiration (90%), penetration (85%), and residue (80%) — hence, findings on one examination tended to agree with findings on the other. However, it should be noted that less than 50% of the examinations (9 of 21) were in total agreement with regard to all four parameters that were scored for each patient.

The FEES was measured against the videofluoroscopic study for sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Calculations for these statistics were taken from Browner et al<sup>13</sup> and were defined as follows: *sensitivity* — the proportion of positive findings on videofluoroscopy that yielded a positive result on the FEES = a true positive/(true positive + false negative); *specificity* — the proportion of negative findings on videofluoroscopy that yielded a negative result on the FEES = true negative/(true negative + false positive); *positive predictive value* — the probability that the subject with a positive finding on the FEES actually had that abnormality (on videofluoroscopy); *negative predictive value* — the probability that the subject with a negative finding on the FEES did not actually have that abnormality (on videofluoroscopy). The values obtained for these statistics are shown in Tables 2 and 3. The FEES was highly sensitive (0.88 or greater) for residue, penetration, and aspiration, indicating that nearly all instances of these abnormalities detected on the videofluoroscopic study were also detected on the FEES. Sensitivity for premature spillage was somewhat lower, suggesting that some instances of spillage on the fluoroscopy study were not observed during the FEES. Specificity, a measure of the ability of the test to correctly detect true negatives, was not quite as high for pre-

TABLE 2. SENSITIVITY AND SPECIFICITY VALUES FOR RESULTS OF FIBEROPTIC ENDOSCOPIC EXAMINATION OF SWALLOWING WHEN COMPARED TO FINDINGS ON VIDEOFLUOROSCOPY (N = 21)

Event Scored	Sensitivity	Specificity
Premature spillage	0.75 (0.55-0.87)*	0.56 (0.47-0.63)*
Pharyngeal residue	0.93 (0.74-0.99)	0.50 (0.38-0.62)
Laryngeal penetration	1.00 (0.75-1.1)	0.75 (0.55-0.87)
Tracheal aspiration	0.88 (0.63-1.01)	0.92 (0.72-1.0)

\*95% confidence intervals.

mature spillage and pharyngeal residue as the other two parameters, suggesting that videofluoroscopy sometimes yielded a negative finding when the FEES yielded a positive finding. However, specificity was very high for laryngeal penetration and aspiration (0.75 and 0.92, respectively), indicating that negative findings for these parameters on videofluoroscopy usually yielded negative findings on the FEES as well.

Positive and negative predictive values, shown in Table 3, indicate the ability of FEES to correctly predict the "true" findings as seen on videofluoroscopy. The PPV and NPV were 0.75 or higher for three of the four parameters, with premature spillage being somewhat less predictable. Laryngeal penetration yielded an NPV of 1.00, since all negative findings on the FEES were also observed on videofluoroscopy. Aspiration yielded figures of 0.88 and 0.92, with 7 of the 8 positive results and 12 of the 13 negative results on the FEES also observed on videofluoroscopy. (The PPV and NPV take the prevalence of findings on the "standard" examination into account, thus accounting for the higher NPV than PPV on this parameter.)

In this study, the occurrence of specific abnormalities according to consistency of bolus (thick liquid, pureed, etc) was not submitted to statistical analysis, since the numbers would have been too low to perform any meaningful analyses. However, a perusal of the data indicated that the two examinations usually agreed with each other regarding bolus consistency involved in the abnormal event. There was no discernible tendency for either examination to detect aspiration or penetration of any particular consistency with greater frequency.

#### DISCUSSION

In this study, the FEES was compared to the videofluoroscopic study, and it proved to be a reliable procedure for detecting some of the major symptoms of dysphagia in the pharyngeal stage. All cases of laryngeal penetration, and all but one case of aspiration and residue on the videofluoroscopic study, were also reported positive on the FEES. Sensitivity and specificity, which give an indication of the number of "true" positive and "true" negative

TABLE 3. ABILITY OF FIBEROPTIC ENDOSCOPIC EXAMINATION OF SWALLOWING TO CORRECTLY PREDICT "TRUE" FINDINGS AS SEEN ON VIDEOFLUOROSCOPY (N = 21)

	PPV of FEES	NPV of FEES
Premature spillage	0.69 (0.46-0.86)*	0.63 (0.43-0.79)*
Pharyngeal residue	0.82 (0.57-0.97)	0.75 (0.55-0.87)
Laryngeal penetration	0.75 (0.55-0.87)	1.00 (0.75-1.12)
Tracheal aspiration	0.88 (0.63-1.01)	0.92 (0.72-1.0)

PPV — positive predictive value, FEES — fiberoptic endoscopic examination of swallowing, NPV — negative predictive value.

\*95% confidence intervals.

results when compared to the "gold standard," were best for aspiration and penetration, and somewhat lower for the other parameters. In general, a finding of penetration or aspiration on the FEES had few false-positive or false-negative results.

Positive and negative predictive values are often used to indicate the clinical usefulness of an examination.<sup>14</sup> In this study, the FEES was found to be a good predictor of a patient's "true status" (as determined by videofluoroscopy) for three of the four parameters. The only parameter with relatively low predictive values (0.70) was premature spillage. The fact that neither the FEES nor the radiographic examination reported a higher number of positive or negative findings suggests that the variability may lie within the patient. The level of variability reported in this study compares favorably to that in other studies that have looked at this issue. Using videofluoroscopy, Lof and Robbins<sup>15</sup> reported that normal subjects showed variability in swallowing performance from one trial to the next and with repeated studies, although the differences in performance were not significant. Similarly, Ekberg et al<sup>14</sup> reported interobserver variability in raters' judgments of findings on fluoroscopic studies, although they concluded that the level of disagreement was "acceptable." Hence, there are several possible sources of the variability we found between the FEES and videofluoroscopic studies, including patient variability, rater variability, and differences between the procedures.

Even though the endoscopic study was shown to be a sensitive procedure for detecting aspiration, penetration, and pharyngeal residue, we are not suggesting that the FEES replace videofluoroscopy as the "gold standard." Videofluoroscopy remains the most thorough diagnostic tool available today for evaluating oral-pharyngeal dysphagia. Precise measurements of oral and pharyngeal transit times, and direction and amplitude of movement of structures, can only be done at present with fluoroscopic images.

However, we do believe that the FEES is a valu-

able tool in the evaluation of the dysphagic patient. With videotape recording and slow playback capabilities, FEES can reveal much about bolus flow through the hypopharynx, movement of the structures in reaction to or anticipation of the bolus, and sensitivity within the hypopharynx and endolarynx. It is possible to visualize and localize residual material within the hypopharynx or larynx better endoscopically than with the two-dimensional view afforded by videofluoroscopy, and this information can be very revealing.<sup>16</sup> Finally, an assessment of airway protection with maneuvers such as holding the breath, coughing, and clearing secretions can only be done adequately with endoscopy.

In addition, the endoscopic examination has practical advantages over the fluoroscopic examination. The FEES is performed with a tool already available to otolaryngologists and can be easily added to a routine flexible laryngoscopic examination whenever the patient's complaints suggest dysphagia. It is also a portable examination; it can be brought to bedside or done in the office and does not require the extensive effort and expense in-

involved when occupying a radiographic suite with a radiologist, a technologist, and a speech pathologist. It can be repeated as often as desired without undue radiation hazard to the patient.

As an initial examination, FEES can tell the examiner whether a pharyngeal dysphagia is present and whether the problem includes clinical symptoms such as aspiration, laryngeal penetration, or excess residue. It can also reveal clinically significant abnormalities such as incomplete vocal cord adduction. If a speech pathologist participates in the examination, more detailed considerations regarding safety of oral feeding, appropriate diet, need for behavioral therapy, and the usefulness of a follow-up videofluoroscopic study can be made (for example, see Logemann<sup>17</sup>). More research is needed with larger samples participating in combined studies in order to sort out the factors accounting for the observed variability and to further investigate the sensitivity of each examination with different food consistencies. However, this study has established that endoscopy is a valid and valuable tool for evaluating oropharyngeal dysphagia.

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