Fibreoptic endoscopic evaluation of swallowing and videofluoroscopy: does examination type influence perception of pharyngeal residue severity?  

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Accepted 24 July 2006  

Objectives: The aim of the study was to investigate whether the type of instrumental swallowing examination (Fibreoptic Endoscopic Evaluation of Swallowing (FEES) or videofluoroscopy) influences perception of post-swallow pharyngeal residue.  

Design: Prospective, single-blind assessment of residue from simultaneous videofluoroscopy and FEES recordings. All raters were blind to participant details, to the pairing of the videofluoroscopy and FEES examinations and to the other raters’ scores.  

Setting: Tertiary specialist ENT teaching hospital.  
Participants: Fifteen adult participants consecutively recruited; seven women and eight men aged between 22 and 73, mean age 53. All participants underwent one FEES examination and one videofluoroscopy examination performed simultaneously. Inclusion criteria: referred to speech and language therapy for assessment of dysphagia. Exclusion criteria: nil by mouth or judged to be at high risk of aspiration.  

Main outcome measures: The FEES and videofluoroscopy examinations were recorded simultaneously. Fifteen speech and language therapists independently scored pharyngeal residue as none, coating, mild, moderate or severe. All examinations were scored twice by all raters.  

Results: Intra- and inter-rater agreement were similar for both examinations. There were significant differences between FEES and videofluoroscopy pharyngeal residue severity scores (ANOVA, P < 0.001). FEES residue scores were consistently higher than videofluoroscopy residue scores.  

Conclusions: Pharyngeal residue was consistently perceived to be greater from FEES than from videofluoroscopy. These findings have significant clinical implications as FEES and videofluoroscopy findings are used to judge aspiration risk and to make recommendations for oral intake. Further research is required to examine the impact of FEES and videofluoroscopy examinations on treatment decisions.  

Aspiration risk is one of the primary factors influencing clinical management in swallowing disorders (dysphagia). Factors associated with increased aspiration risk include salivary pooling, impaired sensation, reduced airway protection and pharyngeal residue. Pharyngeal residue suggests an underlying impairment of oropharyngeal bolus driving forces and reduced swallow efficiency. Clinical judgements of how efficiently the swallow mechanism moves the bolus through the pharynx, and of aspiration risk are influenced by pharyngeal residue seen during instrumental swallowing examinations.  

Videofluoroscopy and Fibreoptic Endoscopic Evaluation of Swallowing (FEES) provide images of post-swallow pharyngeal residue. Both are commonly used in dysphagia management and have been compared for clinical indications, outcomes, cost and ability to detect aspiration. Videofluoroscopy and FEES have also been compared for scoring a number of parameters including pharyngeal clearance. In most studies FEES and videofluoroscopy examinations were conducted up to 2 weeks apart, only one study of patients with dysphagia using simultaneous FEES and videofluoroscopy has been published. Eleven patients had simultaneous FEES and videofluoroscopy examinations, and raters scored pharyngeal residue as present/absent. There was good agreement (84%) between FEES and videofluoroscopy.
scopy under tightly controlled experimental conditions. This might not be reproducible in the real clinical situation, where raters of varying experience rate presence and amount of residue. Our aim was to investigate if the type of instrumental swallowing examination (FEES or videofluoroscopy) influenced perception of post-swallow pharyngeal residue.

**Methods**

**Ethical considerations**

The Royal Free Hampstead NHS Trust Local Research Ethics Committee approved this study. Participants were given an information leaflet at least 24 h before giving written consent. The FEES and videofluoroscopy examinations formed a part of the patients’ routine clinical assessment.

**Participants**

Participants were recruited from dysphagia referrals to speech and language therapy if they met the following criteria: (i) taking food or fluids by mouth; and (ii) not judged to be at high risk of aspiration (on the basis of previous instrumental or clinical evaluations of swallowing).

Using a pilot panel of local raters, we established that a 90-min rating session (≈60 swallows) was the longest that could be tolerated without complaints of fatigue. On this basis, we recruited 15 participants, with four swallows to be rated from each. Twenty-three consecutive patients were recruited over 5 months to obtain 15 participants. Six were excluded due to recording errors or inadequate images. One recruit could not tolerate the nasendoscope and in one case nasal regurgitation obscured the endoscopic view. While the aetiology of the participants’ dysphagia was unimportant they were broadly representative of those with dysphagia (Table 1) and were subsequently shown to have a wide range of pharyngeal residues.

**Instrumentation and recording**

A consultant radiologist, radiographer and two dysphagia specialist speech and language therapists (SLTs) conducted simultaneous FEES and videofluoroscopy examinations. One SLT passed the nasendoscope to the level of the superior border of the oropharynx. Images of the oropharynx, hypopharynx and larynx were displayed on a monitor (Figure S1) and recorded digitally on the Digital Swallowing Workstation (Kay Pentax Ltd, Montvale, NJ, USA).

Simultaneously, the lateral fluoroscopy screening field was established; bordered by lips, hard palate, cervical spine and cervical oesophagus (Figure S1). The video-fluoroscopy images were recorded on Super-VHS video (SVO-9620; Sony, Weybridge, UK). While our fluoroscopy equipment could not screen anterior-posteriorly with the nasendoscope in place, our design reflects clinical best practice of screening the majority of swallows in

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Treatment history</th>
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<tbody>
<tr>
<td>78</td>
<td>F</td>
<td>Bilateral vocal fold palsy</td>
<td>Tracheostomy</td>
</tr>
<tr>
<td>45</td>
<td>F</td>
<td>Suspected sarcoidosis</td>
<td>None</td>
</tr>
<tr>
<td>45</td>
<td>F</td>
<td>Cervical spine degeneration</td>
<td>Anterior cervical spine surgery</td>
</tr>
<tr>
<td>78</td>
<td>M</td>
<td>Cerebral small vessel disease</td>
<td>None</td>
</tr>
<tr>
<td>22</td>
<td>F</td>
<td>Congenital TOF</td>
<td>Partial oesophagectomy</td>
</tr>
<tr>
<td>56</td>
<td>M</td>
<td>Ewings sarcoma mandible</td>
<td>Partial mandibulectomy and partial glossectomy</td>
</tr>
<tr>
<td>64</td>
<td>M</td>
<td>Previous CVA Skull base tumour</td>
<td>None</td>
</tr>
<tr>
<td>58</td>
<td>M</td>
<td>Base of tongue carcinoma</td>
<td>Trans-oral laser resection, chemoradiotherapy</td>
</tr>
<tr>
<td>37</td>
<td>M</td>
<td>None (odynophagia)</td>
<td>None</td>
</tr>
<tr>
<td>58</td>
<td>F</td>
<td>Multiple sclerosis</td>
<td>Medication</td>
</tr>
<tr>
<td>56</td>
<td>M</td>
<td>Base of tongue carcinoma</td>
<td>Trans-oral laser resection, chemoradiotherapy</td>
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<tr>
<td>44</td>
<td>M</td>
<td>Suspected laryngo-pharyngeal reflux</td>
<td>None</td>
</tr>
<tr>
<td>74</td>
<td>M</td>
<td>Laryngeal carcinoma</td>
<td>Trans-oral laser resection</td>
</tr>
<tr>
<td>46</td>
<td>F</td>
<td>Laryngo-pharyngeal reflux</td>
<td>Medication</td>
</tr>
<tr>
<td>40</td>
<td>F</td>
<td>Systemic lupus erythematosus</td>
<td>Oesophageal dilatations</td>
</tr>
</tbody>
</table>

Table 1. Participant details

TOF, tracheo-oesophageal fistula; CVA, cerebrovascular accident.

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the lateral plane. By these methods, simultaneous FEES and videofluoroscopy recordings were made for each bolus.

**Test boluses**

All patients took identical boluses to ensure raters could not identify pairs of FEES and videofluoroscopy recordings. Three boluses were given to each patient in the following order:

1. 5 mL of liquid (2.5 mL of barium (Baritop 100; Sakai Chemical Industry Ltd, Osaka, Japan) and 2.5 mL of water), from a cup.
2. 5 mL of water from a straw, to rinse the pharynx of residue.
3. 15 mL of yoghurt (5 mL of barium and 10 mL of smooth yoghurt), from a standard dessertspoon.

Boluses (1) and (3) were dyed with 1 mL of blue food dye. Bolus (2) was used only to rinse the pharynx; it was not dyed or recorded. For (1) and (3), patients were told to take the entire bolus and hold it in the mouth. Once the fluoroscopy screening was switched on and the fluoroscopic and endoscopic fields were established the command to swallow was given. The fluoroscopy screening was switched off 5 s after the last spontaneous swallow. As in normal clinical practice, the nasendoscope was then lowered to get a detailed view of post-swallow pharyngeal residue. This typically took 10 s and participants were told not to swallow during this period. On removal of the nasendoscope, the videofluoroscopy examination was completed for routine clinical care. This did not form part of the research study.

**Edited video clips**

The recordings were converted into MPEG video clips for computer replay. Background audio recordings were removed to prevent raters identifying the paired FEES and videofluoroscopy images. There were 30 individual video clips (15 FEES, 15 videofluoroscopy), each comprising three segments:

1. The participant swallowing the liquid. The final still frame was displayed for 5 s, to replicate normal practice of freezing an image during playback for scoring (Figure S2).
2. The word ‘yoghurt’ to alert the rater to the next bolus.
3. The participant swallowing the yoghurt. The final still frame was displayed for 5 s.

The 30 video clips were randomised and recorded onto compact disc no. 1. The clips were then re-randomised and recorded onto compact disc no. 2.

**The raters**

Contributors to the Royal College of Speech and Language Therapy FEES policy document, attendees of previous videofluoroscopy and FEES courses and members of swallowing special interest groups, all known to use both FEES and videofluoroscopy were invited to participate in the study. Twenty clinicians were contacted and seventeen volunteered. Raters completed a short questionnaire about their clinical experience of FEES and videofluoroscopy and were advised that all responses were confidential.

Using the residue rating scale (below), the raters were instructed to score compact disc no. 1, then score compact disc no. 2 1 week later. Raters were instructed to view the recordings no more than twice and to complete the scoring in one session. Raters were given no information about the participants or the pairing of the videofluoroscopy and FEES examinations. The ratings of two of raters were excluded. One inadvertently swapped the two discs. The other rater’s scores were illegible to us and to her. These two raters’ responses were excluded; a third rating would have constituted a different procedure to the other 15 raters.

**The residue rating scale**

In order that effects could not be attributed to differences in rating scales, it was important to apply the same scale to both investigations. At the time of the study no published pharyngeal residue severity scale covering FEES and videofluoroscopy existed. Therefore, the raters used a scale based on commonly used descriptors of residue severity (Appendix 1). These descriptors reflect clinical practice when estimating the amount or severity of residue seen during videofluoroscopy and FEES examinations.

**Assessment of rating scale reliability and validity**

Intra- and inter-rater reliability were calculated separately for FEES and for videofluoroscopy using weighted Kappa on the original ratings. Kappa is a conservative measure (i.e. tends to underestimate agreement compared with other measures), and ranges from 0 (chance agreement) to 1 (complete agreement).

If the rating scale is measuring the same construct (i.e. residue size) for FEES and videofluoroscopy videos, there should be a correlation between FEES and videofluoroscopy ratings. Correlation is not a measure of agreement. For example, systematically adding one to all the FEES ratings would have no effect on the correlation.
coefficient. However, a strong correlation indicates good construct validity; as the raters were unaware of the FEES-videofluoroscopy pairings, the construct being measured by the rating scale is being scored from both the FEES and the videofluoroscopy images.

Assessment of factors affecting the residue rating

Five-way analysis of variance (ANOVA) was used to assess systematic differences in the ratings of pharyngeal residue severity due to five factors: examination (FEES or videofluoroscopy); bolus type (liquid or yoghurt); rating (first or second); rater (1–15); and patient (1–15). Data were analysed using SPSS for Windows (V12.0, SPSS Inc., Chicago, IL, USA).

Results

Edited video clips

A wide range of pharyngeal residues was obtained from the participants ranging from none (0) to severe (4) in both examinations (Fig. 1). A sample of exclusively large or small residues would have constituted an experimental bias in the context of this study.

The raters

All raters scored both boluses on all the FEES and videofluoroscopy recordings twice, a total of 1800 individual ratings. One rater did not return the experience and training questionnaire. For the other 14 raters, 11 had attended a videofluoroscopy course and 12 had attended a FEES course. We measured experience in examination-years; one examination-year represents one examination performed and interpreted per week for 1 year, ≈50 examinations. For videofluoroscopy, the mean (sd) experience was 6.0 (4.5) examination-years; for FEES it was slightly lower at 4.9 (4.3) examination-years.

Assessment of rating scale reliability and validity

The similar inter- and inra-rater agreement for FEES and videofluoroscopy (Table 2) indicates that the pharyngeal residue severity scale is equally reliable for use with both examinations. As would be expected, within-rater agreement (subjectively good) was better than agreement between different raters (subjectively moderate).21

There was a strong correlation between residue scores on FEES and on videofluoroscopy (Fig. 2, \( r = 0.74 \) liquid, \( r = 0.87 \) yoghurt). This indicates that the construct of ‘residue size’ was interpreted similarly for FEES and videofluoroscopy images.

Assessment of factors affecting the residue rating

Despite the strong correlation, Fig. 2 shows clearly that FEES scores were consistently higher (more severe) than videofluoroscopy scores. There is no gold standard rating scale for residue, and therefore, we do not know the right answer (if any) for the residues rated. However, for 28 of 30 boluses, a residue was perceived to be more severe on FEES than the identical residue on video fluoroscopy.

Using ANOVA, this effect was assessed across all 15 raters and 30 boluses. The mean residue score on FEES was 1.0 point higher than the mean score on videofluoroscopy, statistically a highly significant effect (ANOVA, \( F > 1000, P < 0.001; 95\% \text{ CI for the difference, 0.91–1.07}. \)

Table 2. Inter- and intra-rater agreement for the residue assessment scale

<table>
<thead>
<tr>
<th></th>
<th>Videofluoroscopy</th>
<th>FEES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-rater agreement</td>
<td>0.56</td>
<td>0.51</td>
</tr>
<tr>
<td>Intra-rater agreement</td>
<td>0.74</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Agreement was measured using the weighted Kappa statistic, on a scale where the agreement expected because of chance alone would score 0, and complete agreement would score 1. Credit is given for partial agreement. More credit is given for small rating differences (e.g. 0 versus 1) than larger rating differences (e.g. 0 versus 3), and no credit is given for complete disagreement (0 versus 4). This provides clinically relevant reliability information.

The ratings being compared are from the 15 separate raters (inter-rater agreement), or ratings a week apart from the same person (intra-rater agreement).
Effects of other factors on residue severity scores

There were statistically significant effects (anova, all $P < 0.03$) because of all the other factors examined in this study: bolus type, rating, rater and participant. The effects of all five factors on the residue scores are summarised in Table 3 and Fig. 3. Notably, the effect of changing the clinical examination (FEES or videofluoroscopy) was larger than any other factor, including the expected large differences between patients or between raters from diverse centres.

Fig. 2. The mean residue score on FEES, plotted against the mean residue score on videofluoroscopy for the same swallow. If there was no difference between FEES and videofluoroscopy, the points would be expected to lie on the line of identity.

Discussion

Key findings of the study

This is the first study to assess pharyngeal residue severity from simultaneous FEES and videofluoroscopy examinations. We have shown that the type of instrumental examination influences perception of post-swallow pharyngeal residue. Across 15 independent raters assessing 30 boluses, residue severity assessed from the FEES images was higher by 1 scale point than from the paired videofluoroscopy images. This effect was statistically extremely significant and corresponds to a change from mild to moderate, or from moderate to severe.

To put this finding in context, we assessed the effects of four other factors: changing the bolus type, re-rating

Table 3. Effects of examination (VF versus FEES) and four other factors on residue severity scores

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean residue score (95% CI)</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF</td>
<td>1.63 (1.59–1.68)</td>
<td>$F = 1016P = 2 \times 10^{-175}$</td>
</tr>
<tr>
<td>FEES</td>
<td>2.69 (2.64–2.73)</td>
<td></td>
</tr>
<tr>
<td>Bolus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td>2.12 (2.08–2.17)</td>
<td>$F = 5.3P = 0.022$</td>
</tr>
<tr>
<td>Yoghurt</td>
<td>2.20 (2.15–2.24)</td>
<td></td>
</tr>
<tr>
<td>Rating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>2.12 (2.08–2.17)</td>
<td>$F = 5.3P = 0.021$</td>
</tr>
<tr>
<td>Second</td>
<td>2.20 (2.15–2.24)</td>
<td></td>
</tr>
<tr>
<td>Rater</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest mean score</td>
<td>1.63</td>
<td>$F = 25.2P = 3 \times 10^{-60}$</td>
</tr>
<tr>
<td>Highest mean score</td>
<td>2.78</td>
<td></td>
</tr>
<tr>
<td>Subject</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest mean score</td>
<td>0.66</td>
<td>$F = 203P &lt; 10^{-300}$</td>
</tr>
<tr>
<td>Highest mean score</td>
<td>3.53</td>
<td></td>
</tr>
</tbody>
</table>

$F$ and $P$-values are from anova. $F$ is the test statistic, and expresses the variance because of the observed change in relation to the error variance because of random variability alone. A higher $F$ indicates a stronger effect, and $P$ indicates the probability that the observed effect is due to chance alone.
the bolus by the same observer, rating the bolus by a different observer and rating a different patient. The effect of changing examination was larger even than the typical effect of changing the patient. We conclude there is a fundamental difference in the perceptions of pharyngeal residue severity between the two examinations; they cannot be used interchangeably.

**Strengths of the study**

*Use of multiple raters.* We recruited 15 raters from 12 UK centres. Previous studies comparing FEES and videofluoroscopy have used one or two raters,12,15,22 and in some cases have failed to specify the number of raters or to measure their reliability.13,14,16 Multiple independent raters reduce (in our case, by almost fourfold) the effects of random rating errors and of bias in individual raters.

*Residue rating scale.* FEES and videofluoroscopy have good agreement for scoring the presence/absence of pharyngeal residue,12,13,15,16 but in these studies residue severity was not measured. Clinicians routinely estimate residue severity using descriptors such as ‘mild’ or ‘severe’, despite there being no published definitions of these terms. We developed a residue rating scale applicable to FEES and videofluoroscopy, using common descriptors of residue severity. The purpose of our study was not to validate the scale (which would require further study), but our preliminary data indicate the scale is equally reliable for FEES and videofluoroscopy, and furthermore has good construct validity.

*Assessment of inter- and intra-rater reliability.* The scale had moderate inter-rater reliability and good intra-rater reliability. The subjectively moderate inter-rater reliability may not be considered acceptable for a clinically applicable scale; reliability would be important in the further development of the scale. A standardized, clearly defined pharyngeal residue severity scale may improve reliability of pharyngeal residue severity scoring in the same way that the Penetration–Aspiration Scale is a clinically useful, reliable tool for scoring aspiration.23,24

While rater reliability has implications for the clinical use of both examinations, good reliability was not necessary to conduct this study. The consequence of poor rater reliability would be to increase the random variability of the residue measurements, making it more difficult to identify a real effect. In our case, we demonstrated a dramatic effect despite moderate inter-rater reliability.

**Potential limitations of the study**

*Number of participants.* As for any study, our patient group could usefully have been extended. However, it is not common clinical practice to spend long periods rating residue. After 90 min our pilot raters reported fatigue and loss of concentration. This would have had a clear detrimental effect on our study, and so the study was limited to 60 ratings per sitting.

*Bias in patients, raters or assessment measures.* The patients were broadly representative of those with dysphagia (Table 1), and no patient was excluded on the basis of any clinical observation. Moreover, it was not the patients or their ability to manage a range of boluses that was under scrutiny. The object of interest was bolus residue, and a wide range of residues was recorded (Fig. 3).

A more plausible source of bias would be in the assessment methods or the raters themselves. We therefore devised a rating scale that could be applied equally to both FEES and videofluoroscopy (Table 2), and the raters had approximately equal experience of the two examinations. The observed differences between FEES and videofluoroscopy were not random, as might be expected from an unreliable rating scale or from unreliable raters. These factors are unlikely to lead to FEES images being scored more severely by more than one rating point across all raters and all boluses.

*Choice of statistical methods.* We presented rater agreement using the weighted Kappa statistic, the widely used in this area of work. Kappa is a conservative coefficient of agreement and so we applied two alternative statistics; intraclass correlation coefficient and Krippendorff’s alpha. While these suggested slightly better overall agreement, they supported Kappa, i.e. agreement was very similar for the two investigations, but marginally better for videofluoroscopy than for FEES.

Analysis of variance (ANOVA) assumes data are normally distributed. This was appropriate because our residue sizes followed a quantised normal distribution (Fig. 2). Nevertheless, we assessed our data using logistic regression, the appropriate test for non-normal data. The results were very similar to those from ANOVA; examination type and rater were the important effects, while bolus type had a weak effect on residue scoring and repeat assessment had no significant effect.

*Unequal recording times.* From pilot work, it was clear that 5 s post-swallow endoscopic screening time was
insufficient to obtain images representative of a standard FEES examination. Extending the fluoroscopy screening time would have increased the patients’ radiation exposure and breached the ethical approval conditions. To ensure the residue images from the two exams were comparable, the patients were told not to swallow during this period, which prevented the residue from moving from the pharynx into the oesophagus or airway. The viscous barium contrast meant that movement of the residue was unlikely during this period.

Clinical implications of the study

FEES versus videofluoroscopy; the effect on residue severity scores. The effect of changing the examination was larger than any other of the other factors. This has clear clinical implications, as pharyngeal residue severity is routinely evaluated during FEES and videofluoroscopy examinations and judgements of residue severity influence perception of aspiration risk. FEES and videofluoroscopy examinations are used interchangeably to evaluate dysphagia severity, modify oral intake and advise treatment strategies. Understanding the differences between the two examinations is essential, particularly where a patient undergoes repeated swallowing examinations, or where a patient is transferred and/or examined in one or more hospitals/care settings that use the different examinations.

The future. In addition to evaluating the amount of residue, clinicians routinely localise it within the pharynx. This helps to estimate aspiration risk (residue near the airway being judged higher risk than residue further away), and to apply strategies improving pharyngeal clearance. It would be interesting to ask clinicians to localise the residue within the pharynx, and then to compare clinical judgements of aspiration risk for FEES and videofluoroscopy. Localising residue requires fluoroscopy screening in all planes, which could be achieved using a system that can record in an anterior–posterior plane with the nasendoscope in place.

FEES and videofluoroscopy have complementary roles in dysphagia management. FEES uses real food and provides superior views of laryngeal movements. Videofluoroscopy provides more information about pharyngeal physiology, and allows us to see the oral and oesophageal stages. The impact of examination type and scoring on oral intake recommendations, treatment efficacy and patient satisfaction remains unknown. There is some evidence that the health outcomes from FEES and videofluoroscopy are comparable. Further research is required to fully evaluate the impact of FEES and videofluoroscopy on treatment decisions and clinical outcomes.

Conclusions

Perceptions of pharyngeal residue severity influence clinical judgements of aspiration risk. We have shown that the type of swallowing examination influences the perception of residue severity more than any other single factor. This is an important consideration when using these examinations to make recommendations about oral intake and dysphagia treatment.

Conflict of interest

None declared.

Acknowledgement

This project was supported by the Rhinology and Laryngology Research Fund, Institute of Laryngology, University College London, UK.

References


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Supplementary material

The following supplementary material is available for this article online:

Figure S1. (a) FEES and (b) videofluoroscopy screening fields.

Figure S2. Simultaneously recorded (a) FEES and (b) videofluoroscopy images of pharyngeal residue.

This material is available as part of the online article from http://blackwell-synergy.com.

Appendix 1

Pharyngeal Residue Severity Scale

None (N): No pharyngeal coating or residue
Coating (C): Coating of the pharyngeal mucosa; no pooling
Mild (Mi): Mild pooling/residue
Moderate (Mo): Moderate pooling/residue
Severe (S): Severe pooling/residue