Can Pulse Oximetry or a Bedside Swallowing Assessment Be Used to Detect Aspiration After Stroke?

Deborah J.C. Ramsey, MRCP; David G. Smithard, MD; Lalit Kalra, PhD

Background and Purpose—Desaturation during swallowing may help to identify aspiration in stroke patients. This study investigated pulse oximetry, bedside swallowing assessment (BSA), and videofluoroscopy as tests for detecting aspiration after stroke.

Methods—Swallowing was assessed in 189 stroke patients (mean±SD age, 70.9±12.3 years) within 5 days of symptom onset with a modified BSA (water replaced by radio-opaque contrast agent, followed by chest radiography to detect aspiration). Simultaneous pulse oximetry recorded the greatest desaturation from baseline for 10 minutes from modified BSA onset. Videofluoroscopy was undertaken in 54 (28%) patients.

Results—Modified BSA showed a safe swallow in 98 (51.9%), unsafe swallow in 85 (45.0%), and silent aspiration in 6 (3.2%) patients. During swallowing, desaturation by >2% occurred in 27 (27.6%) and by >5% in 3 (3.1%) of the 98 safe-swallow patients on modified BSA. Of the 85 unsafe-swallow patients, only 28 (32.9%) desaturated by >2% and 6 (7.1%) by >5%. Desaturation did not occur in any of the 6 silent aspirators. With the modified BSA to detect aspiration, sensitivity and specificity, respectively, were 0.31 and 0.72 for desaturation >2% and 0.07 and 0.97 for desaturation >5%. By videofluoroscopy, sensitivity and specificity for detecting aspiration were 0.47 and 0.72 for modified BSA, 0.33 and 0.62 for desaturation >2%, and 0.13 and 0.95 for desaturation >5%. Combining a failed modified BSA with desaturation >2% or >5% did not significantly improve predictive values.

Conclusions—Modified BSA and pulse oximetry during swallowing, whether alone or in combination, showed inadequate sensitivity, specificity, and predictive values for detection of aspiration compared with videofluoroscopy in stroke patients. (Stroke. 2006;37:2984-2988.)

Key Words: acute stroke ■ aspiration ■ dysphagia ■ pulse oximetry ■ stroke management

Dysphagia is common in acute stroke patients and is associated with an increased risk of aspiration. Dysphagic patients have a higher likelihood of poorer outcomes including pneumonia, prolonged hospital stay, mortality, and institutionalization.1 There are several ways of assessing aspiration risk in acute stroke patients, each with advantages and limitations.2 Videofluoroscopy (VF) and fiberoptic endoscopic evaluation of swallowing (FEES) are well-validated investigations of swallowing2 that provide a detailed understanding of the anatomy and physiology of the process, as well as allowing the assessment of potential therapeutic procedures. However, universal availability of these tests is limited in many clinical settings in which stroke patients are managed, and the bedside clinical swallowing assessment (BSA) has become a widely used initial test to screen for aspiration risk. Such assessments are perceived as simple and quick to perform and can be repeated frequently, but they have limited sensitivity, specificity, and reliability.2

There is considerable debate on the role of pulse oximetry as a bedside test to evaluate aspiration risk. The findings of an association between desaturation and aspiration3–11 have not been consistently replicated in the literature. Three recent studies were unable to demonstrate a clear relation between desaturation during feeding and aspiration,12–14 whereas other studies found some association, but with a wide range of sensitivity and specificity values on comparison with VF or FEES.6,9–11 Much of the uncertainty in the literature relates to differences in patient selection, timing of assessments, assessment techniques, and small sample sizes. More important, the clinically relevant question of whether pulse oximetry can replace or enhance existing bedside assessments in acute stroke patients has not been fully addressed in those studies.

There are very few studies comparing the clinical utility of pulse oximetry with a BSA in acute stroke patients. The objective of this study was to investigate desaturation during swallowing, a modified BSA, and desaturation combined with a modified BSA as initial tests for predicting unsafe swallowing in a group of acute stroke patients, with VF as the “gold standard.”

Patients and Methods

Subjects

Subjects were recruited from consecutive acute stroke patients >18 years of age admitted to 1 of 2 acute care hospitals. Stroke was
TABLE 1. Characteristics of Patients Undergoing VF Compared With Those Who Did Not Undergo VF

<table>
<thead>
<tr>
<th></th>
<th>Total Group (n=189)</th>
<th>Patients Undergoing VF (n=54)</th>
<th>Patients Not Undergoing VF (n=135)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean±SD), y</td>
<td>70.9±12.3</td>
<td>70.9±10.2</td>
<td>70.9±13.0</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>115 (60.8)</td>
<td>36 (66.7)</td>
<td>79 (58.5)</td>
</tr>
<tr>
<td>Previous stroke, n (%)</td>
<td>52 (27.5)</td>
<td>14 (25.9)</td>
<td>38 (28.1)</td>
</tr>
<tr>
<td>Median baseline Barthel Index (IQR)*</td>
<td>11 (6–17)</td>
<td>14 (9–17)</td>
<td>9 (5–17)</td>
</tr>
<tr>
<td>Modified VF score†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td>98 (51.9)</td>
<td>36 (66.7)</td>
<td>62 (45.9)</td>
</tr>
<tr>
<td>Unsafe</td>
<td>85 (45.0)</td>
<td>17 (31.5)</td>
<td>68 (50.4)</td>
</tr>
<tr>
<td>Silent aspirator</td>
<td>6 (3.2)</td>
<td>1 (1.9)</td>
<td>5 (3.7)</td>
</tr>
<tr>
<td>No. desaturating by &gt;2%, n (%)</td>
<td>55 (29.1)</td>
<td>20 (37.0)</td>
<td>35 (25.9)</td>
</tr>
<tr>
<td>No. desaturating by &gt;5%, n (%)</td>
<td>9 (4.8)</td>
<td>4 (7.4)</td>
<td>5 (3.7)</td>
</tr>
</tbody>
</table>

IQR indicates interquartile range.

*P<.004 for difference in median baseline Barthel Index between those undergoing and those not undergoing VF; †P=.035 for difference in safe swallowing on modified BSA between those undergoing and those not undergoing VF.

defined according to World Health Organization criteria and confirmed on computed tomography or magnetic resonance imaging brain scans. Exclusion criteria were stroke onset >5 days before assessment, reduced consciousness level, intolerance of the contrast agent, disseminated malignancy, prior dysphagia, other neurological diseases/local pathology affecting swallowing, or inability to obtain consent. Patients requiring continuous oxygen therapy were excluded, as were those wearing nail varnish because of potential interference with pulse oximetry. The study was approved by the King’s College Hospital and East Kent Research Ethics Committees.

One hundred eighty-nine (27.5%) of the 687 eligible patients screened for inclusion were recruited to the study. Principal reasons for exclusion were as follows: drowsy/too unwell to participate (n=152); unable to give consent because of dysphasia or lack of understanding (n=128); unwilling to give consent (n=62); and previous dysphagia (n=59). An additional 75 patients were excluded for a variety of reasons such as unclear evidence of a recent lesion causing neurological deterioration, unclear timing of stroke onset, distaste or allergy to contrast medium, and inability to comply with instructions. An additional 22 patients were excluded later because of a final diagnosis other than stroke (n=6), nail varnish preventing accurate saturation measurement (n=5), ongoing oxygen therapy at the time of the test (n=2), and inadequate pulse oximetry recordings (n=9).

The mean age of the included subjects was 70.9±12.3 years and 60.8% were male. The median baseline Barthel score, used as a measure of stroke severity at the time of assessment, was 11/20 (interquartile range, 6 to 17). Strokes were due to intracerebral hemorrhage in 20 of 189 (10.58%) patients. Large-artery atherosclerotic strokes occurred in 12 of 189 (6.35%) patients, 18 of 189 (9.52%) had cardioembolic strokes, 85 of 189 (44.97%) had small-vessel occlusions, and 54 of 189 (28.57%) had ischemic strokes due to other or undetermined causes, according to the TOAST criteria.

Swallow Assessment

A modified BSA was performed by a trained clinician (D.J.C.R.). Patients were seated and positioned between 45° and 90° to optimize safe swallowing and underwent oromotor function testing, which included assessment of lip seal, tongue movements, voice quality, and ability to give a voluntary cough. They were then given three 5-mL aliquots of a diluted radio-opaque contrast agent to swallow, and those safe on at least 2 of 3 aliquots (ie, no reflex cough, change in voice quality/respiratory rate, or other difficulty with swallowing) were given a larger volume (75 mL) to drink continuously, if able. Patients were observed throughout the test for signs of aspiration, such as reflexive cough, change in respiratory rate, or alteration in voice quality. A plain chest radiograph was performed within 30 minutes of the clinical assessment to search for signs of aspirated thoracic contrast, and findings were reported by a consultant radiologist who was blinded to the results of the clinical assessment. Patients were categorized as “safe” (safe clinically and no thoracic contrast visible radiologically), “unsafe” (unsafe clinically and/or radiologically), or apparent “silent aspiration” (these subjects had appeared to swallow safely on the clinical assessment, but aspirated thoracic contrast was visible on x-ray films).

Pulse Oximetry

Peripheral blood oxygen saturations were recorded automatically during the modified BSA and stored for later analysis. A Minolta Pulsox-3i pulse oximeter was used, with the oximeter probe attached to the index finger of the patient’s unaffected upper limb. The researcher performing the modified BSA was unaware of pulse oximeter recordings during the procedure, and those recordings were unavailable until after the clinical aspiration risk on modified BSA had been determined. Baseline oxygen saturations were recorded for 1 minute before the start of the modified BSA and measured continuously for 10 minutes from the start to allow time for the swallow assessment, any immediate or delayed aspiration, and a recovery period. The greatest fall in oxygen saturation during 2 time periods from the onset of the modified BSA (0 to 5 minutes, T1, and 5 to 10 minutes, T2) was calculated as the difference between the lowest saturation and the mean baseline saturation after excluding extreme values due to movement or other artifacts.

Videofluoroscopy

All 189 patients were potentially eligible to undergo VF within 24 hours of the modified BSA and oximetry, but 8 patients or their next-of-kin declined VF. Two patients became unwell before it could be performed, and 19 did not have sufficient sitting balance. Although poor sitting balance should not be a contraindication to VF, the specialized chair required for the procedure was unavailable during part of the study owing to unavoidable reasons. Despite the existence of an established VF service, VF could not be undertaken in 106 of the referred patients because of the unavailability of vacant slots for fluoroscopy or a trained speech and language therapist to perform the procedure at short notice. VF was undertaken in the remaining 54 (28.6%) patients by a speech and language therapist experienced in dysphagia management who was blinded to the modified BSA and pulse oximetry results. The patient was seated in an upright position and consumed different consistencies of food/liquid impregnated with barium while their swallow was imaged on a lateral projection from the teeth anteriorly to the posterior pharyngeal wall posteriorly.

TABLE 2. Numbers of Patients Desaturating by >2% or >5% During Modified BSA

<table>
<thead>
<tr>
<th>No. of Patients, %</th>
<th>Total Patients (n=189)</th>
<th>Safe on BSA (n=98)</th>
<th>Unsafe on BSA (n=85)</th>
<th>Silent Aspirators on BSA (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desaturation by &gt;2%</td>
<td>55 (29.1)</td>
<td>27 (27.6)</td>
<td>28 (32.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Desaturation by &gt;5%</td>
<td>9 (4.8)</td>
<td>3 (3.1)</td>
<td>6 (7.1)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>
Patients were scored according to their most unsafe swallow, and the findings were grouped into 4 categories: safe (no penetration or aspiration), penetration (entry of material into the laryngeal vestibule without passage through the true vocal cords), silent aspiration (passage through the cords without cough or accompanying distress), or overt aspiration.

### Data Analysis

Data were analyzed with SPSS 13.0 statistical software. Descriptive data are presented for demography, stroke characteristics, and comorbidities. Absolute percentage desaturation values were dichotomized for the presence/absence of a desaturation of >2% and then again for desaturation by >5% to assess the utility of these 2 thresholds. Univariate analyses were performed with χ² statistics to look for significant associations between the presence of a desaturation at either level and modified BSA results, desaturation and VF results, modified BSA and VF results, and VF and the combined variable of failed modified BSA and/or desaturation. κ Values were calculated to describe the agreement between the different swallow assessments, with the modified BSA results dichotomized into “safe” and “unsafe” (classifying patients with silent aspiration as unsafe) in view of the small numbers of silently aspirating patients. The sensitivity, specificity, and predictive values of desaturation at 2% or 5% thresholds to detect unsafe swallowing were calculated with modified BSA as the clinical standard, and sensitivity, specificity, and predictive values were also calculated for desaturation, modified BSA, and failed modified BSA and/or desaturation to detect aspiration risk compared with VF findings. In view of the limited number of patients who had undergone VF, VF findings were dichotomized into safe (no penetration or aspiration) or unsafe (penetration, silent aspiration, or overt aspiration) for the purposes of analysis.

### Results

Table 1 shows the baseline characteristics of patients included in the study. Although age and sex were comparable between those who underwent VF and those who did not, there were significant differences in their median Barthel index at baseline and the prevalence of unsafe swallowing on modified BSA, suggesting that fewer patients undergoing VF had severe strokes or swallowing problems on clinical examination. These differences became nonsignificant when the patients who were unable to undergo VF because of insufficient sitting balance or because of being unwell were excluded from the analyses. The proportion of patients desaturating by >2% or >5% during swallowing was less in the VF group, but this difference was not statistically significant.

Table 2 compares the results of pulse oximetry with the modified BSA. Of the 189 patients included in the study, 98 (51.9%) were considered to be safe, 85 (45.0%) unsafe, and 6 (3.2%) aspirating silently on the modified BSA. The median desaturation was 1.1% (interquartile range, 1.0 to 2.1) in both T1 (0 to 5 minutes after onset of swallowing) and T2 (5 to 10 minutes after onset of swallowing) time periods. Desaturation by >2% during swallowing occurred in 55 patients: 34 in T1 only, 13 in T2 only, and 8 in both time periods. More than one quarter of the patients (27.6%) who were considered safe on modified BSA desaturated by >2% during swallowing, whereas desaturation on swallowing was seen in 32.9% of patients considered to be unsafe on modified BSA. Desaturation by >5% during swallowing occurred in 9 patients: 5 in T1, 4 in T2, and none in both periods. There was no significant association between modified BSA score and desaturation by either >2% or >5%, with κ values of 0.03 and 0.04, respectively.

Table 3 compares the findings on VF with those on modified BSA in 54 patients. VF showed a safe swallow in 72.2% patients, penetration in 14.8% (entry of material into the laryngeal vestibule without passage through the true vocal cords), silent aspiration in 5.6% (passage through the cords without cough or accompanying distress), and overt aspiration in 7.4% of patients. The presence of an unsafe swallow on modified BSA was not significantly associated with unsafe swallow (penetration or aspiration) on VF (κ=0.17), and none of the patients who showed silent aspiration on VF was identified as a silent aspirator by the modified BSA.

Table 4 compares the findings of pulse oximetry with VF in 54 patients. Desaturation by >2% was seen in 5 (33.3%) and by >5% in 2 (13.3%) of the 15 patients showing penetration or aspiration on VF. In contrast, desaturation by >2% was seen in 15 (38.5%) and by >5% in 2 (5.1%) of the 39 patients who had no penetration/aspiration on VF. There was no association between VF findings of penetration/aspiration and desaturation by either >2% or >5% during swallowing in these patients (κ=−0.05 and 0.11, respectively).

With the modified BSA as the bedside standard to detect aspiration in the whole cohort of 189 patients, desaturation by >2% had a sensitivity of 0.31, a specificity of 0.72, a positive predictive value of 0.51, and a negative predictive value of

### Table 3. Results of Swallow Assessment in Patients Undergoing VF and Modified BSA

<table>
<thead>
<tr>
<th>No. of Patients, %</th>
<th>Total Patients Undergoing VF (n=54)</th>
<th>Safe on BSA (n=36)</th>
<th>Unsafe on BSA (n=17)</th>
<th>Silent Aspirators on BSA (n=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No penetration or aspiration on VF</td>
<td>39 (72.2)</td>
<td>28 (77.8)</td>
<td>10 (58.8)</td>
<td>1 (100)</td>
</tr>
<tr>
<td>Penetration on VF</td>
<td>8 (14.8)</td>
<td>7 (19.4)</td>
<td>1 (5.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Silent aspiration on VF</td>
<td>3 (5.6)</td>
<td>1 (2.8)</td>
<td>2 (11.8)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Overt aspiration on VF</td>
<td>4 (7.4)</td>
<td>0 (0)</td>
<td>4 (23.5)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

### Table 4. Numbers of Patients Desaturating by >2% or >5% During Modified BSA Subdivided by Results on VF

<table>
<thead>
<tr>
<th>No. of Patients, %</th>
<th>Total Patients Undergoing VF (n=54)</th>
<th>No Penetration or Aspiration on VF (n=39)</th>
<th>Penetration on VF (n=8)</th>
<th>Silent Aspiration on VF (n=3)</th>
<th>Overt Aspiration on VF (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desaturation by &gt;2% in either T1 or T2</td>
<td>20 (37.0)</td>
<td>15 (38.5)</td>
<td>2 (25.0)</td>
<td>1 (33.3)</td>
<td>2 (50.0)</td>
</tr>
<tr>
<td>Desaturation by &gt;5% in either T1 or T2</td>
<td>4 (7.4)</td>
<td>2 (5.1)</td>
<td>1 (12.5)</td>
<td>0 (0)</td>
<td>1 (25.0)</td>
</tr>
</tbody>
</table>
modified BSA and desaturation improved the sensitivity but at the expense of specificity and predictive values. The sensitivity and specificity of the 2 bedside assessments, modified BSA and pulse oximetry, were compared with VF as the gold standard in 54 patients and are shown in Table 5. Both modified BSA and pulse oximetry during swallowing showed low sensitivity, specificity, and predictive values for the detection of aspiration risk in acute stroke patients compared with VF. The values for desaturation by either >2% or >5% were lower than that for modified BSA, except for the specificity of desaturation by >5% in detecting aspiration risk. Combining modified BSA and desaturation improved the sensitivity but at the expense of specificity and predictive values.

### Discussion

This study in 189 consecutive hospitalized acute stroke patients showed that there was a poor association between oxygen desaturation during swallowing and failed bedside swallowing assessment for the detection of aspiration risk. In contrast to previous reports, this study is in agreement with those investigations that showed that pulse oximetry was not a reliable method for detecting aspiration risk. The study also showed that neither the modified BSA nor pulse oximetry, whether used alone or in combination, had adequate sensitivity, specificity, or predictive value for identifying the presence or absence of aspiration as seen on VF.

The strengths of the present study are that pulse oximetry and modified BSA assessments were undertaken simultaneously, and saturations were monitored for a 10-minute period to avoid missing late desaturation. In addition, all assessors were blinded to the findings of other assessments to prevent bias from influencing results. There is little agreement on the threshold for desaturation with swallowing that would reliably identify aspiration risk: cutoff values ranging from 2% to 4% have been suggested by different authors. This study assessed desaturation at both the 2% and 5% level and assessed maximum rather than mean desaturation to improve predictive yield.

The study also has limitations. The need for informed consent and the ability to comply with bedside assessment procedures resulted in a high rate of noninclusion and a bias toward patients with mild to moderate strokes. This was particularly evident in the group undergoing VF, for which further limitations were posed by having to exclude 21 patients because of problems with sitting balance and poor medical condition. This is, nevertheless, representative of mainstream practice, wherein most patients with a reduced level of consciousness or who are unable to cooperate are considered unsuitable for assessment. It was not possible in this study to include patients unable to consent because of communication and/or cognitive problems. Such patients are frequently encountered in clinical practice and are more likely to be at greater risk of aspiration. Indicators of aspiration, such as a significant fall in oxygen saturation, may be helpful in these patients but could not be tested in this study because of ethical concerns. As the frequency of swallowing problems increases with stroke severity, the study highlights the importance of adequate facilities for early detection of swallowing problems in acute stroke patients.

### Conclusions

This study shows that neither the widely used BSAs nor simple techniques such as pulse oximetry during swallowing have high enough sensitivity or specificity to be reliable and optimal methods of detecting aspiration risk in acute stroke patients. The routine use of VF has been advocated, but neither this technique nor FEES are available universally, organizing assessments at short notice may present logistical problems, and repeated examinations with VF carry increased radiation risk. Further research is needed to determine reliable subjective screening variables as an alternative means of assessing a stroke patient’s ability to swallow safely when objective techniques are unavailable.

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### Disclosures

No restrictions were placed on the conduct of the work or on resultant publications. D.G.S. has received modest honoraria for speaking on stroke-related topics.

### References

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