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Dysphagia


# Bronchial Auscultation: An Effective Adjunct to Speech and Language Therapy Bedside Assessment When Detecting Dysphagia and Aspiration?

Jane L. Shaw, B Med Sci,[1] Sam Sharpe, BSc,[1] Sarah E. Dyson, BSc,[1] Sue Pownall, BSc,[2] Stephen Walters, BSc, MSc,[3] Carol Saul, BA, MSc,[3] Pam Enderby, PhD, MSc,[3] Kerry Healy, BSc,[1] and Helen O'Sullivan, BSc[1]

[1]Speech and Language Therapy Department, Doncaster and Bassetlaw NHS Trust, Doncaster Royal Infirmary, Doncaster, DN2 5LT; [2]Speech and Language Therapy Department, Sheffield Teaching Hospitals, Royal Hallamshire Hospital (RHH), Sheffield, S10 2JF; and [3]School of Health and Related Research, Regent Court, Sheffield, S1 4DA, United Kingdom

**Abstract.** Detection of aspiration by bedside examination has frequently been found to be clinically inadequate when compared with videofluoroscopy (VF) as the gold standard. In Doncaster, UK, a new multidisciplinary approach to bedside assessment was devised using physiotherapists (PT) performing bronchial auscultation (BA) in combination with the speech and language therapists' (SLT) clinical examination of dysphagia. In this study 105 patients referred for VF examination of dysphagia were first tested by the BA team. Comparison was made between the results of the VF team and the results of the BA team in classifying the patients as "aspirating" or at "risk of aspirating." A high degree of agreement was found for risk of aspiration (sensitivity 87%), although specificity was low (37%). BA was highly specific (88%) when confirming the absence of aspiration, but sensitivity to the presence of aspiration was 45%. From the 105 patients tested, the BA team would have failed to modify the diet in only one subject who was aspirating and would have unnecessarily modified the diet of 17 subjects. In conclusion, in the sample population of individuals with complex dysphagia, the BA team approach reliably detected patients identified by VF as at risk of aspiration. In the group of patients identified by VF as aspirating, the BA team proved unreliable in detecting the presence of aspiration, although it did reliably identify patients who were not aspirating. BA is a potentially useful clinical tool which requires further research.

**Key words:** Aspiration — Bronchial auscultation — Videofluoroscopy — Dysphagia — Deglutition — Deglutition disorders.

Current literature suggests a range of incidence of dysphagia associated with various medical etiologies. Its recorded incidence in stroke is quoted as between 28% and 71% [1–5]. The AHCPR 1999 report states that "based on data from the stroke literature, it is estimated that approximately 43% to 54% of stroke patients with dysphagia experience aspiration, approximately 37% of these patients will develop pneumonia" [6].

Dysphagia is proven to have deleterious effects on patient outcomes with regard to morbidity, mortality, and increased length of hospital stay [5–9], and it is suggested that the presence of dysphagia has a closer link with the incidence of chest infection than does detection of actual aspiration on VF alone [7,10,11]. As Perry and Lowe [8] state: "Dysphagia management is of crucial importance."

Screening and assessment at bedside can potentially reduce the incidence of aspiration and provide more effective management of dysphagia [8,9]. However, the literature does not support the use of speech and language therapy bedside assessment alone [5,11–13] when identifying the presence or ab-

Work performed at Doncaster Royal Infirmary and Royal Hallamshire Hospital, Sheffield, UK.

*Correspondence to:* Jane L. Shaw, B Med Sci, Speech and Language Therapy Department, Doncaster and Bassetlaw NHS Trust, Doncaster Royal Infirmary, Armthorpe Road, Doncaster, DN2 5LT, UK. E-mail: janelshaw@hotmail.com

sence of dysphagia and, in particular, the presence or absence of aspiration. Studies have shown that between 40% and 60% of patients who aspirate in videofluoroscopy are not identified at bedside [5,12,13]. Bedside sensitivity, in fact, is generally at the level of chance [11,13,14].

The challenge is on to find an effective adjunct (or indeed alternative) to the current SLT bedside assessment that is cost effective, easily available to patients, and has no contraindications to serial testing [8]. Fiberoptic endoscopic evaluation of swallowing (FEES) [15,16] can be a useful adjunct but requires expensive equipment, often relies on ear, nose, and throat departmental support, and is invasive. Oxygen saturation or pulse oximetry has shown good sensitivities [17,18], especially when combined with bedside assessment, but it requires further research. It also tends to overestimate aspiration, mistaking laryngeal penetration for aspiration [18].

Cervical auscultation has given sensitivities above 80% in certain studies [19,20]. It uses acoustic analysis, utilizing information from studies that analyzed the characteristic sounds of swallowing—in particular, distinguishing swallowing sounds from associated activities such as coughing, respiration, and vocalization, [21–23]. There is no accepted theory of swallowing sounds to be heard on cervical auscultation, but there is general agreement that the sound of aspiration is recognizable and distinctly different from the sound of the normal swallow [19,20,22,23].

Clinicians using cervical auscultation to assess breath and swallow sounds require specialized training and experience which many SLTs lack. Zenner [19] points out that this can render cervical auscultation an "imprecise clinical method," the sensitivity of the method being reliant on the expertise and training of the individual clinician.

Investigations into the optimal site for detecting swallowing sounds have previously focused on placement of the stethoscope at or above the level of the cricoid [23]. No attempt has yet been made to examine the audibility of aspiration using auscultation lower than this point.

This study investigates a modification to the SLT full bedside examination, involving a PT and a SLT in a multidisciplinary assessment of swallowing. The PT carries out bronchial auscultation during the trial feeding stage of the bedside examination and listens for changes in the breath sounds during deglutition.

Bronchial auscultation is a different technique from cervical auscultation as it involves placement of the stethoscope over the bronchus rather than at laryngeal level. This is the first study designed to investigate the use of a bronchial auscultation multidisciplinary team in the examination of dysphagia.

Doctors and physiotherapists are already trained and often very experienced in the use of auscultation for other diagnostic purposes. Clinical observation suggests that despite not being specifically experienced in the detection of the sounds of aspiration, these professionals' familiarity with the normal lung field sounds enables them to isolate changes to the normal sounds indicative of dysphagia and aspiration with minimal additional training.

Videofluoroscopy is generally accepted as the gold standard [2,5,12,13] for the assessment of oral pharyngeal physiology of swallowing, not only with regard to aspiration but also to overall efficiency of swallowing and the investigation of maneuvers designed to improve swallowing management. There have, however, been recent questions regarding the predictive power of VF for patient outcomes [7] and the limitations of using a nonserial test for patients whose swallowing ability fluctuates [5,9,11].

For the purposes of this study, neither serial testing of individual patients nor patient outcomes are under investigation. VF therefore is used as the most appropriate gold standard against which the BA team bedside examination can be tested for specificity and sensitivity to presence or risk of aspiration.

## Materials and Methods

### *Objectives*

The primary aim of this study was to investigate the clinical value of the combined SLT/PT BA team approach to the bedside assessment of dysphagia by comparing it with VF as the gold standard. The following research questions were addressed:

1. Is BA team assessment sensitive enough to detect aspiration?
2. Is BA team assessment sensitive enough to detect silent aspiration?
3. Is BA team assessment specific enough to avoid classifying patients as aspirating when they are not?
4. Is BA team assessment equally accurate in its classification across all bolus consistencies?
5. Is BA team assessment more effective in accurately classifying patients as aspirating/not-aspirating than bedside assessment alone?

### *Procedures*

Data collection covered a 13-month period (July 2000–August 2001). Subjects were a prospective convenience sample of adult patients referred for VF at a large urban teaching hospital in the Trent region of the UK. Referral followed conventional bedside examination by SLT, which had identified them as dysphagic. Subjects were consented in accordance with the written guidelines and approval of

**Table 1.** Bolus size and consistency protocol

| Order of administration | Bronchial auscultation | Videofluoroscopy (barium type Ez) |
|---|---|---|
| Liquid: 5 ml × 2<br>20 ml × 2 | Water | Thin barium<br>(2: 1 water: barium) |
| Semisolid: 5 ml × 2<br>20 ml × 2 | Yogurt | Barium mixed with yogurt<br>(2:1 yogurt:barium) |
| Solid: Small × 2<br>Large × 2 | Bread | Barium-soaked bread |

South Sheffield Ethics Committee CSUH Research Department. Patients were excluded from the study based on the following criteria: (1) pre-existing chest infection that masked lung sounds for BA, and (2) subjects too ill to undergo assessment on the day.

The data collection was carried out by two bronchial auscultation (BA) teams, consisting of an SLT and a PT experienced in BA dysphagia assessment, and two videofluoroscopy (VF) teams, each consisting of an SLT and a radiologist experienced in videofluoroscopy.

Prior to commencing the project, each pair of teams underwent interrater reliability testing on 10 cases, using the examination protocols for VF and BA defined below. Subjects underwent examination by the BA team first followed by the VF examination. Both investigations were completed within an hour of each other. The teams received the same basic background medical information prior to assessment but were blinded to each other's results.

### *Bronchial Auscultation Examination*

Bronchial auscultation involves placing the flat diaphragm of a standard stethoscope over the top of the right main bronchus, as this is the usual path of aspirated material. The same Universal Hospital Supplies stethoscope was used throughout the project. The PT listens to breath sounds prior to oral intake, then, by continuous listening, monitors for changes in the breath sounds during swallowing and for a minimum of 15 seconds after the swallow [24]. The types of breath sounds' changes that caused the PT to suspect aspiration were flushing sounds, bubbling sounds, and popping, where no additional sounds existed prior to bolus deglutition.

For each subject a history, interview, and oral examination was completed prior to trial feeding. During trial feeding, which followed the standard protocol shown in Table 1, the PT used BA to detect changes in the breath sounds and the SLT observed for clinical signs of aspiration. While the PT continued to listen, head rotation was requested of the patient following each bolus swallow to minimize effects of bolus residue buildup in the pharynx. All observations for every bolus were documented and categorized according to the definitions in Table 2. The assessment was terminated at any stage if a patient refused further oral intake or if the BA team considered it unsafe to continue.

### *Videofluoroscopic Examination*

The VF team completed a fluoroscopic examination of each patient's swallow within an hour of the BA assessment using a Philips Diagnost 96 fluoroscopic unit with digital spot imaging system DSI. A lateral upright position was used throughout.

Presentation of the bolus material followed the same standard protocol (see Table 1) unless the patient aspirated or had significant difficulty clearing material, in which case the protocol sequence was varied where necessary for patient safety. Head rotation was employed after each bolus swallow in VF in order to keep the protocol sequence identical to the BA examination. Observations for each bolus were documented and categorized according to the definitions in Table 2.

### *Data Preparation*

JLS, SS, and the full panel of BA and VF team SLTs completed the preparation of the raw data. The raw data were prepared for analysis by giving each subject an "overall" classification on each of the following binary scales (using the definitions in Table 2):

1. At risk of aspiration/not at risk of aspiration
2. Aspirating/not aspirating
3. Silent/not silent (Subjects who aspirated were judged to be "not silent" if they coughed or throat cleared.)

Each subject was also categorized separately for each bolus type (liquid, semisolid, solid) to allow comparison of agreement for the different bolus consistencies.

### *Analysis*

As there is no information in the available literature as to the accuracy of BA, the following information and criteria were used to give the sample size and statistical analyses.

Assuming the sensitivity of BA compared to that of VF was approximately 90%, then to estimate this proportion with a 95% confidence interval (CI) ranging from 80% to 100%, approximately 35 patients who are true aspirators would be needed. The exact proportion of eligible patients who were likely to be aspirators or nonaspirators was unknown, but it was calculated that a sample of 100 patients would be necessary to achieve the required number of 35 true aspirators to estimate the sensitivity/specificity with $\pm 10\%$ accuracy.

| Bronchial Auscultation | Videofluoroscopy (gold standard) | |
|---|---|---|
| Test result | Aspiration present | Aspiration absent |
| Positive (aspiration) | True positive (TP) | False positive (FP) |
| Negative (nonaspiration) | False negative (FN) | True negative (TN) |

The primary analysis calculated the sensitivity and specificity of BA in detecting aspiration along with 95% CI for these estimates. A positive test result using either VF or BA was defined as aspiration in any bolus consistency. Additionally, these values were also calculated for "risk of aspiration" and "silent aspiration." Secondary analysis calculated the sensitivity and specificity for aspiration (with 95% CI) on each of the three bolus consistencies.

The data were entered and analyzed using SPSS for Windows. Ninety-five percent confidence intervals for the various sensitivity and specificity rates were calculated using CIA software [25].

## Results

### *Interrater Reliability*

The two VF teams showed 100% agreement with each other when the data from the ten test cases was

**Table 2.** Classification categories for each bolus taken

| | Bronchial auscultation | Videofluoroscopy |
|---|---|---|
| Aspirating | (a) If the PT heard the added sound of bolus material entering the bronchus | (a) Bolus material observed to penetrate below the level of the vocal cords (even if coughed back on request or spontaneously) |
| At risk of aspiration | (b) If clinical signs such as wet voice or coughing were observed by the SLT or if the physio heard nonspecific changes to the breath sounds | (b) Any clinical signs of aspiration such as wet voice or coughing observed. Also any radiographic evidence of laryngeal penetration of bolus material and/or residue of bolus material in pyriform fossa or valleculae not spontaneously cleared |
| Not at risk of aspiration | If neither (a) nor (b) was present | If neither (a) nor (b) were present |

**Table 3.** Disorders

| Primary diagnoses | *n* | % |
|---|---|---|
| CVA | 35 | 33 |
| Progressive neurological including: | 24 | 23 |
| Parkinson's disease | (7) | |
| Motor neurone disease | (4) | |
| Multiple sclerosis | (3) | |
| Cancer | 9 | 9 |
| Head injury | 3 | 3 |
| Thyroid tumor | 5 | 5 |
| Mental illness | 5 | 5 |
| Pharyngeal pouch | 3 | 3 |
| Vocal fold palsy | 3 | 3 |
| Other | 18 | 17 |
| Total | 105 | 100% |

**Table 4.** Prevalence according to VF

| | Prevalence in sample of 105 patients | Percentage |
|---|---|---|
| Risk of aspiration | 78 | 74% (95% CI: 65–82) |
| Aspiration | 40 | 38% (95% CI: 29–48) |
| Silent aspiration | 14 | 13% (95% CI: 8–21) |

compared. The two BA teams also showed 100% agreement with each other.

*Characteristics of Sample*

There were 4425 referrals to the four SLT departments in the catchment area of the research study; 160 (3%) were referred for VF. Of the 160 eligible patients, 111 consented to participate (69%). Six patients were excluded from the study using the defined criteria: four due to pre-existing chest infection, two due to illness on the day of assessment. The remaining 105 patients entered the study and were tested on fluids (8 were terminated at this stage; see Materials and Methods for termination criteria). Ninety-seven were tested on fluids and semisolids (53 were terminated at this stage, see Materials and Methods for termination criteria). Forty-four were tested on fluids, semisolids, and solids. Sixty-one subjects (58%) were male and 44 (42%) were female. Ages ranged from 17 to 96 years (median = 71 years). Thirty-six (34%) were inpatients, 69 (66%) were outpatients.

The length of onset of dysphagia ranged from 1 week to 50 years (median = 24 weeks). Most (80%) had experienced problems for less than 1 year. The most common primary diagnosis was cerebrovascular accident (CVA) (35 cases). Other common diagnoses were cancer and progressive neurological disorders (see Table 3).

The prevalence of aspiration, silent aspiration, and risk of aspiration in the sample, as assessed by the gold standard of VF, is shown in Table 4.

*Risk of Aspiration (see Tables 5 and 6)*

VF identified 78 (74%) as at risk. BA identified 68 of these, giving 87% sensitivity (95% CI: 78–93) to the presence of risk of aspiration. However, BA overestimated risk of aspiration (specificity 37%), identifying risk in 17 patients who VF classified as no risk. Cross-tabulating BA risk of aspiration with VF aspiration shows that when BA found no risk of aspiration (20/105), then 95% of the time (19/20) the subject was not aspirating on VF. When VF identified aspiration (40/105), BA almost always identifies

**Table 5.** Whole group analysis: agreement scores

| | Risk of aspiration | Aspiration | Silent aspiration |
|---|---|---|---|
| Sensitivity | 87% (78–93) | 45% (31–60) | 14% (4–40) |
| Specificity | 37% (21–56) | 88% (77–94) | 92% (85–96) |
| Positive predict value (PPV) | 80% (70–87) | 69% (50–83) | 22% (6–55) |
| Negative predictive value (NPV) | 50% (30–70) | 72% (61–81) | 88% (79–93) |

95% confidence intervals in parentheses. The confidence intervals are wide, reflecting the small study size and the uncertainty of the estimates of sensitivity and specificity in this subject group.

**Table 6.** Risk of aspiration

| | | Bronchial auscultation | | |
|---|---|---|---|---|
| Videofluoroscopy | | No | Yes | Total |
| | No | 10 | 17 | 27 |
| | Yes | 10 | 68 | 78 |
| | Total | 20 | 85 | 105 |

**Table 7.** BA Risk of aspiration vs. VF aspiration

| | | BA risk of aspiration | | |
|---|---|---|---|---|
| V.F aspiration | | No | Yes | Total |
| | No | 19 | 46 | 65 |
| | Yes | 1 | 39 | 40 |
| | Total | 20 | 85 | 105 |

the subject as at risk (39/40) (see Table 7). Overall, out of the 78 subjects that VF identifies as "at risk of aspiration," BA agreed on 68. Of the 10 subjects BA did not identify as "at risk," only one of these was found to actually aspirate on VF.

*Aspiration (see Tables 5 and 8)*

Forty subjects (38%) were found by VF to be aspirating. BA identified 18 of these, giving a sensitivity of 45% (95% CI: 31–60). Overall, BA identified 26 individuals as aspirating, including 18 of the 40 identified by VF. This level of accuracy gives a positive predictive value (PPV) of 69% (95% CI: 50–83). BA identified 79 subjects as not aspirating and was incorrect according to VF on 22 of these, giving a negative predictive value (NPV) of 72% (95% CI: 61–81).

BA demonstrates a high level of specificity when ruling out the presence of aspiration (88% and NPV 72%). All 26 subjects identified by BA as aspirating were classified by VF as at risk (see Table 9). Of the 27 patients VF identified as not at risk, BA did not classify any as aspirating.

*Silent Aspiration (see Tables 5 and 10)*

Only 14 (13%) patients were assessed by VF as silently aspirating. The BA team identified two of the silent aspirators, giving a sensitivity of 14% (95% CI: 4–40). The wide confidence interval reflects the small sample size and the uncertainty of the sensitivity estimates. However, even allowing for this, sensitivity is less than 50%.

**Table 8.** Aspiration

| | | Bronchial auscultation | | |
|---|---|---|---|---|
| Videofluoroscopy | | No | Yes | Total |
| | No | 57 | 8 | 65 |
| | Yes | 22 | 18 | 40 |
| | Total | 79 | 26 | 105 |

*Different Bolus Consistencies (see Table 11)*

There was very little difference in the performance of BA across the different bolus consistencies. Again, confidence intervals indicate the uncertainty in the estimates of sensitivity, specificity, PPV, and NPV.

*Subgroup Analysis*

The subgroups within the sample were analyzed by age and disorder. Agreement between BA and VF was highest with CVA patients, where sensitivity to risk of aspiration and specificity for aspiration were both 100%. Agreement between BA and VF was lowest in patients with progressive neurological disorders, where sensitivity to risk of aspiration was 75% and specificity for aspiration was 87%.

**Table 9.** BA aspiration vs. VF risk of aspiration

| | | BA aspiration | | |
|---|---|---|---|---|
| | | No | Yes | Total |
| V.F risk of aspiration | No | 27 | 0 | 27 |
| | Yes | 52 | 26 | 78 |
| | Total | 79 | 26 | 105 |

**Table 10.** Silent aspiration

| | | Bronchial auscultation | | |
|---|---|---|---|---|
| | | No | Yes | Total |
| Videofluoroscopy | No | 84 | 7 | 91 |
| | Yes | 12 | 2 | 14 |
| | Total | 96 | 9 | 105 |

**Table 11.** Aspiration results for different bolus consistencies

| | Whole group ($n = 105$) (aspiration 40/105) | Fluids ($n = 105$) (aspiration 37/105) | Semisolids ($n = 97$) (aspiration 12/97) | Solids ($n = 44$) Aspiration 0/44 |
|---|---|---|---|---|
| Sensitivity agreement | 45% 18/40 (31–60) | 38% 14/37 (24–54) | 33% 4/12 (14–61) | N/A |
| Specificity agreement | 88% 57/65 (77–94) | 90% 61/68 (80–95) | 93% 79/85 (85–97) | 98% 43/44 (88–100) |
| PPV agreement | 69% 18/26 (50–83) | 67% 14/21 (45–83) | 40% 4/10 (17–69) | N/A |
| NPV agreement | 72% 57/79 (61–81) | 73% 61/84 (62–81) | 91% 79/87 (83–95) | 100% 43/43 (92–100) |

95% confidence intervals in parentheses.

## Discussion

As a result of the sample selection procedure, the study population represents the 3% most diagnostically challenging dysphagic patients referred to speech and language therapists. This could mean that generalization of these results to the overall population is misleading. It is possible that BA may prove to be more sensitive and specific if applied to a sample more representative of the general population of dysphagic patients. The results of the subgroup analysis lend weight to this possibility, with sensitivities of up to 100% for CVA patients. CVA patients make up a high percentage of the general hospital dysphagic population.

Although the BA team approach showed high sensitivity (87%) for risk of aspiration, this figure must be viewed in light of the nature of the population sampled. The population can all be assumed to show clinical indicators of risk at bedside (by nature of their selection) and indeed 74% are shown to be at risk in VF. So, although 87% sensitivity for risk of aspiration is clinically useful, it is not remarkable in a population with such a high prevalence of risk.

BA incorrectly classified 22 patients as not aspirating, instead rating them as only at risk. This misclassification could result from the definition of aspiration used by the VF team. In VF a patient was classified as aspirating if the bolus material passed below the level of the vocal folds even if it was then spontaneously coughed and cleared. This is the standard research definition of aspiration. However, if bolus material is spontaneously cleared by coughing, then the bronchial auscultation physiotherapist will not hear it pass into the bronchus. The coughing masks the sounds as the bolus penetrates, and when the coughing subsides it is no longer present in the airway. The patient is then classified as at risk by the BA team in response to the clinical signs.

The analysis supports this hypothesis. Out of the 22 patients judged as not aspirating by BA and aspirating by VF:

(i) BA judged all 22 at risk because they exhibited clinical signs such as coughing
(ii) 15 of them coughed during aspiration in VF.

This suggests that BA can give additional information about the patient's ability to clear penetrated materials and therefore is helpful in the field when formulating a judgment of risk.

In a clinical setting it is not the presence of aspiration on one isolated swallow that is significant but the clinician's ability to manage the overall level of risk of the patient aspirating. In this study, as with other studies before it, there is a very high level of agreement between bedside examination (including BA) and videofluoroscopy in the identification of patients at risk of aspiration (sensitivity 87%).

It is not possible from this study to give an exact evaluation of the contribution made by the BA technique itself to the standard bedside examination's ability to detect dysphagia and aspiration. For reasons already discussed, direct comparisons with other published research could be misleading. However, the methodology is easily replicable and a future study could make a direct comparison with a standard bedside examination that does not include BA.

There is also some evidence within the study of the "value added" by BA if the specificity results of risk of aspiration (37%) are compared with the specificity of aspiration (88%). Risk of aspiration was judged by both members of the BA team based largely on clinical observations (wet voice, coughing, nonspecific breath sound changes, etc.), whereas aspiration was judged solely on the input from the physiotherapist listening to the bronchus. This 88% specificity provided by BA in ruling out aspiration provides the SLT with a powerful tool to enhance the accuracy of a standard bedside examination. It is significant that the test was able to achieve 88% specificity for aspiration in a population with such high prevalence of risk.

The overall number of aspirators (40) and subgroup of silent aspirators (14) mean that statistically the silent aspirators group is not powerful enough to allow us to draw firm conclusions. Compared with other research, this proportion of silent aspirators was unexpectedly low. Other studies quote silent aspiration rates around 20% [5,7,8,11–13]. This may be due to the highly selected nature of the sample used in the study.

Silent aspirators are, by definition, the most difficult to identify as at risk using clinical observations. However, the BA team successfully classified 100% of the subjects identified by VF as silent aspirators as being at risk, and clinically they would have been managed as such. It is also possible that BA did not overestimate the silent aspiration risk because all nine patients judged as silent aspirators by BA were judged as at risk by VF. Indeed, five of them did actually aspirate on VF, they just did not do so silently. So some of the discrepancy in the BA/VF judgments of the silent aspirators group was, in fact, not disagreement over whether a particular patient aspirated but disagreement about whether they were silent or not.

The ideal design for a project of this nature is for the two tests (VF and BA) to be carried out simultaneously so there is no possibility of variability in patient behavior affecting the outcome of each test. At the outset of the project this was judged not to be a feasible design with respect to the protection of therapy staff from radiation exposure. It was hoped that by ensuring that both tests were completed within one hour of each other the potential for subject variability would be reduced to acceptable levels.

However, there is evidence within the results that subjects' behavior during the two examinations did vary. Of the 14 subjects classified as silent aspirators in VF, 12 exhibited clinical signs of risk (i.e., coughing) in the BA examination. Of the 9 subjects judged by BA to silently aspirate, 5 did actually aspirate in VF but only 2 of them did so silently. This suggests that in the silent/non-silent behavior patterns, subjects showed some degree of variability between the two examinations, and this has affected outcomes.

Although the therapists in this study were not asked to make judgments with regard to feeding status, in clinical practice a patient judged to have a high risk of aspiration on a particular food/fluid consistency would receive dietary modification to manage that risk. On that basis, on review of the 105 subjects tested, the BA team approach would have failed to modify the diet in only one subject who was aspirating in VF and would have unnecessarily modified the diet in 17 subjects.

## Conclusions

In a population selected for the diagnostic complexity of their dysphagia, the bronchial auscultation team showed a high level of agreement with videofluoroscopy on the detection of risk of aspiration (87%) and a high level of agreement in detecting patients who were not aspirating (88%). The BA team was overcautious when judging a subject as not at risk and was not sensitive enough to detect the presence of aspiration of bolus material into the trachea.

In the clinical setting the ability to detect actual aspiration on one specific swallow is not the overriding concern [8]. In order to ensure the safe management of dysphagia and a patient's oral intake, the clinician needs to be able to accurately and reliably evaluate the overall risk of that patient aspirating a particular bolus consistency in their normal feeding environment.

The BA team assessment is

1. widely available at bedside with minimal additional training;
2. reliable and accurate at detecting risk of aspiration of all bolus consistencies in a complex dysphagic population; and
3. reliable and accurate at ruling out the presence of aspiration in a complex dysphagic population.

The combination of these three factors renders BA a very promising clinical tool for assessing the presence of dysphagia at the bedside, but it deserves and requires further research before it can be confidently applied more widely.

## Recommendations

BA team should be used to:

(i) detect risk of aspiration
(ii) rule out the presence of aspiration.

BA technique should:

(i) NOT be used to detect aspiration;
(ii) NOT be used in isolation, but always in conjunction with SLT bedside examination of dysphagia;
(iii) NOT be considered as comparable to VF. The BA team examination is a bedside dysphagia assessment, as defined by Perry [8], whereas VF allows for examination of oral pharyngeal physiology, enabling a full diagnostic evaluation of dysphagia.

To improve the confidence intervals on a number of the results, a study on a larger population sample would need to be undertaken.

Further studies involving simultaneous assessment of a patient's swallow by BA/VF on a more standard population will provide a clearer indication of the value and applicability of the test. It would also be useful to evaluate and isolate the actual contribution of the bronchial auscultation technique in order to assess the value added by BA to the standard bedside examination. Acoustic analysis studies of the recorded BA sound signal may provide objective evidence of the presence of aspiration.

An additional study designed to investigate the clinical outcomes (especially development of aspiration pneumonia) of patients classified as at risk/aspirating by BA team compared with VF team would be desirable in order to determine the clinical value of the test.

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