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Dysphagia

Cervical Auscultation Synchronized with Images from Endoscopy Swallow Evaluations

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Abstract. Cervical auscultation is the use of a listening device, typically a stethoscope in clinical practice, to assess swallow sounds and by some definitions airway sounds. Judgments are then made on the normality or degree of impairment of the sounds. Listeners interpret the sounds and suggest what might be happening with the swallow or causing impairment. A major criticism of cervical auscultation is that there is no evidence on what causes the sounds or whether the sounds correspond to physiologically important, health-threatening events. We sought to determine in healthy volunteers (1) if a definitive set of swallow sounds could be identified, (2) the order in which swallow sounds and physiologic events occur, and (3) if swallow sounds could be matched to the observed physiologic events. Swallow sounds were computer recorded via a Littmann stethoscope from 19 healthy volunteers (8 males, 11 females, age range = 18–73 years) during simultaneous fiberoptic laryngoscopy and respiration monitoring. Six sound components could be distinguished but none of these occurred in all swallows. There was a wide spread and a large degree of overlap of the timings of swallow sounds and physiologic events. No individual sound component was consistently associated with a physiologic event, which is a clinically significant finding. Comparisons of groups of sounds and events suggest associations between the preclick and the onset of apnea; the preclick and the start of epiglottic excursion; the click and the epiglottis returning to rest; the click and the end of the swallow apnea. There is no evidence of a causal link. The absence of a swallow sound in itself is not a definite sign of pathologic swallowing, but a repeated abnormal pattern may indicate impairment. At present there is no robust evidence that cervical auscultation of swallow sounds should be adopted in routine clinical practice. There are no data to support the inclusion of the technique into clinical guidelines or management protocols. More evaluation using imaging methods such as videofluoroscopy is required before this subjective technique is validated for clinical use by those assessing swallowing outside of a research context.

Key words: Cervical auscultation — Swallowing — Laryngoscopic swallow evaluation — Dysphagia — Deglutition — Deglutition disorders.

Cervical auscultation is the use of a listening device, typically a stethoscope in clinical practice, to assess the sounds of swallowing. By some definitions this includes airway sounds pre- and postswallow, but many such sounds (coughing, for example) can be recorded without cervical auscultation. For the present study we were particularly interested in the value of the swallow sound itself. Judgments are then made on the normality or degree of impairment of the sounds. Listeners interpret the sounds and make inferences as to what might be happening with the swallow or causing impairment. One of the major criticisms of cervical

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auscultation is that there is no evidence on what causes the sounds. Anecdotal evidence suggests that such things as aspiration, residue pooling, and physiologic abnormalities can be detected.

Sensitivity and specificity figures for the technique in general are not established. Figures for tracheal aspiration were calculated in the Zenner (1995) study [1]; however, they were based on a combination of swallow and other airway sounds including cough, stridor, and throat clearing. The contribution from cervical auscultation of the swallow sound alone is not clear. Dysphagia clinicians are using a procedure that is gaining momentum more rapidly than evidence is being produced to support it. This is not a unique scenario but "common use" is not an acceptable justification for a tool to be used clinically.

Recent years have seen a rise in claims that the assessment of swallow sounds, using cervical auscultation, is an essential adjunct to the clinical swallow assessment. The attractions of cervical auscultation are obvious: a relatively cheap piece of equipment—the stethoscope that can be put in the clinician's pocket and travel to any setting. Placing the stethoscope on the patient's neck is hardly invasive and relies on minimal cooperation. In facilities where there is no access to proven instrumental diagnostic tools such as videofluoroscopy and laryngoscopy, there are strong motivations to accept cervical auscultation as such a tool. There is a danger that cervical auscultation may be used by some to answer questions that it cannot regarding assessment and intervention.

Cervical auscultation is a controversial technique with few published reports [1, 2] and no agreement on the origin and implication of the sounds [3]. Published papers have no consistency of methodology, characteristics under investigation, or terminology. Various researchers have even used different events to mark the onset of timings quoted in papers. This contributes to the poor evidence base for the technique.

Textbook descriptions of the technique tell the listener that the main features to listen for are two clicks and a swallow apnea followed by an expiratory breath [4]. There is no evidence on what these "clicks" are, only a hypothesis that one corresponds to the bolus passing through the upper esophageal sphincter [5]. There are no robust data on the sound patterns heard using a stethoscope in clinical practice in healthy people; thus, to make claims about what indicates a disordered sound is unwise [6–8].

We need studies establishing the causes of sounds, and those linking sounds to definite clinical outcomes. A large study has been underway for some years in the United States [9] but the findings have yet to be published. Similarly in the UK, Stroud et al. [2] performed a study with videofluoroscopy and reported on rater reliability, but other findings from her study still await publication.

There is no robust evidence that links physiologic events with sounds because there are profound difficulties in synchronizing images with physiologic data in a clinically replicable manner. The few commercially available systems are extremely expensive and beyond the means of all but specialist centers. Theories attribute at least one sound to the mechanical lifting of the larynx [3, 10]. A study using simultaneous videofluoroscopy and sound recording found no evidence linking epiglottic inversion with an acoustic signal [11]. Hamlet et al. [5] suggested that the sounds are due to changes in bolus velocity "corresponding to the onset of *pressurized* flow into the esophagus" (p. 751). Again, the Perlman et al. [11] study did not find evidence to support this. Both the Takahashi et al. group [12] and the Hamlet group [5] used accelerometers rather than microphones. McKaig and Stroud [13] state that the sound is due to "compression of the bolus by tongue motion and peristaltic action of the muscles of the pharynx as well as displacement of air." (p. 30, poster abstract). Reddy et al. [14] hypothesized that the accelerometer response was probably due to laryngeal elevation but that it may have been because of pharyngeal contractions.

Selley et al. [15] concluded that the first sound was due to events after movement of the larynx and epiglottis, possibly "due to the bolus, under a large pressure gradient, bursting through the upper esophageal sphincter" (p. 166). There was no explanation of why this might be so; were the authors just reiterating the hypothesis of Hamlet et al. [5]? The second sound "started when most of the bolus was in the esophagus and ended when the tail of the bolus was still at the level of the valleculae" (*ibid.*). The results given by the authors were based on a "detailed description of one swallowing event" (p. 163), which is not a generalizable finding. Because there is no consensus in the literature or in clinical practice as to which physiologic events cause the sounds and what is a "normal" sound, it may be that some features of the swallow sound are less important than the pattern or timing of events.

The goal of this study was to assess the relationship between swallow sounds and physiologic events as assessed by cervical auscultation and simultaneously recorded respiration patterns and laryngoscopic swallowing evaluations in a sample of healthy nondysphagic volunteers. We wanted to (1) establish if a definitive set of sounds could be identified in swallows, (2) identify the order of swallow sounds and physiologic events, and (3) investigate if swallow sounds could be matched to physiologic events.

Methods

Participants

Twenty healthy volunteers were recruited (8 male, 12 female, median age = 33 years, range = 18–73 years). Exclusion criteria were previous history of dysphagia or eating/drinking difficulties, neurologic impairment, current medical conditions requiring medication, or structural abnormalities that could affect the swallowing or respiratory systems. One female volunteer was unable to have the laryngoscope passed due to previous surgery, so the data are from the remaining 19. Written informed consent was obtained for all participants in the study. The Newcastle and North Tyneside Joint Ethics Committee granted ethical approval for the study.

Equipment

The system was a development of a previous one by the research team [16]. We adopted the same technology that professional video editors use, i.e., we had to resynchronize video footage from a number of cameras, all recorded separately. During recording, a master recorder generates a time code that is broadcast to any number of slave recorders. The time code is recorded against each video frame, allowing later synchronization of all the machines at playback. In our system, the slave video recorder was replaced by a personal computer, which recorded the time code, the auscultation sounds, and other physiologic data.

For this study the video source was a laryngoscopy camera (Sharplan iSight 8010, Lumenis Ltd, London, UK, with Wolf 305D lens, Richard Wolf GmbH, Knittlingen, Germany), light source (Storz Laryngostrobe 8020, Karl Storz Endoscopy Ltd, Slough, UK), and scope (Pentax FNL 10RP3, Pentax Ltd, Slough, UK). Laryngoscopy is a diagnostic imaging technique increasingly used in clinical practice and provides complementary information to videofluoroscopy. A separate study has been undertaken with videofluoroscopy and is being written up.

The direction of airflow was measured using an external pressure transducer (Gaeltec, Dunvegan, Scotland) connected to the oxygen input of a standard hospital issue Hudson 1108, twin-prong, over-the-ear, nasal cannula (Teleflex Medical, High Wycombe, UK). A Littmann Cardio III stethoscope (3M, Loughborough, UK) is the most suitable instrument for the frequency range involved in swallowing [17]. A BL 1994 microphone (Knowles Acoustics, Burgess Hill, UK) was mounted at the stethoscope bifurcation (Fig. 1) in preference to previously used accelerometers, which typically have a bandwidth much lower than human hearing [18]. Airflow was sampled to the personal computer at 100 Hz and auscultation sounds at 44,100 Hz.

The recording quality of the system was optimized to match what clinicians actually hear at bedside. Tube length and recording quality were modified iteratively until the consensus of two medical physicists and an experienced clinician agreed that the sound was as close as possible to the sound heard via the stethoscope. This was further checked by three clinicians familiar with cervical auscultation who were blindfolded and then asked to judge whether 15 test swallows of paired boluses from the same person were live or prerecorded. The final length of the tube from microphone to bell connector was 38 cm.

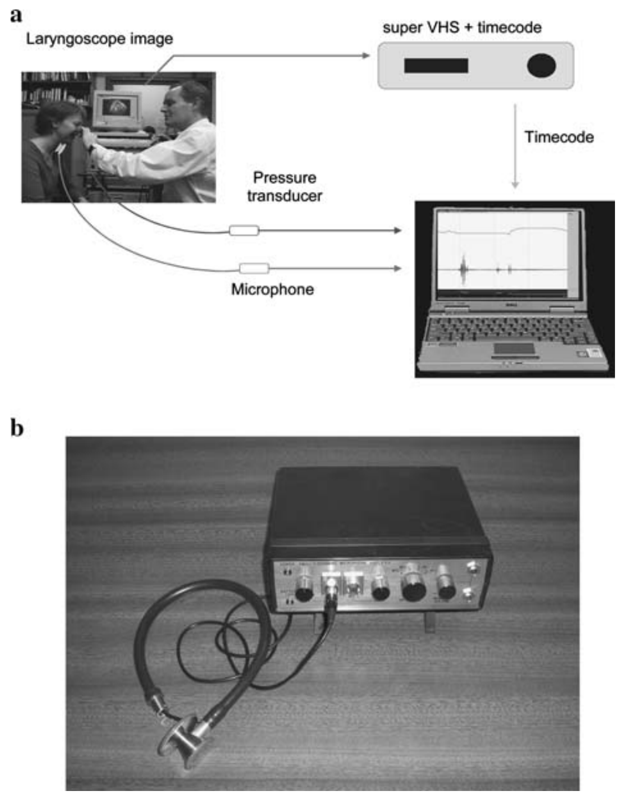

Fig. 1. (**a**) Schematic of the recording equipment. (**b**) The modified stethoscope and amplifier.

On playback, the time-coded video picture was synchronized to within 0.04 s with the sound and airflow signals (Fig. 1).

Procedure

Auscultation was performed with simultaneous laryngoscopy in the Speech and Language Therapy Department at the authors' hospital. Three boluses each of 5 ml and 20 ml blue dyed water and 5 ml yogurt were chosen by consensus of existing studies [1, 2, 6, 7, 11, 12, 15, 16] and were presented in that order to all participants. To avoid learner effects or fatiguing, the boluses would ideally have been presented in a random order. However, we wished to present boluses in the same order as those in a concurrent clinical study [16], where a different order would have posed an unacceptable aspiration risk.

The liquids were measured by graduated syringe into a small plastic cup and the participant was asked to drink the entire contents in one swallow to mimic real drinking as closely as possible. Injecting materials into the mouth may affect the normal swallow process, even if a person is then allowed to swallow at will. Yogurt was measured using an accurate 5 ml medicine spoon. A total of 171 boluses (19 subjects × 9 boluses each) were presented.

Marking of Physiologic Events

From playback of the video recordings, we marked the precise time of key physiologic events for each bolus. Key events (Table 1) were

Table 1. Definitions of physiologic events and swallow sound components

Event	Description
Physiologic events	
ApneaStart	apnea onset, i.e., cessation of nasal airflow (from airflow)
EpiStart	start of epiglottis movement away from rest (from video)
EpiPost	epiglottis hitting the posterior pharyngeal wall preswallow (video)
Whiteout	whiteout onset indicative of pharyngeal contraction (video)
EpiReturn	return of the epiglottis to resting position (video)
ApneaStop	apnea end, i.e. resumption of nasal airflow (airflow)
Spillage	bolus entering the valleculae early (video)
BolVal	postswallow residue in the valleculae (video)
BolPS	postswallow residue in the piriform fossae (video)
Pen	penetration of material into the laryngeal vestibule (video)
Asp	aspiration of material below the true vocal folds (video)
Sound components	
PreClick	any sound (excluding breath sounds) preceding lub-dub
Lub and Dub	a distinctive "heart-like" lub-dub sound during swallow; to be marked it must be separable, i.e., it had to be possible to hear both lub and dub
Misc	midswallow sound, after lub-dub, but audibly before the onset of the prebreath sound or postapnea breath, often a gurgle
Click	prebreath sound just before the postapnea breath, often a dull click
Breath	postapnea expiration onset

identified and marked by agreement of the researcher and a second speech-language pathologist (SLP) experienced in laryngoscopy evaluations. The events were preselected using those commonly looked for by clinicians performing video swallow studies. As with any physiologic study, it was not possible to make some measurements because some laryngoscopy images were not clear enough on which to make judgments.

Marking of Sound Components

After a delay of eight to ten months to exclude one set of judgments influencing another, we marked the time of key components of the swallow sound. These were less straightforward to characterize because there is no consensus regarding the number of sounds heard or the terminology used to describe them. The acoustic terms were based on those commonly used by clinicians using cervical auscultation. First, the lead researcher (PL) and a medical physicist experienced in acoustic analysis (MJD) listened jointly (using two pairs of headphones) to identify a reproducible set of sound components (Table 1). Swallow sounds were then split between PL and MJD, who marked the time of each component that could be identified. Any swallow that produced unclear or unusual sounds was assessed jointly to obtain a decision by consensus.

Linking Swallow Sounds with Physiologic Events

In this study it was not possible to show that a component of the auscultation sound was caused by a specific physiologic event. However, if a sound is caused by some physiologic event, then the two ought to occur at the same time but this is not evidence of a causal relationship. If not, we can say with confidence they are unlikely to be related.

First, we conducted a four-way analysis of variance (ANOVA), with the outcome variable being the time of an event. Subject (1–19), bolus type (5 ml water, 20 ml water, 5 ml yogurt), repeat (1–3), and event type (5 physiologic events and 6 sound components) were factors. Using this model, we allow for any systematic effects on the timing of events due to subject, bolus type, or repeat administration of the bolus. We would expect differences between event types, since we do not expect all sounds and all physiologic events to occur at exactly the same time. However, we hoped that some sounds might occur at the same time as some physiologic events. To test this hypothesis we used the *post-hoc* Bonferroni test to assess each sound with each physiologic event. Data were analyzed using SPSS for Windows v12 (SPSS Inc., Chicago, IL).

Results

Description of Physiologic Events and Sound Components

With physiologic events there were no instances of spillage, penetration or aspiration, and too few usable measurements of the epiglottis hitting the posterior pharyngeal wall preswallow (EpiPost), postswallow residue in the valleculae (BolVal), and postswallow residue in the piriform fossae (BolPS) for meaningful assessment.

Fig. 2 shows the proportion of sound components that could be identified. No component could be identified in 100% of swallows.

Fig. 3 shows the timings of the physiologic events and sounds for every swallow. Apnea onset (ApneaStart) was used as the timing datum because it was the most reliably identifiable marker.

Clearly, the "normal" swallow varies widely between individuals; in some subjects, the swallow was complete and breathing resumed in less than half

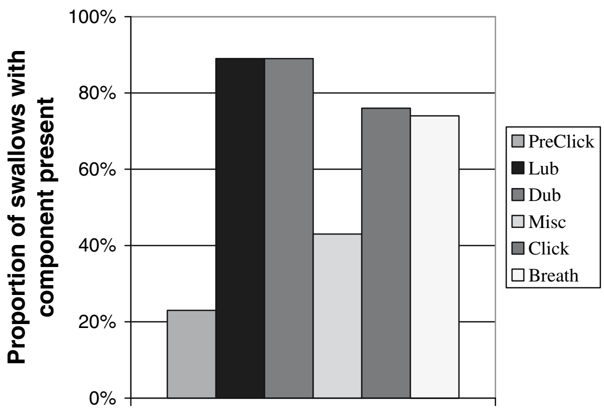

Fig. 2. Proportion of healthy swallows where each sound component could be identified.

a second, which would be before the onset of whiteout in other individuals.

Linking Swallow Sounds with Physiologic Events

By four-way ANOVA there were effects on timing due to subject [$F(16,1134) = 23.6$], event [$F(10,1134) = 527$], and bolus type [$F(2,1134) = 33.8$] (all $p < 10^{-12}$). As would be hoped, there was no effect due to repeats of the same bolus. As can be seen in Table 2, some sounds could be associated with physiologic or respiratory events, namely, the preclick with the onset of apnea; the preclick with the start of epiglottic excursion; the click with the epiglottis returning to rest; and the click with the end of the swallow apnea.

Discussion

This is the first study synchronizing cervical auscultation, laryngoscopy, and respiration monitoring. The wide range of auscultation patterns in asymptomatic, healthy volunteers is noteworthy. No acoustic component could be clearly identified in all swallows; in particular, preswallow and midswallow sounds were less evident. One of the difficulties in measuring swallow sounds is that the acoustic detector is placed on a site that then moves. This movement of the detector may itself produce sounds. Ideally, acoustic detection should use a static instrument. The physiology of individuals varies and it may be that some people have better or worse necks for auscultating. For example, a large layer of subcutaneous fat is likely to dull sounds and this is what is reported anecdotally. Sound component timings varied widely: all except the preswallow sounds overlapped. Some volunteers were at postapnea breath before others produced lub-dub.

In choosing which events to identify on laryngoscopy and to try to match these with sounds, we worked from the literature and from what SLPs claimed they were using [19, 20]. There are currently only theoretical postulations on the cause of swallow sounds. The main drawback with laryngoscopy is the period of whiteout, and events occurring during the pharyngeal stage of the swallow could not be analyzed. Laryngoscopy is also limited because we cannot view upper esophageal sphincter abnormalities or oral preparatory or transit events, some of which have the potential to produce sounds. There is a weak association between the first part of the lub-dub sound and the period of whiteout, and to resolve its origin would require a similar study using videofluoroscopy which we are currently working on.

Variations in methodology limit the direct comparisons that can be made between existing studies and also with this one using laryngoscopy. To put our work in the context of existing findings, the following physiologic events have been suggested as the origin of swallow sounds but are not all visible on laryngoscopy.

Mechanical lifting of the larynx [12] ...is more clearly identified on videofluoroscopy than laryngoscopy.

Changes in bolus velocity "corresponding to the onset of pressurized flow into the esophagus" [5, p. 751] ...opening of cricopharyngeal sphincter is not usually visible during healthy swallowing using laryngoscopy.

"compression of the bolus by tongue motion and peristaltic action of the muscles of the pharynx as well as displacement of air" [13, p. 30] ...it is unclear what is meant by this description. We imagine the authors are suggesting that sounds might be produced as the tongue compresses the bolus during the oral stage and also during pharyngeal contraction. Displacement of air might also cause sounds. None of these things would be clearly visible on laryngoscopy.

*Laryngeal elevation or pharyngeal contra*ctions [14] ...is more clearly identified on videofluoroscopy than laryngoscopy.

Our study did show that there were links between the preclick and the onset of apnea; the preclick and the start of epiglottic excursion; the click and the epiglottis starting to return to rest; and the click and the end of the swallow apnea. In this study we can conclude only that the two events are taking place at the same or similar times, i.e., we cannot infer cause and effect. If these sounds *do* relate to epiglottis movement, this would potentially be an

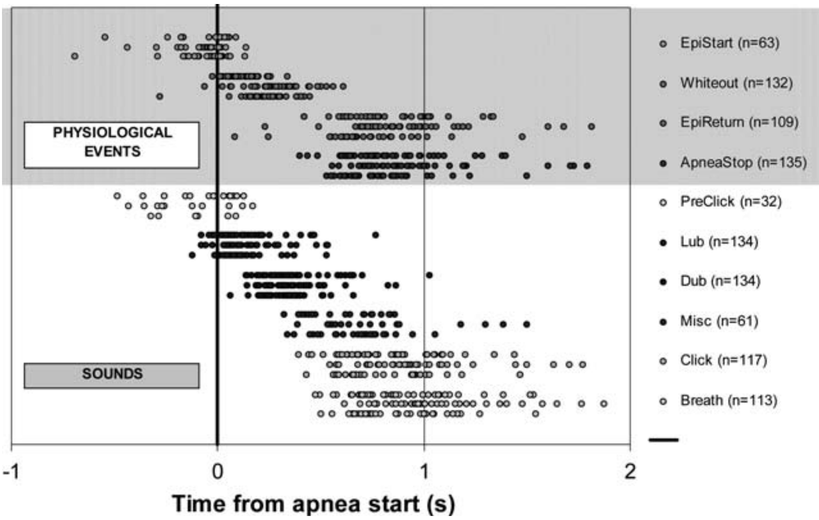

Fig. 3. The times relative to ApneaStart for physiologic and acoustic events. Each dot shows the time of one swallow component from one subject. The upper (gray) area shows the times of four physiologic events (EpiStart ... ApneaStop). The lower (white) area shows the times of six sound components (PreClick ... Breath). For each swallow component, measurements were made for 5 ml of water (top row of dots), 20 ml of water (middle), and 5 ml of yogurt (bottom row of dots). All timings are relative to ApneaStart, which was defined as time zero.

Table 2. Association of sounds with swallow and respiration events

Sounds	Events				
	EpiStart	ApneaStart	Whiteout	EpiReturn	ApneaStop
PreClick	−0.10 to +0.15**	−0.02 to +0.21**	+0.19 to +0.42	+0.79 to +1.03	+0.83 to +1.00
Lub	−0.29 to −0.11	−0.21 to −0.06	+0.01 to +0.15*	+0.61 to +0.76	+0.64 to +0.78
Dub	−0.51 to −0.33	−0.43 to −0.28	−0.21 to −0.07	+0.39 to +0.54	+0.42 to +0.56
Misc	−0.86 to −0.66	−0.78 to −0.60	−0.57 to −0.39	+0.03 to +0.22	+0.07 to +0.24
Click	−1.02 to −0.84	−0.93 to −0.79	−0.72 to −0.57	−0.12 to +0.03**	−0.88 to +0.60**
Breath	−1.10 to −0.91	−1.01 to −0.86	−0.80 to −0.65	−0.20 to −0.04	−0.16 to −0.02*

Values are the 95% confidence interval for the difference in time between the swallow sound and physiologic event; a positive value indicates the event came after the sound, and a negative value indicates the event came before the sound. For a relation to be real, one would expect no difference between the two times, i.e., the confidence interval should include zero. The post-hoc Bonferroni test was used to adjust for multiple comparisons.

* indicates weak evidence that the timing of the sound component is different from that of the physiologic event (all $p > 0.01$). The two may be linked.

** indicates no evidence that the timing of the sound component is different from that of the physiologic event (all $p > 0.1$). There is a strong chance that the two are linked.

For other cells, the timings of the sound component and the physiologic event were too different for them to be associated (all $p < 0.001$).

important observation. However, the sounds were present in only 23% and 76% of swallows; using the "characteristic swish and click of the epiglottis" [21, p. 147] as an indication of normality may have to be treated with some caution.

A previous study did not find any association with epiglottic inversion and sounds [11]. "Epiglottic inversion" could be a period of time rather than an instant as in our study, but details were not given in the article [11]. The association of two sounds with epiglottic movement might allow a measure of the duration of epiglottic excursion, but as the preclick was present in only 23% of swallows and the click in 76% in this study, such a hypothesis would require further investigation.

It is important to note that the physiologic event markers were set up to cover videofluoroscopy and laryngoscopy images. We chose epiglottis movements, penetration, aspiration, and residue pooling because SLPs report that they think some sounds are due to these events. We had to identify a list of all possible events before development of the system. Further work with this system would include events such as base-of-tongue movement. Aspiration and penetration do occur in the healthy population but infrequently. Future work investigating dysphagic swallowing poststroke, where aspiration and penetration are more frequent, might demonstrate a link between these events and a specific sound.

The judgments of both physiologic and acoustic events must come under scrutiny. Although the judges assessing the video/respiratory events were experienced in such matters, this does not necessarily confer reliability or validity. They had been trained in laryngoscopy swallow examination but continual peer review is not routine and therefore reliability would need to be established, which is another study. Acoustic judgments suffered from the same limitations. However, this does reflect clinical practice where listeners do not have a reference set of values from which to work.

If sounds are related to fluid flow (air or liquid boluses) rather than physiologic events they are less likely to be clearly defined. The structure of the oropharynx means that laminar (smooth) flow is unlikely. The sulci and moving structures are likely to cause irregular and turbulent flow such as eddy currents. Where predictable eddies of either the liquid bolus or air are set up, there may be a reproducible and more easily identifiable sound. The added complication of a partially solid bolus would introduce even more variability to swallow sounds.

It is unlikely that the absolute timings of sounds will be of diagnostic value because they would need to be drastically awry to lie outside measured ranges. Some components of the sound may correspond to observable physiologic events. In these healthy volunteers the most important swallow sounds [lub-dub, the click (pre-breath sound), and the breath] were usually present and invariably in the same order. The absence of a swallow sound in itself is not a definite sign of pathologic swallowing, but a repeated abnormal pattern may indicate impairment.

Clinical Implications

Physiologic event and sound matching is still the Holy Grail in cervical auscultation investigations. It was impossible to match a single event consistently with a sound despite repeated, detailed recording and analysis of many swallow types. We still cannot say "this movement causes this sound." We can only say that across a number of swallows, "this sound *seems to be associated* with... ." Sound components are not as easy to identify as some advocates of cervical auscultation claim. This leads us to ponder what exactly practitioners of the technique think they are hearing; how are they making their judgments? No one sound *always* occurred, so we cannot say that absence of a sound signals impairment. Most practitioners are making judgments on only a few swallows that they are not recording and playing back to check.

One of the most cited sounds to listen for, according to practitioners, is the postswallow out–breath, but in this study it could be detected in only 74% of swallows, despite evidence that expiration occurs after at least 85% of swallows [22, 23]. This means that absence of this sound does *not* necessarily indicate abnormality, as has been suggested by some practitioners. There is virtually no evidence in the literature relating to this feature. Zenner et al. [1] do mention postswallow "exhalation" and report that it was one of their criteria in considering a swallow as normal, but no data were given on how often it occurred.

Interestingly, at a recent study day on cervical auscultation [24], 40 clinicians who use cervical auscultation had difficulty identifying whether some breath sounds were inspiratory or expiratory; it was only because we had recorded respiratory information that we could correctly identify this. If you are listening for a breath sound to signal a good (or bad) swallow and you misidentify the direction of airflow, you will either not recognize an unsafe breath direction pattern, or you will risk over-restricting diet/liquid intake. Both courses of action are hazardous for the patient concerned. What is clear is that there is a huge variation in "normal" swallows and a large degree of overlap, so measurement of absolute timings is unlikely to be of use clinically.

Future Directions

At present there is no robust evidence that cervical auscultation of swallow sounds should be adopted in routine clinical practice for screening or diagnostic purposes. The reliability of raters using the technique is poor [2, 16]. There are no data to support the inclusion of the technique in clinical guidelines or management protocols. More evaluation is required before this subjective technique is employed by those assessing swallowing outside of a research context. Further studies comparing the full clinical exam with a full clinical exam plus cervical auscultation and then looking at outcomes would give us information on whether cervical auscultation does improve the clinical exam. This would give us evidence of the appropriateness of cervical auscultation as a screening tool. Simultaneous and blinded scoring of the features taking place in the videofluoroscopy suite that auscultators claim to be able to detect would justify, or not, such claims.

Cervical auscultation as a technique should not be abandoned just yet, although a severe cautionary note should be issued to practitioners. We have two major concerns about cervical auscultation: the first is about patient risk. Anecdotal evidence suggests that clinicians are being more restrictive with oral intake than they would be were their judgments based on the clinical assessment *without* using cervical auscultation. This is acceptable if they are right, but overrestricting oral intake carries a significant risk of dehydration and malnutrition. We already manage oropharyngeal dysphagia too conservatively and to further restrict oral intake must be done only with good reason. The scarce evidence on such measures as thickening liquids shows that the practice decreased the quantity of liquids patients consumed on the ward [25]. Robust evidence supporting the claim that restricting oral intake in people with impaired swallowing results in improved long-term outcomes has yet to be obtained.

Our second concern is for those clinicians who choose not to use cervical auscultation. Anecdotally again, cervical auscultation is becoming *de rigueur*. Other health professionals, SLP peers, clients, and even the nonauscultating clinician themselves perceive their clinical assessment as less worthy than that of an auscultator, with *no sound basis* for this judgment. This is partly due to the very powerful symbolism of the stethoscope in medicine. Indeed one national training course in cervical auscultation asks the question:

> *Why use a stethoscope?...it gives you the* "ability to reflect your knowledge base"*...it fits* "the medical model" [19].

The stethoscope is used to advertise careers, books, international research organizations, even soft drinks:

> While the symbols of a modern physician are the stethoscope and white coat, their medieval counterparts usually appeared in a long furred robe, proudly holding a flask of urine" [26].

Where cervical auscultation may have an alternative future, use is in swallow rehabilitation but again it requires further research. Some clinicians are starting to use cervical auscultation successfully in swallow rehabilitation [27]. Biofeedback is a powerful tool in health management [28]. We already appreciate the usefulness of carers and patients being able to view the videofluoroscopy or laryngoscopy tape to help understand the nature of the swallow problem. The system developed in this project allows direct visualization of breath timing/direction and swallow sounds, which at a gross level can be used simply as a marker for the moment of swallow. This particular system with respiration monitoring could help with training in such techniques as the supraglottic swallow where breath-holding is an integral part of the process but often difficult to explain. The visualization of the sound and breathing signal could help with reprogramming the swallow-respiration patterning.

Whether we choose to use cervical auscultation or not, we must know why and on what grounds we are basing that decision and be prepared to defend our stance. Each individual clinician has to be able to answer "yes" to that final question regarding any intervention strategy with a patient: Is it justified on the basis of real, defensible evidence?

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