Dysphagia 14:212–218 (1999)

Dysphagia

Swallowing Abnormalities after Acute Stroke: A Case Control Study

Cameron Sellars, MA, MPhil, MRCSLT,[1] Angela M. Campbell, BSc (Hons), MBChB, MRCP,[2] David J. Stott, MBChB, FRCP, MD,[2] Murray Stewart, MBChB, FRCS (RCPSG),[3] and Janet A. Wilson, BSc, MD, FRCS (Ed), FRCS (Eng)[4]

[1]Department of Speech and Language Therapy, [2]Academic Section of Geriatric Medicine, and [3]Department of Otolaryngology, Glasgow Royal Infirmary, Glasgow; and [4]Department of Otolaryngology, Head and Neck Surgery, University of Newcastle-upon-Tyne, UK

Abstract. Dysphagia is a common and potentially fatal complication of acute stroke. However, the underlying pathophysiology, especially the relative importance of motor and sensory dysfunction, remains controversial. We conducted a case control study of 23 acute stroke patients (mean age = 72 yr) at a median of 6 days poststroke and 15 healthy controls (mean age = 76 yr). We used novel methods to assess swallowing in detail, including a timed videoendoscopic swallow study and oral sensory threshold testing using electrical stimulation. Vocal cord mobility and voluntary pharyngeal motor activity were impaired in the stroke group compared with the controls ($p = 0.01$ and 0.03). There was a delay during swallowing in the time to onset of epiglottic tilt in the stroke group, particularly for semisolids ($p = 0.02$) and solids ($p = 0.01$), consistent with a delay in initiation of the swallow. Sensory thresholds were not increased in the stroke group compared with controls. We conclude that pharyngeal motor dysfunction and a delay in swallow initiation are common after acute stroke. Vocal cord mobility is reduced, and this may result in reduced airway protection. We found no evidence to support the hypothesis that oropharyngeal sensory dysfunction is common after acute stroke.

Key words: Stroke — Dysphagia — Nasendoscopy — Oral sensory thresholds — Deglutition — Deglutition disorders.

Correspondence to: Cameron Sellars, M.A., Department of Speech and Language Therapy, Glasgow Royal Infirmary, Glasgow G4 0SF, UK

Dysphagia occurs in 45–65% of patients with acute stroke [1–4]. It is associated with poor nutritional state, pneumonia, increased mortality, and increased disability among survivors [3]. Deglutitive aspiration is thought to be a major cause of pneumonia [5,6]. Aspiration is a complex phenomenon that may occur before, during, or after the pharyngeal phase of the swallow; it is seen most frequently in patients with right hemisphere and anterior circulation strokes [7].

Oropharyngeal motor dysfunction is an important cause of swallowing disorder after stroke [4]. In addition, it has been claimed that pharyngeal sensory abnormalities are common after acute stroke and that such abnormalities are associated with an increased risk of aspiration and aspiration pneumonia [8,9].

Various methods have been used to assess swallowing after stroke. Water swallow tests are simple and can be carried out by the nonexpert at the bedside, but may miss up to 50% of aspirators [6,8,10]. The videofluoroscopic swallow study (VFSS) shows bolus progression but has several disadvantages including radiation exposure, the need to move the patient to the radiology department, and high cost. Nonetheless, VFSS is generally recognized as the gold standard for diagnosing aspiration. It has been suggested that nasendoscopy may have a role in assessment of dysphagia in neurologically impaired patients [11–16], but substantive data relating to dysphagia in acute stroke are lacking.

The aim of this preliminary case control study was to develop and assess new methods (including videotimed dye nasendoscopic evaluation and measurement of oral sensory thresholds to electrical stimulation) of quantifying pharyngeal motor and sensory swallowing function after stroke.

Methods

Study Groups

We recruited 23 acute stroke patients (12 men, 11 women; mean age = 72 yr, range = 51–86 yr) and 15 healthy control subjects (four men, 11 women, mean age = 76 yr, range = 61–90, yr). The characteristics of the stroke group are presented in Table 1.

Acute stroke patients were recruited from admissions to the General Medical or Geriatric Assessment Wards at Glasgow Royal Infirmary, and the diagnosis was established by clinical history, neurological examination, and brain computed tomography (CT). Participants had to be fully conscious, fit for trolley transfer to the otolaryngology department, and able to sit upright and cooperate with the various formal swallowing assessments. Exclusion criteria included significant receptive dysphasia, dementia, or other neurological or oropharyngeal diseases that could be associated with dysphagia. Control subjects were recruited from the local chiropody clinic, postsurgical review clinic (minor operations such as varicose veins or hernia repair), and geriatric or general medical hospital discharges. In addition to these criteria, control subjects were required to have no history of previous stroke or transient ischaemic attack. A frequency matching design was used to determine stroke and control groups of similar age and sex composition. The study was approved by the local hospital ethical committee, and all participants gave informed consent.

Table 1. Clinical characteristics of the acute stroke patients ($n = 23$)

Clinical first stroke	17
History of previous stroke	6
Oxford Community Stroke Project classification[a]	
LACS	3
PACS	15
TACS	4
POCS	1
Brain computed tomographic appearance	
Infarction	19
Hemorrhage	2
Normal	2
NIH stroke scale (0–36)[b] ($n = 22$)	
Median	6
Range	1–16
Barthel index (0–20)[c]	
Median	9
Range	2–20
AMT score (0–10)[d] ($n = 16$)	
Median	9
Range	2–10
Water swallow test ($n = 22$)	
Normal	11
Abnormal	11

[a]LACS, Lacunar syndrome; PACS, partial anterior cerebral syndrome; TACS, total anterior cerebral syndrome; POCS, posterior cerebral syndrome.
[b]Greater score = greater neurological disability.
[c]Lower score = increased disability.
[d]Abbreviated Mental Test; lower score = more severe cognitive impairment.

Methods of Measurement

Acute stroke patients had a clinical assessment performed by the same observer (A.M.C.) at a median of 6 days after the event (range = 2–20 days). Neurological impairment was assessed using the U.S. National Institutes for Health (NIH) stroke scale [17], disability by the 20-point Barthel Activities of Daily Living Index [18], and cognitive function using the Abbreviated Mental Test (AMT) score (only in nondysphasic patients) [19].

A standard water swallow test [8,10] was performed (in 22 of 23 of the stroke patients) by sitting the patients upright and asking them to drink 100 ml of cold tap water from a plastic beaker as quickly as possible; patients were asked to stop if difficulty was experienced. Dribbling of water back out of the mouth, failure to initiate the swallow, coughing, choking, or alteration of voice quality (wet hoarse during or immediately after the test) were considered as an abnormal (dysphagic) test result [8,10]. On this basis, 11 of 22 (50%) of the patients were classified as dysphagic.

The characteristics of the stroke patients are presented in Table 1; this was the clinical first stroke in 17 (74%) of patients; six (26%) had a history of previous stroke. The location and type of stroke were coded using the Oxford Community Stroke Project categories [20]. All patients had a CT brain scan. The majority had anterior hemispheric or lacunar ischemic strokes, with only two hemorrhages and one posterior circulation stroke (right cerebellar infarct).

Videoendoscopic Swallow Study (VESS) and Oral Sensory Threshold Testing (OSTT)

In the control group, 10 of 15 underwent VESS, and 10 of 15 completed OSTT. The stroke patients ($n = 23$), wherever possible, were assessed on both VESS and OSTT. For a variety of reasons including patient noncompliance and equipment difficulties, 21 of 23 stroke patients had VESS, and 17 had OSTT. In addition, eight of 11 stroke patients with a positive water swallow test underwent VFSS. In three patients with a positive water swallow test, we were unable to perform VFSS because of staff shortages and temporary nonavailability of this test.

VESS was carried out in a dedicated endoscopy room in the otolaryngology outpatient department, and for most individuals (stroke and control), OSTT immediately followed VESS in this setting. For a few control subjects who consented only to OSTT, this was undertaken in a hospital ward or geriatric day hospital.

Equipment

Endoscopy was undertaken with an Olympus ENF-P3 or L2 endoscope in tandem with a Wolf 5130 light source. The visual signal was recorded with an endoscope camera (Wolf 5257 via Litechnica V2000/II) via a time-code generator (IMP V9000A) with a resolution of 0.02 sec on to broadcast-quality super-VHS format videotape on a video cassette recorder (Panasonic NV-FS88). The audio signal was recorded by a lapel microphone (Realistic) directly to the VCR audio track.

Oral sensory thresholds were tested by means of a purpose-built current generator that delivers current to a hand-held probe featuring two bipolar ball electrodes positioned 1 cm apart. Increases in current can be delivered continuously or in specifiable ramped increments. Current is switched on by means of a foot-pedal operated by the investigator. The subject indicates discrimination of the stimulus on a hand-held joystick button that, when pressed, stops current supply and registers the threshold in milliamperes on a liquid crystal display.

Protocol for VESS

The protocol for VESS was based on and expanded from previous reported studies [11–13,21] and remains broadly in keeping with subsequent publications [16,22]. Subjects were seated upright in a suitably supportive seat. To facilitate passage of the endoscope, a mucosal decongestant (Xylometazoline 0.1%) and topical anaesthetic (Xylocaine 4% topical, two brief bursts given by atomiser) were administered by spray to the anterior nares. As small a dose as possible was used to minimize the risk of inhalation into the pharynx. Subjects were asked to report any abnormal sensation apparent in the pharynx. No reports of altered pharyngeal sensation were made. The endoscope was passed through the nares into the pharynx, where a number of preliminary observations were made before proceeding to the study of the swallow itself.

VESS preliminary investigations comprised the following; pooling of secretions in the larynx and pyriform fossae were noted. Laryngeal structure and function were observed in terms of appearance at rest, position on tight breath-holding, mobility on phonation, and mobility on cough. Pharyngeal constrictor activity (pharyngeal squeeze) was elicited by requesting the subjects to phonate on a "high-pitched, screechy" /i/ sound, with accompanying demonstration by the investigator. Pharyngeal sensation was tested by directing the pharyngeal scope tip to make contact with the aryepiglottic folds bilaterally. Contact was assumed to have taken place at the point when vision of the aryepiglottic fold was lost [13].

To observe swallowing activity, the endoscope was positioned approximately at the junction of the nasopharynx and oropharynx in such a way as to permit an optimal view of the posterior tongue, posterior and lateral pharyngeal walls, valleculae, epiglottis, larynx, and pyriform fossae. From this position, the endoscope was advanced deeper into the oropharynx to permit clearer viewing of the structures of interest postswallow.

Normal subjects were asked to swallow consecutively four 5-ml water boluses, four 10-ml water boluses, two 20-ml water boluses [23], three 5-ml semisolid boluses, three solid boluses, and two 5-ml semisolid sour boluses [24], in that order. It was considered unethical to subject the stroke patients to as many boluses, and in particular to the high volume boluses, in view of the possibility of aspiration. Therefore, the stroke patients received neither the 20-ml water boluses nor the semisolid sour boluses and were given one fewer 5-ml water bolus and two fewer 10-ml water boluses. Water boluses were stained with blue food coloring, semisolid boluses (plain and sour) with green food coloring, and the solid bolus had a natural (light yellow) color. The semisolid food stuff was a set *fromage frais* pudding; to render this "sour," 10 drops of concentrated lemon juice were added to the carton contents, thereby giving (as judged on a straw poll carried out among the investigators) a "sour" flavor while retaining a semisolid consistency. The solid bolus was sponge cake. Administration of the liquids and food stuffs was undertaken by a trained nurse assisting the investigator. Liquids were in all cases presented by syringe to ensure accuracy of quantities and to alleviate some of the difficulties encountered in presenting a cup to the lips of a subject with an endoscope emerging from a nostril. Semisolid boluses were offered more naturally by means of a 5-ml spoon, and the cake was presented in approximately 2- × 2- × 1-cm cubes.

Quantification of VESS

In the absence of any published measurement scales at the time of undertaking this study, a new set of rating scales was devised. Pharyngeal sensation was rated as present or absent. Vocal cord appearance at rest was rated as normal or abnormal (abnormal was taken to include gross asymmetry or hyperabduction), position on tight breath holding as fully opposed/intermediate/abducted/unable, and mobility on phonation and on cough as normal/abnormal/unable (abnormal was understood to include gross asymmetry of function or obvious flaccidity). A 3-point scale (nil or minimal, moderate <50% of the bolus, severe ≥50%) was used to code pooling of secretions and the presence of residual liquid and food in various sites in the pharynx and larynx (posterior pharyngeal wall, right and left vallecula, right and left pyriform fossae, larynx, and subglottic regions) and penetration of the bolus into the vallecula (from the right, from the left, and bilaterally), beyond the vallecula (right, left, and bilaterally), and into the larynx and subglottic regions. To simplify the reporting of the data, the moderate and severe groups have been combined. Note was made of any cough prior to, during, or after the first swallow of each bolus.

To assist in the provision of a starting point for timing, all subjects were requested to await the command "swallow" before proceeding to an attempted swallow. In the case of the cake, subjects also were requested to chew the cake until ready to swallow, indicate readiness by lifting the hand, and swallow only when instructed verbally, as before.

End points in the timing of endoscopic swallow events were adapted from previously published work [15,25,26]. For the purposes of this study, we decided to focus on the following temporal landmarks: arrival of the bolus at the vallecula, initiation of epiglottic tilt, and return of the epiglottis to rest. The time recordings for the swallow were set from the /s/ of the command "swallow" uttered by the investigator as heard on the audio signal of the videorecording, which was the start point for timing from the on-screen timer display.

OSTT

The subjects were given a brief verbal introduction to the equipment described previously. It was explained that the probe end would make light contact with a number of structures in the mouth, and the subject would be asked to wait until he/she was aware of a slight "tingling" sensation at the structure of interest, at which point he/she should press the button on the joystick and thereby stop the sensation. Direct readings in milliamperes were taken from the display of the current generator, which was set to freeze when the subject stopped the application of current.

The structures investigated were tongue tip, posterior tongue (both structures centrally), right and left anterior faucial pillars, and right and left sides of the soft palate. Considerable care was taken to ensure correct placement of the probe to avoid the elicitation of a gag reflex. At times, it was necessary to deploy a tongue blade depressor to permit access to the anterior faucial pillars. If required, the subject was also asked to phonate on /a/ to permit more satisfactory identification of the anterior faucial pillars and true margin of the hard and soft palate. When placement was achieved, subjects were advised that contact had been made and that they should now attend to the onset of the "tingling" sensation. An orientation run was first carried out on all the structures to be tested, which involved setting the ramping facility on the current generator to increments of 64 mA.

Two test runs were then undertaken, with ramping set at 8 mA. The mean of the two thresholds was taken for analysis. Measures were repeated at the anterior faucial pillars following stimulation by 10 strokes of a blunt orange stick ("tactile" stimulation) and 10 strokes of an iced laryngeal mirror ("thermal" stimulation) [27]. Single measurements were made poststimulation.

Data Collection/Statistics

Data were entered on a computer database (dBase IV) and analyzed with SPSS for Windows. Between-group comparisons were made with Student's unpaired *t*-test (two-tailed), Mann-Whitney *U* test, chi-square, and Fisher's exact test. Reproducibility of measurements was assessed with the kappa statistic. Results were accepted as statistically significant at the 5% level of probability.

Results

Nasendoscopy proved possible in nearly all of the stroke patients selected for the study, and quantification of the various swallowing parameters was achieved in the majority of patients who underwent this test. Thirteen of the 21 stroke subjects and one of the nine control subjects had evidence of impaired vocal cord mobility on tight breath-holding, cough, or phonation ($\chi^2 = 6.53$, $p = 0.01$). Stroke patients with impaired vocal cord mobility ($n = 13$) tended to be more neurologically impaired (NIH score = 8.0, SD = 4.7), more dysarthric ($\chi^2 = 5.18$, $p = 0.07$), and more cognitively impaired (AMT score = 7.4, SD = 2.5) when compared with stroke patients with normal vocal cord mobility ($n = 8$; NIH score = 4.3, SD = 2.7, $p = 0.08$; AMT score = 9.0, SD = 1.5, $p = 0.10$; Mann-Whitney *U* test); there was no significant difference in water-swallow test results between these two groups. Voluntary pharyngeal motor activity (pharyngeal squeeze) was visibly impaired in 10 of 20 stroke patients versus zero of nine control subjects ($\chi^2 = 6.87$, $p = 0.03$). Pooling of secretions in the pyriform fossae or larynx prior to the swallow was not seen in any of the control group; three of 21 stroke subjects had pooling of secretions in one or both pyriform fossae. The following summary data are for the first swallow, except for timings that were calculated from the average result of repeated swallows. Preswallow, there was penetration of all bolus consistencies into the vallecula (both centrally and bilaterally) in up to 56% of both the stroke and the control group. Penetration beyond the vallecula and into the larynx was seen only in the stroke group, but the numbers were small and differences between the stroke and control groups were not statistically significant (Table 2).

Postswallow vallecular residue of semisolids and solids was present in the majority of subjects in both groups. No patients or controls had laryngeal residue, and only one stroke patient had subglottic residue (Table 3). Coughing after the 5-ml liquid bolus tended to be more common in the stroke group. Reproducibility of the swallow observations on nasendoscopy was assessed with the kappa statistic by comparing the first and second swallows for each bolus type and volume. The median kappa for all observations was 0.62, with an interquartile range of 0.5–0.69, consistent with a moderate level of agreement for most observations. The level of agreement tended to be highest for the liquid boluses and lowest for the semisolid and solid boluses.

The time to initiation of epiglottic tilt was prolonged in the stroke group for semisolids (Student's unpaired *t* test, $p = 0.02$) and solids ($p = 0.01$), with a similar tendency for liquids. The total duration of the swallow (time to return of the epiglottis to rest) also tended to be prolonged, particularly for solids (Student's unpaired *t* test, $p = 0.06$). There were no significant differences in the duration of epiglottic tilt between the stroke and control groups (Table 4).

Sensory thresholds tended to be reduced in the stroke group in most areas tested; the difference between the stroke and control groups reached statistical significance for postthermal sensory threshhold at the left anterior pillar (Table 5); these changes are in the opposite direction to that expected if sensation was impaired after stroke. Neither thermal nor tactile stimulation significantly affected the sensory thresholds to electrical stimulation.

Table 2. Videoendoscopic penetration prior to swallow[a]

		5 ml liquid		Semisolid		Solid	
		Yes	No	Yes	No	Yes	No
Into vallecula	C	5	4	3	7	1	6
(R/L/bilateral)	S	7	10	7	8	4	9
Central	C	4	5	3	7	1	6
	S	4	14	5	12	1	12
Beyond vallecula	C	1	5	0	8	0	7
	S	8	7	3	12	1	11
Into larynx	C	0	6	0	8	0	7
	S	3	11	0	15	0	12
Subglottic	C	0	6	0	8	0	7
	S	0	12	0	16	0	12

[a]C, control group; S, acute stroke group; R, right; L, left; No, no or minimal bolus penetration; Yes, more than minimal bolus penetration.

Table 3. Videoendoscopic evidence of residue of the bolus postswallow[a]

	5 ml liquid		Semisolid		Solid	
	Yes	No	Yes	No	Yes	No
Posterior pharyngeal wall						
C	0	10	2	7	0	7
S	0	18	6	9	2	13
Vallecula (R/L/bilateral)						
C	2	7	6	2	4	2
S	5	12	8	5	8	6
Pyriform (R/L/bilateral)						
C	1	9	2	5	0	7
S	6	12	7	5	4	10
Larynx						
C	0	9	0	7	0	7
S	0	18	0	11	0	14
Subglottic						
C	0	9	0	6	0	6
S	0	18	0	11	1	13
Cough						
C	1	9	0	10	0	10
S	6	13	0	19	1	15

[a]C, control group; S, acute stroke group; R, right; L, left; No, no or minimal bolus residue; Yes, more than minimal bolus residue.

Table 4. Timing of swallow on videoendoscopy, examining the effects of different bolus consistencies[a]

	Time to arrival of bolus at vallecula (sec)		Time to initiation of epiglottic tilt (sec)		Duration of epiglottic tilt (sec)		Time for return of epiglottis to rest (sec)	
Swallow bolus	C	S	C	S	C	S	C	S
5 ml liquid	1.08 (0.78), $n = 10$	1.72 (1.01), $n = 12$	1.10 (0.86), $n = 10$	1.61 (0.85), $n = 14$	1.37 (0.48), $n = 10$	1.59 (0.81), $n = 14$	2.47 (0.92), $n = 10$	3.05 (0.96), $n = 14$
Semisolid	1.69 (0.87), $n = 4$	2.10 (1.55), $n = 11$	0.89 (0.59), $n = 9$	2.72 (2.02),** $n = 15$	1.66 (0.67), $n = 7$	1.69 (1.23), $n = 14$	2.95 (1.36), $n = 8$	4.23 (2.68), $n = 17$
Solid	1.87 (1.11), $n = 7$	5.39 (6.43), $n = 11$	1.43 (1.09), $n = 11$	6.58 (5.52),*** $n = 11$	1.39 (0.75), $n = 11$	1.76 (0.66), $n = 8$	3.45 (1.11), $n = 9$	7.15 (5.53), $n = 14$

[a]Results are mean (SD). C, control group; S, acute stroke group.
**$p = 0.02$, ***$p = 0.01$.

Table 5. Oral sensory thresholds to electrical stimulation (mA)[a]

	C	S
L anterior pillar	3.22 (1.86)	2.04 (1.60)
L anterior pillar posttactile stimulation	3.37 (2.32)	2.03 (2.08)
L anterior pillar postthermal stimulation	3.32 (2.72)	1.62 (1.13)*
L soft palate	2.28 (1.87)	1.57 (1.30)
Posterior tongue	3.43 (1.55)	2.36 (1.54)
R anterior pillar	2.44 (1.41)	2.07 (1.52)
R anterior pillar posttactile stimulation	3.38 (2.26)	2.06 (2.66)
R anterior pillar postthermal stimulation	3.22 (2.45)	1.74 (2.13)
R soft palate	2.37 (1.72)	2.10 (1.50)
Tongue tip	2.48 (0.98)	2.57 (1.78)

[a]Results are mean (SD). C, control group; S, acute stroke group; R, right; L, left.
*p <0.05, Student unpaired t test.

Videofluoroscopy was performed in eight of 11 patients with an abnormal water swallow test and five of eight had evidence of aspiration on this investigation. During follow-up, four of the 23 stroke patients developed pneumonia; all of these had an abnormal water swallow test.

Discussion

We have characterized the pharyngeal phase of swallowing in a group of acute stroke patients and compared them with age-matched control subjects. We found that videoendoscopy can be used to assess and quantify certain aspects of motor swallowing after stroke. We found that impaired vocal cord mobility was common in stroke patients. The etiology of this is likely to be multifactorial. Dysarthria, severity of stroke (as assessed by the NIH score), and cognitive impairment all tended to be associated with impaired vocal cord mobility. Other factors such as dyspraxia also may have contributed [4]. Whatever its cause, observed impaired vocal cord mobility may be associated with reduced airway protection from aspiration.

Videotiming of nasendoscopic observations enabled objective measurement of the delay in the swallow reflex, seen as a significant increase in the time from the command to swallow to the onset of epiglottic tilt (for semisolids and solids) in the stroke group. Similar findings have been reported on videofluoroscopy [28], with approximately 90% of stroke patients having a delay in triggering the swallow [29,30]. Preswallow pooling of secretions tended to be more common in the stroke group, and this may be associated with an increased risk of aspiration [31]. However, preswallow spillage of liquids into the vallecula and postswallow vallecular and pyriform fossa residue of semisolids and solids were seen in many subjects in both the control and stroke groups, suggesting that these are normal features of the swallow in elderly people. Similar findings have been reported in young healthy subjects, with 100% of liquid and 76% of solid boluses seen in the pharynx before swallow initiation [22]. Clearly, further investigation of what constitutes normal and abnormal pharyngeal loading is required.

We found evidence of pharyngeal motor dysfunction in 50% of acute stroke patients versus none of the controls. These results are consistent with those of other studies that have used different methods. It has been claimed that more than half of dysphagic stroke subjects have evidence of reduced pharyngeal peristalsis on videofluoroscopy [30], but this was an uncontrolled survey of stroke patients. Pharyngeal residue (suggesting reduced peristalsis) has been reported to be more common in stroke patients who aspirate than in nonaspirators [29].

We found some limitations of nasendoscopy. The reproducibility of our methods for videoendoscopic observations was moderately good for liquid boluses but less good for semisolids and solids. Adequate visualization to identify preswallow spillage and postswallow residue was achieved in only two-thirds of stroke and control patients. This was due to a variety of factors including variation in the anatomical features, bolus residue on the lens, and variability of the focus and lighting (caused by changing distances from the object in view and reflection from surfaces). In our study, nasendoscopy did not identify aspiration reliably in acute stroke. Cough after the 5-ml liquid bolus was common in the stroke group, and aspiration was seen on videofluoroscopy in the majority of those with a positive water swallow test. However, only three stroke patients had preswallow penetration into the larynx and one other stroke patient had postswallow subglottic residue. Videofluoroscopic studies of stroke have shown aspiration to be detectable in up to one-third of patients [30]; this is associated with up to eightfold increased risk of pneumonia. Videofluoroscopy and videoendoscopy have been compared in groups of patients with heterogeneous pathologies, where there has been reasonable agreement in detection of aspiration [12,15,16]; such agreement cannot be assumed in acute stroke, where videofluoroscopy should still be seen as the gold standard for detecting aspiration. Studies of aspiration are often difficult to compare because many do not provide clear information regarding the study protocol including how aspiration is defined [31].

Simple touching of pharyngeal and laryngeal structures by endoscope has been advocated as a useful method of detecting sensory abnormalities [11,13]. We assessed pharyngeal sensation to endoscopic touch as part of our preliminary VESS observations. Absent pharyngeal sensation to endoscopic touch was found in similar proportions of the controls and stroke patients, with no significant difference between the two groups. In addition, we developed a new technique for assessing oral sensation by using electrical stimulation. We found no evidence that oral sensation was impaired after stroke; indeed, there was a trend for sensory thresholds to be reduced in the stroke group in most of the anatomical areas tested. These changes were in the opposite direction to that expected if oral sensation was impaired after stroke. No statistically significant evidence of reduction of sensory thresholds could be found following tactile or thermal stimulation, interventions that have been suggested to enhance sensation [32,33]. Assessing oral or pharyngeal sensation after stroke is fraught with difficulty. Accessing structures accurately within the mouth, especially in neurologically impaired individuals, is often difficult. The addition of a supporting tongue spatula or even simple touch of the handle of the probe elsewhere in the mouth may complicate sensory input. In our study, some individuals may have responded to simple instrumental touch and not to the presence of electrical current, despite detailed and repeated instructions. This is likely to be a greater problem in the stroke group due to impaired comprehension of the task. Such difficulties have not been generally acknowledged in other studies of oral and pharyngeal sensation [8,9,33]. An alternative explanation for our findings is that stroke patients genuinely have more rapid appreciation of electrical stimulation of oral structures as opposed to controls. This could have implications for the development of techniques that stimulate the swallow response; electrical stimulation may be a useful therapy for swallowing dysfunction after stroke [34], as has been suggested for thermal and tactile stimulation. In contrast to our findings, other investigators have found reduced pharyngeal sensation to touch with an orange stick in dysphagic stroke patients [8]. Reduced pharyngeal sensation after stroke has been found in a case control study design using the stimulus of puffs of air of different intensities [9,35,36]. Further research to determine the most clinically applicable method of sensory testing of the pharynx and related structures is required.

Our results may not be generalizable to all patients with acute stroke. The patients in our study were selected to include only those who could give informed consent and who were fit for trolley transfer within the hospital. It is possible that stroke patients who are more seriously ill and more dependent may have more sensory and motor swallowing abnormalities than the cohort we have described. We studied patients early after acute stroke when transient swallowing problems are common [1]. Further studies are required to characterize in detail the swallowing abnormalities in the minority of patients with severe persistent dysphagia.

Acknowledgments. We thank Chest Heart and Stroke Scotland for financial support (grant R95/9), and Sister Lesley Bell for practical assistance in performing the detailed swallowing assessments.

References

1. Barer DH: The natural history and functional consequences of dysphagia after hemispheric stroke. *J Neurol Neurosurg Psychiatry 52:*236–241, 1989
2. Gresham SL: Clinical assessment and management of swallowing difficulties after stroke. *Med J Aust 153:*397–399, 1990
3. Smithard DG, O'Neill PA, Park C, Morris J, Wyatt R, England R, Martin DF: Complications and outcome after acute stroke: does dysphagia matter? *Stroke 27:*1200–1204, 1996
4. Daniels SK, Brailey K, Priestly DH, Herrington LR, Weisberg LA, Foundas AL: Aspiration in patients with acute stroke. *Arch Phys Med Rehabil 79:*14–19, 1998
5. Kidd D, Lawson J, Nesbitt R, MacMahon J: The natural history and clinical consequences of aspiration in acute stroke. *Q J Med 88:*409–413, 1995
6. Holas MA, DePippo KL, Reding MJ. Aspiration and relative risk of medical complications following stroke. *Arch Neurol 51:*1051–1053, 1994
7. Robbins J, Levine RL, Maser A, Rosenbek JC, Kempster GB:

Swallowing after unilateral stroke of the cerebral cortex. *Arch Phys Med Rehabil 74:*1295–1300, 1993
8. Kidd D, Lawson J, Nesbitt R, MacMahon J: Aspiration in acute stroke: a clinical study with videofluoroscopy. *Q J Med 86:*825–829, 1993
9. Aviv JE, Martin JH, Sacco RL, Zagar D, Diamond B, Keen MS, Blitzer A: Supraglottic and pharyngeal sensory abnormalities in stroke patients with dysphagia. *Ann Otol Rhinol Laryngol 105:*92–97, 1996
10. De Pippo KL, Holas MA, Reding MJ: Validation of the 3-oz water swallow test for aspiration following stroke. *Neurology 49:*1259–1261, 1992
11. Bastian RW: The videoendoscopic swallowing study: an alternative and partner to videofluoroscopic swallowing study. *Dysphagia 8:*359–367, 1993
12. Langmore SE, Schatz K, Olson N: Endoscopic and videofluoroscopic evaluations of swallowing and aspiration. *Ann Otol Rhinol Laryngol 100:*678–681, 1991
13. Bastian RW: Videoendoscopic evaluation of patients with dysphagia: an adjunct to the modified barium swallow. *Otolaryngol Head Neck Surg 104:*339–350, 1991
14. Kidder TM, Langmore SE, Martin BJW: Indications and techniques of endoscopy in evaluation of cervical dysphagia: comparison with radiographic techniques. *Dysphagia 9:*256–261, 1994
15. Wu CH, Hsiao TY, Chen JC, Chang YC, Lee SY: Evaluation of swallowing safety with fiberoptic endoscope: comparison with videofluoroscopic technique. *Laryngoscope 107:*396–401, 1997
16. Leder SB, Sasaki CT, Burrell MI: Fiberoptic endoscopic evaluation of dysphagia to identify silent aspiration. *Dysphagia 13:*19–21, 1998
17. Van Swieten JC, Koudstaal PJ, Visser MC, Schouten HJA, van Gijn J: Interobserver agreement for the assessment of handicap in stroke patients. *Stroke 19:*604–607, 1988
18. Mahoney FI, Barthel DW: Functional evaluation: the Barthel index. *Md State Med J 14:*61–65, 1965
19. Hodkinson HM: Evaluation of a mental test score for the assessment of mental impairment in the elderly. *Age Ageing 1:*233–238, 1972
20. Burns J, Dennis MS, Bamford J, Sandercock P, Wade D, Warlow C: Long-term risk of recurrent stroke after a first ever stroke; the Oxfordshire Community Stroke Project. *Stroke 25:*333–337, 1994
21. Langmore SE, Schatz K, Olson N: Fibreoptic endoscopic examination of swallowing safety: a new procedure. *Dysphagia 2:*216–219, 1988
22. Dua KS, Ren J, Bardan E, Xie P, Shaker R: Co-ordination of deglutitive glottal function and pharyngeal bolus transit during normal eating. *Gastroenterology 112:*73–83, 1997
23. Adnerhill I, Ekberg O, Groher ME: Determining normal bolus size for thin liquids. *Dysphagia 4:*1–3, 1989
24. Logemann JA, Pauloski BR, Colangelo L, Lazarus C, Fujiu M, Kahrilas PJ: Effects of a sour bolus on oropharyngeal swallowing measures in patients with neurogenic dysphagia. *J Speech Hear Res 38:*556–563, 1995
25. Dua K, Shaker R, Ren J, Arndorfer R, Hofmann C: Mechanism and timing of nasopharyngeal closure during swallowing and belching. *Am J Physiol 268:*1037–1042, 1995
26. Shaker R, Dodds WJ, Dantas RO, Hogan WJ, Arndorfer RC: Co-ordination of deglutitive glottic closure with oropharyngeal swallowing. *Gastroenterology 98:*1478–1484, 1990
27. Logemann J: *Evaluation and Treatment of Swallowing Disorders.* Boston: College-Hill, 1983
28. Johnson ER, McKenzie SW, Rosenquist CJ, Lieberman JS, Sievers AE: Dysphagia following stroke: quantitative evaluation of pharyngeal transit times. *Arch Phys Med Rehabil 73:*419–423, 1992
29. Horner J, Massey EW, Riski JE, Lathrop DL, Chase KN: Aspiration following stroke: clinical correlates and outcome. *Neurology 38:*1359–1362, 1988
30. Veis SL, Logemann JA: Swallowing disorders in person with cerebrovascular accident. *Arch Phys Med Rehabil 66:*372–375, 1985
31. Murray J, Langmore SE, Ginsberg S, Dostie A: The significance of accumulated oropharyngeal secretions and swallowing frequency in predicting aspiration. *Dysphagia 11:*99–103, 1996
32. de Lama Lazzara G, Lazarus MA, Logemann JA: Impact of thermal stimulation on the triggering of the swallowing reflex. *Dysphagia 1:*73–77, 1986
33. Kaatzke-McDonald MN, Post E, David PJ: The effects of cold, touch, and chemical stimulation of the anterior faucial pillar on human swallowing. *Dysphagia 11:*198–206, 1996
34. Park CL, O'Neill PA, Martin DF: A pilot exploratory study of oral electrical stimulation on swallow function following stroke: an innovative technique. *Dysphagia 12:*161–166, 1997
35. Aviv JE, Sacco RL, Mohr JP, Thompson JL, Levin B, Sunshine S: Laryngopharyngeal sensory testing with modified barium swallow as predictors of aspiration pneumonia after stroke. *Laryngoscope 107:*1254–1260, 1997
36. Aviv JE, Sacco RL, Thomson J, Diamond B, Tandon R, Martin JH, Close LG: Silent laryngopharyngeal sensory deficits after stroke. *Ann Otol Rhinol Laryngol 106:*87–93, 1997