Pediatr Radiol (2006) 36: 911–919
DOI 10.1007/s00247-006-0124-3

REVIEW

Melanie P. Hiorns · Martina M. Ryan

Current practice in paediatric videofluoroscopy

Received: 2 December 2005 / Revised: 12 January 2006 / Accepted: 12 January 2006 / Published online: 22 March 2006

Abstract Use of the videofluoroscopy swallow study (VFSS), also known as the modified barium swallow (MBS), continues to increase in children. This article reviews the scope and limitations of the examination, explores the current techniques and illustrates some of the main findings. As moving images are key to the understanding of the use of this technique short videos are available in the on-line version of this paper.

Keywords Videofluoroscopy · Technique · Swallowing · Children

Introduction

The videofluoroscopy swallow study (VFSS) has been used in adults for many years to assess disorders of swallowing. Its use in children is increasingly widespread and it is considered by many to be the gold standard test. Its advantages in the assessment of swallowing include the ability to provide a dynamic view of all the stages of swallowing (oral preparatory, oral, pharyngeal and upper oesophageal), the accurate detection of aspiration and the simulation of a real feeding episode. Disadvantages are those of exposure to ionizing radiation and hence the associated need for a time-limited examination, and the need for patient cooperation.

Dose-limiting techniques such as pulsed fluoroscopy and tight coning should be used. Several different textures of food are usually offered to the child in an order determined by the speech and language therapist (SLT). Aspiration is not an absolute indication for the termination of the study. To optimize the information obtained VFSS is best performed as a multidisciplinary procedure with the radiologist and SLT working in partnership.

Electronic Supplementary Material Supplementary material is available in the online version of this article at http://dx.doi.org/10.1007/s00247-006-0124-3 and is accessible for authorized users

M. P. Hiorns (✉)
Department of Radiology,
Great Ormond Street Hospital for Children,
Great Ormond Street,
London, WC1N 3JH, UK
e-mail: hiornm@gosh.nhs.uk
Tel.: +44-207-4059200
Fax: +44-207-8298665

M. M. Ryan
Department of Speech and Language Therapy,
Great Ormond Street Hospital for Children,
London, UK

Why is videofluoroscopy necessary?

VFSS evaluation of swallow function is frequently described as the definitive investigation to objectively assess the adequacy of airway protection during swallowing. In addition, it allows simultaneous viewing of the oral, pharyngeal and oesophageal stages of swallowing and the way in which these stages interact [1]. VFSS has become an essential adjunct to the clinical assessment of swallowing in children.

A prospective study provides evidence-based data regarding the use of the VFSS to confirm swallowing dysfunction in children [2]. The authors reported confirmation of swallowing dysfunction by use of VFSS following the detection of laryngeal penetration or aspiration during evaluation for gastro-oesophageal reflux by upper gastrointestinal series.

Reilly et al. [3] summarized the evidence from a number of studies that demonstrate that this technique both contributes essential diagnostic information and improves patient outcomes, e.g. by reducing the risk of chest infections by demonstrating tracheal aspiration that is ‘silent’ on clinical assessment [4].

DeMatteo et al. [5] found that clinical evaluation of the risk of penetration or aspiration for fluids may be sensitive in up to 92% of children who do aspirate, but clinical evaluation is only sensitive for detecting aspiration of solids in 33% [5]. Cough is a sensitive predictor of fluid

aspiration and aids the SLT, but if this is not present the clinical evaluation by the SLT is much less sensitive.

It has been demonstrated that infants suspected of dysphagia show abnormalities during VFSS, including nasopharyngeal backflow, laryngeal penetration, and aspiration [6]. A high incidence of silent aspiration (aspiration of material into the trachea without a secondary cough or choking response) was noted, emphasizing the importance of objective study. Whilst silent aspiration is difficult to detect in all children, it is especially so in those with neurologically based dysphagia. Aspiration can lead to complications such as acute pneumonia and chronic lung disease. Thorough evaluation of the oral, pharyngeal, and oesophageal phases of swallowing is crucial for patients with dysphagia. VFSS is the procedure of choice for children to delineate the pharyngeal and upper oesophageal phases of the swallow that can only be inferred by bedside clinical assessment. An early study [7] described the attributes of aspiration and pharyngeal motility in a large sample of infants and children assessed with VFSS. Aspiration was observed in 48 (26%) of 186 children, primarily with liquid, before or during swallows. Aspiration was trace (less than 10% of a bolus) and silent in 94%. In children with cerebral palsy aspiration has been shown to be silent in up to 97% of the patients [8].

A number of studies have compared the merits and defined the deficiencies of other forms of assessment to VFSS in detecting aspiration. Mann et al. [9] found that clinical bedside evaluation of swallowing in acute adult stroke patients underestimated the frequency of dysphagia and overestimated the frequency of aspiration.

In summary, VFSS has been shown unequivocally to be a reliable technique in assessing the paediatric swallow and the risk of aspiration. This allows modification of feeding techniques and prevents secondary complications.

Other techniques

Bronchial auscultation during swallowing has had a minor renaissance in adult practice and has been shown to be reliable at detecting adult patients who are not aspirating, but is not reliable at identifying those who are shown at VFSS to be aspirating [10]. This work has not been correlated in children.

Flexible endoscopic examinations (FEES) are becoming more widely used in adults in assessing dysphagia, and some authors question whether the term ‘gold standard’ should still be applied to VFSS [11]. First described in 1988, FEES uses an endoscope to directly visualize the hypopharynx during the swallowing process to assess airway protection [12]. It has since been described as a feasible examination in paediatric patients [13], although it is not routinely used in the assessment of swallowing disorders in children as it remains a specialist procedure that is not available in many centres. It is also only generally suitable for either very young children or for older children who are able to cooperate. Studies have been completed focusing on documenting the safety of FEES in the paediatric population and in these studies the specificity and sensitivity of FEES and VFSS have been compared [14]. FEES has been shown to be a useful technique for diagnosis and treatment of paediatric patients in the acute care setting [15]. Interobserver and intraobserver reliability of FEES using VFSS in a replication study (as measured by the penetration-aspiration scale, PAS) [16] has shown good reliability of FEES as compared with VFSS [17].

Radiologists and speech therapists

In most centres in which it is practiced, the development of the VFSS has been a combined process between radiologists and SLTs with a special interest in dysphagia, and this has resulted in joint disciplinary working practice. Formal evaluation by the radiologist and SLT results in an understanding of functional and anatomical process, optimizing and facilitating management and feeding recommendations.

In many countries it is a legal requirement that a radiologist or radiographer (technician) controls the delivery of X-rays for screening purposes. Speech therapists, however, offer considerable and vital expertise in the clinical assessment of patients, deciding on suitability for a videofluoroscopic study, and on the format of the study once this has been agreed. Speech therapists and radiologists will usually report together on the findings (although in some centres this is performed solely by the radiologist or by the SLT). Our strongly held view is that an optimal study, and interpretation of the results, is achieved as a combined multidisciplinary procedure and lack of such practice is difficult to defend.

Patient selection

Medical conditions and diagnoses which predispose children to the risk of dysphagia and aspiration have been well documented and defined. Studies by Reilly et al. [18] and Sullivan et al. [19] both confirmed a high prevalence of dysphagia in children with cerebral palsy; 91% and 89% respectively. Not only is this high, but Arvedson et al. [7] also identified high rates of silent aspiration in children with neurologically-based dysphagia. It is also recognized that swallow dysfunction may occur in infants with feeding difficulties in the absence of other medical problems, which may not be demonstrated on an upper gastrointestinal study (UGI) [20]. Morgan et al. [21] used VFSS to define specific characteristics of swallow impairment in children who had sustained moderate/severe traumatic brain injury.

In our centre we have also recognized a high incidence of swallow dysfunction in different complex paediatric groups; for example, children in the acute stage of juvenile dermatomyositis. This group has benefited from feeding modifications based on information obtained from VFSS.

The literature unanimously recommends that children be seen for a clinical assessment of feeding and swallowing by

the SLT before being referred for VFSS. This involves taking a detailed history that covers medical, developmental and feeding factors. Such assessment involves oromotor evaluation and direct observation of the practicalities of a meal for those children who are orally fed at the time. This allows clinicians to determine the child's swallow function, optimum positioning for feeding, possible interference from uncontrolled movements, and foods to be assessed, so that the VFSS can simulate as near as possible the conditions under which the child would eat, and the information obtained be of practical use. Many children with feeding difficulties will be anxious during mealtimes and this may lead to food refusal with difficult behaviour [22]. In discussion about patient selection for VFSS, Arvedson and Lefton-Grief [23] recommend that patients who are lethargic, orally defensive or medically unstable are generally unable to participate adequately in a VFSS. Pre-VFSS assessment gives the SLT the opportunity to assess these factors. Furthermore it is possible to assess whether the child is likely to be able to cooperate enough during the assessment for a successful study to be completed, or whether there should be a period of therapy to reduce difficult behaviour before attempting a study. A child should never be fed whilst crying or struggling as this will both change the swallowing physiology (increasing the aspiration risk) and will negatively reinforce adverse feelings about feeding [24]. While there are very many indications for VFSS, it is important to note clinical presentations which are *not* indications and these include primarily behavioural problems such as 'spitting out lumps', 'gagging' and refusal of solids after successful feeding on liquids.

Practical technique

Preparation

For many children and their families, visiting a hospital for any new procedure brings with it anxiety and concern as to any discomfort while the procedure is carried out as well as the possibility of the study resulting in bad news. An early explanation of the procedure, with a leaflet or information sheet, can prepare families for what to expect. It can give practical advice regarding bringing appropriate and contrast-accepting foods, such as fromage frais, and familiar utensils, e.g. bottle, cup etc. Where possible, families are also asked to bring seating systems for those children who use them during meal times in order to achieve optimal positioning and functional relevance for the study. There is little point undertaking this assessment in a nonfunctional position. The study needs to involve the carer who is the child's familiar feeder. Children do not need to be prestarved but conversely are unlikely to be willing to take any sufficient volumes of food and drink if they have just been fed.

Environment

As our studies are performed in the setting of a children's hospital, the fluoroscopy room is child-friendly with toys, mobiles and boxes of rewards. It should not be underestimated how much an environment can contribute to a successful study by distracting or settling the child. There is a need to have the capacity and understanding to be as flexible as possible—we have worked around a TV for a child who would only eat when watching videos. One should aim to keep the number of people within the child's line of vision as small as possible.

Presence of tubes

For children who are mainly fed by gastrostomy or nasogastric tube (NGT), we recommend that, with the agreement of the medical team, they become accustomed to taking small tastes of the foods to be assessed for 1–2 weeks prior to the VFSS. Removing NGTs is not considered necessary in most cases and indeed the trauma of having to have the tube repassed rarely justifies its removal for VFSS. A study in young adult volunteers showed that whilst nasogastric tubes slow swallowing they do not alter swallowing function (bolus transit and clearance), and airway protection [25]. However both fine (8F) and wide-bore tubes (16F) cause significant duration changes in several swallowing measures, including the duration of stage transition, pharyngeal response, pharyngeal transit, and upper oesophageal sphincter opening.

Presentation of foods

VFSS is often considered the 'gold-standard' technique to assess dysphagia but despite this status, unanimous agreement has not been reached regarding the protocol for this procedure. Some authors suggest that dysphagia specialists should achieve greater consistency in the VFSS procedure before claiming to be implementing a 'gold-standard' technique [26]. Although adult protocols tend towards uniform procedures, paediatric studies aim to be more individualized and tailor-made. There is variability in the literature regarding the correct order of presentation of the different food consistencies that are to be assessed. For adult studies a uniform protocol of liquid, followed by paste and then cookie was described early in the literature [4] and has subsequently been expanded to include gradually increasing volumes of thin liquids progressing through to solid foods [24], but a contrasting more tailored approach has also been outlined [27] using foods similar to those which the patient usually eats, with the safest being presented first and the high-risk textures being presented last.

It is our experience that a more pragmatic individual approach can be helpful in children who frequently have strong likes and dislikes with regard to food. Arvedson and Lefton-Grief [23] recommend starting with liquids, as the major texture in the diet and one that is least likely to cause residue after swallowing. Residue would make interpretation of function for other foods more difficult. However, we find that gaining a child's cooperation by giving them a favourite food at the start of the study is reassuring and is likely to result in a higher yield of information as the child is then more likely to accept other more challenging foods. Where it is immediately apparent that the child's level of cooperation is likely to be poor throughout, we start with the food/liquid texture about which there is most concern so as not to miss evaluating this, as it may be that compliance ceases after the first 'odd-tasting' mouthful.

Most authors agree that at the end of the examination it is necessary to provide realistic and practical advice for feeding, to have assessed multiple swallows as aspiration may not be demonstrated with a single bolus, and to present a range of textures.

Barium textures

Studies have shown that the perceived thicknesses of various barium textures do not correlate well with the actual textures given at meal times [28] when objective criteria are measured (viscosity, density and yield stress). The authors point out that there is a need for objective measurement of fluids used in dysphagia assessment, as subjective assessments do not provide acceptable rheological matches between meal time and VFSS fluids. They suggest fluid recipes should be adjusted to create a standardized set of dietary fluids with match VFSS counterparts. Clinicians should be particularly aware that a thin barium solution that is more nectar-like than a 'true' thin fluid may suggest that the patient can safely swallow thin fluids, when in fact he/she may aspirate 'true' thin fluids. Whilst more viscous fluids can be therapeutic for dysphagic patients, there is a balance between the therapeutic value and the additional effort and strength required to swallow more viscous substances.

Typically, textures offered to the patient may include very thin barium, cream consistency barium, purée or yoghurt consistency barium, and possibly barium-coated solids such as biscuits. Thickening agents can be used to adjust the textures of liquids. Each institution should have a repeatable method for preparing the textures for consistency both between patients and for repeat studies in the same patient. Premixed barium preparations of varying consistencies (thin liquid, nectar, thin honey, honey, pudding) have recently become licensed in some countries (Varibar; E-Z-EM, Lake Success, N.Y.) and may help standardize examinations.

Multiple swallows

In a study of 43 infants younger than 1 year with suspected dysphagia, most infants with suspected dysphagia showed overt abnormalities on VFSS: laryngeal penetration, aspiration, and/or nasopharyngeal backflow. Importantly, most of these infants did not demonstrate abnormalities in the first few swallows, but displayed deterioration in swallowing function as they continued to feed. Thus, radiographic assessments in infants must examine multiple swallows. The high incidence of silent aspiration demonstrates the necessity for a videofluoroscopic assessment to evaluate swallowing function in these infants [6].

Fatiguing

One of the features that may become evident after multiple swallows is fatiguing, and it may be necessary to deliberately 'fatigue' the swallow, i.e. allow the child to continue feeding to see what happens to swallow function as he/she tires. Fluoroscopic screening should not be used during this period. When the patient's swallow appears to be slowing, screening can be restarted.

Deterioration in an infant's ability to maintain airway protection has been demonstrated as the feeding progresses and this provides evidence to support this use of interval fluoroscopic imaging during ongoing feeding as opposed to termination of the study after imaging of only the first several swallowing chains [6]. This technique is recommended for infants whose medical condition may make them susceptible to fatigue during bottle-feeding, and for children of all ages with conditions such as neuromuscular disease and chronic cardiac or respiratory problems that may decompensate on effort.

Terminating the study

Generally we feel this will be when the SLT and radiologist agree that the goals of the study have been achieved. It does not always have to be aborted when aspiration is seen. We will abort a VFSS if there is gross aspiration, a significant drop in oxygen saturation levels, or if the child is crying or struggling, therefore changing the physiology of the swallow [26]. The study may be continued if we feel we can safely proceed to define how feeding can be adjusted to eliminate risk.

Palmer et al. [29] argue that it is appropriate to continue the study in order to determine the cause of aspiration and whether it can be eliminated by a change in technique. On some occasions the patient will not be cooperative and the SLT with the radiologist will make a joint decision to abandon the study for that particular day. It is preferable to do this than to persist, thereby increasing the radiation dose and further distressing the child, for only a slim chance of useful information.

Radiological technique

The primary aim in performing VFSS in children is to provide a diagnostic study for the minimum exposure to ionizing radiation.

Seating equipment

It is essential that the baby, infant, child or adolescent is either gently restrained or is able to independently maintain a relatively static position. Otherwise radiation dose will be increased as the radiologist attempts to 'follow the patient' as he or she moves. For babies and infants, and for children up to approximately 3 years, a preformed foam or polystyrene seat that can be mounted on the X-ray equipment is ideal (Fig. 1). Sometimes referred to as 'Tumbleform' chairs (Sammons Preston Rolyan, Bolingbrook, Ill.), these seats must be virtually radiolucent, provide secure strapping for the patient, be easily attached and removed from the fluoroscopic equipment, and be easily cleaned. Different sized preformed seats are available to accommodate children of different ages. If the child is too large for a preformed seat, but is able to cooperate, the child may alternatively sit on a step mounted on the lower end of the fluoroscopy table when it is in the vertical position. Children who are usually confined to a wheelchair may have the study performed in their normal sitting position, provided the radioopaque parts of the chair, such as the backrest and the handles, can be placed out of the field of view. Finally, a 'Mangar' chair (Mangar International, Presteigne, Powys, UK) can be used which has a removable and radiolucent Perspex backrest (Fig. 2).

Fig. 1 A Tumbleform chair on the base of the fluoroscopy unit. The lateral X-ray beam will project over the area as shown by the light beam diaphragm

Fig. 2 Mangar chair. The removable Perspex seat back is shown

Fluoroscopic technique

The patient needs to be seated in a position lateral to the X-ray beam and as close to the image intensifier as possible. The distance between the X-ray source and the image intensifier should be maximized to reduce dose. An X-ray grid should not be used in younger children as this significantly increases dose, but may be necessary in older children for delineation of fine detail such as in the case of aspiration.

A light-beam diaphragm is strongly recommended to optimize the positioning of the patient and coning of the image, without having to screen the patient on each occasion. Optimum image size is usually achieved with mid-level magnification. It is not generally necessary to have the maximum magnification. Not only does this increase dose, it can make it more difficult to follow the patient if there is slight movement of the head during the swallowing phase.

Coning of the image should be such that the orbits are excluded superiorly, the clavicles form the lower part of the image, the cervical spine forms the lateral limit of one side of the image and the front of the lips forms the lateral limit of the other side of the image. The mA and kV settings will be determined by the program chosen, and will vary according to the size of the child. Typical mA and kV settings for a 6-month-old to 5-year-old child are 58–

60 kVp with 1–1.1 mA and for a 10-year-old child 62 kVp and 1.5 mA.

If using a unit with pulsed fluoroscopy, we would recommend confirming a satisfactory position with a rate of 3 pulses/s, but then increasing the rate to 15 pulses/s for the study itself. A pulse rate of less than 15 pulses/s may miss a very rapid aspiration. Continuous fluoroscopy or 30 pulses/s has been used by some authors [2]. Frame by frame review of 100 consecutive episodes of tracheal aspiration in infants <1 year of age showed barium below the vocal cords in 3–60 frames, i.e. for between 0.1 and 2 s (Table 1). It is therefore our practice to image the study at 15 pulses/s, which will still detect the briefest of aspirations whilst ensuring the radiation dose is minimized. We believe continuous screening (30 pulses/s and above) is not necessary for diagnostic accuracy and only increases the radiation dose. As this is a video study, full radiographic exposures (i.e. frames per second) should not be used.

Dose

Diagnostic reference levels (DRLs) should be set within each department for the varying ages of the patients, and will be dependent on the type of equipment used in any individual department. Usually DRLs are set such that 75% of the examinations will record a dose area product less than or equal to the DRL. Examples of diagnostic reference levels used in our institution are given in Table 2. Radiation doses in our patients are much lower than those described in adults. A study of 23 adult patients gave a mean dose area product of 400 cGy cm^2 (minimum 28 cGy cm^2, maximum 974 cGy cm^2) [30] compared with a range of 0.3–80 cGy cm^2 (median for a child aged 1–7 years is 9.3 cGy cm^2) in our paediatric population.

The image obtained should be linked to a medical quality video recorder, or DVD recorder, and this should be synchronized with the screening pedal.

During the study the radiologist and the SLT should work closely so that the timing of the fluoroscopy coincides with the oral and pharyngeal phases of swallowing, and there are not long periods of fluoroscopic screening between swallows or between the use of different textures of foodstuff that do not contribute to the diagnostic study, but increase the dose. In our practice the SLT tells the radiologist at exactly which point to start screening, but the radiologist will advise the SLT when the screening is becoming too prolonged, or when the diagnostic reference levels are being approached.

Table 1 Frame-by-frame review of 100 consecutive episodes of tracheal aspiration in infants <1 year of age on VFSS videotapes (30 frames/s) [2]

No. of frames	
Range	3–60
Average per episode of aspiration	15.8
No. of episodes of aspiration	
1–5 frames in duration	19
6–10 frames in duration	24
11–15 frames in duration	23
>15 frames in duration	34

Table 2 Dose area product values for VFSS over a 12-month period at our institution

	<1 year	1–7 years	≥8 years
Number of patients	116	246	84
Dose range (cGy cm^2)	0.3–39.2	0.1–80.6	1.3–76.8
Median dose (cGy cm^2)	9.95	9.3	13.45
75th percentile (cGy cm^2)	16	17	23
Current local DRL (cGy cm^2)	16	17	23

Parents and staff may sometimes ask about the (scattered) radiation dose they may receive by being present at the examination. This has been shown to be within acceptable levels when studies are performed in adults [31] and as doses are very much lower in children the dose would be expected to be miniscule, if recordable. Nevertheless pregnant mothers of patients are not allowed in the examination room during the study. If there is a possibility that the mother/main caregiver could be pregnant, families/caregivers should be advised to bring someone who is additionally accustomed to feeding the child.

Interpretation of results

The radiologist and SLT will agree the key features of a child's swallow function when the study is completed. The main structures visible on VFSS are shown in Figs. 3 and 4. A more detailed report by the SLT will describe functional changes at oral and pharyngeal stages of swallowing and their impact on the child's ability to feed safely and adequately. Where features such as aspiration, penetration, delayed initiation of swallow reflex or residue have been seen, a cause for these will be proposed and possible manoeuvres or therapeutic modifications may be suggested. This might include texture variations, for example thickening or liquids or changing the viscosity of solids, postural changes, alteration of bolus size or utensil changes. Management decisions following VFSS will also take into account the pre-VFSS clinical assessment and involve the multidisciplinary team and the family. Some studies have investigated the interobserver reliability in interpreting VFSS and in one study, nine SLTs reviewed VFSS images of subjects swallowing liquid and semisolid boluses. A five-point rating scale was used in three conditions: individually after careful reading; together with other SLTs in group discussion; and individually after the group discussion. Analysis of the ratings for the three conditions revealed that the level of agreement among raters was generally higher for semisolid swallows (presumably due to slower transit times) than for liquid swallows. The highest levels of agreement occurred for ratings made after group discussions. The levels of agreement were lowest when raters worked alone, relying

only on reading the scale [32]. High agreement is also noted if the study is normal or if there is aspiration of barium into the trachea. This, and other studies, emphasize the benefits of therapists reviewing images together or with other trained professionals. However, several studies have shown significant inter- and intraobserver variability [33, 34] and suggest that standard definitions of findings are still required.

Aspiration and pneumonia

It has been shown that there is a relationship between aspiration (as documented on VFSS) and pneumonia [35]. Patients who aspirated thicker consistencies had a 5.6 times greater risk of developing pneumonia than those who did not aspirate or, importantly, those who aspirated thin liquids only. In the adult population the likelihood of developing pneumonia is directly related to the degree of swallowing dysfunction seen on VFSS. Patients with no laryngeal penetration, regardless of whether they had normal or abnormal swallowing, have the lowest risk of developing pneumonia. Patients with laryngeal penetration, tracheobronchial aspiration, or silent tracheobronchial aspiration were found to be approximately 4 times (P=0.008), 10 times (P<0.0001), and 13 times (P<0.0001), respectively, more likely to develop pneumonia than those with normal swallowing [36]. It is likely that this is similar in the paediatric population.

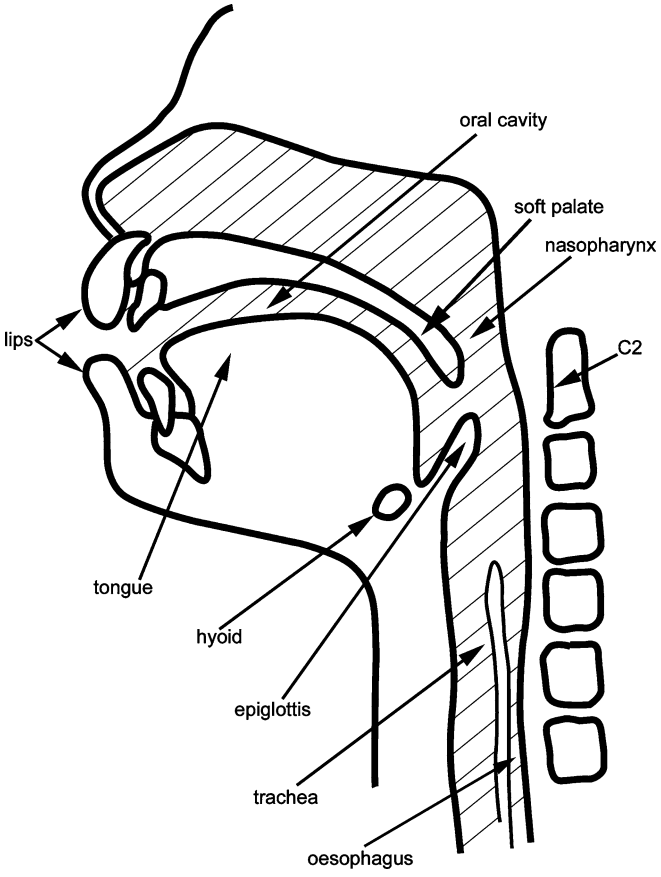

Fig. 3 Schematic lateral view of the neck in a young child showing the main anatomical landmarks that can be identified at VFSS; the *hatched areas* represent air-filled structures

Fig. 4 Lateral view of the neck showing the position of the valleculae and pyriform fossae. There is abnormal filling of the valleculae (*short arrow*) and pyriform fossae (*long arrows*). The patient is very slightly oblique allowing the pyriform fossa on each side to be seen. In a normal swallow neither of these structures should be seen to contain contrast

Penetration as a predictor of aspiration

In a study of 125 dysphagic children ranging in age from 7 days to 19 years, laryngeal penetration was identified in 60% of the study group, with 31% demonstrating deep laryngeal penetration. Of the children exhibiting deep laryngeal penetration, 85% aspirated, suggesting a strong correlation between these two events [37].

Coping with increasing demand for VFSS in children

It is the experience of most centres that there has been an increasing demand for VFSS, and a consequent increase in the number of procedures performed. In patients who may be silently aspirating, VFSS is now more frequently requested. It is also such that videofluoroscopy is now requested by more specialties; these include neurosciences, respiratory medicine, gastroenterology, surgery, intensive care, cardiology and otorhinolaryngology. It is inevitably the case that as demand continues to rise it becomes more difficult to provide adequate resources, particularly in radiology. To address this we have developed role extension of the senior radiographers who now perform some of the follow-up studies and report the study in conjunction with the SLT. This has not led to any increase in dose to the patient or detriment to the quality of the study, and has enhanced the role of the radiographers. It has been shown that 4 h of training of clinicians in the identification of head and neck anatomy and oropharyngeal swallowing disorders viewed radiographically resulted in significant improvement in identification of both radiographic anatomy and swallowing disorders [38] and our radiographers receive ongoing training in this area to enhance their practical and observational skills.

We have fluoroscopy lists dedicated to VFSS with each patient being allocated a 20-min study. This increases throughput as food textures do not have to be mixed on a one-off basis, but can be prepared for the session. This also optimizes the use of the radiologist's and SLT's time. Our institution currently performs approximately 600 studies per year in children.

Definitions

Aspiration:	food or liquid entering the trachea (airway).
Penetration:	food or liquid penetrating the laryngeal inlet to just above the level of the vocal folds and clearing (i.e. *not* aspirated).
Residue:	the presence of food or liquid remaining in the pharynx after swallowing.
Reflux:	the backward movement of food or liquid as in gastro-oesophageal reflux or nasopharyngeal reflux.
Epiglottic undercoating:	penetration of material underneath the epiglottis above the level of the laryngeal vestibule.
Delay:	a delay in the initiation of the swallow reflex of more than 1 s is interpreted as abnormal in infants, children and adults [24].

References

1. Miller CK, Willging JP (2003) Advances in the evaluation and management of pediatric dysphagia. Curr Opin Otolaryngol Head Neck Surg 11:442–446
2. Mercado-Deane MG, Burton EM, Harlow SA, et al (2001) Swallowing dysfunction in infants less than 1 year of age. Pediatr Radiol 31:423–428
3. Reilly S, Oates J, Douglas J (2003) Evidence based practice in speech pathology. Whurr, London
4. Logemann J (1983) Evaluation and treatment of swallowing disorders. College-Hill Press, San Diego
5. DeMatteo C, Matovich D, Hjartarson A (2005) Comparison of clinical and videofluoroscopic evaluation of children with feeding and swallowing difficulties. Dev Med Child Neurol 47:149–157
6. Newman LA, Keckley C, Petersen MC, et al (2001) Swallowing function and medical diagnoses in infants suspected of dysphagia. Pediatrics 108:E106
7. Arvedson J, Rogers B, Buck G, et al (1994) Silent aspiration prominent in children with dysphagia. Int J Pediatr Otorhinolaryngol 28:173–181
8. Rogers B, Arvedson J, Buck G, et al (1994) Characteristics of dysphagia in children with cerebral palsy. Dysphagia 9:69–73
9. Mann G, Hankey GJ, Cameron D (2000) Swallowing disorders following acute stroke: prevalence and diagnostic accuracy. Cerebrovasc Dis 10:380–386
10. Shaw JL, Sharpe S, Dyson SE, et al (2004) Bronchial auscultation: an effective adjunct to speech and language therapy bedside assessment when detecting dysphagia and aspiration? Dysphagia 19:211–218
11. Langmore SE (2003) Evaluation of oropharyngeal dysphagia: which diagnostic tool is superior? Curr Opin Otolaryngol Head Neck Surg 11:485–489
12. Langmore SE, Schatz K, Olsen N (1988) Fiberoptic endoscopic examination of swallowing safety: a new procedure. Dysphagia 2:216–219
13. Willging JP (1995) Endoscopic evaluation of swallowing in children. Int J Pediatr Otorhinolaryngol 32 Suppl:S107–S108
14. Madden C, Fenton J, Hughes J, et al (2000) Comparison between videofluoroscopy and milk-swallow endoscopy in the assessment of swallowing function. Clin Otolaryngol Allied Sci 25:504–506
15. Leder SB, Karas DE (2000) Fiberoptic endoscopic evaluation of swallowing in the pediatric population. Laryngoscope 110:1132–1136
16. Rosenbek JC, Robbins JA, Roecker EB, et al (1996) A penetration-aspiration scale. Dysphagia 11:93–98
17. Colodny N (2002) Interjudge and intrajudge reliabilities in fiberoptic endoscopic evaluation of swallowing (fees) using the penetration-aspiration scale: a replication study. Dysphagia 17:308–315
18. Reilly S, Skuse D, Poblete X (1996) Prevalence of feeding problems and oral motor dysfunction in children with cerebral palsy: a community survey. J Pediatr 129:877–882
19. Sullivan PB, Lambert B, Rose M, et al (2000) Prevalence and severity of feeding and nutritional problems in children with neurological impairment: Oxford Feeding Study. Dev Med Child Neurol 42:674–680
20. Vazquez JL, Buonomo C (1999) Feeding difficulties in the first days of life: findings on upper gastrointestinal series and the role of the videofluoroscopic swallowing study. Pediatr Radiol 29:894–896
21. Morgan A, Ward E, Murdoch B, et al (2002) Acute characteristics of pediatric dysphagia subsequent to traumatic brain injury: videofluoroscopic assessment. J Head Trauma Rehabil 17:220–241
22. Field D, Garland M, Williams K (2003) Correlates of specific childhood feeding problems. J Paediatr Child Health 39: 299–304

23. Arvedson J, Lefton-Grief M (1998) Pediatric videofluoroscopic swallow studies: a professional manual with caregiver guidelines. Communication Skill Builders/Psychological Corporation, San Antonia
24. Logemann J (1993) Manual for the videofluorographic study of swallowing. Pro-Ed, Austin
25. Huggins PS, Tuomi SK, Young C (1999) Effects of nasogastric tubes on the young, normal swallowing mechanism. Dysphagia 14:157–161
26. O'Donoghue S, Bagnall A (1999) Videofluoroscopic evaluation in the assessment of swallowing disorders in paediatric and adult populations. Folia Phoniatr Logop 51:158–171
27. Linden P, Siebens AA (1983) Dysphagia: predicting laryngeal penetration. Arch Phys Med Rehabil 64:281–284
28. Cichero JA, Jackson O, Halley PJ, et al (2000) How thick is thick? Multicenter study of the rheological and material property characteristics of mealtime fluids and videofluoroscopy fluids. Dysphagia 15:188–200
29. Palmer JB, Kuhlemeier KV, Tippett DC, et al (1993) A protocol for the videofluorographic swallowing study. Dysphagia 8: 209–214
30. Wright RE, Boyd CS, Workman A (1998) Radiation doses to patients during pharyngeal videofluoroscopy. Dysphagia 13:113–115
31. Chan CB, Chan LK, Lam HS (2002) Scattered radiation level during videofluoroscopy for swallowing study. Clin Radiol 57:614–616
32. Scott A, Perry A, Bench J (1998) A study of interrater reliability when using videofluoroscopy as an assessment of swallowing. Dysphagia 13:223–227
33. Stoeckli SJ, Huisman TA, Seifert B, et al (2003) Interrater reliability of videofluoroscopic swallow evaluation. Dysphagia 18:53–57
34. Ott DJ (1998) Observer variation in evaluation of videofluoroscopic swallowing studies: a continuing problem. Dysphagia 13:148–150
35. Taniguchi MH, Moyer RS (1994) Assessment of risk factors for pneumonia in dysphagic children: significance of videofluoroscopic swallowing evaluation. Dev Med Child Neurol 36: 495–502
36. Pikus L, Levine MS, Yang YX, et al (2003) Videofluoroscopic studies of swallowing dysfunction and the relative risk of pneumonia. AJR 180:1613–1616
37. Friedman B, Frazier JB (2000) Deep laryngeal penetration as a predictor of aspiration. Dysphagia 15:153–158
38. Logemann JA, Lazarus CL, Keeley SP, et al (2000) Effectiveness of four hours of education in interpretation of radiographic studies. Dysphagia 15:180–183