

Video analysis of swallowing and speech defects

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Part I – Introduction, techniques and phase assessment

Video swallows, or as previously performed cine swallow studies, are valuable in the sense that they render obscure images both detectable and usually identifiable. The analogy is the animal in the game park that is invisible by virtue of its camouflage among the surrounding vegetation. A slight movement by the animal will immediately betray its presence, following which identification is usually possible.

Since the act of swallowing occupies only 0.40 of a second, continuous image recording allows not only the holistic aspect of the physiological mechanism but also ensures registration of momentary episodes of the process, rendering them satisfactorily comprehensible

The request

In many X-ray departments vague and non-descriptive requests for a swallow examination often results in the ensuing examination being of an indifferent nature. Reasons for video or cine studies other than specific requests to assess post-laryngectomy cases for leaks, or when carcinoma has been identified on oesophagoscopy, are often in the nature of a single word: 'dysphagia'.

This latter request should immediately alert the examining radiologist to obtain an adequate history from the patient. The following points should be ascertained prior to any video study: (i) is there coughing after ingestion of fluid or solids? (ii) is there a sense of obstruction or pain in the chest anteriorly or posteriorly?; (iii) is there

heartburn?; (iv) is there inflammatory change in the lungs, seen on a chest control film?; and (v) is there any evidence of possible gastric or duodenal symptomatology?

Depending on the information listed, the nature of the examination should be crafted to the circumstances. In all dysphagia studies the examination should be initiated using Hexabrix (Mallinckrodt Inc, St Louis, Missouri, USA), a solution composed of meglumine loxaglate (39.30 g) and sodium loxaglate (19.65 g) as the contrast medium of choice.

Objectives of the procedure

The objectives of the procedure are: (i) to obtain a complete anatomical and dynamic study of the swallowing mechanism; (ii) to be able to replay the episodes so as to fine-tune diagnostic assessment; (iii) for the video record to be available for review by referring clinicians; and (iv) for the video study to enhance any presentation to interested groups, e.g. swallowing and speech therapy units, etc.

Technical considerations (positioning)

Variable postural imaging includes: (i) supine lateral with horizontal beam; (ii) supine anteroposterior; (iii) erect lateral; (iv) erect anteroposterior; and (v) lateral in variable angles, e.g. 45°.

The importance of postural imaging is to ascertain whether tracheal spill at the laryngeal level is observed. Does it disappear or diminish with changes in position as itemised above. It is naturally of importance to the clinician or swallowing therapists to have this information in order to minimise the risk of pulmonary infection, e.g. during the healing phase of inco-ordination arising from a stroke, trauma or surgery.

Video swallows in children

Whether a child is either breast or bottle-fed, it is important to assess the sucking reflex, and to this end a bottle using sweetened Hexabrix mixed with a small amount of milk formula should be used. Where the reflex is absent, a syringe with a tubal extension should be used to introduce the contrast into the mouth.

In children with swallowing defects, e.g. in cerebral palsy, the study should be commenced in the supine lateral position, the beam being directed horizontally enabled by a 90° rotation of the tube and intensifier. An anteroposterior position is then assumed with return of the tubal intensifier assembly to the overhead position. The mother or accompanying attendant should ensure that the head is kept in a true anteroposterior position. An extra radiographer or assistant can keep the child's arms at his or her side. This avoids repetitive radiation to the attendant radiographer.

With this phase of the examination completed, the removable footplate is added to the table at a suitable height to allow the mother to sit in a sideways position facing the radiologist. She will then hold the child on her lap, the patient also facing the radiologist. Administration of the contrast either by bottle or syringe will then be repeated, commencing the video run immediately before the contrast is administered. Apart from identifying any aberration of swallowing, the presence or absence of an adenoid pad in the post-nasal space should be noted. The presence of a large adenoid pad will significantly complicate any existing inco-ordination. The lateral study completed, the child will then rotate through 90° and face the tube. An anteroposterior study will then be repeated in the erect position, a manoeuvre that will identify the symmetrical use of both lateral food channels or alternatively one of the commonest variations, the unilateral food channel filling.

If the child is old enough to have reached the 'puree' or semi-solid stage, 'thick-and-easy' is added to the Hexabrix, thickening it to the extent that the mother

identifies it as the same consistency as food normally given to the child. This done, the supine and erect procedures already described will be repeated.

Sometimes in children it will be necessary to examine the handling of ingested solids, and to this end biscuits and bread soaked in Hexabrix should be administered in a teaspoon. By now it should be sufficiently clear to the reader that the examination can be prolonged and fairly complicated.

In children the procedure should be completed by placing the child on the right side in a slight Trendelenberg position to assess the presence or absence of gastro-oesophageal reflux, which may well complicate pre-existing inco-ordination. Reflux may occur spontaneously or be initiated by giving the child water, either by bottle or syringe.

Video swallows in adults

In adults who are able to stand, the sequence is reversed, commencing with erect lateral studies of the cervical region and ending in the supine position. An important exception to this rule is where coughing follows ingestion of food or fluid, raising the suspicion of a tracheo-oesophageal fistula. This is even more the case when there is the longstanding existence of a tracheostomy tube. In this instance Hexabrix should be given with the patient in the erect right oblique position centering the beam on the upper thoracic region.

This study should identify a tracheo-oesophageal fistula (TOF) which might be obscured by spill at laryngeal level and which may not be appreciated if the imaging is initially at cervical level. Not infrequently a tracheo-oesophageal fistula appears to give rise to laryngeal or pharyngeal inco-ordination, which will result in a concomitant spill at vallecular level.

Patients in the erect position who exhibit tracheal spill at laryngeal level may not spill in the supine positions due to gravitational posterior displacement of food or contrast. It may in fact be possible to demonstrate a critical angle of the patient

on the tilting table at which level spill commences. This may well simplify feeding compared with problems encountered feeding the patient in a supine position.

In adults, repetition of the sequences, using thickened or solid mixtures may be necessary. In all cases the inco-ordination may be of such a degree that marked nasopharyngeal or oesophago-pharyngeal reflux will occur. In such cases contrast entering the ethmoid recess will sometimes pass into the ethmoidal sinuses and thence into the sphenoidal sinus. Turning the patient into the prone position will empty the sinus, contrast exiting by the same channel, and into the nasal cavity. Contrast is shown in both the sphenoidal sinus and maxillary antra (Fig. 1) indicating the necessity to exclude gastro-oesophageal reflux in all cases of resistant sinusitis (Figs 1 and 2a,b).

Nasogastric tubes

In infants the tube should be removed and repositioned after the examination is complete. In adults and older children the swallow study may be preceded by giving a small bolus of Hexabrix. If no tracheal spill is present a larger bolus is given, this in the most suitable position for the patient. Not infrequently, especially in cerebrovascular accident (CVA) patients, this will be the

supine position. The larger bolus may produce distress and laryngeal block, which consists of coughing mixed with rapid swallowing, which in turn results in ingestion of the fluid as it passes the vocal cords. Alternatively there may be actual spill into the trachea. If no spill is present with a small bolus, even though filling of only one food channel is noted, this being due to unilateral deflection of the epiglottis, the tube should be permanently removed and nutrition established by small frequent feeds. Fluids would appear to be the only form of nutrition given at this stage, but as the swallowing improves, as is the case in most CVAs, a repeat study using thickened and solid medium may be requested. If after the tube has been removed tracheal spill is still present, the tube should be repositioned.

Phase assessment

Assessment of the swallowing mechanism should be divided into three phases, namely oral, pharyngo-laryngeal and oesophageal.

Oral phase

The efficiency of the propulsive mechanism of the tongue should be registered. With severe inco-ordination of neurological origin the propulsive movement may be



Fig. 1. Contrast in the sphenoidal sinus and maxillary antra.

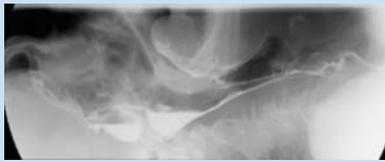


Fig. 2a. Lateral study in the supine position showing contrast in the sphenoidal sinus.



Fig. 2b. Prone lateral study. The contrast in the sphenoidal sinus has emptied via the same channel, into the nasal cavity leaving a thin mucosal coating in the sinus.

poor or non-existent. A characteristic feature is tongue rocking. In children oral incompetence may occur, with marked spill from the mouth. Ignore this and carry on with the investigation. Inadequate velopalatal apposition may result in significant naso-pharyngeal reflux, with contrast being ejected from the nose.

Pharyngeal phase

The primary cause of inco-ordination is failure of posterior deflection of the epiglottis. This may be complete or unilateral. The causes are as follows:

1. Unilateral fixation due to carcinoma of the larynx. This may be the earliest sign. In one case this phenomenon was apparent some 6 months prior to the lesion being identified endoscopically.
2. Direct trauma with haematoma formation.
3. Neurological, where a clinical indication of a central lesion is often present.
4. Following laryngeal surgery.
5. Infections, viral or otherwise, in which instance the anomaly is transient.
6. Gastro-oesophageal reflux extending to the larynx.

Oesophageal phase

Idiopathic or post laryngectomy-induced spasm of the commencement of the oesophagus may occur. This results in failure of clearance of the contrast bolus which immediately challenges the larynx, resulting in what is often a massive tracheal aspiration (Fig. 3a-c).



Fig 3a. Lateral erect study revealing failure of the oesophagus to accept contrast bolus, with consequent reflux into the nasopharynx.



Fig. 3b. Tracheal spill as vocal cords open.



Fig. 3c. Anteroposterior study showing tracheal spill.

This may be related to extensive laryngeal surgery and is possibly in the nature of a lower motor neuron lesion due to nerve injury. In other cases the cause is not immediately apparent and repeated dilations do no appear to relieve the defect significantly.

Where such oesophageal spasm follows a stroke, healing will on occasion result in the swallowing mechanism returning to a normal or near-normal state. This may occur as early as 3 months after initial demonstration of the inco-ordination. Donner and Jones^{1,2} describe the assessment of swallowing defects, and in their video of abnormal swallowing indicate the association between gastro-oesophageal reflux and crico-pharyngeal hypertrophy and diverticulum formation. The mechanism would appear to be chronic mucosal irritation with underlying muscle stimulation eventually resulting in hypertrophy. This in turn leads to obstruction and diverticulum formation. Failure of contrast clearance will clearly lead to spill into the trachea as the vocal cords open. These authors also describe the presence of congenital laryngo-oesophageal fistula and demonstrate this lesion in their video study.

The presence of extensive gastro-oesophageal reflux will also result in tracheal aspiration, particularly at night, and is recognised as a prominent factor in precipitating asthma attacks.



Fig. 4a. Oesophageal web shown in lateral erect position.



Fig. 4b. Lesion shown in erect anteroposterior position.

Thoracic lesions of the oesophagus, which may be associated with pharyngo-laryngeal inco-ordination, include: (i) traumatic lesions; (ii) malignant lesions; (iii) reflux-related lesions; and (iv) surgical lesions, e.g. gastro-oesophageal (Fig. 4a and b).

Part II – Apparatus, indications and speech assessment technique

Technical considerations — apparatus

A screening unit capable of rotatory tube and intensifier movement across the long axis of the X-ray table is essential (Fig. 5). The table itself should tilt from vertical to at least 15° - 30° Trendelenburg. The image registration system should preferably be digital allowing for direct filming from the screen, which has the advantage over conventional radiography of being instantaneous. Conventional radiography has an inherent pause due to the relay delay, which allows the anode to reach the required speed. Modern machines have a built-in cine capacity (15 - 25 frames per second) and most have a work station enabling tape or disc recording to take place.



Fig. 5. Apparatus allowing for a horizontal position of the image intensifier and X-ray tube is essential to assess the possible beneficial result of swallowing in the supine position.

The unit should also have the facility for radiography at a frame rate of 8/s, which does tend to be instantaneous, but

has the disadvantage of tube overload and wear in addition to increased radiation doses to the patient.

A video recorder has the facility of slow-motion replay. It should also be equipped with sound recording, which enables the examiner to vocally preface different swallowing positions, and as described later, it is necessary for speech-defect studies. The intensifier should be 38 cm in size and is adequate for all examinations. Specific attention should be paid to coning if the machine is not provided with a filtration system, which cuts down extra light resulting in a premature cessation of the exposure.

The processing is electronic and the imaging choice varies from one single exposure to six on a 35 x 43 cm film. It is also possible during video recording to choose one of three image sizes, namely small, medium, or enlarged.

In infants chest control is done with the third modality, but the cervical region is usually recorded on the middle magnification.

Indications

Acid laryngitis

This is caused by chronic gastro-oesophageal reflux with or without an associated hiatus hernia. This was well described by Ardran and Delahunty.³ Delahunty subsequently confirmed the initial finding of reflux oesophagitis being an aetiological factor in globus hystericus.⁴ This is the commonest cause of dysphagia in this department, and as previously indicated may be associated with: (i) unilateral food channel filling; and (ii) tracheal spill at night.

Local cervical lesions

1. Trauma, e.g. laryngeal haematoma with epiglottic fixation and unilateral food channel filling.

2. Laryngeal surgery: (i) postoperative leaks; and (ii) tracheal spill, which occurs particularly with the supraglottic type of laryngectomy — the image resembles an inverted Y, the contrast being shared equally by trachea and oesophagus.

3. Spasm of oesophageal commencement as described previously, with consequent laryngeal overload and spill through intermittently open vocal cords. Note that movement of the vocal cords following the expiratory phonation EEEE should be commented on. Paralysis of one of both will be found from time to time.

4. Cricopharyngeal hypertrophy with or without diverticulum formation and obstruction as described previously.

5. Possible tracheo-oesophageal fistula, the handling of which has already been described.

6. Kirschner⁵ describes the effects of neurological upper and lower motor neurone pseudobulbar lesions.

Causes of upper motor neurone lesions are: (i) strokes; (ii) anoxic damage; (iii) traumatic injuries; (iv) tumours; (v) demyelinating plaques; (vi) degenerative diseases; and (vii) Huntingtons disease.

Upper motor neurone lesions related to the above conditions reveal increased jaw and gag reflexes, dysarthria and emotional lability. Lower motor neurone lesions are as follows: (i) tumours; (ii) strokes; (iii) syrinx cavities; (iv) multiple sclerosis; (v) motor neurone disease; (vi) post-polio syndrome; (vii) focal cranial neuropathies; and (viii) neuromuscular junction lesions, i.e. bulbar weakness as seen in botulism, myasthenia gravis and the myopathies.

Mixed upper and lower motor neurone lesions may be seen as strokes, multiple sclerosis, amyotrophic lateral sclerosis (ALS) and Parkinson's disease.

All the above conditions may produce oral, pharyngeal and laryngeal inco-ordination manifested by: (i) oral incompetence; (ii) tongue rocking; (iii) nasopharyngeal reflux; (iv) pharyngo-oral reflux; (v) epiglottic insufficiency; (vi) vallecula spill; and (vii) failure of oesophageal clearance with consequent tracheal spill.

In relation to childhood inco-ordination, ascertain the position in which the child is fed, i.e. semi erect or supine. If spill occurs in the semi-erect and supine positions and gastro oesophageal reflux is identified in the supine position, the child should be held erect for 60 minutes after feeding is completed.

Speech aberration

Here the video swallow is associated with the relevant speech studies, which record the patient's voice and image simultaneously. This is most frequently done in children.

The method of the examination is as follows.

The examination is usually done in conjunction with speech therapists, but in their absence the radiographer can read from the vocal list (which has been supplied by the therapists).

Contrast coating of the pharynx

High-density barium (1 oz) is given to the patient to gargle. This should be fully explained to the child by the mother or the radiographer before commencing the coating; this also applies to nasopharyngeal coating.

Nasopharyngeal coating

It is advisable to bring the child to the examination room so as to acquaint him or her with the environment, and the apparatus to be used.

A 12 or 14 calibre French Foley's catheter is inserted into the one nostril and high-density barium is injected whilst the patient is instructed to sniff. This is repeated in the opposite nostril. It is recom-

mended that the mother or speech therapist accustom the child to this procedure before the day of examination. Obviously this is confined to insertion of the Foley tube into the nasal cavity.

The vocal examination is then commenced after control lateral and vertically angled AP views are done. The latter is done with the head extended and the tube angled vertically so that it tends to form a right angle with the base line.

Various sounds and sentences to be uttered are included in the speech supplement.

In the lateral study uvulo-palatal occlusion is assessed whilst the angled submento-vertical study reveals approximation of the lateral walls of the pharynx. These movements, adequate or otherwise, are correlated with synchronous vocal recording on the tape, which is usually supplied by the speech therapist.

It is worth repeating that in CVA and other neurological lesions, ventilation may be an associated problem necessitating a tracheostomy. Be aware that a long indwelling tracheostomy tube may erode through the trachea into the oesophagus. The tracheal spill arising at laryngeal level, induced by inco-ordination associated with the stroke may then be complicated by additional spill through a TOF. Initial thoracic imaging will identify the two separate

lesions. The laryngeal spill can be confirmed by a repeat study at cervical level.

Note that if anatomical deformity of the larynx or pharynx is demonstrated, laryngeal tomography or other further sectional imaging should be carried out.

Conclusion

A video swallow is a highly varied examination, tailored according to the nature of the underlying clinical defect and also the age of the patient. Swallowing therapists are of great assistance and often attend the examinations in our department. The proper fluoroscopic and recording apparatus is essential for completion of a satisfactory examination.

The author has no financial, personal or other interest in the product Hexabrix.

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