The Oesophageal Swallow (Barium Oesophagram) Test: Classical Radiological Signs from an 'out-dated' study and its role in the modern era of cross-sectional imaging.

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Learning objectives

• To provide an approach to the interpretation of the barium oesophagram and aid detection of abnormal radiological findings on a study that is being performed less frequently.

• Provide a pictorial review of the spectrum of imaging findings on the barium oesophagram to include benign/malignant pathologies.

• To discuss the role of both barium and water-soluble contrast swallow studies in the modern era of cross sectional imaging.

Background

• The barium oesophagram/swallow remains a useful method for assessment of the upper GI tract providing both structural and functional information.

• Barium swallow technique and indications are discussed particularly as there are numerous methods available to assess the upper GI tract.

• Both common and uncommon radiological findings (e.g. flask-shaped deformities in pseudodiverticulosis) are explained with the aid of cross sectional imaging where appropriate.

• The role of the water soluble contrast swallow study is discussed in relation to post-operative assessment following head/neck and upper GI surgery.

Imaging findings OR Procedure details

Applied anatomy for the Barium Swallow

The pharynx extends from the nasal cavity to the larynx and it is generally divided into (Image 1);

1. Nasopharynx - from the skull base to the soft palate

2. Oropharynx - posterior to the oral cavity and extending from soft palate to hyoid bone
3. Hypopharynx - extending from the hyoid bone to the cricopharyngeus

Valleculae - superficial pouches in the recess between the base of the tongue and epiglottis (Image 2 black arrows).

Pyriform sinuses - deep symmetrical lateral recesses (Image 2 thick white arrows) formed by protrusion of the larynx into the hypopharynx. The cricoid cartilage makes a prominent impression on the hypopharynx (Image 2 long white arrows)

Larynx is separated from the oropharynx and hypopharynx by the epiglottis and aryepiglottic folds.

The oesophagus extends from the cricopharyngeus to the gastro-oesophageal junction. The fibres of the cricopharyngeus muscle from the upper oesophageal sphincter.

Layers of the oesophagus;

1. MUCOSA - primarily of stratified squamous epithelium with columnar epithelium at its distal end.
2. MUSCULARIS MUCOSA - smooth muscle
3. SUBMUCOSA - loose connective tissue, nerve fibres, blood vessels and lymphatics.
4. INNER CIRCULAR and OUTER LONGITUDINAL MUSCLE - striated muscle in the upper 1/3, smooth muscle in the lower 2/3 of the oesophagus
5. No surrounding SEROSA except in the distal aspect of the oesophagus. This accounts for the pattern of spread of oesophageal tumours.

Cervical oesophagus extends from the C5/6 level to the thoracic inlet there is a curved anterior impression that is due to the cricoid impression. Below this, there is a web-like indentation due to a submucosal plexus of veins.

Normal impressions on the intra-thoracic oesophagus are caused by the aortic arch, left main stem bronchus and left sided heart chambers.

Barium Swallow Techniques

1
The oesophageal swallow study can provide information on both morphology and motility and various techniques can be utilised;

1. Single Contrast Technique

Aims to achieve maximal distension which can be further increased with the patient in a prone position

Provides information on the oesophageal contour and distensibility

Good for strictures, circumferential lesions and extrinsic lesions

Not ideal for superficial lesions (erosions, ulcers, small tumours) and oesophageal varices may be compressed.

2. Double Contrast Technique

Patient typically examined erect in the left posterior oblique (LPO) / right anterior oblique (RAO) position with the oesophagus anterior to the spine

Effervescent agent utilised to generate carbon dioxide within the stomach

Attempt to get full distension of the oesophagus

Good for superficial mucosal lesions

May overlook varices, small hernias, rings and webs

3. Mucosal Relief Technique

Assess mucosal folds in a collapsed/empty oesophagus.

Images are acquired following passage of barium bolus into the stomach with the patient in the erect LPO/RAO position.

Mucosa is coated by barium but not distended

Good for assessment of varices and thickened oesophageal folds

Standard Technique
At our institution, the following technique is utilised for routine barium swallow examinations. The barium sulphate preparation is Baritop 100% weight/volume;

- Lateral image of the pharynx and cervical oesophagus - images acquired at 4 frames per second with a good bolus with the aim of good distension (image 1);

- Anteroposterior images of the pharynx - images acquired at 4 frames per second with a good bolus with the aim of good distension (image 3);

- Single mucosal view of the pharynx with valsalva manoeuvre in order to distend the pyriform sinuses / lateral pharyngeal wall (Image 2);

- Erect right anterior oblique positioning to image the mid-lower oesophagus and gastro-oesophageal junction. Full distension single contrast technique or double contrast technique depending on the indication for the study. Single frame images or a sequence of acquired images at 2 frames per second. (images 4);

- Prone positioning with screening of a single swallow to assess the primary and secondary peristaltic waves. (image 5);

Rapid swallows in order to achieve maximal distension - single spot images are acquired. If the patients' main complaint is that of dysphagia then a food bolus coated in barium is administered.

Horizontal positioning is advocated by many authors as it negates the effect of gravity and hence propagation of barium is dependent upon oropharyngeal and oesophageal muscles.

- Supine view of the stomach in the supine position followed by reflux testing that involves;

Turning the patient
Inspiration/coughing
Water siphon test

**Normal Barium Swallow**
On the distended views of the oesophagus, the oesophageal mucosal folds flatten and there should be a smooth mucosal surface and smooth luminal contours.

On the collapsed views the coated oesophageal mucosal folds are thin (<3mm) and smooth.

Distal oesophagus has a fusiform shape referred to as the oesophageal vestibule. The **A ring** is a symmetrical muscular ring that separates the tubulovestibular junction and is apparent on barium swallow studies as a bilateral semilunar indentation.

**B ring**/Schatzki ring is a transient contractile area which is typically shelf like in appearance at the level of the gastro-oesophageal junction. During normal swallowing the B ring may be identified up to 1cm cephalad to the diaphragmatic hiatus.

Swallowing is a complex co-ordinated process that in general involves three phases; (oral, pharyngeal and oesophageal).

The oral phase is a voluntary phase that involves passage of food from the oral cavity into the oropharynx. The soft palate elevates and the tongue depresses in order to accommodate the food bolus and the oropharynx and hypopharynx act as a conduit for the passage of food into the oesophagus (pharyngeal).

**Primary peristalsis** involves a rapid wave of inhibition to open sphincters followed by a slow wave of contraction to move the food bolus from the cricopharyngeus to the vestibule.

**Secondary peristalsis** is initiated by oesophageal distension and typically starts at the point of the retained fluid bolus with contractions spreading up and down the oesophagus to ensure any residual bolus passes into the stomach.

A transient 'herring-bone' appearance or 'feline' oesophagus results from the transient spasm muscularis mucosa. This can be a normal finding but it can also represent an early sign of dysmotility and oesophagitis (Image 6A, Image 7 White line arrow)

**Tertiary contractions** (Image 6B) are non propulsive contractions that result in a non peristaltic corkscrew / beaded appearance. They signify a motility disorder and this can be secondary to reflux disease.
Fig. 6: Oesophageal motility.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

Barium Swallow Findings; Morphology

HIATAL HERNIA

- Herniation of stomach through the diaphragmatic hiatus into the thorax;
Sliding hiatus hernia - both gastro-oesophageal junction and stomach herniated into the stomach.

Paraoesophageal hernia (rare) - the gastro-oesophageal junction remains in the same position, only the stomach herniates into the thorax.

- Position of the gastro-oesophageal junction cannot be directly determined by the oesophageal swallow and is a controversial topic\(^2\)

- Sliding hiatus hernia is generally accepted to be present if the B ring is more than 1 cm above the diaphragmatic hiatus (White arrow Image 7)

- If >5 mucosal folds are present more than 1 cm above the diaphragmatic hiatus on a single contrast view this is also taken as a less direct sign of a sliding hiatus hernia (Black arrow Image 7).
OESOPHAGITIS

Peptic oesophagitis

- Inflammatory oesophageal changes due to reflux of stomach contents into oesophagus
- Healthy individuals experience episodes of reflux
- 40-50% with confirmed reflux oesophagitis demonstrate reflux on fluoroscopic examination
- Radiographic findings include mucosal granularity, ulceration, motility disorder and stricture formation with lack of distensibility (Black arrow Image 8)

Fig. 7: Hiatus hernia.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

Pseudodiverticulosis

Fig. 8: Peptic stricture.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM
• Morphological changes secondary to oesophagitis
• **Candida albicans** and **peptic oesophagitis** comprise a large % of cases, association in patients with diabetes mellitus
• Multiple small flask-shaped outpouchings (1-3mm) that represent dilated excretory ducts of the oesophageal mucosal glands (Yellow arrows Image 9)
• Located anywhere along the oesophagus, concurrent strictures may be identified

**Fig. 9**: Oesophageal diverticulosis.

**References**: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

**Infective**
• Suspect clinically if there is a history of odynophagia
• Candidiasis due to Candida albicans best assessed with double contrast technique. Linear lucencies best seen en face and there are discrete linear/oval shallow ulcers (White arrows Image 10)
• Candidiasis may progress to a cobblestone / shaggy irregular appearance due to a combination of transverse and longitudinal ulceration with plaque formation.
• Similar presentation with herpetic oesophagitis but this fails to respond to antifungal treatment.
Other

- **Crohns disease** - can result in significant ulceration with surrounding inflammatory changes. Deeper ulceration may result in sinus and fistula tract formation as well as strictures
- **Drug induced, corrosive ingestion**
- **Radiotherapy** Mild dysphagia and impaired peristalsis can result (20 Gy / 2000 rads) with ulceration and stricture formation at higher doses (White arrows Image 11)

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**Fig. 10**: Infectious oesophagitis.

**References**: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

**Fig. 11**: Oesophageal stricture.

**References**: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

**WEBS AND OUTPOUCHINGS**
Webs

- Thin, discrete membranes that sweep partially across the lumen.
- May occur in the pharynx and oesophagus (Black arrow Image 12)
- May be multiple and they are often incidental findings
Fig. 12: Oesophageal web.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

Lateral pharyngeal diverticula

- Protrusion of pharyngeal mucosa through an area of weakness in the lateral pharyngeal wall (White arrow image 13)
- Related to increased pharyngeal pressure and occurs in wind instrument players

Fig. 13: Lateral pharyngeal pouch.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

Zenker’s diverticulum
• Arises in the hypopharynx proximal to the upper oesophageal sphincter
• Located in the posterior midline at the plane between the circular and oblique fibres of the cricopharyngeus - Killian Dehiscence (Black arrow Image 14).
• Diverticulae have a small neck and can compress the oesophagus.
• Typically present with dysphagia, halitosis or regurgitation

Fig. 14: Zenker's diverticulum / pharyngeal pouch.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM
Mid-oesophageal diverticulum

- Pulsion diverticulae are due to disordered peristalsis
- Traction diverticulae are the result of adjacent fibrous inflammatory change
- Most are wide-necked and asymptomatic (White arrow Image 15)
Fig. 15: Oesophageal diverticulum.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

Epiphrenic diverticulum

- Located above the lower oesophageal sphincter, usually right sided

NEOPLASMS

Malignant Neoplasms

1. Squamous cell carcinoma - most common malignancy (90%) with common presenting symptom of progressive dysphagia
2. Adenocarcinoma - (less common, up to 10%)
3. Others are rare - lymphoma, verrucous squamous cell carcinoma

Different patterns of spread are identifiable on a barium swallow examination;

1. **Annular constricting lesion**

Oesophageal neoplasms may encircle the oesophagus and create an annular pattern with an 'apple core' appearance (Image 16).

Malignant strictures generally begin and end abruptly (Yellow arrows) and the overhanging edges are best identified at the superior margin. The oesophageal lumen is irregular / nodular and the mucosa is destroyed / ulcerated (Black arrows). Note the oesophagopleural fistula formation (blue arrow)
**Fig. 16**: Oesophageal carcinoma with stricture and fistulous tract formation.

**References**: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

- **Polypoid / Fungating pattern**

Prominent intraluminal growth and when seen in profile the margins are slightly undercut signifying a mucosal origin (Black arrows Image 17). The oesophageal wall from which it arises lacks distensibility
Fig. 17: Oesophageal carcinoma.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM
   • Infiltrative

The spread is primarily intramural and extends under normal mucosa. There is often loss of normal pliability and stenoses may result.

Barium swallow findings may show gradual tapering which may be indistinguishable from a benign stricture (Image 18). Longitudinal spread along the oesophagus is typical and may result in long segment strictures.
Fig. 18: Oesophageal neoplasm with stricture formation.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM
- *Ulcerative*

The presence of a possible oesophageal malignancy requires a combination of endoscopy with tissue biopsy followed by staging with CT imaging. The oesophagus is typically thickened in the region of the oesophageal malignancy and the aim of the staging is to determine further medical / surgical management of the tumour. PET imaging is utilised to determine if there is possible metastatic spread (Images 19, 20, 21, and 22).
Fig. 19: Oesophageal carcinoma.
References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM
Fig. 20: Oesophageal carcinoma on the barium swallow study. Marked oesophageal wall thickening on the axial contrast enhanced CT image with avid uptake on the corresponding PET/CT image.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM
Fig. 21: Findings suspicious for an oesophageal neoplasm identified on the barium swallow. Corresponding CT and PET images on Figure 22.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

Fig. 22: Oesophageal wall thickening on the axial contrast enhanced CT image corresponding to the area of abnormality on the barium swallow from image 21. Avid uptake identified on the PET/CT image.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

Barium Swallow Findings: Motility

PHARYNGEAL DYSFUNCTION

- Pharyngeal Stasis - Impaired pharyngeal transport with pooling of contrast in the valleculae and pyriform sinuses
• **Laryngeal penetration** - Entry of barium into the laryngeal vestibule but above the vocal cords

• **Aspiration** - Passage of barium below the vocal cords (Arrow Image 23)

**Fig. 23:** Aspiration of contrast.
References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

- Cricopharyngeal spasm (Black arrow Image) - May result in pharyngeal distension and subsequent laryngeal penetration (White arrow Image 24) and aspiration. Narrowing of >50% of luminal diameter is considered a definite cause of dysphagia.
Fig. 24: Cricopharyngeal spasm and laryngeal penetration.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

OESOPHAGEAL ACHALASIA
• Absence of peristalsis in the body of the oesophagus, increased resting pressure of the lower oesophageal sphincter and failure of the lower oesophageal sphincter to relax (Images 25).

• Deficiency of ganglion cells in the myenteric plexus (Auerbach’s plexus). On the swallow it results in uniform dilatation of the oesophagus (White arrow Image 25) with air-fluid level, absence of peristalsis with tertiary waves and a tapered beak deformity at the lower oesophageal sphincter (Black arrow Image 25).

• DDx to consider include carcinoma of the gastro-oesophageal region, scleroderma and Chagas disease.
Barium Swallow Findings: Outside the oesophagus

- During the barium swallow study or when interpreting the images from the barium swallow study it is important to also assess the surrounding structures imaged.
- E.g. important incidental findings include the presence of incidental bronchogenic neoplasms within the visualised lung (image 26).

Fig. 26: Incidental finding of a bronchogenic carcinoma on a barium swallow examination. Corresponding chest radiograph confirmed the finding.

References: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

Barium Swallow Findings: Post-operative
In our institution, water soluble contrast studies involve the administration of low osmolar contrast media (Omnipaque 150, Omnipaque 300) with similar imaging acquisitions depending on the indication. Post-operative films often necessitate the need for a control film in order to aid interpretation.

Common indications for water soluble contrast studies in our institution include:

- Suspected oesophageal perforation - both spontaneous and iatrogenic aetiologies in order to guide further medical/surgical management (Image 27).

**Fig. 27**: Oesophageal perforation post cardiothoracic surgery.

**References**: A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM
- Post-operatively following laryngectomy if there is a suspected anastomotic leak. Other indications post head/neck surgery include the assessment of fistulous tracts (Image 28).

**Fig. 28:** Fistula tract formation post head and neck surgery. Radioopaque marker to confirm location of skin opening of the tract.

**References:** A. Adams; Diagnostic imaging and therapeutics, Barts and the London NHS trust, London, UNITED KINGDOM

- Post-oesophagectomy patients in order to assess the surgical anastomosis and exclude an anastomotic leak.

**Images for this section:**
Fig. 1: Lateral View of Pharynx and Cervical Oesophagus.

Fig. 2: Magnified AP view to indicate the valleculae and pyriform sinuses.
Fig. 3: AP view of the pharynx and cervical oesophagus.

Fig. 4: Oblique erect views of the oesophagus.
**Fig. 5:** Prone positioning with view of the oesophagus following rapid swallows.
Conclusion

Summary:

• The barium oesophagram/swallow remains a useful method for assessment of the upper GI tract providing both structural and functional information.

• The water-soluble contrast swallow remains an essential investigation in the assessment of post-operative patients and in the emergency setting.

Personal Information

References

References